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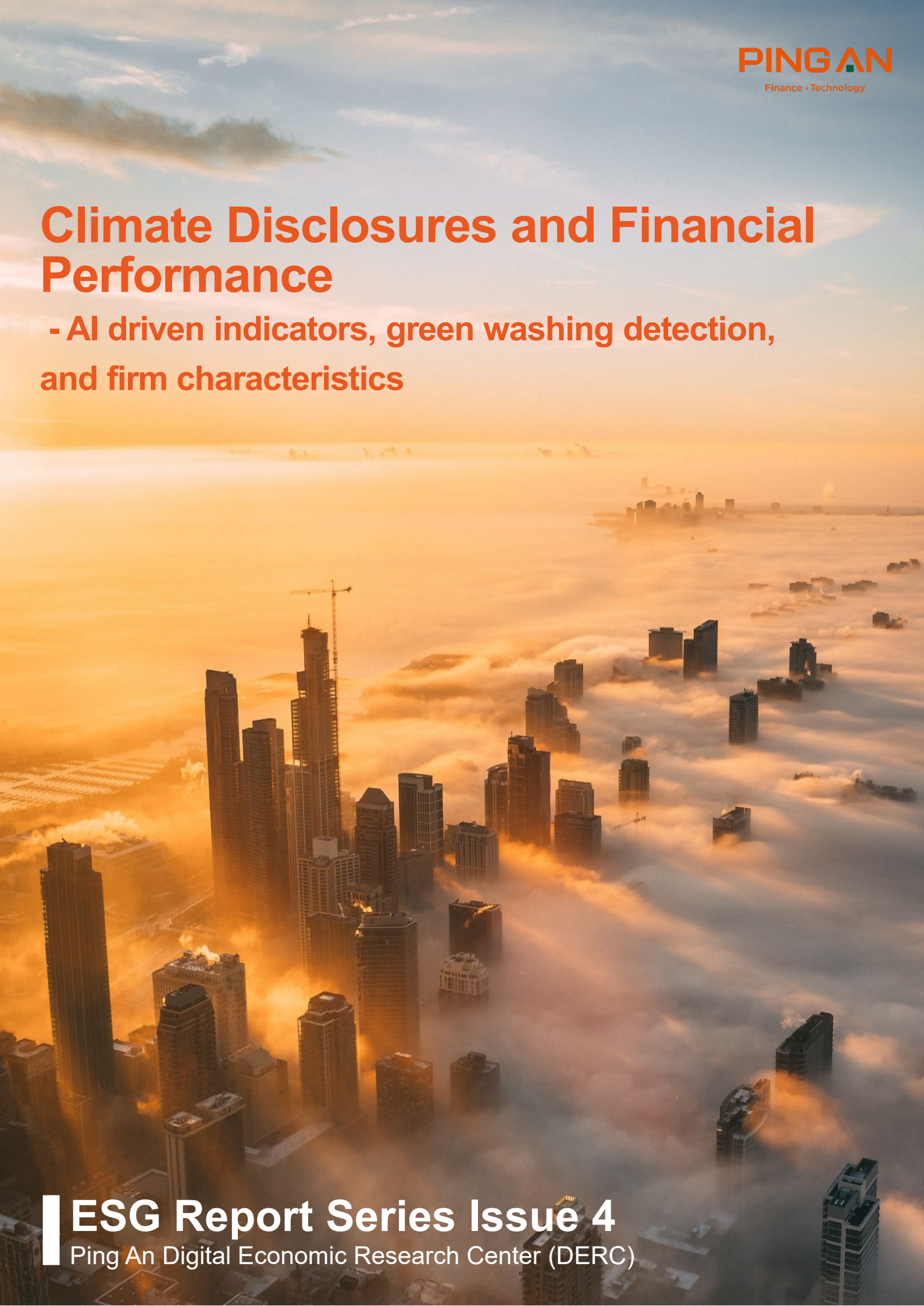
Climate Disclosures and Financial Performance

- AI driven indicators, green washing detection, and firm characteristics



ESG Report Series Issue 4

Ping An Digital Economic Research Center (DERC)

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ESG Report Series

Issue 4

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Executive Summary

In our previous report, "*Where we stand with climate disclosures and why we need them? Natural Language Processing applications in analysis of sustainability reporting,*" (Ping An Digital Economic Research Center, 2020), we applied Natural Language Processing (NLP) to climate risk disclosures by US and Chinese firms to gauge the coverage of climate related and financial impact metrics according to Task Force for Climate-related Financial Disclosures (TCFD) recommendations. The results demonstrated that emissions and energy metrics are in general widely covered, whereas water and land use disclosures are limited and sparse. Similarly, disclosure of financial impact metrics shows considerable heterogeneity across sectors, with some important impact dimensions largely under-reported. In this report, we build on these insights and develop NLP based indicators that allow us to better capture the breadth and depth of companies' climate risk disclosures. The objective is three-fold: first, we leverage AI tools to better assess a firm's climate risk exposure and its compliance with TCFD reporting guidelines; second, we use AI based indicators to detect potential evidence of greenwashing; third, we explore the relationship between climate risk disclosure and firm characteristics, including financial performance. The analysis presented here focuses on US and Chinese firms (constituents of S&P500 and CSI300) that have disclosed climate risks[1], although parallel work on European firms shows consistent results. A summary of our findings is as follows:

AI driven indicators: AI driven transparency indicators are a valuable complement to ESG analytics tools and ratings currently available in the market.

- We use NLP to develop climate risk disclosure indicators informing us on the scope and depth of disclosures. Of particular importance are climate risk metrics and financial impact disclosure indicators. We also create composite transparency indicators to carry out automated assessment of TCFD reporting compliance.
- As opposed to ratings relying on linear aggregation of particular attributes, which currently dominate the industry[2], our indicators use **a mixture of NLP and probabilistic tools** to identify and aggregate relevant attributes.
- The indicators developed perform better than existing ESG ratings in the market in differentiating between Green and Brown firms. They also offer insights into the relationship between firm characteristics and climate disclosures.

