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Nothing but the truth?
Climate risk disclosure by US companies



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Abstract

As a proxy for a company's overall risk management efforts and its long-term health, corporate disclosure of climate change-related risks is a topic of growing relevance for investors, regulators, and consumers around the world. This paper analyses climate-related disclosure from a randomly-drawn sample of 100 publicly-traded US companies in their mandatory annual (10-K) reports. It examines the current extent and quality of disclosure and investigates the correlation between the disclosure level and ten variables at the company, industry, and state-level. The ten variables are: company size, financial performance, dual listing, governance traits (CEO duality, percentage of independent directors, percentage of female directors), industrial sector type, belonging to a highly-polluting sector, state GDP per capita and state political party. To summarize the current 'state of the market' on this topic the paper also assesses relevant empirical studies on factors affecting climate and environmental, social and governance (ESG) related disclosure.

Results show an overall low level disclosure in the sample analyzed and a very low climate risk disclosure score – lower than scores reported by previous studies on samples of companies from the S&P 500 Index. Only 31% of companies in the sample mention climate change in their 10-K reports, while 69% remain completely silent on this topic. The average disclosure score is 12.2, measured on a scale from 0 to 100. Of the companies that mentioned climate change in their 10-Ks, most only identified potential risks, while none disclosed how the company's management oversees and manages risks and opportunities linked to climate change. Variables which are found to be statistically significant, and correlated with the level of disclosure, are firms' financial performance, industrial sector indicator and belonging to a high-polluting sector. Firms in the energy sector exhibit significantly higher disclosure scores.

This paper contributes to the ongoing debate on the determinants of climate-related disclosure. Findings emphasize the need for stronger scrutiny and action on behalf of the regulators to incentivize disclosure or impose stricter requirements following the leading disclosure standards.

Key words: Climate risk disclosure; Environmental disclosure; ESG disclosure; 10-K; US public companies

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Abbreviations

10-K	Annual report, submitted to the SEC
10-Q	Quarterly report, submitted to the SEC
AI	Artificial intelligence
AMEX	American Stock Exchange
CDP	CDP (formerly 'Carbon Disclosure Project')
CDSB	Climate Disclosure Standards Board
CEO	Chief Executive Officer
Ceres	Coalition for Environmentally Responsible Economies
CRD	Climate Risk Disclosure
EDGAR	Electronic Data Gathering, Analysis, and Retrieval system
ESG	Environmental, social and governance
FSB	Financial Stability Board
G20	Group of Twenty
GDP	Gross Domestic Product
GHG	Greenhouse gas
GRI	Global Reporting Initiative
NASDAQ	Nasdaq (National Association of Securities Dealers Automated Quotations)
NYSE	New York Stock Exchange
OECD	Organisation for Economic Co-operation and Development
S&P 500	Standard & Poor's 500 Index
SASB	Sustainability Accounting Standards Board
SEC	Securities and Exchange Commission
SME	Small and medium-sized enterprises
TCFD	Task Force on Climate-related Financial Disclosure
UK	United Kingdom
US	United States of America
USD	United States Dollar

1 Introduction

Climate change risks are becoming increasingly material, affecting the health of global natural and economic systems. Investors and the general public are increasingly expecting and demanding corporations to step up to the plate, do their part to minimize the risks and disclose their efforts in this regard. Without an effective and widespread disclosure of climate change risks and its effect on businesses, regulators' ability to mitigate such risks and to create new economic opportunities is also severely restricted. Yet, climate-related risks are still largely absent from companies' financial statements. Understanding which companies disclose more than others within the current regulatory structure is the starting point to create incentives for greater disclosure and may open novel ways towards more widely adopted and thorough climate risk disclosure.

1.1 A new normal: Climate change's growing impacts on natural and economic systems

Climate change is already dramatically impacting natural and human systems to a degree that is unprecedented over human history (IPCC, 2014). Observed changes include sea-level rise, ocean acidification, higher incidence of extreme weather events such as droughts, storms and floods, and a vast loss of biodiversity (IPCC, 2014; IPBES, 2019). As we continue to emit greenhouse gases and warm the Earth, climate change impacts will intensify with potentially irreversible effects (IPCC, 2014).

Impacts on the economy and companies around the world are also increasingly material. They include direct physical effects on company physical infrastructure, supply chains, and personnel, as well as many non-physical effects, such as the legislative, regulatory, business and market impacts related to climate change, and which can result in significant financial losses (SEC, 2010). Recent losses incurred by the insurance industry are a stark warning of things to come. In addition to destroying lives, the large number of hurricanes, wildfires, and earthquakes which occurred in North America in 2017 also triggered insurance claims of about USD 135 billion. This is a record payout for the insurance sector but no longer deemed unusual in a world of extreme weather events. As the head of reinsurer's Munich Re's Corporate Climate Center declared: "We have a new normal... 2017 was not an outlier. We must have on our radar the trend of new magnitudes." (Sims, Hübner, 2018).

Besides insurers, other businesses impacted by climate change and the associated trends of increasing physical damages and regulatory constraints, changing market preferences and the growth of

more sustainable industries such as renewable energy, are also at great risk of financial losses, turning their resources into stranded assets – usually defined as fossil fuel supply and generation resources which do not yield their expected economic return due to wider economic changes, such as the transition to a low-carbon economy (CTI, 2017). In addition to the usual suspects such as the fossil fuel industry (e.g. unused oil, gas and coal reserves), economic sectors at danger of stranded assets include companies active in capital goods (e.g. gas turbines), transportation infrastructure (e.g. coal ports, oil pipelines), automotive sector, and companies which provide financing and invest in the directly affected companies, such as banks and other asset managers, among others (CTI, 2018). Ill-prepared companies also risk missing out on opportunities offered by new and more sustainable solutions.

Recent losses announced by General Electric (GE) provide a striking example. Due to its badly-timed purchase of Alstom's energy assets, mainly consisting of gas turbines, GE suffered a USD 23 billion loss. As clean energy became cheaper, the demand for gas turbines decreased and the expected cash flows from the Alstom business never materialized (Sutherland, 2018). In addition to GE, its financiers and shareholders, including the world's largest asset managers such as BlackRock, Vanguard, State Street and Fidelity, also lost billions due to their holdings of the plunging GE shares (IEEFA, 2019).

While economy-wide estimates of stranded assets vary widely, the figures are alarming. The Economist Intelligence Unit (EIU, 2015) for example, estimated the global value at risk to be between USD 4.2 trillion in the best case and USD 43 trillion in the worst-case scenario (the latter representing 30% of total global assets), while the International Renewable Energy Agency (IRENA, 2017) estimated the stranded assets to be between USD 10 trillion and USD 20 trillion, depending on the speed of global deployment of renewable energy and energy efficiency. Despite the large range of value at risk estimates, one thing is fairly certain: without a widely-adopted calculation and disclosure of climate change-related risks, policymakers' ability to mitigate against such risks is severely restricted, increasing the likelihood that asset devaluations will be abrupt and destabilizing.

1.2 Climate risk disclosure: growing but still in infancy

Poor disclosure of climate risks faced by companies is likely one of the causes of the large range of value at risk estimates quoted earlier. Poor disclosure, however, is not surprising. As a subset of the larger environmental, social and governance (ESG) field, corporate climate risk disclosure is a relatively young subject. And even though this young field is experiencing growing research coverage and is increasingly benefiting from a diverse community of stakeholders furthering its development, corporate climate risk disclosure still lacks uniform, widely adopted standards on which regulators, investors, consumers, and the general public can rely to make informed decisions.

The abundance and relative newness of the empirical studies of the disclosure of ESG risks point to a fairly vibrant research field of the past couple of decades (Adams et al., 1998; Baldini et al., 2018; Brammer et al., 2006; da Silva Monteiro and Aibar Guzman, 2009; Freedman and Bikki, 2005; Friede et al., 2015; Giannarakis et al., 2014; Jenkins and Yakovleva, 2004; Liu and Anbumozhi, 2009; Lu and Abeysekera, 2017; Luo et al., 2012; Mallin et al., 2013; Meng et al., 2014; Neu et al., 1998; O'Donovan, 2002; Patten, 2002a; Patten 2002b; Stanwick and Stanwick, 2000; Sulaiman et al., 2014; Tamimi and Sebastianelli, 2017).

In the more recent past, due to the growing concern over the effects of climate change impacts, the research lens has also turned towards climate-related risks and disclosures (Amran et al., 2014; CDP, 2018; Ceres and Calvert, 2007; Doran and Quinn, 2009; Doran et al., 2009; Hahn et al., 2015; Kouloukoui et al., 2018; Leurig, 2011; McFarland, 2009; Pellegrino and Lodhia, 2012; Reid and Toffel, 2009; Sakhel, 2017; Smith et al., 2008; TCFD, 2018; TCFD, 2019). Such research typically evaluates the frequency, extent, and quality of disclosures made by companies, analyzes trends over time, and increasingly attempts to identify the determinants for such disclosure. Table 1 in Appendix A shows the summary of relevant empirical studies that analyzed factors affecting ESG or climate-related disclosure.

In addition to research work, a diverse group of stakeholders is currently actively engaged in furthering climate-related disclosure, developing reporting standards, aggregating and analyzing disclosure from companies across the world, and promoting a more frequent and enhanced disclosure. The Task Force on Climate-Related Financial Disclosure (TCFD) is a particularly influential entity, which set out recommendations regarding what “decision-useful” climate-related disclosure looks like in 2017 (TCFD, 2017). The TCFD was initiated by the Financial Stability Board (FSB), the global banking regulator

convened by G20 countries in 2009 in the wake of the 2008 financial crisis “to promote stability of the financial system” (FSB, 2019). Recognizing the growing threat that climate change poses to the financial system, FSB launched the TCFD in 2015. Building on the work of TCFD, accounting standard-setters are currently working on integrating TCFD’s recommendations in their accounting standards, and also aligning their requirements with each other (Enochs, 2018; SASB and CDSB, 2017). Well-known climate risks reporting standards include those developed by the Sustainability Accounting Standards Board (SASB), Climate Disclosure Standards Board (CDSB), Global Reporting Initiative (GRI) and CDP (formerly the Carbon Disclosure Project), to name a few.

Investors are also increasingly becoming engaged in the climate risk disclosure debate, demanding more disclosure from companies and more action from the regulators. Rauf (2018) reported that in 2018, initiatives on climate change were among the most frequent resolutions demanded by shareholders at corporate annual meetings, representing about 20% of some 420 shareholder resolutions initially proposed. A recent example of investors demanding more disclosure is a public letter from institutional investors who manage more than USD 34 trillion in assets addressed to the “governments of the world”, delivered ahead of the G20 summit in Japan, demanding urgent action on climate change, and also improvement on climate-related financial reporting (Jessop and Chestney, 2019). Furthermore, as of May 2019, 785 companies and organizations have announced their support for the work done by the TCFD, an excellent growth from 101 as of June 2017 (TCFD, 2019).

Regulators meanwhile are largely observing the developments from sidelines, stepping in occasionally to clarify general disclosure rules but rarely explicitly demanding disclosure of climate risks. OECD (2015) review of climate disclosure regulations of G20 countries showed that 15 out of 20 countries have mandatory corporate climate reporting schemes, however, such schemes largely focus on companies’ direct greenhouse (GHG) emissions (i.e. company’s contribution to climate change) and very rarely on the impacts of climate change on the company. Only nine schemes encourage (as opposed to requiring or mandating) reporting of risks and strategies related to climate change.

In the US, the Securities and Exchange Commission (SEC), the federal entity regulating the financial securities industry, requires all publicly listed companies to disclose “material risks that could affect their finances or operations in their [SEC] filings” (GAO, 2018). Following several requests from the investing community for more clarity on climate change disclosure, the SEC issued its *Commission*

guidance regarding disclosure related to climate change' in February 2010. In the guidance, the SEC reiterated that "information is material if there is a substantial likelihood that a reasonable investor would consider it important in deciding how to vote or make an investment decision" and further stated that "for many companies, climate risk remains a "material" risk, and is subject to compulsory disclosure under US Securities and Exchange Commission (SEC) regulations" (Ceres, 2010; SEC, 2010).

