

# Where we stand with Climate Disclosures and why we need them

- Natural Language Processing applications in analysis of sustainability reporting



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## Executive Summary

According to the World Economic Forum, out of the top 10 long-term global risks, five are related to environment and climate change. To respond to the urgent need of mitigating climate risks, regulators, companies, and investors have all stepped up to aim for more transparent and thorough disclosure of companies' sustainability performance. Compared to ESG disclosures, climate risk disclosures are more demanding of companies as they require an explicit link between climate risks and financial impact. Fewer companies have climate risk disclosures. For example, out of all China domiciled companies listed in US exchanges, 13 have ESG reports, but zero mention "climate risks" and only two mention the broad term of "climate change." However, climate risk issues have become more prevalent so climate-specific disclosures have become an important consideration for both investors and companies. Despite increasing adoption of climate disclosure frameworks such as the Task Force on Climate-related Financial Disclosures (TCFD), little is known on the extent to which companies actually follow the specific recommendations of such guidelines. In this study, we apply Natural Language Processing (NLP) techniques to 277 documents from 182 companies in S&P500 and CSI300 that disclose climate risks to study the breadth and depth of their disclosures. We provide a deep dive into S&P500 and CSI300 using textual analysis because they are the most representative indices of the United States and China, which are the world's two largest economies and constitute 52 percent of the global equity market.<sup>1</sup>

Given the novelty of climate risk disclosure frameworks and their fast adoption, the identification of best practice benchmarks in a scalable fashion (e.g. using textual analysis to construct a "transparency index") can allow investors to gauge the quality of firms' climate disclosures, as well as help identify companies that make selective disclosures to misrepresent their climate risk profiles, i.e., those who might engage in "greenwashing." A summary of our key findings is as follows:

- 1. Japanese companies have the most frequent discussions of climate risks in their sustainability reports and European and US companies follow closely behind. Chinese companies significantly lag behind their global peers.**
  - Among the four major equity indices we examined including CSI300, S&P500, EURO STOXX 50, and NIKKEI 225, Japanese companies lead in terms of frequency of climate risk discussions. Fifty two percent of companies in NIKKEI225, which represents 68 percent of market capitalization discuss climate risks in their company reports. Forty percent of EURO STOXX 50 companies (44 percent of market capitalization) and 33 percent of S&P500 companies (53 percent of market capitalization) do so.
  - Chinese companies part of the CSI300 index significantly lag behind. Only three percent of companies (13 percent of market capitalization) in CSI300 currently discuss climate risks in their sustainability reports.
  - We provide a deep dive into Chinese and US companies for the following textual analysis results as they are two biggest equity markets, with the caveat that the population of Chinese companies that discuss climate risks is small (9 out of 182). We will expand the analysis into other markets for future reports.
- 2. Among US and Chinese companies that disclose climate risks, we identify six unique themes across companies' sustainability disclosure reports, including "Energy usage", "Governance", "Human rights and employee health and safety", "Climate related risk management", "Emissions", and "GRI reporting and materiality."**
  - "Emissions" is the best covered theme (21.4 percent coverage rate), whereas "GRI reporting and materiality" is the least well covered (10.1 percent coverage rate).
  - Across TCFD's four recommendations pillars (labelled as "Governance", "Strategy", "Risk management", "Metrics and targets"), none of the six themes identified maps exactly into the "Strategy" pillar, thus suggesting that companies under-disclose on "Strategy" related to climate change. The most well covered TCFD recommendation is "Metrics and target."
  - Although they are not part of TCFD recommendations, "Human rights and employee health and safety" and "GRI reporting and materiality" are important, additional themes discussed by companies.

<sup>1</sup>Calculated from data obtained on Bloomberg terminal (August 24, 2020)

### 3. Climate-related metrics all have high disclosure rates, with the exception of land use. Financial impact metrics are not as well covered as climate-related metrics.

- Among companies that do provide climate disclosures, more than 90 percent report on metrics related to carbon emissions and energy usage. There is almost no sector that lags far behind – within every sector, more than 90 percent disclose **carbon emission** and **energy use**, except for the transportation sector. Disclosure of **water usage** is less prominent, with an average rate of 58 percent. Land use, on the other hand, is considerably underreported, with only 6 percent of companies disclosing it, possibly because it is only relevant for certain sectors.
- Despite climate risk disclosures such as the Task Force for Climate-related Financial Disclosures (TCFD) specifically asking for links to financial performance, **financial impact metrics** are not particularly well disclosed by companies. This is especially true for impact on capital and financing, with a disclosure rate of only 16 percent.
- Sector-level granularity shed additional light on disclosures. Our analysis reveals that insurance companies are more articulated in quantitative disclosures on “asset & liabilities” impacts, together with the Infrastructure and Transportation sectors. The latter are also better than other sectors in covering the “revenue and expenditures” dimension.

### 4. Recommendations to improve climate risk disclosures.

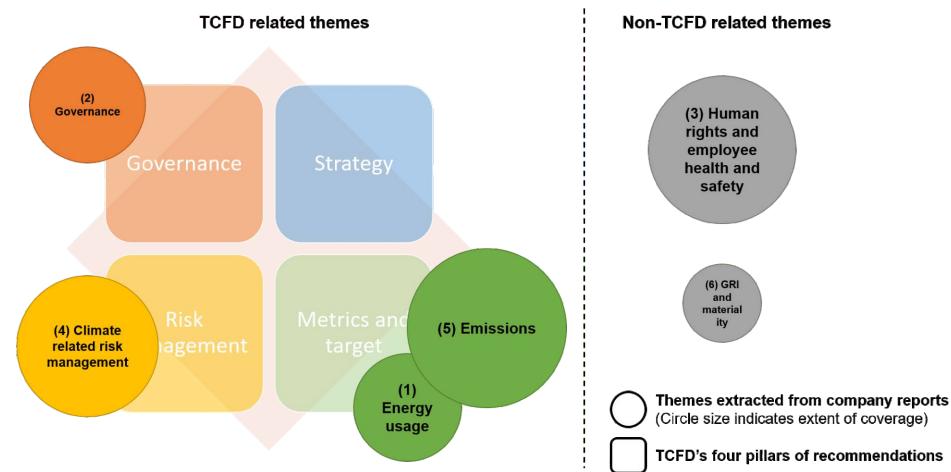
Despite regional differences in terms of disclosure rate, recommendations below apply to companies in all regions. Chinese companies in particular have much to catch up, as many need to take the step to disclose in the first place. For companies in developed markets that have already taken the first step, there is still gap between current state of disclosures and requirements from guidelines such as TCFD, especially in terms of clear quantitative measures on financial impact. Recommendations below would improve their current breadth and depth of disclosures.

- **Establish tighter links between climate risk exposures and financial performance.** Due to limited data availability, there is weak evidence linking financial performance and climate risk exposures. Compared to physical risks (such as extreme weather events), transition risks are harder to model and their effects difficult to disentangle empirically due to limited historical data. Companies should use at least stylized frameworks to help navigate how market participants link climate change exposure to valuations when the economy transitions from partial climate-awareness to an equilibrium where climate risks are fully priced in. Companies can conduct bottom-up analyses on key forthcoming policies as we transition to a low-carbon economy (e.g. carbon pricing, change in energy mix, etc.) to project costs and opportunities in terms of cost of capital, valuations, and market share. Ping An is currently working on asset-repricing models for portfolios that price in climate risks, based on portfolio companies' specific revenue streams and prospective impact from physical and transition policy risks. For the next report in this series, we will study the relationship between climate disclosures and performance, for example whether companies appearing relatively “unconcerned” about climate risk might actually be associated with heavier climate risk metrics, or vice versa.
- **Move from backward-looking to forward-looking information.** Climate change risks have largely relied on carbon footprints to approximate climate risk exposures. However, such backward-looking data have limited relevance for company valuations, as the latter are based on future financial prospects. Also, carbon footprints do not consider companies' pricing power, i.e., their ability to pass on the cost to its customers. In addition to current emission data, companies should use forward-looking projections, such as future production curves, and disclose investments and/or strategies that companies are currently adopting to address climate risks going forward. The emergence of climate related tail risk metrics, such as climate Value-at-Risk, is promising and supports market participants' efforts to screen for resilience to downside risks brought about by climate change. Symmetrically, the explicit consideration of climate change opportunities provides a way to gauge innovation upside. In the insurance sector for example, market leaders such as AXA and AVIVA are already using forward-looking metrics such as climate Value-at-Risk in their disclosures.

- **Converge towards truthful, transparent, and communicable disclosures with scalable tools for automatic detection of disclosure quality.** The lack of unified standards, clear definitions, well-accepted methodologies, and stricter enforcement on disclosures may have made it easier for companies to engage in “greenwashing.” This is partly because only a minority of companies have their sustainability reports audited. Pressure has to first come from regulators and standard-setting bodies to move toward more trust-worthy and transparent disclosures. In addition, the identification of best practice benchmark can allow investors to gauge the breadth and depth of an entity's climate disclosures, as well as help identify those that make selective disclosure to misrepresent their climate risk profiles. Some of the analytics tools showcased here can be used to assess the comprehensiveness of companies' climate disclosures and detect potential greenwashing. Application of these tools across particular sectors could inform the creation of indicators of climate risk disclosure and hence allow ranking of climate risk disclosure performance in a scalable fashion. Explicit linkage to financial performance, which will be explored in a follow-up report, will also inform on the extent to which climate disclosure efforts are indeed conducive to value creation, which is a topical question in several leading jurisdictions.

## Climate Disclosure in Charts

We identify six unique themes, four of which map to TCFD recommendations, with “Emissions” being the most widely covered theme.