Enrico Biffis
Associate Director for Development Finance
Brevan Howard Centre,
Imperial College London
e.biffis@imperial.ac.uk

Francesco Rocciolo
Post-doctoral Research Fellow
Brevan Howard Centre,
Imperial College London
f.rocciolo@imperial.ac.uk

Chenxi Yu
Deputy Director
Ping An Digital Economic Research Center
yuchenxi301@pingan.com.cn

Weiqi Cui
Senior Algorithm Analyst
Ping An Digital Economic Research Center
cuiweiqi811@pingan.com.cn

Zehua Li
Algorithm Engineer
Ping An Digital Economic Research Center
lizehua751@pingan.com.cn

1 For CSI300 firms we use disclosure information available in English as well as Chinese.

2 See, for example, Berg et al. (2019).

Green washing detection: we find patterns of disclosure suggesting possible green washing by high emission firms; also, unsophisticated rating tools may implicitly reward the opaqueness of disclosures.

- Possible evidence of green washing for high emission firms:
  - Compliance around disclosure of climate related metrics is higher on average for lower emission firms, thus suggesting **underreporting by high emission firms**.
  - High emission firms score better in disclosing financial impact metrics, but with an important exception: information on **capital and financing impact is systematically underreported**. As the issue of stranded assets and liabilities[3] is of major importance to high emission sectors, such as oil and coal companies, the results indicate that a number of firms selectively leave this impact dimension undisclosed.
  - **Disclosure of scope 3 emissions** is considerably worse for high emission firms, despite the increasing focus of regulators and investors on this dimension.
- **Opaqueness may implicitly be rewarded instead of penalized** by unsophisticated rating tools, as some companies engaging in climate risk disclosure appear to be penalized by some ESG rating tools. This gives perverse incentives for selective non-disclosure, leading to greenwashing.
- Similar to existing literature, we find **dispersion between ESG ratings**[4] and hence they should be used with caution. Some ESG ratings appear to be positively associated with leverage, after controlling for emissions and other firm characteristics, whereas our AI driven indicators suggest systematically lower leverage for companies engaging in climate risk disclosure.

Valuations: companies with greater disclosure of metrics on climate risk impact on financial performance have higher valuations and lower leverage, after controlling for carbon emissions and other firm characteristics.

- Firms with better disclosure of financial impact metrics tend to have higher valuations, lower leverage, and lower cost of capital.
- Large cap firms that are TCFD compliant tend to have higher valuations, whereas **small and medium cap firms engaging in climate disclosures may still offer considerable opportunities for appreciation.**
- The results are consistent across a number of specifications and apply after controlling for traditional ESG ratings, which instead appear to have weak or inconclusive bearing.
- The results also apply after controlling for carbon emissions, which recent literature has found to be associated with a carbon risk premium and hence lower valuations[5]. Our indicators therefore offer investors and corporates a more granular understanding of valuations beyond carbon emissions.

Firm value: AI driven indicators suggest that greater disclosure is associated with lower cost of capital, thus boosting firm value.

- Despite the increasing popularity of ESG criteria[6], demonstrating whether and how ESG compliance adds value to the firm is notoriously difficult and so far the empirical evidence is mixed or inconclusive[7].
- We find evidence that companies that are more transparent in disclosing financial impact metrics have lower cost of capital[8], especially among firms that disclose impact of climate risks on expenditure and assets & liabilities.
- Our results on valuations offer a consistent picture in terms of cost of equity, whereas our parallel findings on leverage support consistent implications for the cost of debt. Both these channels represent important components of any corporate valuation framework and hence provide support for climate risk disclosures contributing to firm value. Further research is needed to understand other dimensions, such as revenues and operating margins.

3 Stranded assets are assets that have become uneconomic (firms are unable to recover their investment cost) or turned into liabilities, due to transition risks such as taxation of fossil fuel supply or consumption (e.g., Caldecott et al. 2015). Stranded liabilities refer to the cost of retiring uneconomical long-lived assets, such as oil and gas infrastructure.

4 See Berg et al. (2019), for example.

5 See Bolton and Kacperczyc (2020).

6 See Amel-Zadeh and Serafeim (2020).

7 See Cornell and Damodaran (2020) for an overview.

8 See Goss and Roberts (2011) for similar evidence on bank loans and corporate social responsibility. Using US data, they find that socially responsible firms pay between 7 and 18 basis points less than other firms, unsecured loans being the most sensitive to social responsibility concerns.

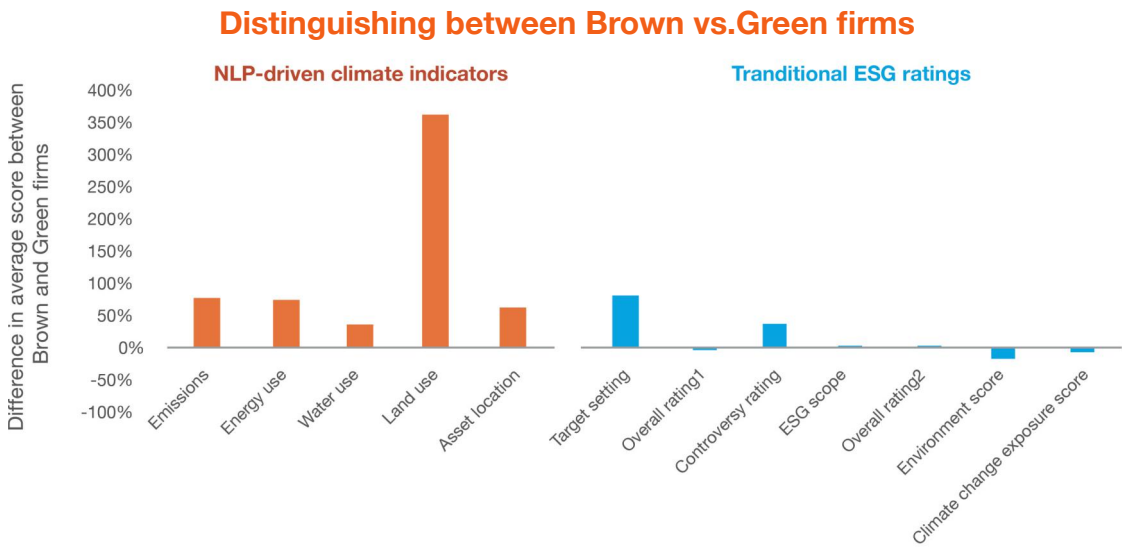
Summary of AI driven indicators and greenwashing detection