Nevertheless, American companies do not score well on climate risk disclosure metrics, especially concerning disclosure in mandatory annual statements. The situation does seem to be improving over time, as illustrated in the below graph, albeit starting from a very low base. Doran et al. (2009) study found that in 2008, 76.3% of S&P 500 companies remained silent on climate change risks in their mandatory annual (10-K) filings. Ceres (2014) study found that the 'silent group' decreased to 41% of companies based on 10-K statements filed in 2013. Ceres also found that companies that did disclose did not say much – only 14% of the companies received more than 5 points on the disclosure score from 0 to 100. This is significantly different from voluntary climate risk disclosures by the S&P 500 companies in 2013 made to CDP, where 70% of the 332 responding companies scored 70 or above on the 0-100 scoring scale (Ceres, 2014). It is clear that if the US decision-makers are to receive "decision-useful" climate risk information from the businesses, disclosure level and quality must drastically improve.

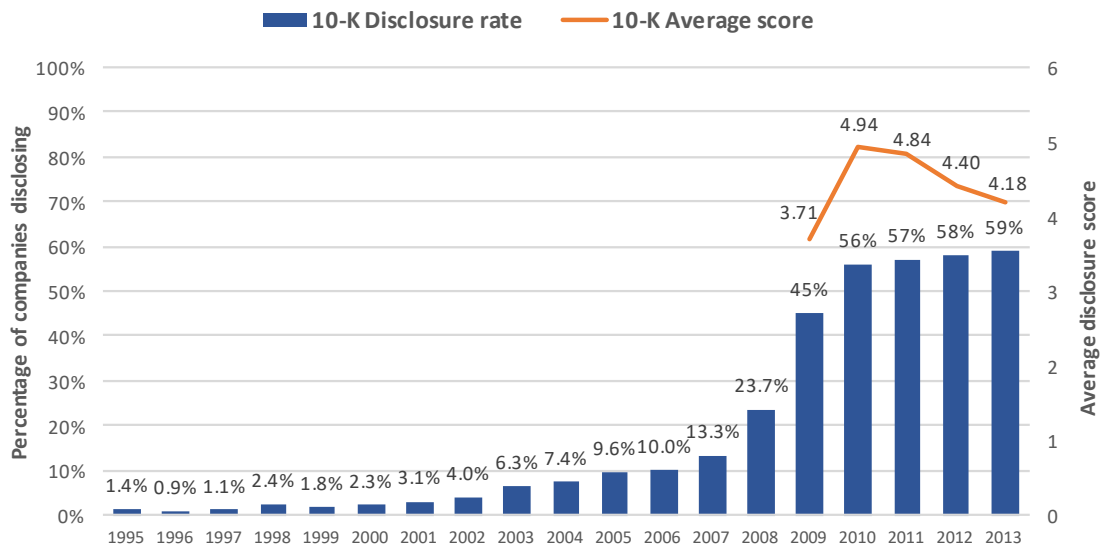


Figure 1. Climate disclosure by S&P 500 companies in 10-K reports, 1995-2013
Adapted from (Ceres, 2014) and (Doran and Quinn, 2009)

1.3 Research focus and hypotheses

The research described in this report focuses on climate risk disclosure by publicly traded companies in the US. It seeks to analyze the current state of disclosure in mandatory reports and examine characteristics that may impact such disclosure in a comprehensive way, by including company, industry and state-level characteristics within the analytical framework. The ultimate goal is to investigate whether regulators can incentivize greater disclosure by alleviating the obstacles and therefore also achieve a closer engagement with the business community, instead of relying only on mandatory requirements. As mentioned earlier, this paper also provides a mapping of select empirical studies conducted on this topic and therefore, sets out the current ‘state of the market’ on this topic.

The research focus is illustrated in Figure 2 below. The analysis described in this report targets US publicly listed companies and the following ten characteristics: (i) at the company-level: company size, financial performance, dual listing on stock exchanges, percentage of independent directors on the company’s board of directors, CEO duality indicator (i.e. whether the CEO is also acting as the Chairman of the board), percentage of women on the board, (ii) at the industry-level: industry sector, high-polluting industry indicator (‘high-polluting’ industries are defined below), and (iii) at the state of domicile-level: state’s gross domestic product (GDP) per capita and political party in power.

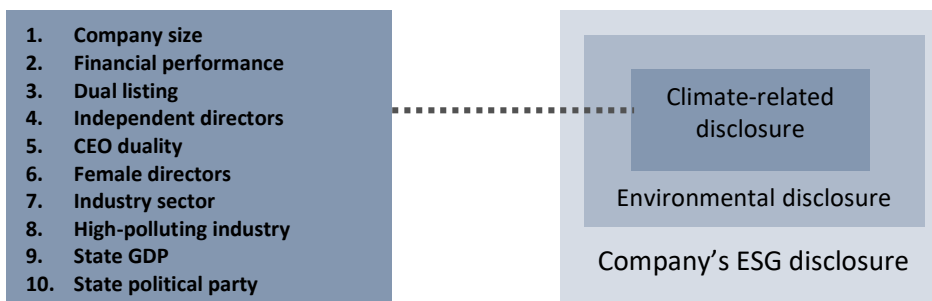


Figure 2. Research focus of this report

Based largely on the literature review of ESG and climate disclosure studies done to date, the following hypotheses are subjected to statistical tests:

H1: There is a positive relationship between company size and its climate-related disclosure level.

Larger companies attract more public scrutiny and also have the means to devote internal resources to climate-related analysis, disclosure and potentially mitigating action. Positive correlation has been found by multiple studies to date in various contexts (Adams et al., 1998, Baldini et al., 2018; Ben-Amar and

McIlkenny (2014); Brammer and Pavelin, 2016; Choi et al., 2013; Freedman and Bikki, 2005; Grauel and Gotthardt, 2016; to name a few). However, Kouloukoui et al's (2018) study of the largest 100 companies in the world found no relationship between the company size and its level of disclosure of climate risks.

H2: Companies with better financial performance have a higher level of climate-related disclosure.

It is expected that poor financial performers would not consider environmental aspects or disclosure to be a high priority, hence would exhibit lower disclosure rates. If true, this would imply a positive correlation between financial performance and level of disclosure. Empirical evidence on this relationship, however, is rather mixed. A positive relationship was found in studies on companies in Canada (Ben-Amar and McIlkenny, 2014), China (Liu and Anbumozhi, 2009) and in the US, for the largest 500 companies on the Forbes 500 list (Tamimi and Sebastianelli, 2017). Some studies, however, found no relationship (Brammer and Pavelin, 2006; Luo et al., 2012; Sulaiman et al., 2014), while Grauel and Gotthardt (2016) found a negative relationship between firm profitability and climate change disclosure. Stanwick and Stanwick (2000) found that while firms with high financial performance report more than poor financial performers, firms with an average financial performance report the most – in other words, the relationship may be positive but non-linear.

H3: Companies listed on multiple exchanges have a higher level of climate change risk disclosure.

Due to a higher level of scrutiny from regulators and investors that listing on multiple exchanges imposes on the listed company, a positive relationship is expected. This hypothesis is supported by findings from Baldini et al's (2018) study on ESG disclosure by global companies and by the Ben-Amar and McIlkenny's (2014) study on climate disclosure by Canadian companies.

H4: A higher portion of independent directors is associated with a higher level of climate disclosure.

The board of directors monitors the actions of the company's management on behalf of shareholders. As such, the board's effectiveness is related to directors' independence from the company's management. 'Independence' is further defined by exchanges to mean the absence of a material relationship between the director and the listed company, or another organization that has a relationship with the listed company (WSGR, 2017). Hence a positive relationship is expected between a high portion of independent directors and the level of climate risk disclosure. Empirical results are however mixed. A positive relationship was found by Amran et al's (2014) study on firms in the Asia Pacific, while Brammer and Pavelin's (2006) study on UK firms found no relationship.

H5: CEO duality is associated with a lower level of climate-related disclosure.

As for the prior hypothesis, companies whose top executive, the chief executive officer (CEO), is also its chairman of the board, are expected to have a lower level of board independence and hence board effectiveness. Such companies may also be expected to have a lower level of environmental or climate-related disclosure. However, the only study found on this relationship, Tamimi and Sebastianelli's (2017) study on US firms, suggests an inverse relationship, i.e. that companies with CEO duality have a higher ESG disclosure score.

H6: A higher portion of female directors is associated with a higher level of climate-related disclosure.

Female executives seem to display higher regard for the company's environmental and social impacts. A positive relationship between a higher ratio of female directors on the board of directors and company's ESG or climate-related disclosure is supported by a few empirical studies, such as Kouloukoui et al's (2018) global study and Tamimi and Sebastianelli's (2017) US-focused study, although Amran et al's (2014) study on firms in the Asia Pacific found no relationship.

H7: There is a relationship between the industry sector and the company's climate-related disclosure.

Certain sectors, such as power and mining, are more directly affected by climate change, scrutinized more and are hence, more likely to report climate-related risks. A strong industry effect is reported by multiple studies, although the disclosure rankings tend to vary. In broad brush strokes, the non-financial sector tends to report more than the financial sector. TCFD (2018) found that a higher percentage of non-financial companies (transportation, materials and building, energy, agriculture) reported climate risks compared to financial companies (insurance companies, banks, asset managers). Harrast and Olsen's (2016) study of disclosures by US companies in the 2006-2015 period found that the manufacturing sector had the largest number of climate change risk disclosures, followed by transportation, finance and insurance, and then by the mining sector. Doran et al's (2009) study of climate risk disclosures made by the companies in the S&P 500 found that utilities reported the most and the financial sector the least. Similarly, Brammmer and Pavelin (2006) found that finance and high technology companies are least likely to disclose environmental information. Utilities and resource companies were found not very likely to disclose, but when they did, their disclosure was of relatively high quality.

H8: Companies in high-polluting industries have a higher level of climate-related disclosure.

Continuing from the prior hypothesis that some sectors are more likely to disclose, this paper postulates

that companies from high-polluting industries tend to report more. This hypothesis is supported by some empirical studies, such as those mentioned in the prior hypothesis (Doran et al., 2009; TCFD, 2018), also by Kouloukoui et al's (2018) study of global companies and by Patten's (2002a) study of US companies. However, both Dawkins and Fraas (2011) and Mallin et al's (2013) study found that better environmental performance is positively correlated with a higher level of environmental disclosure. Meng et al. (2014) study on Chinese firms, on the other hand found, a nonlinear relationship between the firm's environmental performance and its environmental disclosure, whereby poor and good environmental performers report more, while average environmental performers disclose less environmental information.

In this report, 'high-polluting' is defined as belonging to either of the following five sectors: basic industries, capital goods, energy, public utilities, and transportation. Industries included in each category are listed in Table 2 of Appendix B.

H9: Companies headquartered in richer states have a higher disclosure of climate risks.

No studies of this relationship seem to have been done to date although it has been found that companies headquartered in richer countries tend to report more climate risks. Example, Amran et al's (2014) study found that companies in developed and advanced economies in the Asia Pacific disclose more climate change information compared to less developed countries in the region, while Liu and Anbumozhi's (2012) study found that companies in more economically developed regions of China had higher levels of environmental disclosure.

H10: Companies headquartered in predominantly Liberal states have a higher level of climate change risk disclosure than companies headquartered in predominantly Republican states.

No studies on this relationship seem to have been done to date. However, it can be expected that more 'environmentally-minded' states like California for example, host companies that are also more environmentally oriented and more likely to make environmental or climate-related disclosures. A few empirical studies support this hypothesis. Grauel and Gotthardt (2016) for example, found that firms in countries with stronger environmental regulations are more likely to disclose climate change effects. Freedman and Bikki (2005) found that environmental disclosure is higher in countries that have ratified the Kyoto Protocol, and Reid and Toffel's (2009) study found that US companies headquartered in states posing a regulatory threat to polluting industries disclose more climate-related information.