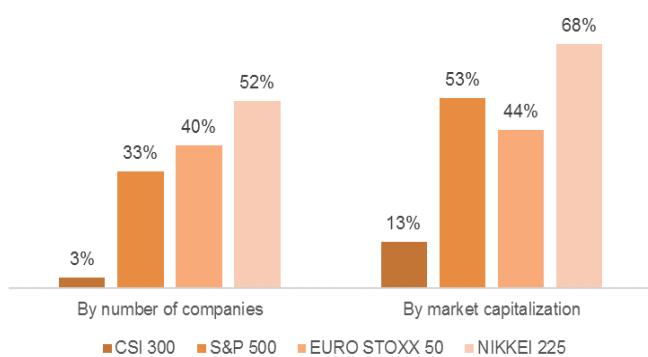


### Key words in theme “Emissions”

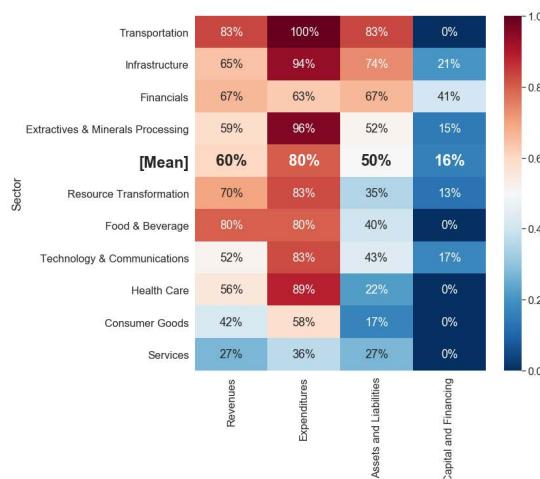
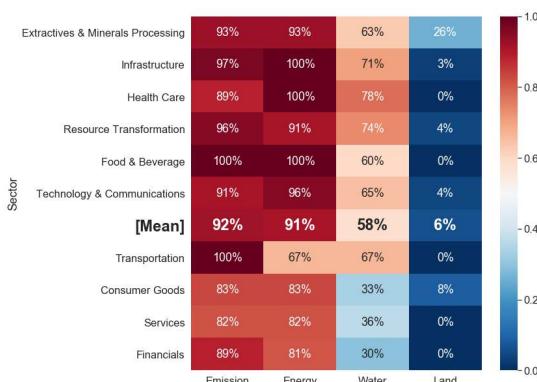


### Japanese companies lead in climate risk disclosures

Percentage of companies with climate risk discussions in sustainability reports



Among climate-related metrics, emission and energy usage have the highest disclosure rate and land the lowest. Among financial impact metrics, impact on expenditures has the highest disclosure rate and capital & financial the lowest.



Source: Ping An Digital Economic Research Center; Company sustainability reports (S&P500, CSI300)

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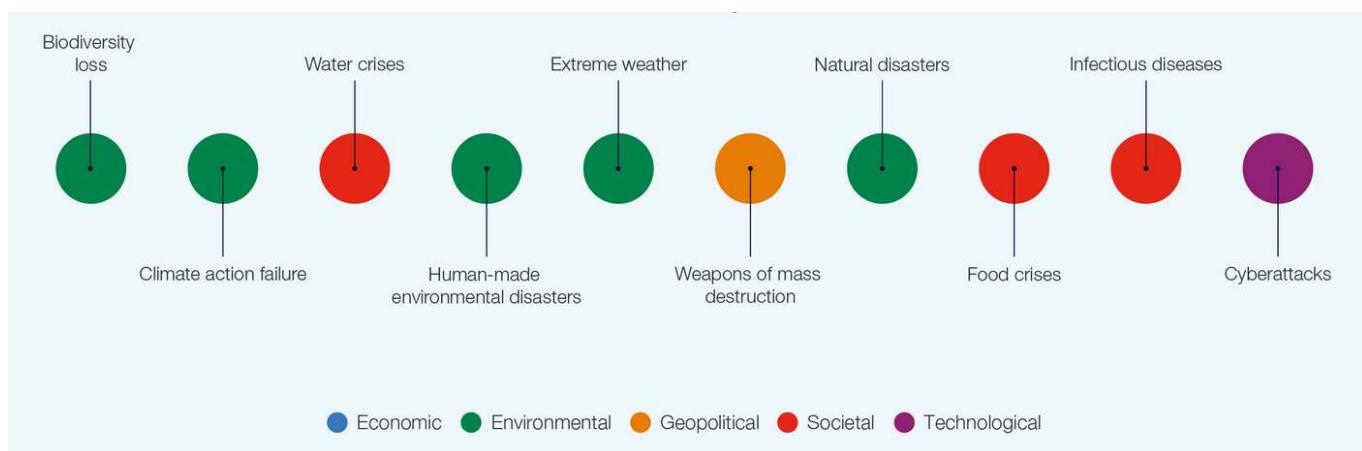
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## 1. Introduction

According to the World Economic Forum (WEF, 2020), amongst the top 10 global risks that society and the economy face in the coming decades, five are directly related to weather and climate change risks, as shown in Figure 1. Environmental risks such as biodiversity loss, climate action failure, human-made environmental disasters, extreme weather, and natural disasters pose some of the most pressing challenges to the global economy and society at large. The management of environmental risks is increasingly considered as a core driver of businesses competitiveness. The increase in both the frequency and intensity of extreme weather events such as heat waves, floods, as well as the shift of average or “normal” climate conditions have all spurred the development of metrics and standards to help companies and investors manage their risks and guide investment decisions.

In order to respond to the urgent need to address environmental and climate risks, disclosure guidelines have been promoted to help companies reliably assess and transparently communicate their environmental impact. Compared to standard ESG disclosures, climate risk disclosures have a shorter history but are in a way more demanding for companies, as companies are required to explicitly address the link between climate change and business impacts.

Figure 1. Top 10 long-term global risks



Source: World Economic Forum, 2020

### 1.1 What are climate risk disclosures?

One of the main challenges that companies face in adopting ESG and climate risk disclosures is the plethora of frameworks and guidelines they are asked to follow. In our previous report - *“ESG in China: Current State and Challenges in Disclosures and Integration,”* we note that among just the 300 Chinese companies that are part of the CSI300 index, a total of nine different guidelines are being followed (Ping An Digital Economic Research Center, 2019). Climate risk disclosures are a subset of the broader ESG or sustainability disclosures. However, even within a narrower scope, there are already several frameworks and initiatives that have emerged during the last few years (Pagano, 2018). Amongst these, three disclosure initiatives have gained the most prominence globally: the Climate Disclosure Project (CDP), the Global Reporting Initiative (GRI), and more recently the Task Force on Climate-related Financial Disclosures (TCFD). We outline details and significance of these three frameworks in Box 1.

The strengthening of national and regional environmental regulations has also been a key factor in accelerating the development and adoption of voluntary climate disclosure mechanisms (Zhang and Liu, 2020, Walker and Salt, 2006; Kolk, 2005). For example, the EU regulation on Sustainability-Related Disclosures will start to apply in 2021, thus broadening the requirement of incorporating sustainability risks for financial advisors (Mavela-Otto and Wright, 2020). Some academic research has also documented an increase in shareholder value of firms from climate activism when the business environment they operate in becomes more climate aware, which also motivates the need for a common set of metrics and transparency across businesses (Cormier et al, 2005; Kim and Lyon, 2011).

## Box 1. Major climate risk disclosure frameworks



The Carbon Disclosure Project (CDP) is a voluntary climate and environmental disclosure framework. It aims to create a standardized framework for reporting direct and indirect emissions by businesses and public entities such as cities. The CDP has to date gathered and enabled the disclosure of climate and environmental performance datasets of over 8,400 companies as well as 800 cities (CDP, 2020). Empirical studies have concluded that the scheme has achieved contrasting results in increasing the transparency of carbon emissions. Disclosures by public entities have increased in quality for scope 2 emissions while they have decreased for private ones (Matisoff et al 2013). In addition, an increasing trend towards private-only rather than public disclosure raises questions regarding the impact on firms. Studies focused on the quality of disclosure have identified variations across time and regions pointing to the inherent limitation of voluntary schemes in comparison with mandatory disclosures. However, cross-sectional analysis of firm-level carbon intensities indicates that the voluntary disclosures carried out correlate with firms' carbon emission reduction performance (Luo and Tang, 2014).



To respond to the multitude of frameworks on reporting companies' social and environmental performance, the Global Reporting Initiative (GRI) was set up in 1997 by the Coalition for Environmentally Responsible Economies (CERERS). The GRI is the most used corporate responsibility reporting framework with 89 percent of G250 companies using it in 2017 (KPMG 2017). The GRI framework provides a standardised set of guidelines to report positive and negative environmental and social impacts of corporates activities. However, the nature of its voluntary reporting is such that rhetoric could often be used to obscure the reporting of negative effects (Hahn and Lülfis, 2014) and avoid negative stakeholders' perception. The analysis of CO<sub>2</sub> emissions performances across five different industrial sectors (automotive, chemicals, energy, utilities, mining and materials) of GRI-reporting and non-reporting companies reveals that substantially lower emissions can only be identified for utilities (Bernard et al 2015, Bernard et al. 2017).



The Task Force on Climate-related Financial Disclosures (TCFD) was set up by the G20 Financial Stability Board (FSB) in 2015 in the wake of the Paris 15th Climate Conference of Parties. The release of final recommendations from the industry-led task force in 2017 elevated the playing field of climate disclosures. It has gone a step further compared to existing frameworks to emphasize the financial implications of climate risks and opportunities, tightly linking climate change impact and companies' financial metrics. In addition to emphasis on financial impact, TCFD disclosures also outline scenario analysis tools, pushing companies to be forward-looking in evaluating the biggest business risks under different climate change scenarios. Since its release in 2017, the TCFD recommendations have been endorsed by more than 800 organizations, including investors, banks and other financial institutions responsible for US\$118 trillion in assets (Corporate Report Dialogue, 2019). Beyond the company level, as of early 2019, more than 10 governments and financial regulators have also endorsed it and actively integrating into existing regulations (PRI, 2019).