	AI driven indicators	Greenwashing detection
What is it?	AI-based indicators that assess coverage rate of various climate and financial impact related indicators, as well as themes discussed in companies' climate disclosure reports.	Detect anomalies between companies' disclosures of climate risks and actual exposure.
How is it done?	• Rule-based matching: For each indicator, construct relevant anchor words or expressions to locate relevant text in disclosure reports and then estimate probability of coverage by assessing sample precision and number of matches found. • Unsupervised learning: extract distinct themes from companies' disclosure reports and then calculate companies' relative coverage rate of each theme.	• Detect anomalies in ESG ratings of companies who engage in climate disclosures vs. those who do not. • Benchmark high vs. low emission firms in terms of disclosure of climate metrics (e.g. emissions, energy use, water use, land use) and financial impact metrics to detect any under-reporting by high emission firms. • When evaluating relationship between disclosures and company performance, detect where traditional ESG ratings and AI driven indicators show inconsistent results.
What are the implications?	Firms with better disclosure of AI driven financial impact indicators have higher valuations, lower leverage, and lower cost of capital. Traditional ESG ratings present either diverging or statistically weaker results.	Allows for Automatic detection of under-reporting by high-emission firms, and inconsistency between ESG ratings, which allows investors to use ESG ratings with caution when integrating them in investment analysis.

Climate Disclosure and Firm Characteristics in Charts

AI-driven indicators perform better than traditional ESG ratings in differentiating Brown vs. Green firms. They also reveal patterns of greenwashing for Brown firms around: under-reporting of capital & financing impact, limited disclosure of scope 3 emissions, and limited discussion of climate related risk management.

Relative difference between average scores for Brown firms and Green firms



Firms engaging in climate risk disclosure have higher Earnings per Share.

Relationship between companies' Earnings per Share vs. climate risk disclosure, anonymized ESG ratings, and emissions

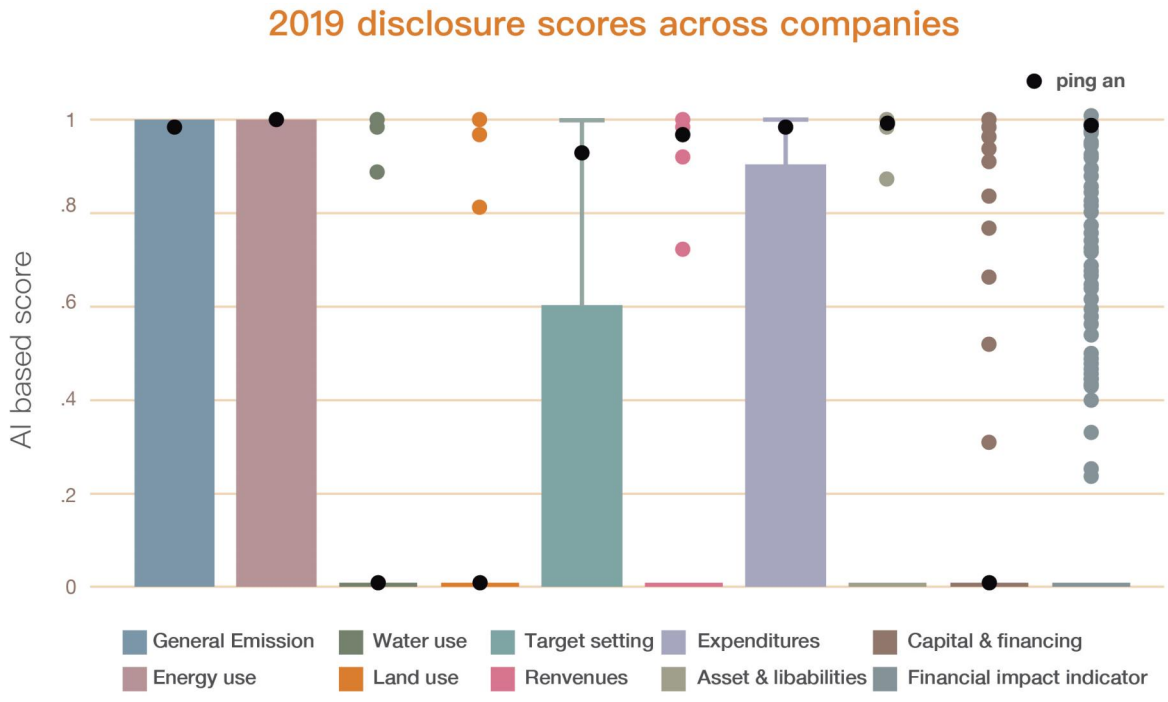
	Earnings per Share (EPS)										
Climate risk disclosure		0.895**	0.738**					0.638**	0.674**	0.785**	0.812**
Overall ESG rating 1	-0.028**		-0.024*					-0.017*			
Controversy score											
ESG scope											
Overall ESG rating 2											
Environmental score											
Climate change exposure score		0.293***	0.346***					0.273***	0.298***	0.394***	0.384***
Scope 1 emission				-0.158***			-0.125**				
Scope 2 emission					-0.211***				-0.176**		
Scope 3 emission							0.017				
Controls1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Controls2	Y	Y	Y	N	N	N	N	N	N	N	N

Statistically signifcant relationship: Positive | Negative

Non-statistically signifcant relationship: Positive | Negative

Using Ping An as a case study, AI driven indicators show that the company performs well, relative to other firms in our sample, along financial impact indicators, emission and energy use, but there is scope for improvement in water/land use and capital & financing disclosure. Our empirical results show that financial impact disclosure is an important driver of high valuations, thus demonstrating that Ping An's efforts to improve its sustainability reporting are well placed.

NLP analysis of main climate risk disclosure indicators for Ping An's sustainability report



Source: Ping An Digital Economic Research Center

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Figures and Tables

1. Automated screening of climate risk disclosures

1.1 AI driven climate disclosure indicators

In the last report (Ping An Digital Economic Research Center, 2020), we used Natural Language Processing (NLP) techniques to assess the breadth and depth of companies' climate disclosures. One of the main ways in which we do that is by generating indicators for the coverage rate of various climate and financial impact related metrics at the company level based on TCFD recommendations. We developed indicators covering 19 metrics in total listed in Table 1.