2 Methodology

The research described in this paper seeks to analyze a sample of US publicly listed companies and establish a correlation between various characteristics of the companies contained in the sample and the sample's level of climate change risk disclosure, at a given point in time. This is, therefore, a cross-sectional correlation-type study with the characteristics and methodology described in the below sections.

2.1 Target sample and data sources

Sample analyzed contains 100 randomly selected US companies listed on the New York Stock Exchange ("NYSE"), the Nasdaq and the American Stock Exchange ("AMEX") and the climate risk information contained in their annual financial statements, so-called "Form 10-K" reports filed annually with the regulator, the SEC, which the SEC makes publicly available on its online database called EDGAR (2019).

[US public companies listed on the NYSE, NASDAQ and the AMEX](#). This analysis focuses on companies headquartered in US only to remove the effect of regulatory requirements guiding company's climate risk disclosures and different national commitments to environmental sustainability, which have been found to exert a significant influence on company's climate risk disclosure as mentioned earlier (Adams and Roberts, 1998; Amran et al., 2014; Baldini et al., 2018; Freedman and Bikki, 2005; Grauel and Gotthardt, 2016). Publicly-listed companies were chosen because most Americans have a stake in such companies through their pension funds or general investment portfolios. As well, due to their public nature, such companies face more scrutiny regarding their operations and reporting obligations, set by the federal securities laws (SEC, 2019).

A sample was formed from the list of companies quoted on the NYSE (New York Stock Exchange), the Nasdaq (which stands for 'National Association of Securities Dealers Automated Quotations') and NYSE Amex (still mostly referred to as 'AMEX', the American Stock Exchange, the name applicable before its acquisition by NYSE). These are the three largest stock exchanges in the US and therefore a very good proxy for the whole 'universe' of publicly listed companies in the US. A sample drawn from such a large population includes companies of various sizes and from different industrial sectors. NYSE lists large 'blue-chip' companies such as General Motors, AT&T and Exxon Mobil, while Nasdaq lists high-technology and high-growth stocks such as Amazon, Apple, and Facebook, and AMEX

lists small-capitalization companies (Nasdaq, 2019; NYSE, 2019; Pankratyeva, 2018). This choice of the target population differs from previous studies which have mostly focused on companies in the S&P 500 index (Ceres and Calvert, 2007; Dawkins and Fraas, 2011; Doran et al., 2009; Doran and Quinn, 2009; Tamimi and Sebastianelli, 2017). However, the S&P 500 index includes only the largest 500 companies in US whose minimum value (expressed as market capitalization) is about USD 2.8 billion, with an average of USD 50.7 billion capitalization in the index, and the total S&P 500 market capitalization of about USD 3.4 trillion (S&P, 2019). The population of companies listed on NYSE, Nasdaq, and AMEX, contains about 7000 companies, with an average capitalization of about USD 5 billion and the total market capitalization of about USD 33 trillion (Pankratyeva, 2018).

Companies to be included in the sample were chosen from the full list of 6923 companies listed on the three exchanges, downloaded from the exchanges' websites (Nasdaq, 2019), grouped in one list and sorted by ascending alphabetical order of their name. For example, the company "111, Inc." was ranked first, company "1347 Property Insurance Holdings Inc." was ranked second, and so on. Random number generator function in Excel, with 100 random numbers generated from 1 to 6923, was used to pick companies to be included in the sample. Some of the companies picked however were excluded as they were either investment funds (e.g. exchange-traded funds), derivative instruments (e.g. warrants, rights), were found to be headquartered outside of the US, were delisted, or did not submit 10-K reports to SEC. Therefore, the process of random number generation, followed by a screen check, followed by another random number generation to pick additional companies to replace excluded ones was repeated several times before a final sample of 100 companies was generated.

Form 10-K reports. American public companies produce different publications throughout the year, such as quarterly and annual financial reports ("10-Qs" and "10-Ks", respectively) which are a regulatory requirement but also sustainability reports, press releases and responses to voluntary questionnaires, among others, with different report types facing different levels of attention and scrutiny. Several empirical studies to date have analyzed ESG or climate disclosure in voluntary reports, such as sustainability reports or responses to questionnaires (Dawkins and Fraas, 2011; Mallin et al., 2013; Stanwick and Stanwick, 2000; Tamimi and Sebastianelli, 2017). However, one can argue that 10-Ks are the most relevant reports where all relevant risks need to be disclosed, and therefore should be the main target of scrutiny and analysis. Most publicly listed companies in the US must file with the SEC the annual 10-K report which contains information about the financial health of the company for its

reporting year. Such reports are therefore a regulatory requirement, financial statements within it must be audited by a third party, and they are widely considered to be the most important source of information on the financial health of the company. In addition to being filed with the SEC and publicly available on SEC's EDGAR website, 10-K is also the only document that is automatically sent to all shareholders. For the generated sample, the latest available 10-K reports were selected, which were for the most part for the financial year-end of December 31, 2018 (88 out of 100 companies). In addition to 10-Ks, and for information on the company's characteristics, the company's web-site, exchange web-site and other sources listed in Table 3 below were consulted.

Company data. Each company was mapped out for its climate risk disclosure ("CRD", the dependent variable in statistical tests) and its ten characteristics mentioned earlier (the independent variables). The table below shows the description of each variable and the data source.

Table 3. CRD and independent variables: Description, nature and data sources

Variable	Description	Nature	Data source
<i>CRD</i>	Climate risk disclosure level, as determined through content analysis (further description below)	Metric/discrete	Company's latest 10-K report retrieved from EDGAR
<i>Size</i>	Company size, expressed as its current market capitalization, and grouped in three categories: small-cap (<USD 2 bn) large-cap (>= USD 10bn), and mid-cap (between small and large-cap).	Metric	Market capitalization retrieved from exchange website (Nasdaq, 2019)
<i>FinPerf</i>	Company's financial performance, expressed as net income/total assets (Stanwick & Stanwick, 2000)	Metric	Company's latest 10-K report, retrieved from EDGAR
<i>DualList</i>	Indicating whether the company is listed on multiple exchanges	Qualitative (1 if yes, 0 if no)	Exchange website
<i>IndExec</i>	Ratio of independent executives on the Board of Directors	Metric (ratio)	10-K, Reuters (2019)
<i>CEODual</i>	Indicating whether the CEO also acts as the Chairman of the Board	Qualitative (1 if yes, 0 if no)	10-K, Reuters (2019)
<i>FemExec</i>	Ratio of female executives on the Board of Directors	Metric (ratio)	10-K, Reuters (2019)
<i>Sector</i>	Sector in which the company operates, as per the stock exchange classification	Qualitative	Nasdaq (2019)
<i>SectorPoll</i>	Indicating whether the company is in the highly-polluting sector	Qualitative (1 if yes, 0 if no)	Sector as per Nasdaq (2019)
<i>StateGDP</i>	GDP per capital of the state in which the company is headquartered, for 2018	Metric	BEA (2019)
<i>StateParty</i>	Political party which won the state's electoral vote in the 2016 presidential elections	Qualitative (1 if Republican, 0 if Liberal)	FEC (2019)

CRD index and content analysis. To evaluate the company’s climate risk disclosure level (“CRD” variable), a CRD index was created, composed of five components – one indicator for any mention of climate risks in company’s 10-K and the other four components corresponding to four recommended disclosure areas put forward by the TCFD (2017), shown in Appendix C. To calculate the score for each of the five components, content analysis technique was deployed. This methodology is frequently used in studies analyzing companies’ ESG or climate-related disclosure (Adams et al., 1998; Amran et al., 2014; da Silva Monteiro and Aibar-Guzman, 2009; Freedman and Bikki, 2005; Kouloukoui et al., 2018; Suleiman et al., 2014). The methodology consists of “codifying qualitative information in anecdotal and literary form into categories in order to derive quantitative scales of varying levels of complexity” (da Silva Monteiro and Aibar Guzman, 2009). In this case, it consisted of a keyword search (“climate change”, “climate”, “climatic”, “global warming”, “GHG” and “greenhouse gases”) which if found in the 10-K, led to evaluation of the company’s climate risk disclosure (CRD) as per the following index:

$$CRD_i = Mention_i \times w_1 + Govern_i \times w_2 + Impact_i \times w_3 + Plan_i \times w_4 + Metric_i \times w_5$$

where

- *i* represents the individual company, with *i* ranging from 1 to 100;
- *w* represents the weight of the individual factor in the CRD index, where each weight equals 0.2;
- the resulting score per company therefore ranges from 0 to 1, and for the sample from 0 to 100, and the five components have the following meaning and calculation method:

Table 4. CRD index components

Component	Description	Nature
<i>Mention</i>	Indicating whether the company mentions climate change in its 10-K report	Qualitative, 1 if yes, 0 if no
<i>Govern</i>	Indicating whether the company discloses management’s or board’s role in assessing or managing climate risks and opportunities	Qualitative, 1 if yes, 0 if no
<i>Impact</i>	Indicating whether the company discloses particular risks or opportunities due to climate change (e.g. regulatory, physical, market risks). Corresponds to the ‘Strategy’ metric of TCFD (2017).	Qualitative, 1 if yes, 0 if no
<i>Plan</i>	Determination of whether disclosure contains mention of an action plan to mitigate climate change risks and/or benefit from new opportunities Corresponds to the ‘Risk management’ metric of TCFD (2017).	Qualitative, 1 if yes, 0 if no
<i>Metric</i>	Indicating whether company discloses any metrics and targets to manage risks and opportunities, including its own contribution to climate change (i.e. GHG accounting)	Qualitative, 1 if yes, 0 if no

2.2 Statistical analysis

To test which of the ten company, sector and state characteristics (i.e. independent variables) were correlated with the CRD level (the dependent, response variable), non-parametric tests listed below were used, similar to those chosen by Tamimi and Sebastianelli (2017). Non-parametric tests are the appropriate choice given that they do not make any assumptions about data's underlying distributions. For the chosen variables, both independent and most of the dependent variables are categorical (as opposed to continuous) variables, and the CRD score does not seem to be normally distributed based on the plot of residuals.

Table 5. Statistical tests used

Variable	Type	Non-parametric test
<i>Size</i>	Ordinal (3 categories: small, medium and large-cap)	Kruskal-Wallis test
<i>FinPerf</i>	Quantitative (number, ratio)	Pearson and Spearman rank correlations
<i>DualList</i>	Ordinal (2 categories: Y = 1, N = 0)	Mann-Whitney test
<i>IndExec</i>	Quantitative (number, %)	Pearson and Spearman rank correlations
<i>CEODual</i>	Ordinal 2 categories: Y = 1, N = 0	Mann-Whitney test
<i>FemExec</i>	Quantitative (number, %)	Pearson and Spearman rank correlations
<i>Sector</i>	Ordinal 12 categories	Kruskal-Wallis test (group test) Mann-Whitney test (between pairs test)
<i>SectorPoll</i>	Ordinal (2 categories: Y = 1, N = 0)	Mann-Whitney test
<i>StateGDP</i>	Quantitative (number, USD)	Pearson and Spearman rank correlations
<i>StateParty</i>	Ordinal (2 categories: Rep = 1, Dem = 0)	Mann-Whitney test

3 Results

The following sections contain the summary characteristics of the 100 companies included in the sample, in terms of their defining company characteristics and their climate risk disclosure, as well as the results of the statistical analyses of the correlation between company traits and the level of climate risk disclosure.

3.1 Target sample characteristics

The full list of 100 companies included in the sample and their mapping is shown in Table 6 of Appendix D. Tables below show the summary statistics of companies' characteristics.