## 1.2 Climate risk disclosures vs. the “E” in ESG?

The environmental “E” indicators in ESG include a wide range of metrics both directly and indirectly related to climate. Examples of those that directly relate to climate risks include:

- i. Green-house gas emissions per unit of revenue and trading activity as well as reductions;
- ii. The disaggregated evaluation of all types of energy consumed by unit of revenue and the amount renewables included in the consumption mix.

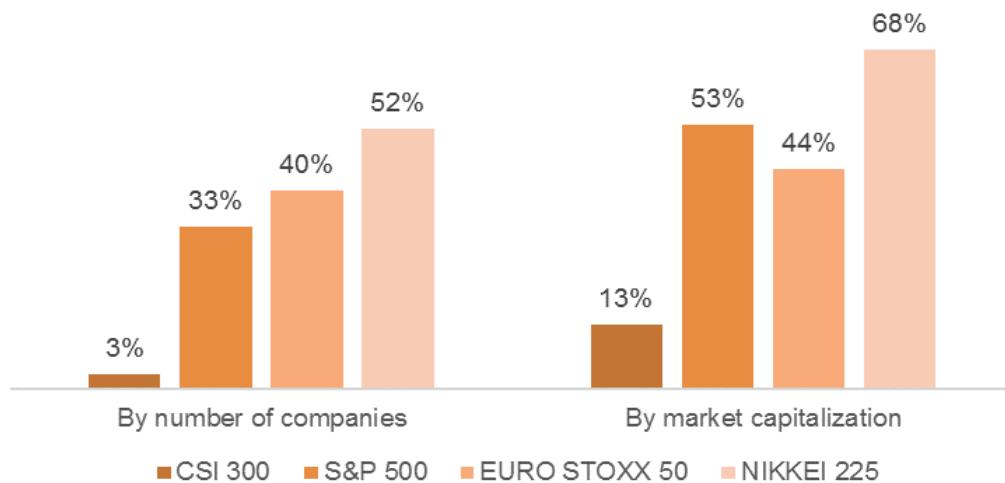
Examples of indirect climate indicators include:

- i. Amount of waste generated and recycled;
- ii. Amount of water consumed, recycled or discharged;
- iii. Participation in different international environmental sustainability initiatives such as the Principles for Responsible Investments, the GRI Sustainability Reporting Standards (GRI Standards), or the UN Global Compact.

The rapid development and adoption of ESG frameworks and reporting by investors and public companies has started to lay the foundations for data availability and transparency. Nevertheless, ESG frameworks currently do not allow for robust linkages between companies' environmental performance and exposure of their fundamentals to climate risks. Although ESG performance has been linked to the profitability of firms (e.g., Kotsantonis et al 2016), the underlying methodology of ESG reporting does not inform the extent to which revenues or profitability are at risk due to increasing climate risks and uncertainties. New risk exposure-oriented frameworks, such as the one offered by TCFD, allow firms to develop new analyses that introduce end-to-end risk management measures at the heart of core business decision making. However, despite wide endorsement and unique positioning of TCFD to link business performance and climate risks, the breadth and depth of companies' disclosures according to TCFD recommendations are still less than satisfactory. Although the percentage of companies disclosing information increased by almost 15 percent over a two-year period globally, the average number of recommended disclosures addressed is only 3.6 out of the total 11 (TCFD, 2017a).

Frequency of climate risk disclosures differ by region. Among the four major equity indices, including CSI300, S&P500, EURO STOXX 50 and NIKKEI 225, Japanese companies lead in frequency of climate risk discussions in company reports by both number of companies and market capitalization. Chinese companies that are part of CSI300 significantly lag behind. Only three percent of companies (13 percent of market capitalization) in CSI300 currently discuss climate risks in their sustainability reports (Figure 2).

Figure 2. Percentage of companies that discuss climate risks in company reports (2020)



Companies are identified in Bloomberg Terminal by searching for key words related to climate risks such as “climate risks,” “TCFD,” “climate risk disclosures,” “climate disclosures” that appear in companies' corporate responsibility or ESG reports. Time frame: July 2019-July 2020. All languages are included but the key words are supplied in English, which may bias the results. However, a robustness check of including Chinese key words only resulted in one extra companies among CSI300 companies.

Source: Ping An Digital Economic Research Center; Bloomberg Terminal



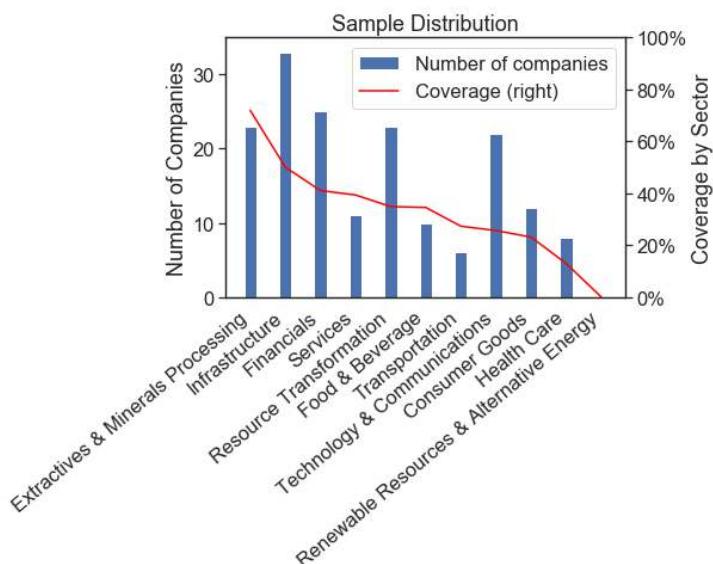
In this report, we leverage Natural Language Processing (NLP) techniques to automate the discovery of themes covered by companies' climate disclosures across firms in the S&P 500 and CSI 300, and estimate the themes' relative coverage distribution. We also use text mining to gauge the breadth and depth of companies' disclosures. Given the novelty of such frameworks and their fast adoption, the identification of best practice benchmarks in a scalable fashion can allow investors to appreciate the quality of firms' climate disclosures, as well as help identify companies that make selective disclosures to misrepresent their climate risk profiles. Optionality in reporting and differing risk rating methodologies already make the ESG space quite opaque for market participants.<sup>2</sup> This study aims to shed light on the current status of climate risk disclosures and contribute to a set of coordinated and reliable reporting methodologies.

## 2. A textual analysis of the depth and breadth of climate disclosures

### 2.1 Our reference sample

We construct the dataset for our analysis by searching for company disclosure documents that contain key words such as "climate risks," "climate risk disclosures," "task force for climate-related financial disclosures," or "TCFD" among the S&P500 and CSI300 companies during the latest annual reporting period (2019-2020). We choose S&P500 and CSI300 because they are the most representative indices of the United States and China, which are the world's two largest economies and constitute 52 percent of the global equity market. All documents were identified using the Bloomberg Terminal.<sup>3</sup> We outline detailed steps of our analysis in the methodology section. In total, we obtained 277 company documents including 167 corporate responsibility reports, 110 ESG reports (including CDP reports). These 277 documents come from 182 companies, of which 173 are part of the S&P 500 and only nine are part of the CSI300 index.<sup>4</sup> As shown in Figure 3, these companies cover a total of 11 sectors, with the most coming from the extractives & mineral processing sector, possibly because there is more public scrutiny of environmental impact due to the high polluting nature of such businesses.

Figure 3. Number and percentage of companies that have climate risk disclosures by sector among reference sample



Sector distribution of companies included analysis sample. Sectors are based on SASB categorization. Only coverage in S&P500 index is shown because there are too few sample from CSI300.

Source: Ping An Digital Economic Research Center

<sup>2</sup>A speech by SEC's commissioner Hester Peirce is telling in this respect (see <https://www.sec.gov/news/speech-peirce-061819>)Recent literature further demonstrates that for a sample of 800 companies the average correlation between five major ESG rating (KLD, Sustainalytics, Video-Eiris, Asset4, and RobecoSAM) is barely above 0.6. A company such as Wells Fargo may rank in the 12th percentile or the 94th percentile depending on the provider considered. See Berg et al. (2019) and Dimson et al. (2020), for example.

<sup>3</sup>Current analysis is limited to company documents available on the Bloomberg Terminal. The economic significance of any selection bias is limited by the market capitalization of companies covered. Initial findings from a broader web scraping exercise provides support for the robustness of the results in the reporting period considered.

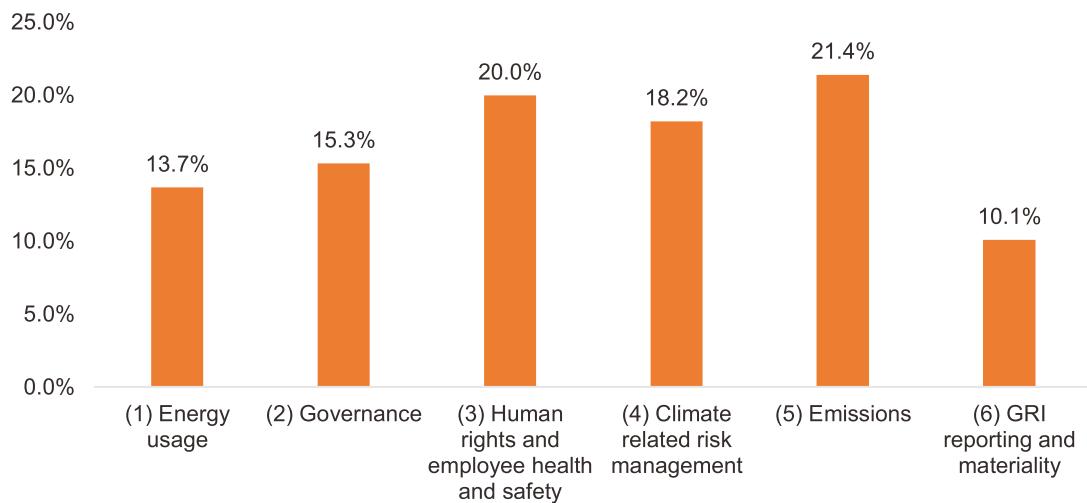
<sup>4</sup>While ESG as a concept has been gaining traction in China, climate risk disclosures and TCFD reporting are still very new concepts for Chinese corporates. In 2019, 85 percent of CSI300 companies released ESG reports. In contrast, only nine companies (13 percent of market capitalization) released information on climate risks aligning with TCFD recommendations. Starting from January 2020, all signatories to the United Nations Principles for Responsible Investment will be mandated to implement aspects of TCFD, which will prompt more major Chinese companies to implement TCFD disclosures.