Table 1: AI driven indicators

	Category	Individual indicators included	How are they generated
A	Climate-related indicators	1. Energy use (CM-ENR) 2. Water use (CM-WTR) 3. Land use (CM-LND) 4. General emissions (CM-EMS) 5. Scope 1 emissions (CM-SCP1) 6. Scope 2 emissions (CM-SCP2) 7. Scope 3 emissions (CM-SCP3) 8. Target setting (CM-TARGET) 9. Locations of physical risks (CM-LOCATION)	Based on rule-based matching. • For each indicator, we use descriptions and examples from TCFD to construct relevant anchor words and expressions to locate relevant text in disclosure reports. • We then estimate the probability of a company having covered a dimension by evaluating our sample precision and number of matches found.[9]
B	Financial impact related indicators	10. Expenditures (FI-EXP) 11. Revenues (FI-REV) 12. Assets and liabilities (FI-A&L) 13. Capital and financing (FI-C&F)	
C	Themes of disclosure reports	14. Discussion of energy use (TH-ENR) 15. Discussion of governance (TH-GOV) 16. Discussion of human rights and employee health and safety (TH-HUM) 17. Discussion of climate related risk management (TH-CRM) 18. Discussion of emissions (TH-EMS) 19. Discussion of Global Reporting Initiative and materiality (TH-GRI)	Based on unsupervised learning. • We use the Latent Dirichlet Allocation (LDA) model to extract distinct themes from passages of texts from companies' disclosure reports. • Then we calculate companies' relative coverage rate of all individual themes.

We use these indicators individually and as composite indicators (for categories A and B only). The composite indicators are constructed by using different weighting methods with a combination of linear aggregation and NLP-based probabilistic methods. The resulting indicators are tested across a number of configurations and selected based on consistency of findings. We found that the composite indicators capture well companies' disclosure transparency and TCFD reporting compliance. Variations of the composite baseline indicators are obtained by varying the weighting scheme to tailored questions. Detailed weighting methods are outlined in the Methodology section.

9 A company is only considered as having covered a dimension of the probability is > 95%.

Box 1. Traditional ESG ratings and how our AI driven indicators differ from them.

To understand whether and how our indicators differ from other indicators available in the marketplace, we compare them with seven well known **ESG ratings**.

Anonymized well-known ESG rating in the market	Definition
Rating 1	Overall ESG rating
Rating 2	ESG controversy rating relying on negative news appearing in public domain, as well as court judgements and regulatory penalties
Rating 3	Rating on companies based on the scope of their ESG reporting, where scope is meant as capturing the fraction of the company's activities covered by its disclosures
Rating 4	Overall ESG rating, an alternative provider to Rating 1
Rating 5	A score only related to the E ("Environmental") dimension of ESG
Rating 6	A deeper level score more narrowly focuses on climate change exposure (e.g. carbon emissions, vulnerability to climate risks, etc.)
Rating 7	An indicator on whether Global Reporting Initiative (GRI) guidelines are followed in generating sustainability reports

Our AI indicators depart from existing ESG ratings in the market along several dimensions, and represent a valuable, complementary addition to the tools currently available in the marketplace. With the exception of Rating 2, all ratings make use of information contained in firms' climate risk disclosures. Additional tools and external sources are advertised as being used to enrich and validate the ratings provided. As documented in Berg et al. (2019), ESG rating providers differ along at least three dimensions:

i. definition of attributes relevant for ESG compliance;
ii. measurement of those attributes;
iii. aggregation of measurements to produce final scores.

Berg et al. (2019) find that a simple linear aggregation rule does a good job of replicating the ratings of different providers. This means that definition and measurement of attributes, as well as any weights attached to them, are the essential drivers of rating heterogeneity. Importantly, our indicators **use a combination of unsupervised and supervised approaches** to identify and measure attributes.

Moreover, aggregation **relies on probabilistic tools and is often non-linear**. Hence, our AI driven indicators differ along all three sources of ratings heterogeneity and therefore represent a valuable, complementary addition to existing tools.

1.2 Climate risk disclosure and ESG ratings

Our analysis reveals that some existing ESG ratings in the market present some anomalies and may fail to capture appropriately the information contained in climate risk disclosures. On one hand, rating 5 (Environmental score) and 6 (Climate change exposure score should be more aligned with our indicators, as they focus on issues covered by climate risk disclosures. On the other hand, the broader or different focus of other ratings would justify some divergence. However, we find that these hypotheses are not supported by the data. As illustrated in Table 2, we obtain the following results:

- GRI compliance positively explains both rating 1 and 4 (overall ESG rating from two providers), meaning that **better GRI compliance is associated with higher overall ESG ratings**.
- **Disclosure has a negative impact on controversy score** (rating 2) and a positive impact on ESG scope (rating 3), a result aligned with the plausible idea that disclosure mitigates the likelihood of controversies and improves the breadth of information available to market participants.
- **Climate risk disclosure only raises one provider's broad ESG score (rating 1), but not the other (rating 4)**. This might be due to the fact that broad ESG scores consider a wider array of issues and information sources than what is contained by climate risk disclosures. However, as soon as we consider ratings more narrowly focusing on environmental issues and climate change (indices that do contribute to the broad ESG ratings themselves by construction), we notice a striking and unexpected divergence.
- Surprisingly, **firms that do not engage in climate risk disclosure are implicitly rewarded by some rating providers**. Indeed, we observe that climate disclosures negatively impact both environmental score (rating 5) and climate change exposure score (rating 6), which is inconsistent with their main purpose, i.e., to signal the ability to understand, manage, and address environmental and climate change issues. This may be the result of overly generous priors being encoded in unsophisticated rating tools and/or the generation of downward-biased posteriors once climate disclosure information is taken into account.
- Although the proprietary nature of rating methodologies makes it difficult to properly understand the trade-offs at play, our results suggest that some tools available in the marketplace do a poor job of using the information provided in climate risk disclosures. They may actually provide strong incentives for selective non-disclosure.