Table 7. Sample summary statistics (excl. industrial sector)

	<i>Size</i> (USD M)	<i>FinPerf</i>	<i>DualList</i> (Y=1,N=0)	<i>IndExec</i> (%)	<i>FemExec</i> (%)	<i>SectorPoll</i> (Y=1,N=0)	<i>StateGDP</i> (USD M)	<i>StateParty</i> (Rep=1, Dem=0)
Total	439,823		Y: 0 N: 100			Y: 32 N: 68	24 states	Rep: 44 Dem: 56
Min	6	-2.75		0%	0%		39,883	
Max	64,200	92.98		92%	56%		73,531	
Average	4,398	0.96		71%	17%		58,440	

Table 8. Breakdown by industrial sector

Sector	Nb of firms	Total size (USD M)	Avg. size (USD M)	% of total (by size)
Basic industries	4	2,654	663	1%
Capital goods	14	130,190	9,299	30%
Consumer durables	3	6,962	2,320	2%
Consumer non-durables	3	17,370	4,342	4%
Consumer services	10	30,811	3,081	7%
Energy	6	4,429	738	1%
Finance	23	60,146	2,615	14%
Health care	17	26,711	1,571	6%
Miscellaneous	4	40,420	10,105	9%
Public utilities	6	101,394	16,899	23%
Technology	7	18,198	2,600	4%
Transportation	2	537	268	0%

Descriptive statistics show several interesting traits for the generated sample:

1. Company size: The total market capitalization for the 100 companies in the sample is about USD 440 billion, with an average of USD 4.4 billion. The range is quite large, including companies worth USD 6 billion (InVivo Therapeutics) to giants worth USD 64.2 billion (T-Mobile US). Sample's average capitalization of USD 4.4 billion, however, is much smaller than USD 50.7 billion average capitalization of companies in the S&P 500 Index which have been subject of most climate disclosure analysis to date.

2. Financial performance: Measured as the ratio of net income to total assets, financial performance indicator also exhibits a large range of -2.75 to +92.98, with an average of 0.96. However, two companies had a performance that is far outside the group: TriCo BancShares with +92.98 and Raytheon Company with +11.06. The third best performer recorded +0.24. Sector by sector comparison shows the highest average performance to correspond to the financial sector (+4.07) and the lowest to basic industries (-0.49) and health care (-0.41). State by state comparison shows California in the lead (4.77), with Massachusetts in the distant second place (2) and Arizona in the last spot (-0.86).

3. Dual listing: None of the companies in the sample were listed on more than one exchange, hence this variable was excluded from the statistical analysis.

4. Independent executives: The ratio of independent directors on the Board of Directors to the total number of directors averages 71% for the sample as a whole. Sectors that score better on this metric include basic industries (average of 81%), technology (81%) and finance (80%), compared to low-scorers such as consumer services (56%) and consumer non-durables (59%). State by state comparison shows Georgia and Wisconsin in the lead (89% each), and Colorado at the bottom (39%). Split by 'Democrat vs. Republican' states shows that Republican states score better on this metric with an average of 74% compared to Democrat states' average of 68% of independent executives on the board.

5. CEO duality: 45 companies in the sample have the same person acting as both the CEO and the Chairman of the Board, which seems to be a high number. Transportation and miscellaneous sectors score particularly low (100% and 75% duality score), although the sample sizes were very small (2 and 4 companies, respectively). Public utilities have the best CEO duality score of 17% which could be due to the level of scrutiny that such companies attract due to their public nature. Unlike the results by a political party for the previous metric, Republican states score worse on CEO duality with a 54.5% average duality score for the states in the sample, compared to Democrats' score of 37.5%.

6. Female executives: The average ratio of female directors on the Board of Directors to the total number of directors is woefully low, at 17%, with the company scores ranging from 0% to 56%. Sectors that rank higher on this metric include consumer non-durables (26%) and basic industries (25%), with energy (3%) and transportation (6%) sectors at the bottom. Among the top scores on the state level are Illinois (31%) and Tennessee (29%), while the lowest scores go to North Carolina (0%) and Washington (3%). Democrat states score better on this metric with an average of 19% compared to Republican states' average of 14%.

7. Industrial sector: Twelve industrial sectors are represented in the generated sample. By the number of firms, the sample is dominated by finance (23 companies), followed by health care (17) and capital goods (14). In terms of the breakdown by assets, capital goods (30%) and public utilities (25%) represent more than half the sample, followed by finance (14%).

8. Highly-polluting sector: Defined as companies belonging to basic industries, capital goods, energy, public utilities and transportation, companies in the 'highly-polluting' sector represent 32% of the sample by the number of firms, but 54% of the sample by market capitalization, demonstrating the financial clout that such companies have. Companies in the 'highly-polluting' sector have an average market capitalization of USD 7.5 billion, compared to USD 2.9 billion average for other sectors combined. On the measures related to corporate governance, 'low polluters' score better on the average ratio of female directors (17% vs. 15%), but high-polluters score better on CEO duality (with 38% of companies having one person as both CEO and the Chairman, compared to 49% average for low-polluters) and ratio of independent executives (73% vs. 70% for low-polluters).

9. State GDP: 24 states are represented in the generated sample, with GDP per capita for 2018 ranging from USD 39,883 (South Carolina) to USD 73,531 (New York). The richest state, therefore, has the average income that is almost twice the size of the poorest state. The average GDP per capita for the states in the sample is USD 58,440, which is lower than the 2018 average for the country as a whole of USD 62,641 (WB, 2019).

10. State political party: Based on their electoral vote in the 2016 presidential elections, states were divided into two groups, Democrat and Republican states. As the portion of the overall sample, Democrat states are over-represented with 56 companies and 69% of the sample by market capitalization.

3.2 Sample's climate risk disclosure

Descriptive results shown in the table below indicate that for the sample as a whole, the disclosure level is very low. Only 31 companies in the sample mentioned climate change in their 10-Ks (i.e. 31%), while 69% remained silent on the topic. This is a considerably larger number for the 'silent group' compared to 41% found in the Ceres (2014) study based on 10-K statements filed in 2013 by companies listed on the S&P 500 Index.

The overall CRD score for the whole sample is only 12.2, measured on the scale from 0 to 100. For individual companies, this translates to a mean of 0.122 on the scale from 0 to 1. Median and mode values are both 0, with a standard deviation of 0.195.

Looking at the individual components of the overall CRD score, companies scored highest on the *Mention* component, with the overall sample total of 6.2 points (out of the maximum possible 20), followed by the 5-point score for the *Impact* component which indicates the identification of risks and/or opportunities due to climate change. Only four companies mentioned how they assess and intend to manage climate risks and opportunities, making the sample's total *Plan* score only 0.8 (out of possible 20). Only one included a metric that was linked to its GHG emissions, making the sample's total *Metric* score 0.2. None disclosed how its management or the board oversees risks and opportunities linked to climate change, making the sample's total *Governance* score 0.

Table 9. Sample's CRD score

	CRD score (0 to 100)	Climate risk mention? (Y=1, N=0)	Governance (0 to 100)	Impact (0 to 100)	Plan (0 to 100)	Metric (0 to 100)
Total (for sample, 0-100)	12.2	Y: 31 Score: 6.2	Y: 0 Score: 0	Y: 25 Score: 5	Y: 4 Score: 0.8	Y: 1 Score: 0.2
Min (per company)	0	0	0	0	0	0
Max (per company, 0-1)	0.6	0.2	0	0.2	0.2	0.2
Mean (per company, 0-1)	0.122	0.062	0	0.05	0.008	0.002

Looking at the CRD score by different groupings based on the independent variables reveals interesting variations. These are shown in Appendix E (Figures 4-9). However, based on the non-parametric analysis, only three independent variables have a statistically significant correlation with the CRD score. These are discussed in the next section and shown in Figures 10-12 below.

3.3 Statistical test results

Table 10, below shows the results and interpretation of the non-parametric analyses, testing the null hypothesis of no correlation between the sample CRD level and the ten independent variables. It shows that only three variables were both statistically significant and positively correlated with the CRD score. These are the company's financial performance (significant per Pearson correlation but not Spearman's), the industrial sector indicator and the high-polluting sector indicator.

Table 10. Results of the statistical tests

Variable	Statistical test	Result	Interpretation
<i>Size</i>	Kruskal-Wallis test	H = 1.847 p = 0.397; df = 2	Not statistically significant at p < 0.05
<i>FinPerf</i>	Pearson and Spearman rank correlations	Spearman's: $r_s = 0.148$; df = 98; p-value = 0.1418 Pearson: r = 0.14	Spearman: not stat. signif. at p < 0.05 Pearson: Small +ve correlation.
<i>DualList</i>	n/a		No dual-listed companies in the sample
<i>IndExec</i>	Pearson and Spearman rank correlations	Spearman's: $r_s = 0.078$; df = 98; p-value = 0.4407 Pearson: r = 0.005	Not statistically significant at p < 0.05
<i>CEODual</i>	Mann-Whitney test	U = 1068.5; z = 1.16746 p-value = 0.242	Not statistically significant at p < 0.05
<i>FemExec</i>	Pearson and Spearman rank correlations	Spearman's: $r_s = 0.047$; df = 98; p-value = 0.6396 Pearson: r = 0.003	Not statistically significant at p < 0.05
<i>Sector</i>	Kruskal-Wallis test (group test) Mann-Whitney test (between-pairs test)	KW: H = 28.831; p = 0.002411; df = 11 MW: Energy vs. Finance, Health Care, Technology (at p < 0.05).	Statistically significant at p < 0.05 Reject Ho that means are st. equal. Signif: Energy vs. Finance, Health Care and Technology.
<i>SectorPoll</i>	Mann-Whitney test	U = 751.5; z = -2.48279 p-value = 0.01314	Statistically significant at p < 0.05 Reject Ho that means are st. equal
<i>StateGDP</i>	Pearson and Spearman rank correlations	Spearman's: $r_s = 0.016$; df = 98; p-value = 0.8718 Pearson: r = 0.0006	Not statistically significant at p < 0.05
<i>StateParty</i>	Mann-Whitney test	U = 1117.5; z = 0.79162 p-value = 0.42952	Not statistically significant at p < 0.05

Independent variables that had larger CRD scores as postulated by alternative hypotheses, but which were not found to be statistically significant, are company size, CEO duality indicator, the ratio of female executives and state political party indicator. In terms of size, large and mid-cap companies had an average CRD of 0.15 and 0.16, compared to 0.10 average CRD of small-cap companies. Companies with CEO duality had a lower average CRD (0.09) compared to companies that split the role of the CEO and the Chairman (0.15). Companies with a higher ratio of female executives (first and second tier) had a higher average CRD (0.12 and 0.19, respectively) compared to companies with a low ratio of female executives (third and fourth tiers) which had average CRD of 0.06 and 0, respectively. Finally, Democrat states had an average CRD of 0.14, compared to Republican states with the average CRD of 0.10.

Financial performance: Average CRD scores and statistical analysis by Pearson ranked correlation (though not by Spearman’s test) indicate that better performing companies tend to have higher CRD scores. The average CRD by the group is shown in the figure below. The four groups were created by ranking companies by their financial performance and dividing them into four categories (‘tiers’), as follows:

- (i) Fourth-tier performers: ratio < - 0.08; *n* = 25;
- (ii) $- 0.08 \leq$ Third-tier performers ratio < 0.02, *n* = 25;
- (iii) $0.02 \leq$ Second-tier performers ratio < 0.07, *n* = 23;
- (iv) First-tier performers ratio ≥ 0.07 ; *n* = 27.

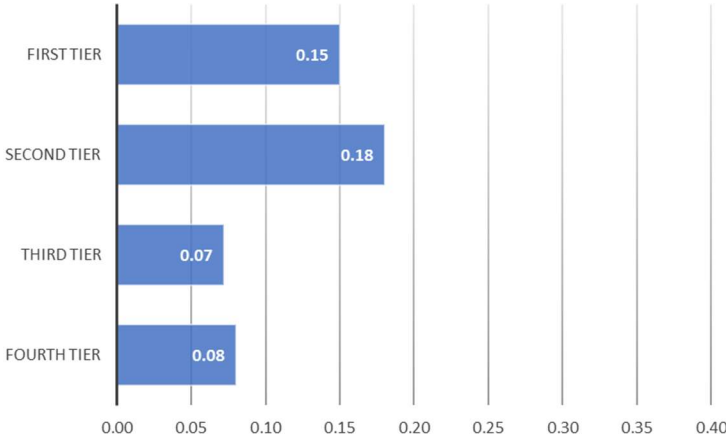


Figure 10. Average CRD score by financial performance

Industrial sector: Figure below shows twelve industrial sectors and their average CRD scores.