## 2.2 Themes of climate disclosures based on unsupervised learning

In order to discover unique themes covered by companies in their climate disclosures, we adopt an unsupervised learning approach – the Latent Dirichlet Allocation (LDA) model to extract “latent” topics from all the company reports in our sample (Blei et.al, 2003). LDA treats reports as a mixture of topics, which in turn are shaped by mixtures of words. In total, we identified six themes including: (1) energy usage, (2) governance, (3) human rights and employee health and safety, (4) climate related risk management, (5) emissions, and (6) GRI reporting and materiality. Among these six themes, “emissions” and “human rights and employee health and safety” are discussed the most extensively by companies, although coverage of all six themes is relatively well balanced (Figure 4a). The main key words contributing to each theme are displayed in the word clouds in Figure 4b.

Figure 4a. Distribution of themes across company sustainability reports



Extent of coverage for different themes across companies' sustainability reports. To calculate companies' relative coverage of all topics, we first calculate coverage of topics by page and then aggregate at company level.

Source: Ping An Digital Economic Research Center

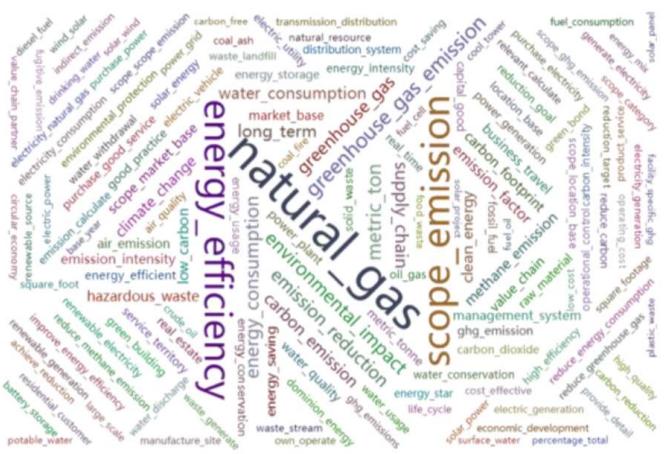
Figure 4b. Word clouds of extracted themes



### **(3) Human rights and employee health and safety**



## (5) Emissions



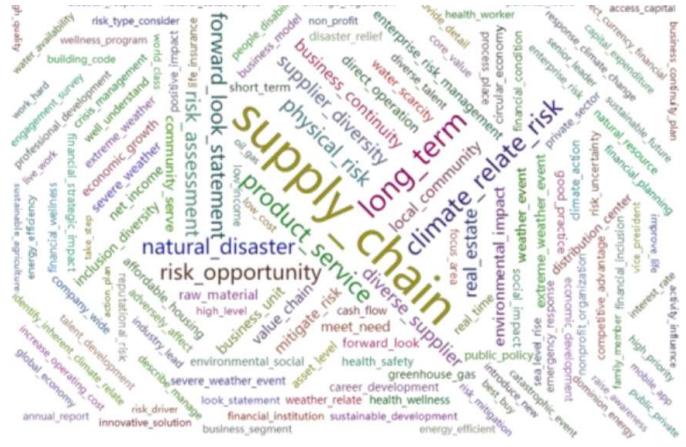
The most salient words of each theme displayed as word clouds. See the methodology section for a definition of salience.

Source: Ping An Digital Economic Research Center

We map these six themes to the four pillars of TCFD recommendations, including “Governance”, “Strategy”, “Risk Management”, and “Metrics and target”. Our main findings can be summarized as follows (Figure 5):

- The TCFD recommendations around “Governance”, “Risk Management”, and “Metrics and target” are well covered by the themes we extracted from company reports.
  - None of the six themes maps directly to “Strategy.”
  - “Metrics and target” are best covered, with theme 5 on emission and theme 1 on energy usage mapped directly into.
  - Two out of the six themes extracted do not map to any of the TCFD's recommendations. These are theme 3 – Human rights and employee health and safety and theme 6 – GRI and materiality. This suggests that as companies engage in disclosing climate risks as part of their CSR or ESG reports, human rights naturally emerge a key topic. This shows in addition that many companies do indeed follow GRI guidelines for their climate and sustainability reporting.

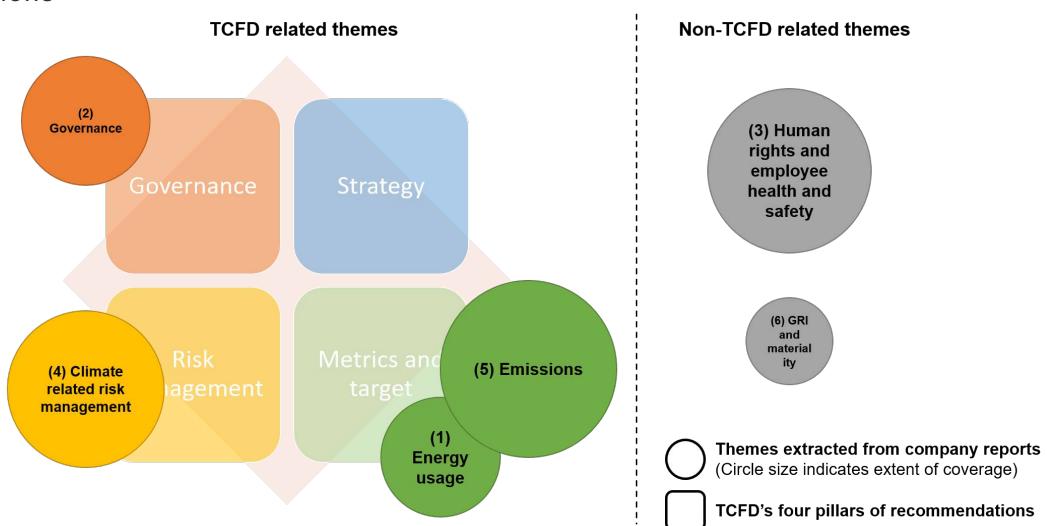
#### **(4) Climate related risk management**



#### **(6) GRI reporting and materiality**



Figure 5. Climate disclosure themes extracted from company reports and how they map to TCFD's recommendations

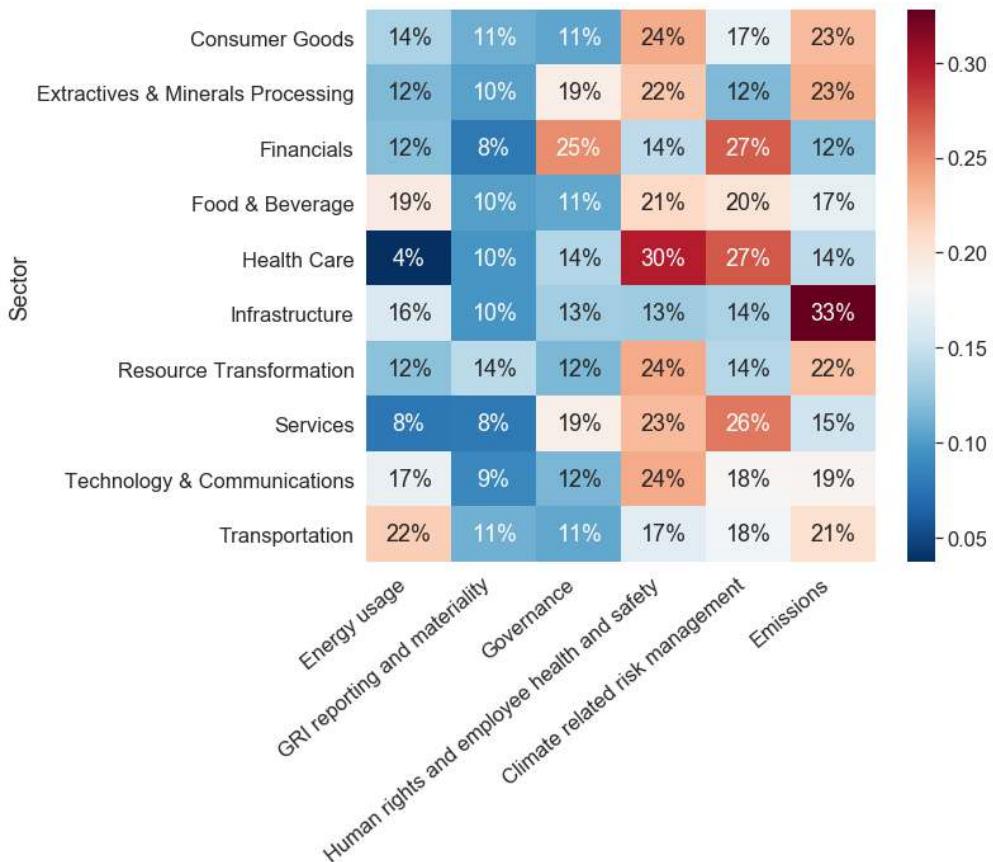


Themes identified through the unsupervised learning approach (indicated in circles) are mapped to TCFD's four pillars of recommendations (indicated in squares). The "Strategy" pillar of recommendation has negligible coverage, while "Metrics and target" has the most coverage. Two themes covered by companies do not feature as separate items in TCFD's recommendations: these are "Human rights and employee health and safety" and "GRI and materiality."