Table 2: Regression results of anonymized ESG ratings against disclosure

	Rating 1 (Overall rating)			Rating 4 (Overall rating)			
Cliamte risk disclosure		2.778***	2.470***				Key insight 1
Rating 7 (GRI indicator)	0.095***		0.095***	0.011**		0.011**	Key insight 3
	Rating 2 (Controversy score)			Rating 5 (Environmental score)			
Climate risk disclosure		-2.090***	-1.962**		-0.392***	-0.465***	
Rating 7 (GRI indicator)							
Key insight 2	Rating 3 (ESG scope)			Rating 6 (Climate change exposure score)			Key insight 4
Cliamte risk disclosure		0.608***	0.792***		-0.656***	-0.656***	
Rating 7 (GRI indicator)	-0.021***		-0.021***				

Statistically signifcant relationship		Non-statistically signifcant relationship	
Positive	Negative	Positive	Negative

Regressing anonymized ratings against variables capturing engagement in climate disclosures, compliance with GRI standards, log-emissions broken down by scope (Scope 1 to 3), and after controlling for firm characteristics (revenue, leverage, earnings per share, price to book, etc.) and year fixed effects. Only statistically significant coefficients are reported.

Key insights:

1. GRI compliance is associated with higher overall ESG ratings.
2. Disclosure has a negative impact on controversy score (rating 2) and a positive impact on ESG scope (rating 3), suggesting disclosure mitigates the likelihood of controversies and improves the breadth of information available to market participants.
3. Climate risk disclo sure only raises one provider's broad ESG score (rating 1), but not the other (rating 4).
4. Climate disclosures negatively impact both environmental score (rating 5) and climate change exposure score (rating 6), suggesting firms that do not disclose climate risks may be implicitly rewarded by some ratings.

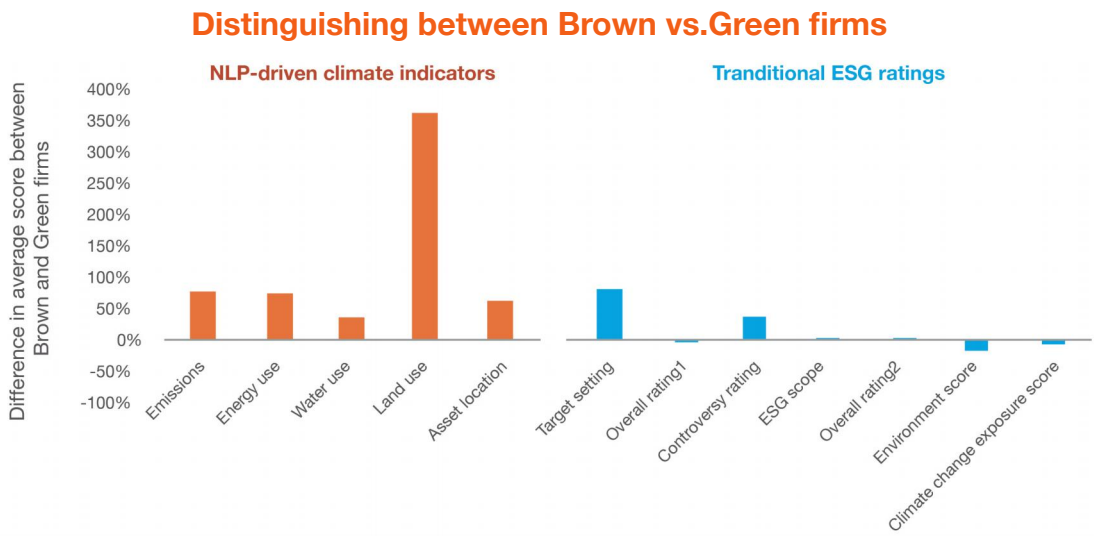
2. Greenwashing detection

2.1 AI driven indicators as a detection tool vs. traditional ESG ratings

The previous analysis revealed elements of potential greenwashing emerging from anomalies observed in anonymized ESG ratings in the market between companies that engage in climate disclosures vs. those who do not. We now look at greenwashing from a different angle and use AI driven indicators as a greenwashing detection tool.

AI driven climate disclosure indicators perform better than traditional ESG ratings in terms of differentiating between Brown and Green firms. As a simple experiment, we cluster companies into two groups, **Brown and Green firms**[10]. The former include high emission industries, as classified by the Intergovernmental Panel on Climate Change (IPCC). Using the SASB classification, we include the Extractive & Minerals Processing, Transportation, Resource Transformation, and Infrastructure sectors in the Brown category. We include the remaining sectors in the Green group, where the label should be understood as simply referring to companies having relatively lower emissions than those included in the Brown group. In Figure 1, we show how our indicators compare with those available in the industry by depicting the relative difference between the scores for Brown and Green firms for each indicator. We consider indicators addressing the disclosure of climate related indicators pertaining to emissions, energy use, water use, land use, asset location, and target setting information.

Figure 1: Relative difference between average scores for Brown firms and Green firms



Relative difference between average scores for Brown firms and Green firms are calculated by (score_brown/score_green-1). AI driven indicators considered: indicators addressing the disclosure of climate related indicators pertaining to emissions, energy use, water use, land use, asset location, and target setting information. Anonymized ESG ratings in the market include broad ESG rating 1, controversy rating, ESG scope, broad ESG rating 2, environmental score, and climate change exposure score.

Climate disclosures contain risk metrics that are particularly important for Brown firms relative to Green firms. Transparency and depth of disclosures should therefore score highly for Brown firms. On the other hand, broad ESG ratings that rely on additional sources of information should be able to differentiate even better the two groups. Figure 1, however, shows that for companies that engage in climate disclosures, only AI driven indicators perform well in separating Brown from Green firms, whereas broad ESG ratings in the market including overall ratings 1 and 2 show almost negligible differences across the two groups of firms. Environmental and climate change exposure scores show slightly better ratings for greener firms, although still almost negligible. This, however, makes the findings for broad ESG indices even more puzzling, as by construction overall rating 2 takes into account environmental and climate change exposure scores. The results indicate that aggregation of attributes considered by rating firms may greatly dilute the informational content of environmental/climate metrics.

The controversy score does a better job of singling out Brown firms as being more exposed to controversies, possibly because it uses information appearing in the news or reaching the public domain via litigation (e.g., court judgements) or regulatory intervention (e.g., fines and penalties).