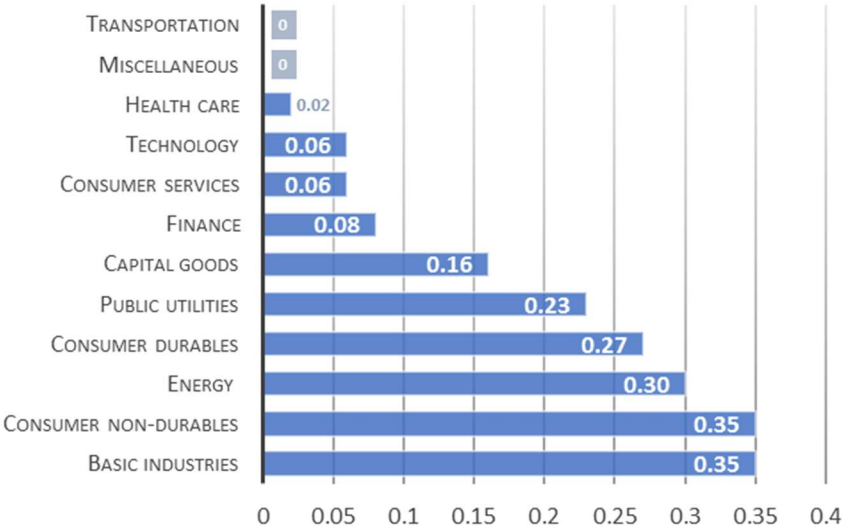


Figure 11. Average CRD score by industrial sector

Results of the Kruskal-Wallis test indicate that average CRD scores are indeed different among different industrial sectors. However, to know which sector is different from another sector, a series of Mann-Whitney tests were performed among all the possible pairings, for the sectors which had a sample size larger than five. Results of the Mann-Whitney tests between pairs are shown in Table 11 in Appendix F. They show that the energy sector had a statistically higher average CRD compared to finance, health care and technology sectors.

Highly-polluting sector: Defined as companies belonging to basic industries, capital goods, energy, public utilities and transportation, companies in the 'highly-polluting' sector represent 32% of the sample by the number of firms and scored an average CRD of 0.21, compared to the 0.08 average CRD of other sectors. Based on the results of the Mann-Whitney test, this difference is statistically significant indicating that companies in highly-polluting sectors tend to report more climate-related risks.

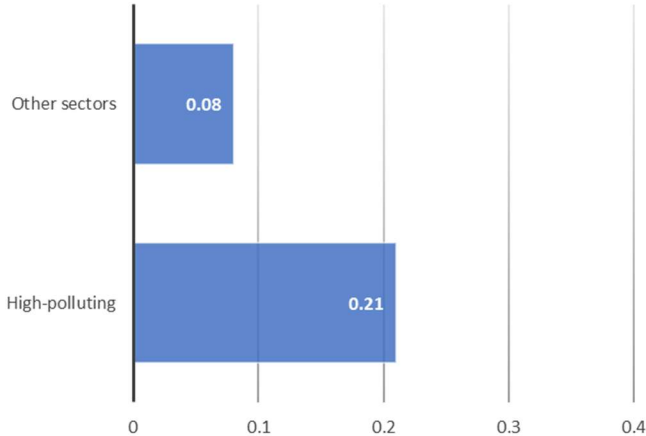


Figure 12. Average CRD score by highly-polluting sector indicator

4 Discussion and conclusion

This study shows that, even though the overall level of climate-related risk disclosure by US companies is very low, in terms of frequency and depth of discussion, several common company traits play a role in the level of disclosure for the sample analyzed. Regulators can benefit from this information to remove impediments, bring clarity and awareness to the market and increase climate risk disclosure.

4.1 What the results show and implications

To summarize the information presented in the previous section, the main findings of this paper suggest the following:

- For the randomly generated sample of 100 publicly-listed companies in the US, frequency and depth of climate risk disclosure in their mandatory (10-K) reports filed with the SEC for 2018 is very low.
- 31 companies mention climate change in their 10-Ks, while 69 are silent on this topic.
- The 'silent' group size (of 69%) is larger compared to other studies on this topic, namely the 41% that Ceres (2014) found in its review of 10-Ks filed in 2013 by companies in the S&P 500 Index. This could be because S&P 500 contains largest 500 companies in the US with an average capitalization of about USD 50 billion, whereas the sample analyzed herein comes from a population of about 7,000 companies and has the average capitalization of about USD 4.4 billion. Given that company size and climate disclosure may be correlated, based on the literature review, the climate disclosure level in the US may be lower than commonly reported scores based on S&P 500 companies.
- The average CRD (climate risk disclosure) score for the sample is 12.2 on the 0 to 100 scale, with a minimum of 0 and a maximum of 60. This is substantially lower than the disclosure scores reported by studies that analyzed disclosure made in voluntary reports. Ceres (2014) review of S&P 500 companies' (non-mandatory) responses to CDP questionnaire gave 70% of the 332 responding companies a climate disclosure score of 70 or above on the 0 to 100 scale. Though not directly comparable, Tamimi and Sebastianelli (2017) study of ESG disclosure made by S&P 500 companies, based on the Bloomberg's ESG score which reviews all publicly available information (mandatory filings, but also sustainability reports, news articles, etc.), gave an average environmental disclosure score of 25 to the sample (also measured on the 0-100 scale). While the scoring methodology most likely differs from one study to the next in terms of index components, weights, reviews methods,

and other factors, results herein may also indicate that where disclosure matters most (i.e. in mandatory reports sent to the regulator and shareholders), the companies tend to report the least.

- When the climate-related disclosure was made by the companies in the sample, companies most often disclosed potential risks, rarely mentioned an action plan or specific metrics used to assess or mitigate climate-related effects, and none mentioned their internal governance structure concerning climate change.
- Out of ten independent variables analyzed, three were both statistically significant and positively correlated with the CRD score. These are the company's financial performance, the industrial sector indicator, and the high-polluting sector indicator.
 - Companies that perform well financially tend to disclose more, although the causation is unclear. Higher CRD score may be due to the company's superior overall risk management and strategic vision/positioning which result in both good financial performance and high ESG and CRD scores. For the poor financial performers, results can indicate that climate change is not their priority and that they do not have the resources to assess risks and opportunities and create an analytical, reporting and strategic plan to cope with changes.
 - Companies in the high-polluting group and the companies in the energy sector tend to report more. This could indicate that higher public scrutiny that such companies face regarding their environmental impacts leads to better disclosure. At the same time, companies in other sectors may hold the view that given that they may not be directly impacted by climate change, as fossil fuel companies for example, they can therefore disregard both the risks and disclosure requirements.

These findings suggest several actionable areas where the regulator (i.e. the SEC) and other stakeholders can make inroads to improve disclosure levels. They are as follows:

Raise awareness about climate change: Given that climate change affects every region and ecosystem on this planet, and its negative impacts are increasing, every business, big or small, profitable or not, in energy or other industry sectors, should feel affected and identify what the changes mean for them, both in terms of risks and opportunities. The SEC and other stakeholders involved (e.g. CDP, Ceres, Global Reporting Initiative and others) can join forces to educate companies and their staff about the

effects of climate change on their businesses, via webinars, live seminars and workshops, the educational written material on SEC's website, and other media.

Mainstream leading disclosure standards: Once companies identify risks and opportunities, they need to know how to analyze the impacts, create an action plan, and also discuss and disclose their climate-related actions in their mandatory and voluntary reports. In addition to raising awareness about climate change, far more needs to be done to 'mainstream' the climate risk disclosure among the business community by teaching them about the leading disclosure standards, like the ones put forward by the TCFD. An example of how this could be done is the recent CDSB webinar entitled 'Masterclass in implementing the TCFD recommendations' (CDSB, 2019).

Incentivize greater disclosure among SMEs: To help companies which are financially struggling or small to medium-sized enterprises (SMEs) which may not have enough resources to dedicate to the question of climate change, public agencies could incentivize greater action through public grants or low-interest loans earmarked for expenses related to the training of the staff, and development of internal software and management tools to analyze and report climate change effects.

Reiterate disclosure requirements and monitor compliance: Current level of climate-related disclosure in 10-Ks is low, despite the SEC's guidance in 2010 stating that "for many companies, climate risk remains a "material" risk, and is subject to compulsory disclosure under US Securities and Exchange Commission (SEC) regulations" (SEC, 2010). It may be worth reminding the publicly-listed companies in the US of this requirement. Furthermore, compliance should be monitored over time and any lapses penalized in accordance with the securities laws. The SEC should also further require that disclosure is made following the leading disclosure standards (such as the TCFD) and set out disclosure components.

Actionable areas highlighted above point to several limitations of the work described in this report and additional considerations that may further raise the disclosure level.

4.2 Limitations and additional considerations

Research presented here can be further enhanced with the addition of the following elements:

- Use of more sophisticated content analysis techniques compared to the rather ‘manual’ and slow technique used herein as well as in numerous other empirical studies. Artificial intelligence (AI) for example, could be deployed to analyze and assign scores to companies’ disclosures in a faster, more standardized and possibly more thorough way as well. For its review of climate risk disclosures made by global companies, TCFD partnered with the consulting company PricewaterhouseCoopers (PwC), which created a custom-built AI tool for TCFD ‘using natural processing and machine learning’ (EA, 2019). Subject to its budget limitations, SEC could proceed similarly.
- Using AI to do content analysis would also have the benefits of (i) increasing the sample size, from 100 to possibly all reporting companies, (ii) being able to track and report scores over time to oversee trends (current study is done for one year only, 2018), and (iii) analyzing other variables at company, industry, geographical and other levels that may impact disclosure frequency and quality (this research analyzed ten variables).
- Assessing the quality of disclosure and ensuring that the disclosure represents true, precise, comprehensive and “decision-useful” information, as opposed to an attempt at greenwashing, is a crucial feature of any climate-related disclosure assessment methodology. In this report, the quality was estimated via a CRD index that has multiple components related to the identification of risks and opportunities, governance, action plans, and metrics, as opposed to a simple count of sentences that characterizes early empirical studies on this topic. However, with the CRD methodology here deployed, it is still not possible to assess how true, comprehensive or decision-useful the disclosed information is. Making climate-related disclosure subject to a third-party audit, in the same way the company’s financial statements in 10-K reports are subject to audits, may ultimately be the most potent way to resolve the greenwashing concern.
- Finally, in addition to determinants of disclosure, stakeholders should also pay attention to the *effects* of greater disclosure, in terms of reducing companies’ potential environmental impacts and affecting investment decisions made by the financial community.

4.3 Conclusion

While climate-related disclosure is a young and rapidly growing field, with a multitude of actively engaged stakeholders developing reporting standards and advocating enhanced disclosure, we also need to keep in mind that we must allocate a massive amount of capital to sustainable industries in order to have a chance to meet global development and climate goals. And we must do so fast. IRENA's estimate of the cumulative investment needed in 2016-2050 to meet climate goals is USD 110 trillion. For renewable energy power alone, this implies more than doubling the current annual investment amount of about USD 300 billion (IRENA, 2019). Greater disclosure of risks related to climate change by companies could facilitate this necessary capital shift towards more climate-proof and sustainable industries. Climate disclosure is, however, just one of the many levers that policymakers should be strengthening and scaling up rapidly to climate-proof their economies.