Source: Ping An Digital Economic Research Center

We also disaggregate the relative coverage of the six themes by sector. "GRI reporting and materiality" remains the one with the least coverage across sectors. Only 4 percent of healthcare sector reports on energy usage, but 30 percent report on human rights and employee health and safety. The Financial sector has the most coverage for "Climate-related risk management", whereas the Infrastructure sector has the most coverage for "Emissions." (Figure 6)

Figure 6. Distribution of themes by sector



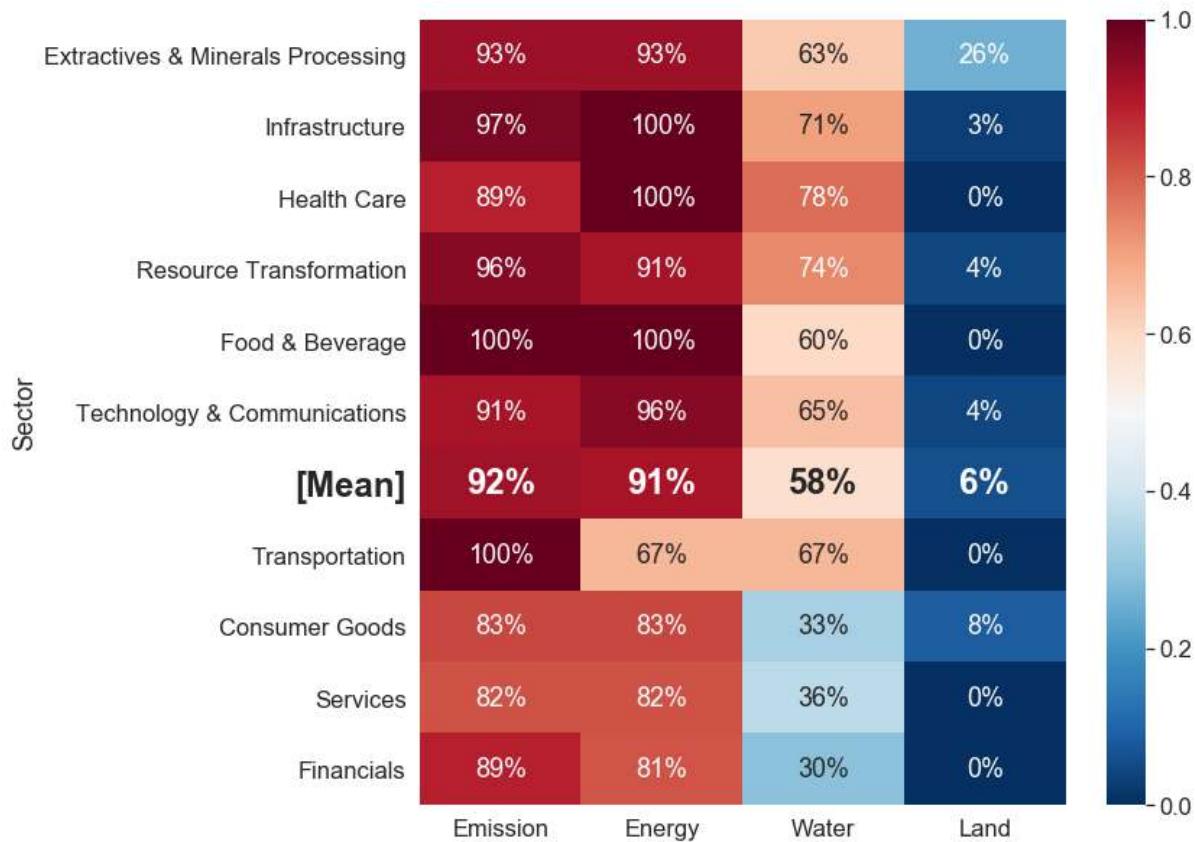
Coverage of themes by sector. “GRI reporting and materiality” has the least coverage across sectors. Only 4 percent of the Healthcare sector reports on energy usage, but 30 percent report on human rights and employee health and safety. The Financial sector has the most coverage for “Climate-related risk management”, whereas the Infrastructure sector has the most coverage for “Emissions.” Sector classification is based on SASB categorization.

Source: Ping An Digital Economic Research Center

### 2.3 Coverage of climate-related metrics

To further shed light on the different kinds of climate-related metrics covered, we examined the percentage of companies that disclose the four recommended climate-related metrics and their associated risks including emission, energy, water use, and land use. Across all sectors, emission (92 percent) are energy (91 percent) are well covered by companies, whereas water (58 percent) is moderately covered and land use (6 percent) has the least coverage, possibly because the latter is only relevant for selected sectors (Figure 7).

Figure 7. Disclosure rate of climate-related metrics by sector



Disclosure rate of climate-related metrics by sector. Emission and energy are covered by more than 90 percent of companies. Water has moderate coverage, while land has the least coverage. Sector classification is based on SASB categorization.

Source: Ping An Digital Economic Research Center

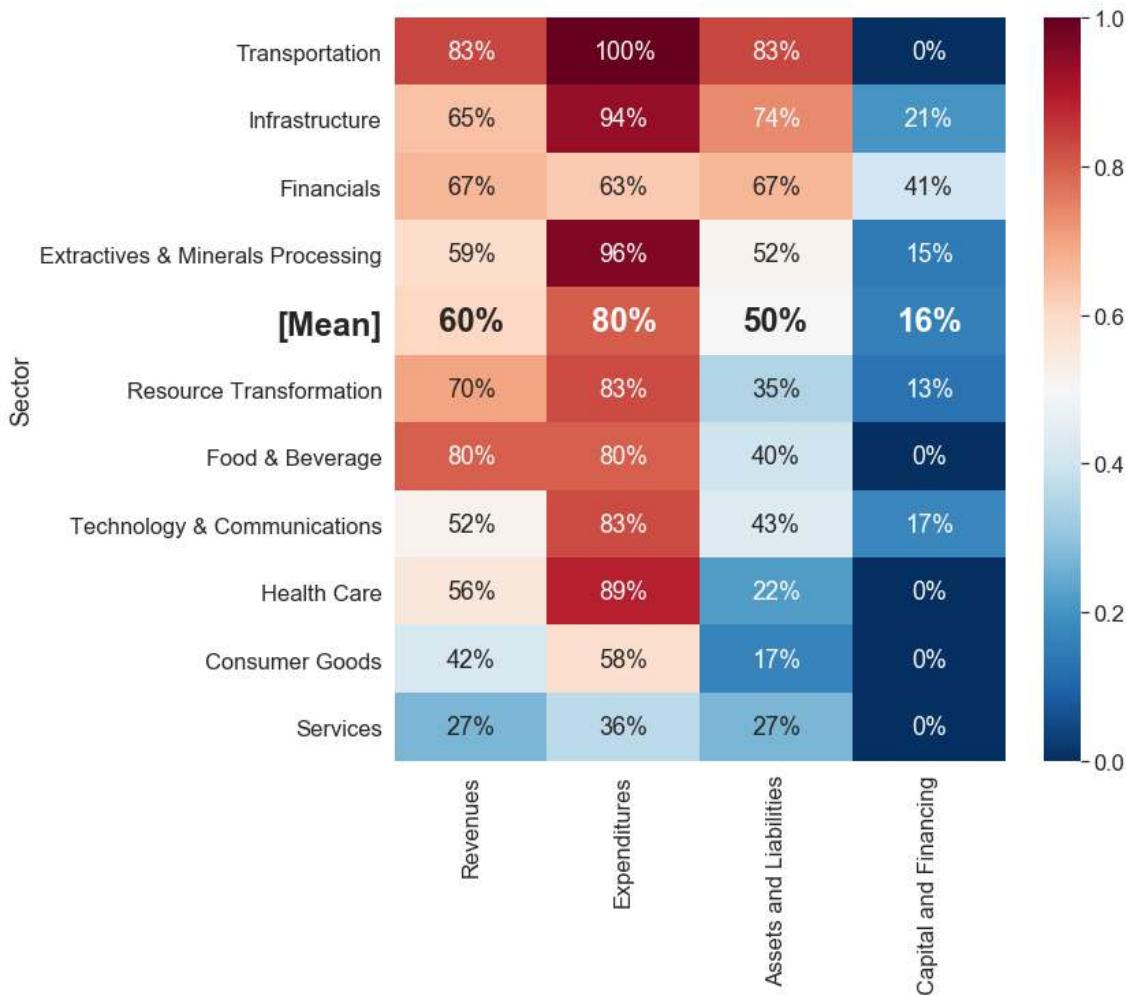
### 2.4 Coverage of financial impact metrics

Since a key differentiator of climate risks disclosures is the tight linkage between climate factors and concrete business risks, we then analyze how well companies actually follow such guidelines. To the best of our knowledge, the one presented here is the first analysis of disclosures at the financial metrics level. Following the impact matrix suggested by TCFD (2017a), we deploy NLP to detect disclosure of impact across the following financial metrics: revenues, expenditures, assets & liabilities, and capital & financing.

All in all, the impact of climate risk on financial metrics is documented to have lower disclosure rates than for straight climate metrics. Having said that, we find that the impact on revenues (60 percent) and expenditures (80 percent) is relatively well covered. Impact on capital and financing is the least well covered financial metric, with a disclosure rate of only 16 percent (Figure 8). This is a delicate impact dimension as it goes at the heart of firms' capital structure decisions and sits at the confluence of other financial impact dimensions in determining how agency conflicts and other frictions might ultimately shape the cost of debt; see section 3 for a more articulated discussion.

When looking at disclosure rates by sector, we emphasize that further granularity is needed to properly understand the results. For example, when considering financials, our analysis revealed that insurance companies are more comfortable and articulated in providing quantitative statements on asset & liabilities impacts. Whereas non-life companies may be more concerned with physical risks, however, life insurers may instead put greater emphasis on the implications of transition risks for the asset side. On the other hand, when looking at banks we noticed that these firms' ability to get to grips with the impact of physical risks on collateral values and lending risks and opportunities is still underdeveloped. This is surprising for a sector that during the last few decades has reached considerable sophistication in developing risk management tools which are extensively applied from a regulatory perspective as well. When looking at the infrastructure and transportation sectors, we noticed that they seemed well versed in covering assets & liabilities in addition to the revenues and expenditure dimensions. This may be related to companies dominating these sectors being accustomed to running long term scenario analysis for large infrastructure projects or to allowing for the complexities their risk exposures (e.g., transportation networks).