All in all, the results suggest that despite the availability of information contained in climate risk disclosures, some rating methodologies do not achieve a signifcant level of granularity to allow end users to reliably differentiate between firms.

10 Similar stylized breakdowns are used in Choi et al. (2020) and Santi (2020) to build portfolios helping to gauge the difference between the equity valuations of high and low emission firms.

2.2 Evidence of greenwashing by Brown firms from AI driven indicators

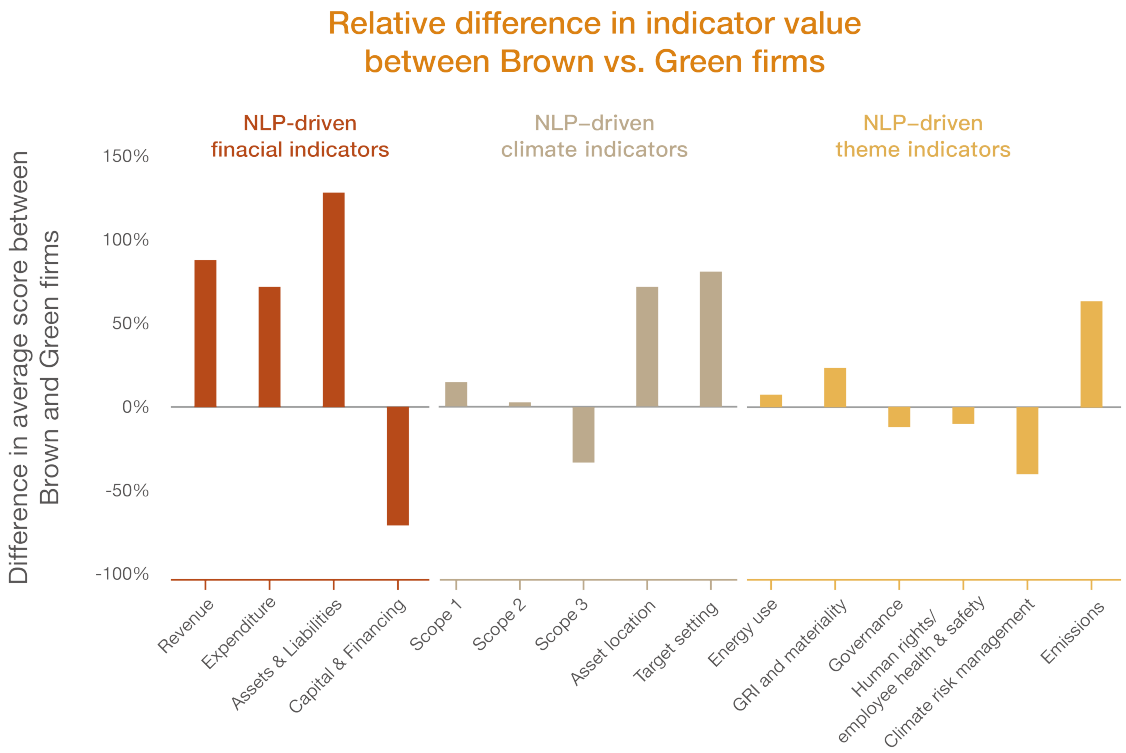
We consider a range of indicators designed to assess TCFD compliance to identify instances of potential greenwashing. We start by considering the four main dimensions of financial impact metrics identified by TCFD: revenues, expenditures, assets & liabilities, and capital & financing. We then consider climate metrics pertaining to granular disclosure of scope 1 to 3 emissions, as well as the themes identified in previous work via unsupervised topic detection techniques[11].

Application of our AI indicators to Green vs. Brown firms reveals some striking anomalies further pointing in the direction of possible greenwashing. In Figure 2, we depict the relative difference in score for the two groups of firms for each indicator, demonstrating the following results:

- The capital and financing impact dimension is disproportionately under-disclosed by Brown firms.
- The themes identified with unsupervised methods appear to have Brown firms loading heavily on the emissions theme, while neglecting other themes, with the climate related risk management theme being considerably better addressed by Green firms.
- Finally, scope 3 emissions are sizeably under-disclosed by Brown firms relative to Green firms.

These findings all point in the direction of some greenwashing being at play, particularly in high emission sectors.

Figure 2: Relative difference between average scores for Brown firms and Green firms



AI driven indicators considered: financial impact metrics pertaining to revenues, expenditures, assets & liabilities, and capital & financing; climate metrics pertaining to disclosure of scope 1 to 3 emissions and target setting; indicators of themes identified with unsupervised topic detection techniques (including energy, GRI materiality, governance theme, human rights and employee health and safety, climate risk management, and emissions.

11 We use Latent Dirichlet Allocation (LDA) and different saliency measures to detect distinct themes in companies' climate disclosure reports. Themes detected earlier include: energy use, governance, human rights and employee health and safety, climate related risk management, emissions, and GRI reporting and materiality. See Digital Economic Research Center (2020) for details.

2.3 Climate disclosure and leverage: inconsistency between ESG ratings

Climate disclosure is associated with lower leverage, whereas ESG ratings are often associated with higher leverage with inconsistent results among various ESG ratings. Greater leverage and higher cost of debt is a proxy for probability of financial distress. As ESG ratings are inconsistent in terms of their relationship with firms' leverage, firms can exploit the dispersion of ESG ratings to appear less risky to investors, another form of greenwashing. On one hand, Table 3 shows that companies engaging in climate risk disclosure have lower leverage, after controlling for carbon emissions. The latter usually explain instead higher leverage in our regressions. The findings are confirmed for small and medium capitalization firms after controlling for firm size (see Table 5 further below), and even for high emission sectors such as infrastructure and resource transformation after controlling for industry (see Table 6).

On the other hand, ESG ratings provide a rather inconsistent, and often contradictory picture. For example, we find that broad ESG rating 2 is consistently associated with greater leverage, whereas overall rating 1, controversy score, and climate change exposure score explain lower leverage only for some regression configurations. When controlling for firm size, the results are even more striking (Table 5), as most ratings are associated with greater leverage, particularly for large firms. The results may suggest that firms which do not engage in climate risk disclosure may benefit from generous ESG ratings by being able to borrow more.