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Appendix A

Summary of relevant studies on determinants of ESG/climate disclosure

Table 1. A summary of relevant studies on ESG/climate disclosure

Author(s), year	Sample	Disclosure analysed	Firm-level traits											Industry				Country traits												
			Size	Fin. perf.	Leverage	Env. cent.	Env. perf.	Visibility	Dual list	Board size	Board non-execs	Board mnx	Others	Sector	Env. sensitive	Country	Econ. depts	Environ	Others											
Adams et al., 1998	Western Europe, 6 countries Largest 25 companies	Environmental and social reporting in annual reports, as of June 1993	+																											
Amran et al., 2014	Asia Pacific, 13 countries Firms in 10 industries	Climate change disclosure in sustainability and annual reports	0			+																								
Baldini et al., 2018	Global (n = 14,172 firm-years)	ESG disclosure, 2005-2012	+			+																								
Ben-Amar and McLikenny, 2014	Canada Listed companies (n = 59 firm-years)	Climate change disclosure in CDP questionnaire, 2008-2011	+																											
Berthelot and Robert, 2011	Canada Listed oil and gas companies (n = 64 firms)	Climate change disclosure in annual reports, 2007																												
Brammer and Pavelin, 2006	UK Listed companies (n = 459 firms)	Environmental disclosure, 2000	+	0	-																									
Choi et al., 2013	Australia Large companies	Climate change and carbon emissions disclosure in annual and sustainability reports, 2006-2008	+																											
Dawkins and Fraas, 2011	US Listed (S&P500) companies (n = 344 firms)	Climate change disclosure in Ceres questionnaires, 2006-2008																												
Freedman and Bikki, 2005	Global Largest public firms in climate-sensitive industries (n = 120 firms)	Pollution and GHG disclosure, in annual reports, env. reports and websites	+																											
Grauel and Gotthardt, 2016	Global, 51 countries Largest companies (n = 2379 firms)	Climate change disclosure, in CDP questionnaires, 2011-2013	+	-																										
Haikos and Skouldis, 2016	Greece Listed companies (n = 100 firms)	Climate change disclosure	+																											
Kouloukoui et al., 2018	Global Largest 100 companies (n = 71 firms)	Climate risk disclosure, in CDP questionnaires, GRI and sustainability reports, 2018	0																											
Liu and Anbumozhi, 2009	China Listed companies (n = 175 firms)	Environmental disclosure, in annual, env. and sustainability reports, 2006	+																											

Author(s), year	Sample	Disclosure analysed	Firm-level traits										Industry				Country traits		
			Size	Fin. perf.	Leverage	Env. cert.	Env. perf.	Visibility	Dual list.	Board size	Board non-execs	Board gender mix	Others	Sector	Env. sensitive	Country	Econ. dvpt	Env. regulation	Others
Luo et al., 2012	Global, 15 countries Large firms (n = 291 firms)	Carbon disclosure in CDP questionnaires, 2009	+	0	0														+ GHG intensive industry
Luo et al., 2013	Global, 15 countries Large firms (n = 205 firms)	Carbon disclosure in CDP questionnaires, 2009																	
Mallin et al. 2013	US Best Corporate Citizens (n = 100 firms)	Social and environmental disclosure in sustainability and annual reports, 2005-2007				+													
Meng et al., 2014	China Listed companies (n = 533 firms)	Environmental disclosure in annual reports, independent CSR or env. reports, 2009-2010		+/-		+/-													
Neu et al., 1998	Canadian Listed companies, env-sensitive industries (n = 33 firms)	Environmental reporting in annual reports, 1982-1991	+																
Patten, 2002a	US (n = 133 firms)	Environmental reporting in annual reports, 1990				-													
Patten, 2002b	US Companies included in Toxic release Inventory (n = 122 firms)	Environmental reporting in 10-Ks, 1990					+												
Reid and Toffel, 2009	US Listed S&P500 companies (n = 524 firms)	Climate change strategies disclosure in CDP questionnaire, 2006-2007																	
da Silva Monteiro and Albar-Guzman, 2009	Portugal Large firms (n = 109 firms)	Environmental disclosure in annual reports, 2002-2004	+	0	0														0: foreign ownership, +: listing
Stanwick and Stanwick, 2000	US Companies on Forbes 500 (n = 469 firms)	Environmental disclosure, as per responses to a letter		+															[Avg. fin. performers disclose most]
Sulaiman et al, 2014	Malaysia Listed companies, in env. sensitive industries (n = 164 firms)	Environmental disclosure in annual reports, 2009	+	0	+														0: ownership concentration
Tamimi and Sebastaneli, 2017	US Listed S&P500 companies	ESG reporting, in all reports	+					+											+ CEO duality, link of exec. pay to ESG score
Wegener et al., 2013	Canada (n = 319 firms)	Carbon disclosure in CDP questionnaires, 2006-2009																	+ shareholder activism, litigation risk, publicity opportunity
Yu and Ting, 2012	Global, 31 countries Large listed companies on FTSE Global 500 (n = 369 firms)	CDP leadership index level																	+ investor protection -: shareholder rights

Appendix B Industry classification

Table 2. Classification per industrial sector

Sector	Industries included
Basic industries	Chemicals, mining, aluminium, steel/iron one, engineering & construction, forest products, home building, textiles, etc.
Capital goods	Aerospace, auto parts, containers/packaging, industrial machinery, building products, electrical products, etc.
Consumer durables	Consumer electronics/appliances, home furnishings, metal fabrications, building products, etc.
Consumer non-durables	Packaged foods, meat/poultry/fish, beverages, plastic products, apparel, recreational products, telecom. equipment, etc.
Consumer services	Movies/entertainment, newspapers/magazines, clothing/shoe/accessory stores, real estate investment trusts, etc.
Energy	Oil & gas production, coal mining, natural gas distribution, oilfield services/equipment, integrated oil companies, etc.
Finance	Banks/brokers, savings institutions, investment managers, life/property/casualty/specialty insurers, real estate, etc.
Health care	Major pharmaceuticals, medical/dental instruments, hospital/nursery management, medical specialties, etc.
Miscellaneous	Business services, industrial machinery/components, office equipment/supplies, publishing, etc.
Public utilities	Power generation, natural gas distribution, oil/gas transmission, electric utilities: central, water supply, etc.
Technology	Computer software/communication equipment, EDP services, semiconductors, electrical products, industrial machinery, etc.
Transportation	Air freight/delivery, railroads, marine transportation, oil refining & marketing, trucking, etc.

Source: Nasdaq, 2019

Appendix C

TCFD recommended disclosure categories

Governance	Strategy	Risk Management	Metrics and Targets
Disclose the organization's governance around climate-related risks and opportunities.	Disclose the actual and potential impacts of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning where such information is material.	Disclose how the organization identifies, assesses, and manages climate-related risks.	Disclose the metrics and targets used to assess and manage relevant climate-related risks and opportunities where such information is material.
a) Describe the board's oversight of climate-related risks and opportunities.	a) Describe the climate-related risks and opportunities the organization has identified over the short, medium, and long term.	a) Describe the organization's processes for identifying and assessing climate-related risks.	a) Disclose the metrics used by the organization to assess climate-related risks and opportunities in line with its strategy and risk management process.
b) Describe management's role in assessing and managing climate-related risks and opportunities.	b) Describe the impact of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning.	b) Describe the organization's processes for managing climate-related risks.	b) Disclose Scope 1, Scope 2, and, if appropriate, Scope 3 greenhouse gas (GHG) emissions, and the related risks.
	c) Describe the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including a 2°C or lower scenario.	c) Describe how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management.	c) Describe the targets used by the organization to manage climate-related risks and opportunities and performance against targets.

Figure 3. TCFD recommended disclosure categories
Source: TCFD, 2017

Appendix D Sample mapping

Table 6. Sample mapping: Independent variables and CRD score

#	Name	Sector	Size (in M USD)	Fin. perf.	CEODual (Y=1, N=0)	Ind.Direct (%)	Fem.Direct (%)	State	StateGDP (USD,2018)	StateParty (1=R, 0=D)	CRD score	Mention	Govern	Impact	Plan	Metrics
1	Agilent Technologies, Inc.	Capital Goods	23210	0.0370	0	100%	22%	California	67,698	0	0	0	0	0	0	0
2	Aaron's, Inc.	Technology	4230	0.0694	1	88%	25%	Georgia	49,663	1	0	0	0	0	0	0
3	Axcelis Technologies, Inc.	Technology	488.86	0.0837	0	88%	13%	Massachusetts	72,635	0	0	0	0	0	0	0
4	Aduro Biotech, Inc.	Health Care	122.47	-0.2667	1	83%	17%	California	67,698	0	0	0	0	0	0	0
5	Airgain, Inc.	Technology	144.08	-0.0488	1	83%	33%	California	67,698	0	0	0	0	0	0	0
6	Alpine Immune Sciences, Inc.	Health Care	79.86	-0.6649	1	29%	0%	Washington	67,242	0	0	0	0	0	0	0
7	Amercan National Bankshares, Inc.	Finance	421.71	0.0121	0	71%	14%	Virginia	55,929	0	0	0	0	0	0	0
8	ANGI Homeservices Inc.	Consumer Services	6840	0.0413	0	36%	36%	Colorado	59,057	0	0	0	0	0	0	0
9	pdvWireless, Inc.	Public Utilities	700.25	-0.2134	0	50%	13%	New Jersey	62,263	0	0	0	0	0	0	0
10	AeroVironment, Inc.	Capital Goods	1360	0.0932	0	63%	13%	California	67,698	0	0	0	0	0	0	0
11	AMREP Corporation	Consumer Services	53.24	0.0152	0	25%	0%	New Jersey	62,263	0	0	0	0	0	0	0
12	Bel Fuse Inc.	Capital Goods	183.75	0.0467	0	89%	0%	New Jersey	62,263	0	0.4	0.2	0	0.2	0	0
13	B&G Foods, Inc.	Consumer Non-Durable	1350	0.0564	0	67%	22%	New Jersey	62,263	0	0.6	0.2	0	0.2	0	0.2
14	Bio-Rad Laboratories, Inc.	Capital Goods	9100	0.0652	1	50%	33%	California	67,698	0	0	0	0	0	0	0
15	Biolase, Inc.	Health Care	41.31	-0.5586	0	0%	17%	California	67,698	0	0.4	0.2	0	0.2	0	0
16	BioLife Solutions, Inc.	Health Care	341.21	0.0718	0	60%	0%	Washington	67,242	0	0	0	0	0	0	0
17	Citigroup Inc.	Finance	544.28	0.0094	0	87%	47%	New York	73,531	0	0.2	0.2	0	0	0	0
18	Cadence Bancorporation	Finance	2590	0.0131	1	89%	33%	Texas	58,417	1	0	0	0	0	0	0
19	CSI Compresso LP	Energy	168.5	-0.0447	0	57%	0%	Texas	58,417	1	0.4	0.2	0	0.2	0	0
20	CareDx, Inc.	Health Care	1620	-0.3579	1	67%	0%	California	67,698	0	0	0	0	0	0	0
21	C&F Financial Corporation	Finance	183.21	0.0118	0	64%	27%	Virginia	55,929	0	0	0	0	0	0	0
22	Ciena Corporation	Public Utilities	6710	-0.0918	0	56%	22%	Maryland	60,886	0	0.4	0.2	0	0.2	0	0
23	CIT Group Inc (DEL)	Finance	4990	0.0092	1	92%	33%	New York	73,531	0	0.2	0.2	0	0	0	0
24	Constellation Alpha Capital Corp.	Health Care	192.71	0.0759	1	75%	0%	Florida	43,052	1	0	0	0	0	0	0
25	Mr. Cooper Group Inc.	Finance	720.19	-0.0091	0	63%	0%	Texas	58,417	1	0	0	0	0	0	0
26	Cooper-Standard Holdings Inc.	Capital Goods	761	0.0399	1	67%	22%	Michigan	46,858	1	0	0	0	0	0	0
27	Corvus Pharmaceuticals, Inc.	Health Care	164.52	-0.3970	1	71%	14%	California	67,698	0	0	0	0	0	0	0
28	Covanta Holding Corporation	Basic Industries	2360	0.0396	0	91%	27%	New Jersey	62,263	0	0.4	0.2	0	0.2	0	0
29	Covenant Transportation Group, Inc.	Transportation	264.32	0.0549	1	67%	0%	Tennessee	47,695	1	0	0	0	0	0	0
30	Quest Diagnostics Incorporated	Health Care	13710	0.0716	1	55%	45%	New Jersey	62,263	0	0	0	0	0	0	0
31	DHI Group, Inc.	Miscellaneous	211.34	0.0126	1	63%	25%	New York	73,531	0	0	0	0	0	0	0
32	Dolphin Entertainment, Inc.	Consumer Services	14.25	-0.0767	1	0%	0%	Florida	43,052	1	0	0	0	0	0	0
33	The Dixie Group, Inc.	Consumer Durables	9.48	-0.0846	1	88%	13%	Georgia	49,663	1	0	0	0	0	0	0
34	Euronet Worldwide, Inc.	Finance	8790	0.0699	1	75%	13%	Kansas	52,297	1	0	0	0	0	0	0
35	Enanta Pharmaceuticals, Inc.	Health Care	1730	0.1737	0	63%	25%	Massachusetts	72,635	0	0	0	0	0	0	0
36	Forum Merger II Corporation	Finance	257.58	0.0053	1	67%	0%	Florida	43,052	1	0	0	0	0	0	0
37	FedNat Holding Company	Finance	173.93	0.0159	1	88%	25%	Florida	43,052	1	0.6	0.2	0	0.2	0.2	0
38	FRP Holdings, Inc.	Finance	520.01	0.2435	1	80%	0%	Florida	43,052	1	0	0	0	0	0	0
39	Forterra, Inc.	Capital Goods	350.43	-0.0136	0	44%	11%	Texas	58,417	1	0.4	0.2	0	0.2	0	0
40	Federal Signal Corporation	Capital Goods	1580	0.0823	0	89%	22%	Illinois	59,980	0	0	0	0	0	0	0
41	frontdoor, inc.	Finance	3730	0.1201	0	86%	29%	Tennessee	47,695	1	0.4	0.2	0	0.2	0	0
42	Gencor Industries Inc.	Capital Goods	187.44	0.0821	0	75%	0%	Florida	43,052	1	0	0	0	0	0	0
43	Glaukos Corporation	Health Care	2820	-0.0626	0	83%	17%	California	67,698	0	0	0	0	0	0	0
44	Harpoon Therapeutics, Inc.	Health Care	362.1	-0.0948	0	75%	13%	California	67,698	0	0	0	0	0	0	0
45	Hi-Crush Inc.	Basic Industries	231.53	0.0960	1	75%	0%	Texas	58,417	1	0.6	0.2	0	0.2	0.2	0
46	Hornbeck Offshore Services	Consumer Services	45.45	-0.0808	1	75%	13%	Louisiana	49,606	1	0.4	0.2	0	0.2	0	0
47	Hersha Hospitality Trust	Consumer Services	653.71	0.0039	0	63%	13%	Pennsylvania	55,602	1	0	0	0	0	0	0
48	Iovance Biotherapeutics, Inc.	Health Care	3050	-0.2570	0	67%	17%	California	67,698	0	0	0	0	0	0	0
49	iPic Entertainment Inc.	Consumer Services	31.61	-0.3576	1	60%	0%	Florida	43,052	1	0	0	0	0	0	0
50	Isramco, Inc.	Energy	334.71	0.1476	1	67%	0%	Texas	58,417	1	0	0	0	0	0	0