Figure 8. Disclosure rates of financial impact metrics by sector



Disclosure rate of financial impact metrics by sector. Impact of climate risks on revenues and expenditures are relatively well covered. Impact on capital and financing is the least well covered

### 3. The business case for climate disclosures: why should companies care?

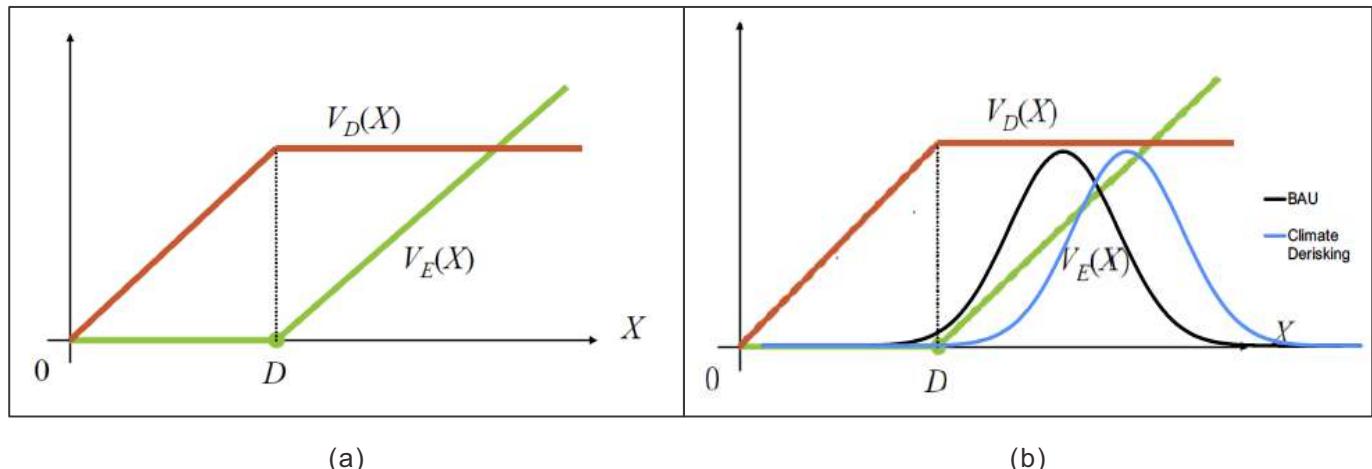
Although the findings so far demonstrate some gaps and limitations in current climate disclosures, granular analysis of particular themes and financial risk metrics reveal a virtuous trajectory experienced by disclosures in terms of both pace, breadth, and depth. This is not surprising, as climate risk metrics can help businesses navigate a fast-changing landscape, which is increasingly shaped by climate change awareness and green policies. In addition to material transition risks brought about by shifts in regulation and policymakers' attitude, the physical risks of climate change present cash flow and valuation challenges that should be appropriately managed by companies. Green technology, innovation, and changes in consumer behaviour present opportunities that should not be underestimated (e.g., TCFD, 2017a). Probably more important is the recognition that investors are becoming increasingly vocal and sophisticated about climate exposures and factoring in climate resilience in their assessments. The relatively low coverage of capital & financing metrics (and assets & liabilities for some sectors) emphasized in Figure 7 should not be misunderstood for a lack of interest in that dimension. Rather, they are delicate dimensions that have profound implications for companies and their capital structure, as we now illustrate.

Some market participants hold the view that climate risk metrics mainly appeal to investors with green preferences. In line with the literature on 'sin stocks', this means that investors driven by green considerations leave money on the table for the benefit of those who do not constrain their investment opportunity set (e.g., Hong and Kacperczyk, 2009). Some market participants are instead in favour of recognizing, where appropriate, the informative value of climate risk metrics for a firm's fundamentals and for its exposure to aggregate risk (e.g., Benedetti et al., 2019). Indeed, climate change represents a major source of systematic risk, which is hard to diversify away and should be priced in accordingly. Investors' attitude toward climate exposure is changing rapidly and suggests that climate risk metrics will play an important role in shaping companies valuations going forward (e.g., Bose and Springsteel, 2017; Esty and Karpilow, 2019). The return on shareholders' capital is only part of the story. Although in the last few years the discussion of climate risks and ESG ratings has predominantly focused on the equity space, debt markets are very important and actually essential for millions of SMEs globally. There is evidence that debt investors are becoming more climate conscious and some commercial lenders have begun to peg lending rates to ESG performance (Bae and Chang, 2018; Gatti and Florio, 2018; Barth, Hübel, Scholz, 2019). For example, our analysis revealed a growing interest in these aspect and a strong motivation for disclosure among top real estate firms, which make extensive use of leverage and often long dated debt.

The rationale for climate risk disclosure for equity and debt markets can be illustrated by looking at Figure 9 below. Panel (a) presents the standard convex payoff faced by equity holders, who have a call option on the assets of the firm, and the concave payoff faced by bondholders, who effectively sell a put option on the asset of the firm. In a simple one-period, two-date model, the firm raises debt of amount D at time 0. After the firm's cash flows are realized during the period, the level of the firm's assets at time 1, denoted by X, determines the payoffs to shareholders and bondholders. Should the firm's assets fall below the face value of debt, equityholders would be wiped out, whereas bondholders would recover whatever is left. Market participants rationally anticipate these outcomes and price equity and debt accordingly. On the other hand, companies engage in risk management to signal to investors that such issues are under control and mitigated where needed. Indeed, the risk taking incentives induced by equityholders' convex payoff may make standard agency problems such as asset substitution<sup>5</sup> particularly acute (Doherty, 2000; Brealey et al., 2012). Proper risk disclosure and risk management will mitigate these frictions by aligning more closely the incentives of bondholders and equity holders. Panel (b) provides an illustration of these aspects by considering two distributions for the firm's terminal assets. The "business as usual distribution" has an associated default probability that will be priced in by prospective bondholders when the firm issues debt. The "climate de-risking" distribution reduces downside risk by addressing physical/transition risks and may increase the upside by exploiting climate change opportunities. Proper disclosure and engagement with market participants may result in sizeably lower cost of debt and higher valuations.

<sup>5</sup>Asset substitution is characterized by situations in which resources are invested in riskier projects than lenders anticipated. An example would be to use borrowed funds to invest in high-upside projects which nonetheless present a material tail risk. As shareholders benefit from the upside, but are protected by limited liability, assets are effectively diverted away from bondholders to benefit shareholders. See Doherty (2000).

Figure 9. An illustration of capital structure and climate risks



Consider a one period model for a firm issuing at time 0 debt of face value  $D$ . After cash flows are realized during the period, either the assets of the firm at time 1, denoted by  $X$ , are above  $D$ , in which case the firm is able to repay its debt, or is below  $D$ , in which case debtholders only recover a fraction of the outstanding debt. Panel (a) depicts the payoffs to equityholders and bondholders, which are denoted by  $V_E(X)$  and  $V_D(X)$ , respectively. Panel (b) depicts the case of two distributions for the firm's assets, one for the business as usual scenario and one for a climate de-risking scenario, in which climate risks and opportunities are properly addressed (with a net positive result in the chart presented here). In addition to making an equityholder's call option more valuable, the de-risking strategy reduces the cost of debt by reducing the probability of insolvency.

Source: Ping An Digital Economic Research Center

Figure 9(b) provides support for the growing interest in tail risk measures for climate risk disclosures. Examples include the use of climate stress testing and the computation of climate Value-at-Risk measures attempting to quantify the impact of different global temperatures scenarios on the prospects of a firm in present value terms. The technical guidance on the use of scenario analysis provided by TCFD (2017b) represents an important milestone in this direction. In addition to long term investors, which are clearly interested in the pricing of such impacts into equity and debt holdings (e.g., Gründl, 2016), regulators have demonstrated a growing interest in understanding the systemic risk implications of climate risks (e.g., Carney, 2015). These are important, but challenging questions; we expect tools currently available in this space to be replaced by sounder, more market consistent approaches going forward. A parallel with the development of reliable economic scenarios generators for long term insurance liabilities during the last two decades offers a blueprint for the developments we are likely to experience going forward.

## 4. What should we do to improve climate risk disclosures?

### 4.1 Establish tighter links between climate risk exposures with financial performance

The literature linking financial performance to climate risk exposure is in its infancy. Two main hurdles are represented by i) limited data availability, whereby the relevance of climate change has only recently been recognized within the wider investors' community, and ii) the materiality of climate change for companies' future performance. Although there is some evidence that the physical risks of climate change, as represented by an increase in the frequency and severity of extreme weather events, have been adversely impacting some sectors (e.g., insurers and food producers), the impact of transition risks are more difficult to disentangle empirically, as they will become more relevant as society transitions more decisively to a greener path (see Bolton and Kacperczyk, 2020a,b, for some recent evidence). One of the most notable channels of transition risk is represented by stranded assets for energy producers (e.g., Caldecott et al., 2019). However, the volatility of oil prices has made it difficult for analysts and researchers to estimate unambiguously any contribution of transition risks to oil firms' valuations (e.g., Benedetti et al., 2019).

A stylized framework that can help firms and investors navigate the linkage between climate change exposure and valuations is one in which the economy transitions from an equilibrium in which only a fraction of investors is climate-aware, or climate exposure signals are imprecise, to an equilibrium in which most investors are climate-aware, or equivalently the precision of climate exposure signals improves dramatically. As the economy transitions from one equilibrium to the other, firms' valuations will be affected leaving climate-aware investors and greener companies better off. For those market participants who think that climate repricing will be abrupt, there is the conviction that gains will be greatest for those companies that have moved ahead of the curve in climate de-risking well in advance (e.g., Simm et al., 2016). In line with our discussion in the previous section, gains must here be understood in terms of lower cost of capital, improved valuations, and greater market share to be seized from competitors unprepared to face the pressures of dramatically increased carbon/climate scrutiny. We can elaborate on these points by looking more explicit at how investors can benefit from appropriate, forward looking climate risk disclosures in the following section.