Table 3: Relationship between engaging in climate risk disclosure, various ESG ratings and leverage

	LEVERAGE							
Climate risk disclosure						-0.445***	-0.593***	-0.755***
Overall ESG rating 1							-0.019**	
Controversy score						-0.051**		
ESG scope								
Overall ESG rating 2					0.216**	0.194**	0.219*	0.212**
Environmental score								
Climate change exposure score							-0.102*	
Scope 1 emission	0.074***			0.072*	0.116***			0.141***
Scope 2 emission		0.098***				0.127**		
Scope 3 emission			0.083**				0.114***	

Key insight 1 — Climate risk disclosure

Key insight 2 — Overall ESG rating 1, Controversy score, ESG scope, Overall ESG rating 2, Environmental score, Climate change exposure score

Statistically signifcant relationship: Positive | Negative

Non-statistically signifcant relationship: Positive | Negative

Controls included are company financials, emissions by scope, and AI driven theme indicators.

Key insights:

1. Companies engaging in climate risk disclosure have lower leverage, after controlling for emissions.

2. ESG ratings show inconsistent results. Overall rating 2 is consistently associated with higher leverage, while overall rating 1, controversy score, and climate change exposure are associated with lower leverage for some regression configurations.

3. Climate risk disclosures and firm characteristics

In this section we present results from panel regressions and cross-sectional analysis. Panel regressions are carried out for S&P500 firms that have climate risk disclosures, during the period 2010-19 to understand the main characteristics of firms engaging in climate risk disclosures relative to those which do not[12]. We then focus on both S&P500 and CSI300 firms on the cross-sectional heterogeneity of firms engaging in climate risk disclosure after the publication of TCFD's guidance in 2017 (see TCFD, 2017a,b,c; Ping An Digital Economic Research Center, 2020).

3.1 What distinguishes firms engaging in climate risk disclosures

We find evidence that investors care about climate change and that climate risk disclosures are associated with higher valuations and lower leverage. Some recent literature suggest that emissions are associated with a carbon risk premium, i.e., higher emission company stocks trade at a discount (Bolton and Kacperczyk, 2020). Despite differences in sampling period and data sources, we find support for such a conclusion when controlling for other firm characteristics, but not for climate disclosure information (see Tables 7 and 9 further below). AI driven indicators of climate disclosure allow us to go beyond carbon emissions, understand more granularly how climate change risk might shape valuations, and identify value opportunities. We find that:

- Firms engaging in climate risk disclosure have higher Earnings per Share (Table 4). We find a similarly statistically significant relationship for anonymized climate change exposure score, but the relationship vanishes once climate change exposure information is aggregated with other information to produce environmental score and broad ESG rating 2. Emissions are also found to be negatively related to earnings per share.
- Firms engaging in climate risk disclosure tend to be less leveraged (Table 3 and 5). This is particularly true for small and medium capitalization firms. As discussed in section 2, anonymized rating scores often portray a different picture and may be associated with higher leverage.
- In some high emission sectors, such as Infrastructure and Resource Transformation, climate disclosure is a very good explanatory variable for leverage, which is lower for disclosing firms (Table 6).
- For Extractives and Mineral Processing firms, the evidence is weaker.
- Large cap firms engaging in climate disclosure are associated with higher valuations (Table 7). Taken together with our findings on leverage, this result suggests that small and medium cap firms engaging in climate risk disclosure may still offer considerable opportunities for appreciation.

Table 4: Relationship between companies' Earnings per Share vs. climate risk disclosure, anonymized ESG ratings, and emissions

	Earnings per Share (EPS)										
Climate risk disclosure		0.895**	0.738**					0.638**	0.674**	0.785**	0.812**
Overall ESG rating 1	-0.028**		-0.024*					-0.017*			
Controversy score											
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Overall ESG rating 2											
Environmental score											
Climate change exposure score		0.293***	0.346***					0.273***	0.298***	0.394***	0.384***
Scope 1 emission				-0.158***			-0.125**				
Scope 2 emission					-0.211***				-0.176**		
Scope 3 emission											
Controls1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Controls2	Y	Y	Y	N	N	N	N	N	N	N	N

Key insight 1

Statistically signifcant relationship: Positive | Negative

Non-statistically signifcant relationship: Positive | Negative

Controls potentially included are firms' financials (Controls1) and un-logged emissions (Controls2).

Key insights:

1. Firms engaging in climate risk disclosure have higher Earnings per Share.

12 We do not include CSI300 firms in the panel regressions because we distinguish between firms that disclose vs. firms that do not. Since very few CSI300 companies actually engage in climate risk disclosures, it would lead to an unbalanced panel.

Table 5: Relationship between companies' leverage vs. climate risk disclosure and anonymized ESG ratings by firm market capitalization

	LEVERAGE (For large/medium/small market cap firms)							
	L	M/S	L	M/S	L	M/S	L	M/S
Climate risk disclosure		-0.885***		-0.927***		-0.906***		-0.907***
Overall ESG rating 1								
Controversy score			0.121***				0.110**	
ESG scope			0.034*	-0.015**			0.071***	
Overall ESG rating 2						0.293***		0.277**
Environmental score					0.254***		0.354***	
Climate change exposure score								

Key insight 1

Statistically signifcant relationship: Positive | Negative

Non-statistically signifcant relationship: Positive | Negative

Controls included are firms' financials and emissions. L/M/S represent large/medium/small capitalization.

Key insights:

1. Firms engaging in climate risk disclosure tend to be less leveraged (table 3), the finding being driven by small and medium sized firms as shown above.

Table 6: Relationship between leverage vs. climate risk disclosure and anonymized ESG ratings for selected sectors

	LEVERAGE											
	Extractives & Minerals Processing				Infrastructure				Resource Transformation			
Climate risk disclosure					-0.572***	-0.886***	-0.547**	-0.807***	-1.106***	-0.983***	-1.373***	-1.092***
Overall ESG rating 1						-0.026***		-0.029***				
Controversy score		0.157***		0.188**								
ESG scope												
Overall ESG rating 2												
Environmental score								0.219*				
Climate change exposure score												

Key insight 1

Statistically signifcant relationship: Positive | Negative

Non-statistically signifcant relationship: Positive | Negative

Controls included are firm financials and emissions.