#	Name	Sector	Size (in M USD)	Fin. perf.	CEODual (Y=1, N=0)	Ind.Direct (%)	Fem.Direct (%)	State	StateGDP (USD,2018)	StateParty (1=R, 0=D)	CRD score	Mention	Govern	Impact	Plan	Metrics
51	Investors Title Company	Finance	307.86	0.0895	1	75%	0%	North Carolina	47,778	1	0	0	0	0	0	0
52	Jagged Peak Energy Inc.	Energy	1820	0.0936	0	30%	20%	Colorado	59,057	0	0.4	0.2	0	0.2	0	0
53	KLX Energy Services Holdings, Inc.	Energy	436.13	0.0467	1	88%	0%	Florida	43,052	1	0.4	0.2	0	0.2	0	0
54	Liberty Oilfield Services Inc.	Energy	1580	0.2230	1	50%	0%	Colorado	59,057	0	0.4	0.2	0	0.2	0	0
55	Leidos Holdings, Inc.	Technology	11760	0.0664	1	85%	15%	Virginia	55,929	0	0.2	0.2	0	0	0	0
56	Levi Strauss & Co	Consumer Non-Durable	9290	0.0799	0	31%	31%	California	67,698	0	0.4	0.2	0	0.2	0	0
57	LegacyTexas Financial Group, Inc.	Finance	2040	0.0170	0	86%	29%	Texas	58,417	1	0	0	0	0	0	0
58	Mesa Air Group, Inc.	Transportation	272.6	0.1680	1	89%	11%	Arizona	43,096	1	0	0	0	0	0	0
59	Mosaic Acquisition Corp.	Finance	441.17	0.0154	1	80%	0%	New York	73,531	0	0	0	0	0	0	0
60	MGIC Investment Corporation	Finance	4800	0.1180	0	92%	25%	Wisconsin	51,575	1	0	0	0	0	0	0
61	NACCO Industries, Inc.	Consumer Durables	373.09	0.0923	0	73%	0%	Ohio	51,456	1	0.4	0.2	0	0.2	0	0
62	Navigant Consulting, Inc.	Consumer Services	912.84	0.1319	1	80%	40%	Illinois	59,980	0	0	0	0	0	0	0
63	Norwegian Cruise Line Holdings Ltd.	Consumer Services	10930	0.0628	0	60%	30%	Florida	43,052	1	0	0	0	0	0	0
64	Nebula Acquisition Corporation	Finance	347.19	0.0096	1	67%	0%	California	67,698	0	0	0	0	0	0	0
65	Nuverra Environmental Solutions, Inc.	Energy	90.01	-1.1971	1	75%	0%	Arizona	43,096	1	0.2	0.2	0	0	0	0
66	NextDecade Corporation	Public Utilities	644.15	-0.2447	1	90%	0%	Texas	58,417	1	0	0	0	0	0	0
67	NeoPhotonics Corporation	Technology	212.39	-0.1281	1	86%	0%	California	67,698	0	0.2	0.2	0	0	0	0
68	InVivo Therapeutics Holdings Corp.	Health Care	6.05	-1.2746	0	67%	33%	Massachusetts	72,635	0	0	0	0	0	0	0
69	Omega Healthcare Investors, Inc.	Consumer Services	8150	0.0342	0	75%	25%	Maryland	60,886	0	0.2	0.2	0	0	0	0
70	Otter Tail Corporation	Public Utilities	2110	0.0401	0	78%	22%	Minnesota	59,057	0	0.6	0.2	0	0.2	0.2	0
71	Peoples Bancorp of North Carolina, In	Finance	165.33	0.0122	0	82%	0%	North Carolina	47,778	1	0	0	0	0	0	0
72	Performance Food Group Company	Consumer Non-Durable	4320	0.0497	1	70%	20%	Virginia	55,929	0	0.4	0.2	0	0.2	0	0
73	Quidel Corporation	Health Care	2280	0.0920	0	67%	22%	California	67,698	0	0	0	0	0	0	0
74	Qumu Corporation	Technology	42.59	-0.1374	1	56%	11%	Minnesota	59,057	0	0	0	0	0	0	0
75	Arcadia Biosciences, Inc.	Basic Industries	18.93	-0.5611	0	71%	29%	California	67,698	0	0.4	0.2	0	0.2	0	0
76	Rambus, Inc.	Technology	1320	-0.1160	0	86%	14%	California	67,698	0	0	0	0	0	0	0
77	Raytheon Company	Capital Goods	48730	11.0562	1	92%	31%	Massachusetts	72,635	0	0	0	0	0	0	0
78	SCYNEXIS, Inc.	Health Care	68.67	-0.2345	0	86%	14%	New Jersey	62,263	0	0	0	0	0	0	0
79	Safeguard Scientifics, Inc.	Finance	243.63	-0.1072	0	67%	17%	Pennsylvania	55,602	1	0	0	0	0	0	0
80	SenesTech, Inc.	Basic Industries	43.74	-1.5357	0	86%	43%	Arizona	43,096	1	0	0	0	0	0	0
81	Synovus Financial Corp.	Finance	5510	0.0131	1	93%	29%	Georgia	49,663	1	0	0	0	0	0	0
82	Sonoco Products Company	Consumer Durables	6580	0.0687	0	77%	23%	South Carolina	39,883	1	0.4	0.2	0	0.2	0	0
83	Spirit Aerosystems Holdings, Inc.	Capital Goods	7750	0.1085	0	78%	22%	Kansas	52,297	1	0	0	0	0	0	0
84	Extended Stay America, Inc.	Consumer Services	3180	0.0540	0	86%	43%	Florida	43,052	1	0	0	0	0	0	0
85	State Street Corporation	Finance	20550	0.0106	0	83%	25%	Massachusetts	72,635	0	0	0	0	0	0	0
86	Triumph Bancorp, Inc.	Finance	770.18	0.0113	0	91%	9%	Texas	58,417	1	0	0	0	0	0	0
87	TriCo Bancshares	Finance	1150	92.9807	0	83%	8%	California	67,698	0	0.4	0.2	0	0.2	0	0
88	Teledyne Technologies Incorporated	Capital Goods	9960	0.0876	0	82%	27%	California	67,698	0	0.4	0.2	0	0.2	0	0
89	T-Mobile US, Inc.	Public Utilities	64200	0.0399	0	36%	9%	Washington	67,242	0	0	0	0	0	0	0
90	Trevena, Inc.	Health Care	95.12	-0.4567	0	67%	56%	Pennsylvania	55,602	1	0	0	0	0	0	0
91	Textron Inc.	Capital Goods	12420	0.0857	1	91%	27%	Rhode Island	50,827	0	0.4	0.2	0	0.2	0	0
92	Unique Fabricating, Inc.	Capital Goods	26.99	0.0300	0	86%	14%	Michigan	46,858	1	0	0	0	0	0	0
93	Ultralife Corporation	Miscellaneous	128.9	0.2081	0	83%	0%	New York	73,531	0	0	0	0	0	0	0
94	Washington Trust Bancorp, Inc.	Finance	899.5	0.0137	1	85%	23%	Rhode Island	50,827	0	0	0	0	0	0	0
95	WEC Energy Group, Inc.	Public Utilities	27030	0.0317	0	86%	21%	Wisconsin	51,575	1	0.4	0.2	0	0.2	0	0
96	Worldpay, Inc.	Miscellaneous	40030	0.0008	1	78%	11%	Ohio	51,456	1	0	0	0	0	0	0
97	Wolverine World Wide, Inc.	Consumer Non-Durable	2410	0.0918	1	70%	30%	Michigan	46,858	1	0	0	0	0	0	0
98	Xcel Brands, Inc	Miscellaneous	49.94	0.0079	1	29%	14%	New York	73,531	0	0	0	0	0	0	0
99	Xylem Inc.	Capital Goods	14570	0.0760	0	91%	18%	New York	73,531	0	0.6	0.2	0	0.2	0.2	0
100	Zomedica Pharmaceuticals Corp.	Health Care	27.01	-2.7479	1	60%	0%	Michigan	46,858	1	0	0	0	0	0	0

Appendix E

CRD score by independent variable

1. **Company size:** Companies in the sample were divided into three categories, based on their market capitalization and a commonly used rule of thumb in finance (Financial Engines, 2018; Tamimi and Sebastianelli, 2017).

- (i) Small-cap < USD 2 billion; sample size (n) is 65;
- (ii) USD 2 billion \leq medium-cap < USD 10 billion, $n = 24$;
- (iii) Large-cap \geq USD 10 billion; $n = 11$.

Larger companies seem to display a higher CRD score, however, the difference is not statistically significant.