#### 4.2 Move from backward-looking to forward-looking information

The literature of climate change risks has to a large extent relied on carbon footprints to proxy for climate risk exposures. The extension of analyses focusing on Scope 1 and Scope 2 emissions to the inclusion of Scope 3 emissions is certainly valuable, but is still limited to a backward looking snapshot of a company's carbon footprint. As pointed out by Simm et al. (2016) and Benedetti et al. (2019), the simple idea that a high carbon footprint implies a high level of financial risk has two material flaws. First, a company's carbon footprint is generally based on current emissions data, while its equity valuation is based on an aggregated view of the company's future financial prospects, for example its cash flows. Second, although a company's carbon footprint may be correlated with its exposure to rising costs linked to climate change, for example taxes on fossil fuels, the footprint takes no account of the company's pricing power, i.e., its ability to pass on cost increases to its customers (e.g., Simm et al. 2016). Benedetti et al. (2019) take into account forward production curves of oil companies to assess the potential impact of carbon pricing on their valuations. They find that there is considerable cross-sectional heterogeneity making naive divestment strategies questionable. This suggests that climate risk disclosure can inform a correct valuation of a business by offering valuable insights into how a company is preparing to address climate risks going forward.

Let us now provide a stylized illustration of how forward looking information can benefit investors and hence a company's valuation. As an example, we consider mean-variance investors, and for simplicity focus on the transition risk captured by the introduction of a carbon tax. We consider therefore two states of the world, a "business as usual" state and a "carbon pricing" state. The asset allocation implications can be understood by adopting at least two useful perspectives.

First, we can think of the two states of the world as being associated with two different efficient frontiers (Figure 10a). A market participant could (i) invest according to the single frontier obtained by averaging across the two state-specific frontiers<sup>6</sup>, or (ii) aim at timing the transition to the new state by rebalancing his/her portfolio only in response to a high enough probability of state transition. It is well known that approach (ii) is able to exploit an investment opportunity set dominating that offered by approach (i) (Clarke and de Silva, 1998). Ang and Bekaert (2004), for example, show that a regime switching model can be used to rebalance an investor's portfolio when the transition from a low-volatility to a high-volatility market state is likely to occur. In a similar vein, Avramov and Wermers (2006) document the out-of-sample performance of some predictability-based strategies. Forward looking climate disclosures are essential for investors to make informed decisions on the extent and depth of portfolio re-allocations resulting from a transition to more a carbon pricing state. Those companies that are more reluctant to share information on their exposure to climate risk are likely to get caught in a disorderly price discovery process following the introduction of carbon pricing or similar transition regulatory measures.

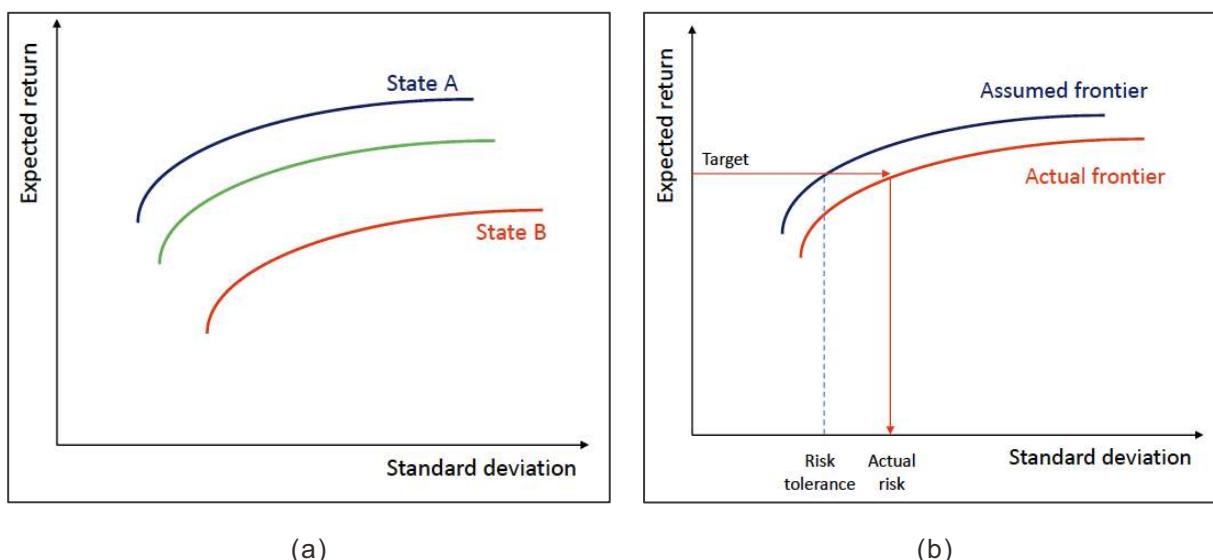
A second perspective that is useful to appreciate the importance of forward looking measures is to think of investors' reliance on frontiers based on historical data as being misplaced. Optimal allocations are bound to be suboptimal relative to frontiers that would be applicable following the realization of systematic physical and transition risks, and their impacts becoming fully embedded into valuations and hence market parameters. In line with the literature on portfolio construction under estimation risk (e.g., Lai et al., 2011), investors should consider a robust version of the efficient frontier and trade

<sup>6</sup>More precisely, the ex-ante frontier would be obtained by using the unconditional first two moments implied by the conditional moments, given the probability of transition from the business as usual to the carbon pricing state,



according to its optimal allocations, which would therefore appear as being suboptimal relative to the original frontier. Among the most popular methods developed in this space are semi-Bayesian approaches (e.g., Black and Litterman, 1992) allowing an investor to anchor his/her views on the future to market based information (e.g., CAPM implied) in recognition of the fact that the investor's view might not be superior to market valuations. Benedetti et al. (2019) provide an example of such an approach by using of forward production curves of oil and gas companies and a range of probabilistic scenarios for the timing and magnitude of carbon taxes to determine optimal portfolio allocations across energy producers and energy efficiency stocks. They show that forward looking measures such as production curves can be considerably more informative than carbon footprints and other backward looking information. Other examples of application of forward-looking climate risk metrics have been provided in the context of physical risk and agricultural value chain de-risking (Biffis and Chavez, 2017), as well as climate resilient technology adoption in emerging countries (Biffis et al., 2020) and European electric utility companies (Cormack et al. 2020).

**Figure 10. Two perspectives on the value of forward looking information for investors**



Panel (a) depicts the efficient frontiers for two states of the world (e.g., business as usual and carbon pricing), as well as the unconditional efficient frontier suitably averaging across the two. Use of both the unconditional and state B's frontiers is suboptimal as long as state A applies. Both the unconditional and state A's frontiers are suboptimal once state B is realized. Panel (b) reports the assumed efficient frontier computed on the basis of historical data, as well as the actual efficient frontier the investor will de facto be using once physical/transition risks materialise. According to the example depicted, any target expected return will be associated with a level of risk which is higher than the risk tolerance level originally specified by the investor.

Source: Ping An Digital Economic Research Center

#### **4.3 Converge towards truthful, transparent, and communicable disclosures**

There is a growing interest in developing climate and ESG metrics allowing investors to meet green mandates or align their capital allocation with the longer term goal of supporting specific climate targets. However, the lack of unified standards, clear definitions, well-accepted methodologies, and stricter enforcement on disclosures have made it easier for companies to conduct “greenwashing.”

"Greenwashing" refers to the phenomenon of corporates having positive communication on their environmental performance while lacking good performance in reality (Delmas and Burbano, 2011; Yang, 2019).

One of the reasons greenwashing is hard to detect is because only a minority of companies actually have their sustainability reports audited by a third-party. For example, according to Ceres's analysis of 476

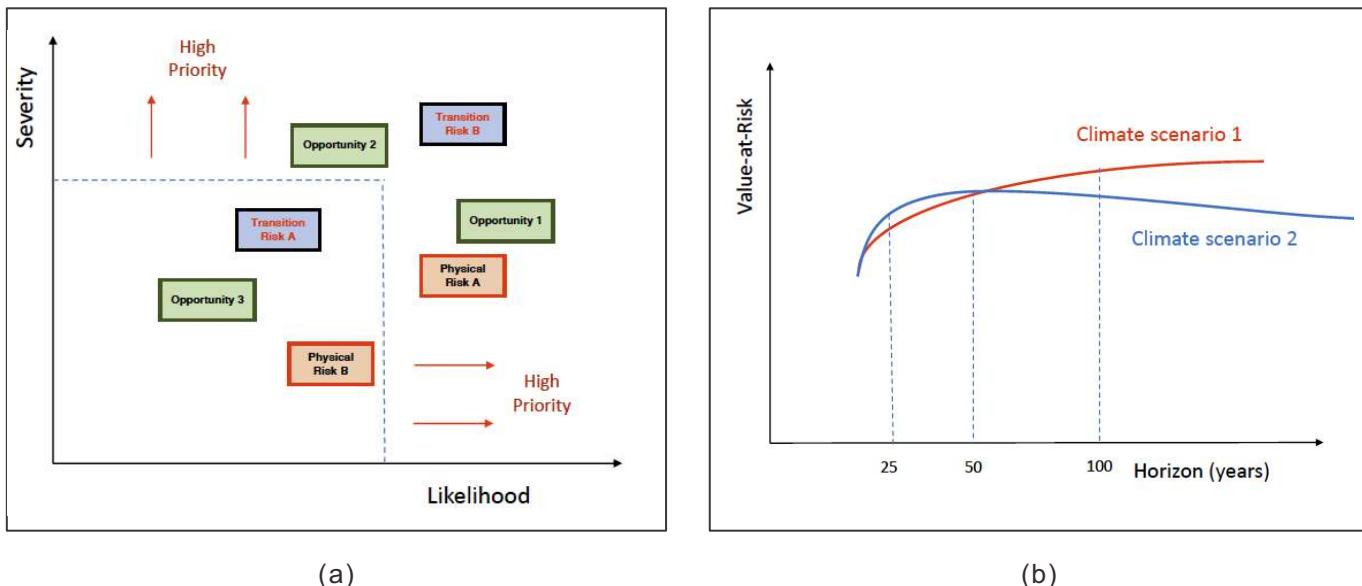
large companies of the Forbes Global 2000 index, 58 percent of companies provide no evidence of formal assurance of sustainability disclosures. Less than 10 percent provide third-party verification with some improvement recommendations (Ceres, 2018). Companies in emerging markets also have subpar performance on this measure. In our first ESG series report, we noted that only 12 percent of CSI300 companies in China have a third-party audit of their ESG reports, or 26 percent by market capitalization (Ping An Digital Economics Research Center, 2020).