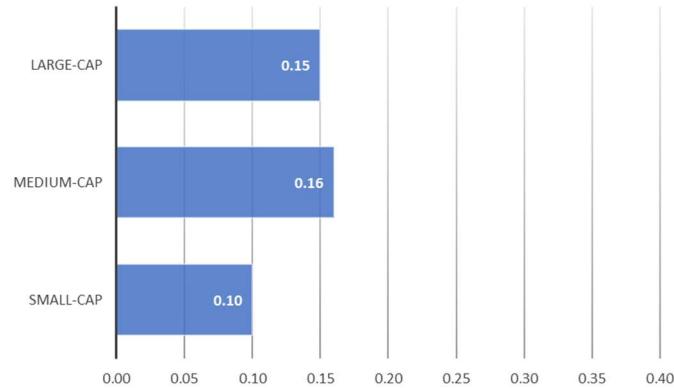


Figure 4. Average CRD score by company size

2. **Financial performance:** CRD score by financial performance categories is shown in Section 3.3.

3. **Dual listing:** There were no dually-listed companies in the generated sample.

4. **Independent executives:** The ratio of independent directors on the Board of Directors to the total number of directors averages 71% for the sample as a whole, with a range of 0% to 92%. To divide companies into different categories, companies were ranked by their percentage of independent directors and divided into four groups:

- (i) Fourth-tier: ratio < 60%; $n = 23$;
- (ii) 61% \leq Third-tier ratio < 73%, $n = 26$;
- (iii) 74% \leq Second-tier ratio < 85%, $n = 26$;
- (iv) First-tier ratio \geq 85%; $n = 25$.

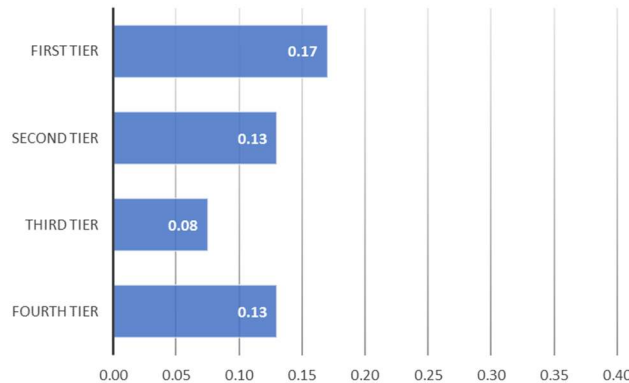


Figure 5. Average CRD score by ratio of independent directors [greater definition of what you mean by independence of directors is needed]

5. **CEO duality:** 45 companies in the sample have the same person acting as both the CEO and the Chairman of the Board, and the average CRD score for the 'Yes' group is 0.09. The other 55 firms do not exhibit DEO duality. The 'No' group has the average CRD score of 0.15, which seems to be significantly larger than the score for the 'Yes' group, however, the difference is not statistically significant.

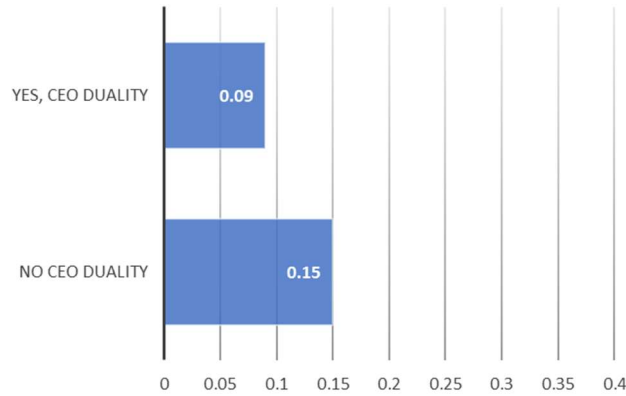


Figure 6. Average CRD score by CEO duality indicator

6. **Female executives:** The ratio of female directors on the Board of Directors to the total number of directors averages 17% for the sample as a whole, with a range of 0% to 56%. To divide companies into different categories, companies were ranked by their percentage of female directors and divided into four roughly equally-sized groups:

- (i) Fourth-tier: ratio < 8%; $n = 28$;
- (ii) $8\% \leq$ Third-tier ratio < 15%, $n = 22$;
- (iii) $15\% \leq$ Second-tier ratio < 25%, $n = 26$;
- (iv) First-tier ratio $\geq 25\%$; $n = 24$.

Companies that rank higher in this category, i.e. have a higher percentage of female executives on the board, seem to have a higher CRD score as well, however, the difference is not statistically significant.

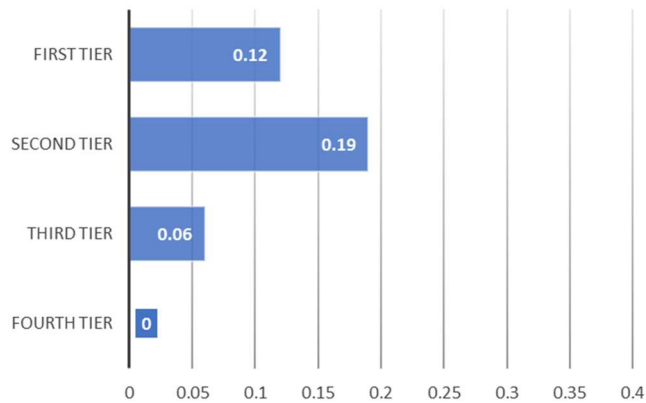


Figure 7. Average CRD score by ratio of female directors

7. **Industrial sector:** CRD score by financial performance categories is shown in Section 3.3.

8. **Highly-polluting sector:** CRD score by financial performance categories is shown in Section 3.3.

9. State GDP: 24 states are represented in the generated sample, with GDP per capita for 2018 ranging from USD 39,883 to USD 73,531, and with an average of USD 58,440. To divide states into different categories based on their GDP per capita, states were ranked by their GDP per capita levels and then divided into four roughly equally-sized groups:

- (i) Fourth-tier: GDP per capita < USD 50,000; $n = 26$;
- (ii) USD 50,000 \leq Third-tier ratio < USD 59,000, $n = 24$;
- (iii) USD 59,000 \leq Second-tier ratio < USD 67,300, $n = 19$;
- (iv) First-tier ratio \geq USD 67,300; $n = 31$. [Due to a large number of companies in California, 19, the fourth category has a disproportionately large total number of companies.]

It seems that aside for the top tier states, i.e. the highest GDP per capita states which includes California, Massachusetts and New York, the lower the GDP per capita, the higher the average CRD score is. The non-parametric tests, however, did not detect a significantly large difference among average CRD scores.

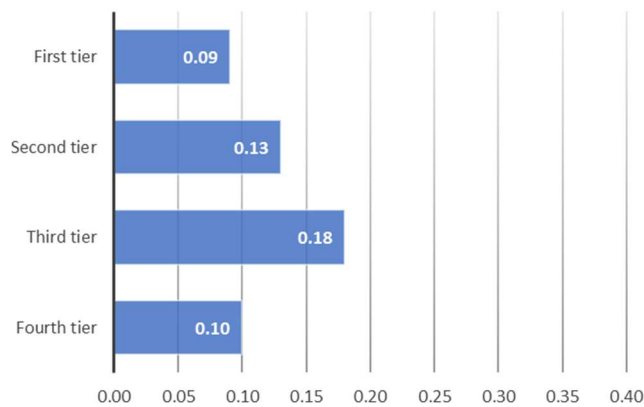


Figure 8. Average CRD score by state GDP per capita

10. State political party: States which voted Democrat in the last presidential elections were over-represented in the generated sample, with 56 companies. Such states also seem to exhibit a higher average CRD score (of 0.14) compared to states which voted Republican (0.10). However, the difference was not found to be statistically significant.

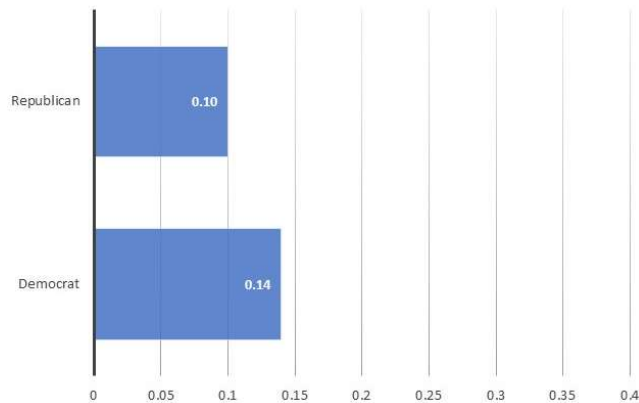


Figure 9. Average CRD score by state political party

Appendix F

Results of the Mann-Whitney tests on industry sectors

Table 11. Results of the Mann-Whitney tests on industry sectors

	Basic industries	Capital goods	Consumer durables	Consumer non-durables	Consumer services
Basic industries	n/a n < 5				
Capital goods	n/a n < 5	n/a n < 5			
Consumer durables	n/a n < 5	n/a n < 5	n/a n < 5		
Consumer non-durables	n/a n < 5	n/a n < 5	n/a n < 5		
Consumer services	n/a n < 5	U = 56; Crit.value = 36; z = 0.79045; p-value = 0.42952 Not-signif. at p < 0.05	n/a n < 5	n/a n < 5	U = 9.5; Crit.value = 11; z = -2.1693; p-value = 0.03 Signif at p < 0.05
Energy	n/a n < 5	U = 26.5; Crit.value = 17; z = -1.23718; p-value = 0.21498 Not-signif. at p < 0.05	n/a n < 5	n/a n < 5	U = 112 z = 0.09793; p-value = 0.92034 Not-signif. at p < 0.05
Finance	n/a n < 5	U = 134.5 z = -0.81422; p-value = 0.41794 Not-signif. at p < 0.05	n/a n < 5	n/a n < 5	U = 73.5; Crit.value = 45; z = -0.55231; p-value = 0.58232 Not-signif. at p < 0.05
Health care	n/a n < 5	U = 83; Crit.value = 67; z = -1.40914; p-value = 0.15854 Not-signif. at p < 0.05	n/a n < 5	n/a n < 5	
Miscellaneous	n/a n < 5	n/a n < 5	n/a n < 5	n/a n < 5	n/a n < 5
Public utilities	n/a n < 5	U = 35; Crit.value = 17; z = -0.53611; p-value = 0.5892 Not-signif. at p < 0.05	n/a n < 5	n/a n < 5	U = 19; Crit.value = 11; z = -1.13888; p-value = 0.25428 Not-signif. at p < 0.05
Technology	n/a n < 5	U = 40.5; Crit.value = 22; z = 0.59684; p-value = 0.5485 Not-signif. at p < 0.05	n/a n < 5	n/a n < 5	U = 33; Crit.value = 14; z = -0.14639; p-value = 0.88076 Not-signif. at p < 0.05
Transportation	n/a n < 5	n/a n < 5	n/a n < 5	n/a n < 5	n/a n < 5

	Energy	Finance	Health care	Miscellaneous	Public utilities	Technology
Basic industries						
Capital goods						
Consumer durables						
Consumer non-durables						
Consumer services						
Energy						
Finance	U = 26 z = -2.28812; p-value = 0.02202 Signif at p < 0.05					
Health care	U = 12; Crit.value = 22; z = -2.69554; p-value = 0.00694 Signif at p < 0.05	U = 165 z = 0.82079; p-value = 0.41222 Not-signif. at p < 0.05				
Miscellaneous	n/a n < 5	n/a n < 5	n/a n < 5			
Public utilities	U = 15.5; Crit.value = 5; z = 0.32026; p-value = 0.74896 Not-signif. at p < 0.05	U = 46.5 z = -1.18444; p-value = 0.238 Not-signif. at p < 0.05	U = 28; Crit.value = 22; z = -1.5732; p-value = 0.1141 Not-signif. at p < 0.05	n/a n < 5		
Technology	U = 5.5; Crit.value = 6; z = -2.14286; p-value = 0.03236 Signif at p < 0.05	U = 78 z = -0.09807; p-value = 0.92034 Not-signif. at p < 0.05	U = 47; Crit.value = 28; z = -0.76213; p-value = 0.44726 Not-signif. at p < 0.05	n/a n < 5	U = 13.5; Crit.value = 6; z = -1; p-value = 0.31732 Not-signif. at p < 0.05	
Transportation	n/a n < 5	n/a n < 5	n/a n < 5	n/a n < 5	n/a n < 5	n/a n < 5