To mitigate greenwashing, pressure has to first come from regulators and standard-setting bodies. Even though TCFD recommendations cut across a comprehensive set of climate risk considerations and not just what portrays companies positively, companies still do not face any penalty for selective disclosures. In addition, the identification of best practice benchmark can allow investors to gauge the breadth and depth of an entity's climate disclosure, as well as help identify those companies that make selective disclosure to misrepresent their climate risk profiles.

On the positive side, our extensive analysis of climate risk disclosure reports revealed an expanding cohort of firms engaging in increasingly granular, forward looking disclosure of climate impacts. Guidance provided by TCFD (2017b) appears to have been crucial in prompting this market development. The results of such analyses, often reported under the heading of climate change scenario planning, provide a meaningful presentation of climate related threats and opportunities often distinguished by likelihood and severity of impact; see Figure 11(a) for a possible benchmark example. Ideally, threats are broken down into the most relevant physical and transition risks faced by a business. The most sophisticated companies provide a quantification (as opposed to a qualitative ranking) of likelihood and impact severity associated with each threat and opportunity, thus making it easier to define objective priorities shaping a strategy to address climate change. Although likelihood and severity metrics are bound to suffer from estimation difficulties, the quality and depth of such disclosures are considerably more informative than reports based on merely qualitative statements. They can in particular provide more credible support for aggressive strategies and fundraising exercises tackling climate change.

When it comes to gauging tail risk, it was apparent from the reports analyzed that metrics such as climate Value-at-Risk are increasingly adopted within sectors for which such measures are already part of standard risk management toolkits (e.g., in the insurance sector). This is a very promising finding that hopefully will be accompanied by greater take up of similar risk metrics within other sectors. However, we also found that there is considerable scope for improvement from both a methodological and an implementation perspective. We noticed, for example, that very few companies attempt to provide a fully fledged term structure of Value-at-Risk estimates by climate scenarios and time horizon; see Figure 11(b) for an example. Such information would be very appealing to different classes of market participants, such as medium to long term investors (e.g., insurers and pension funds) vs. ultra-long term investors (e.g., endowments and sovereign wealth funds) seeking granular information on climate exposure at different durations. Moreover, as considerable uncertainty affects climate projections, disclosure of more complete information on the term structure of climate impact estimates would allow market participants to better appreciate any assumptions supporting the risk analytics framework (e.g. Jorion, 1996; Christoffersen, 2011). Consider as an example the term structures of Value-at-Risk estimates depicted in Figure 11(b): they appear to show that illustrative Climate Scenario 2 is riskier than competing Climate Scenario 1 for relatively short maturities (25 to 50 years). However, extrapolation beyond 50 years and into ultra-long maturities (100 years) reveals exactly the opposite, due to mean reversion driving climate impact projections. A poor understanding of these aspects coupled with over-reliance on modelling black-boxes can make the disclosure framework prone to abuse when optionality and selective disclosures are possible. We believe this and similar gaps in the market will offer a tremendous opportunity for a dramatic improvement in climate risk modelling and valuation tools during the next few years.

Figure 11. Best practice examples



Panel (a) provides an example of mapping of risks and opportunities by likelihood and impact severity. Risks are broken down into physical and transition risks. Use of quantitative scores for severity and likelihood allows companies to set thresholds allowing them to meaningfully prioritize certain threats/opportunities. Panel (b) depicts a term structure of climate Value-at-Risk estimates by climate scenarios. Estimates could be provided at aggregate level or disaggregated by financial impact dimension as per TCFD guidance (revenues, expenditures, assets/liabilities, capital and financing). Some companies provide the marginal contribution of different impact dimensions to the aggregate Value-at-Risk, possibly allowing for different climate scenarios. Presentation of a fully-fledged term structure of Value-at-Risk estimates is to date quite rare.

Source: Ping An Digital Economic Research Center

In line with recent improvements in climate risk disclosures and the promising rise in use of metrics such as climate Value-at-Risk, further steps need to be undertaken to provide a transparent and communicable framework to produce climate risks exposure metrics. In particular, we need to transparently reflect the state of climate science knowledge and their uncertainties. Uncertainties to be brought to the forefront, including uncertainties on (i) the trajectories of greenhouse gas emissions, (ii) the response of the climate system to changes of greenhouse gas concentrations, and (iii) the impacts of physical and transition climate risks on country-to-firm-level activity.

The complexity of the climate system's local-to-global response to emission increase combined with the non-linear interaction between climate variability and economic activity should be fully acknowledged, and transparently priced. Recent developments in climate risk quantification based on climate Value-at-Risk or mean variance-based metrics can be adapted to reflect uncertainties at different time horizons. This challenge can be addressed through structural models enabling the assessment of uncertain possible futures that cannot be represented by historical events. To achieve this, interdisciplinary research and development at the interface of finance and geosciences engaging both academia and companies are essential.

## Data and Methodology

All company documents are obtained from the Bloomberg Terminal, using the following criteria:

- Stock universe: S&P 500 and CSI300
- Document types: ESG reports, CSR Reports, CDP reports
- Key words: "climate risks", "climate risks disclosures", "Task Force on Climate-related Financial Disclosures", "TCFD"
- Timeframe: July 2019-July 2020
- Language: English (all CSI300 companies we obtained using criteria above published both English and Chinese versions of company documents)

We filtered the acquired documents for duplications, mismatched content, and unusable formats to obtain a total of 277 documents from 182 companies, as seen in Section 2. Since we surveyed industries beyond those specifically mentioned by TCFD, we assigned companies' sectors according to SASB categorization, which was referenced by the TCFD standard.

SASB sector	Company count	SASB sub-industries
Consumer Goods	12	Toys & Sporting Goods, Multiline and Specialty Retailers & Distributors, Apparel, Accessories & Footwear, Household & Personal Products, Appliance Manufacturing, E-commerce
Extractives & Minerals Processing	27	Oil & Gas - Services, Oil & Gas - Refining & Marketing, Oil & Gas - Midstream, Metals & Mining, Oil & Gas - Exploration & Production, Coal Operations, Construction Materials
Financials	27	Insurance, Commercial Banks, Asset Management & Custody Activities, Investment Banking & Brokerage, Consumer Finance
Food & Beverage	10	Non-Alcoholic Beverages, Restaurants, Food Retailers & Distributors, Processed Foods, Tobacco
Health Care	9	Biotechnology & Pharmaceuticals, Medical Equipment & Supplies, Drug Retailers, Health Care Distributors
Infrastructure	34	Real Estate Services, Water Utilities & Services, Electric Utilities & Power Generators, Real Estate, Gas Utilities & Distributors, Waste Management
Resource Transformation	23	Industrial Machinery & Goods, Chemicals, Aerospace & Defense, Electrical & Electronic Equipment
Services	11	Professional & Commercial Services, Casinos & Gaming, Hotels & Lodging, Media & Entertainment
Technology & Communications	23	Hardware, Software & IT Services, Semiconductors, Telecommunication Services, Internet Media & Services
Transportation	6	Airlines, Rail Transportation, Automobiles

For the topic model to analyze themes across company documents, we adopted an unsupervised learning approach, specifically the Latent Dirichlet Allocation (LDA) model. We extracted texts from all PDF documents for pre-processing. We extracted every page of all documents as passages of texts, with 17,568 pages in total. We apply Named Entity Recognition and Part-of-Speech filtering, as well as normalization, before constructing an n-grams dictionary used by the model. We iterated to reduce impact of specific companies, industries, and geo-locations in our model to obtain topics that are descriptive of climate-related risk exposures. For each topic, we displayed the most salient words as word clouds. Saliency is defined as:  $\text{saliency}(\text{term } w) = \text{frequency}(w) * [\sum_t p(t|w) * \log(p(t|w)/p(t))]$  for topic t (Chuang et. al, 2012). To calculate companies' relative coverage of all topics, we first calculated coverage of topics by page and then aggregated to the company level.

For the coverage analysis, due to having unlabelled samples, we used rule-based matching instead of machine-learning techniques to identify relevant segments of the documents. Descriptions and examples from the TCFD recommendations were used to construct these rules for each metric. For example, for disclosures of "emission," we used words such as "carbon dioxide/sulphur dioxide/emission/CO2/methane/CH4/nitrous oxide/N2O/hydrofluorocarbon/perfluorocarbon/sulphur hexafluoride/greenhouse /gases/ghg/tCO2e" to locate relevant text. We go through a similar process for the other metrics we analysed. In an iterative approach, a sample of the identified segments were manually reviewed and labelled each time to evaluate the effectiveness (out-of-sample performance) of our rules, which improved on using the cumulative labelled sample database. All the segments within a drawn sample were labelled to indicate whether it was a valid disclosure, and precisions of correct identifications were calculated based on the sample segments drawn. At the company level, the number of identified segments was counted, and a company was classified as having covered a certain dimension of disclosure if the probability of the company covering this dimension exceeded 95%. The probability of a company covering this dimension was estimated by:

$$1 - (1 - \text{sample precision})^{\text{Number of matches at the company level}}$$

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