Key insights:

1. In some high emission sectors, such as Infrastructure and Resource Transformation, climate disclosure show strong relationship with leverage, which is lower for disclosing firms. The evidence is weaker for Extractives and Mineral Processing firms.

Table 7: Relationship between companies' return vs. climate risk disclosures and anonymized ESG ratings

	RETURN (For large/medium/small market cap firms)							
	L	M/S	L	M/S	L	M/S	L	M/S
Climate risk disclosure	-0.082*		-0.112**		-0.082*		-0.114*	
Overall ESG rating 1			0.004**					
Controversy score								0.004*
ESG scope								
Overall ESG rating 2								
Environmental score								-0.011**
Climate change exposure score								

Key insight 1

Statistically signifcant relationship: Positive | Negative

Non-statistically signifcant relationship: Positive | Negative

Controls included are firm financials, emissions by scope, and AI driven themes

Key insights:

1. Large cap firms engaging in climate disclosures have a lower risk premium, hence higher valuations. Small and medium cap firms engaging in climate risk disclosures may still offer consideration appreciation opportunities.

3.2 AI driven disclosure indicators and firm characteristics

We find evidence that AI driven indicators can help identify firms with relevant target characteristics. After controlling for emissions and other firm characteristics, we summarize the results of different regression specifications in Table 8. The table allows us to navigate a number of relationships, which may be positive (green) or negative (orange). Lighter shading of colors indicates weaker statistical significance, whereas a grey color is used for results that are statistically insignificant or inconclusive across regression specifications.

Table 8: Regressing different financial variables against anonymized ESG ratings and selected AI driven indicators, after controlling for emissions, other financial variables, and themes

		Earnings per share	Return on Assets	Return on Equity	Return on Invested Capital	Leverage	WACC	Risk Premium
ESG ratings	Overall ESG rating 1							
	Controversy score							
	ESG scope							
	Overall ESG rating 2							
	Environmental score							
	Climate change exposure score							
AI driven climate indicators	General Emissions							
	Energy Use							
	Water Use							
	Land Use							
	Location of physical risks							
	Target setting							
AI driven financial impact indicators	Revenues							
	Expenditures							
	Assets & Liabilities							
	Capital & Financing							
AI driven composite indicators	Composite climate indicator							
	Financial impact indicator							

We can make the following general remarks on our findings:

- Overall, we find evidence of stronger relationships between financial impact disclosure indicators and firms' financial characteristics (bottom half of Table 8).
- **Earnings per Share**, **Return on Assets** and **Return on Equity** are in general positively explained by AI driven indicators. The Capital & Financing impact dimension is particularly important across firms' financials.
- Target Setting and Capital & Financing indicators appear to positively explain **Return on Invested Capital**, which appears to be dragged down instead by Expenditures.
- Both composite indicators and Water/Land use and Location of Physical Risks explain lower **leverage**. Both General Emissions and Capital & Financing indicators are instead associated with higher leverage.

We find that several AI driven indicators can help explain valuations and cost of capital. AI driven indicators of climate disclosure allow us to go beyond carbon emissions and more granularly understand how climate change risk might shape discount rates and hence valuations. They also contribute to our understanding of how climate disclosures might affect firm value by lowering their **cost of capital**. In particular, after controlling for emissions and firm characteristics, we find the following (Table 8):

- The **Weighted Average Cost of Capital** (WACC) is in general lower with greater TCFD compliance (both composite indicators) and disclosure of Water/Land use and Location of physical risks. We find instead that General Emissions and Capital & Financing explain higher cost of capital.
- The climate **Risk Premium** is lower for firms disclosing Energy/Water use, Location of physical risk, and Target setting, indicators that explain therefore higher valuations. General Emissions, Land Use, Expenditures and Capital & Financing are instead associated with a higher risk premium, and hence lower valuations.
- When using composite indicators capturing overall climate risk metrics and financial impact disclosure, we find that there are two competing effects at play: the former positively explain the risk premium, the latter negatively. Noting that both composite indicators explain lower WACC, financial impact disclosure emerges as an important channel contributing to firm value.

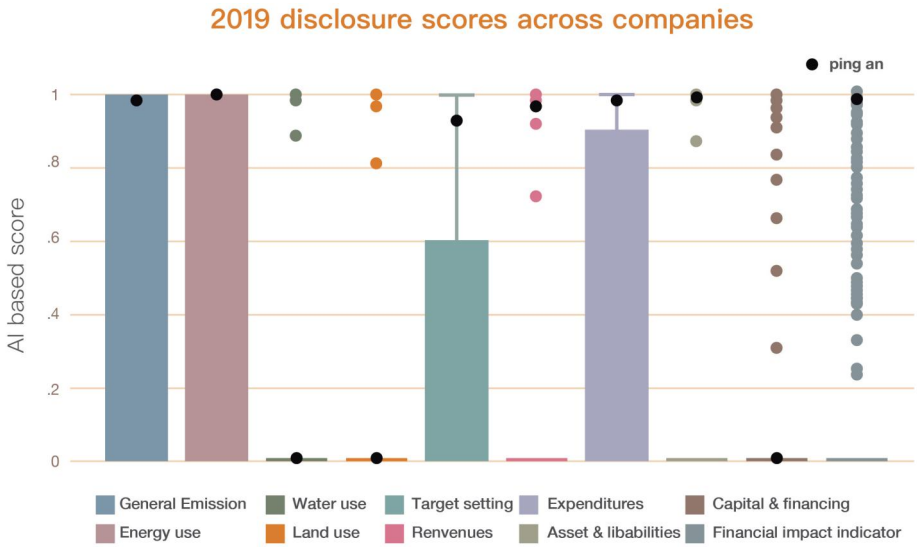
The findings confirm that **ESG ratings** should be used with caution. We find that several ratings have weak or inconclusive bearing on the financial measures examined. Importantly, climate change rating 6 is reasonably aligned with our findings, but its information value is diluted once it is included in environmental rating 5 or general ESG rating 4, often leading to very different results. See the first five rows of Table 8.

Box 2. Ping An as a case study.

Environmental, social and governance (ESG) criteria represent an important dimension of Ping An's strategy. In 2019, Ping An officially established its ESG policy system, which encompasses the business code of conduct, corporate governance, responsible investment, sustainable insurance, information security, AI governance, sustainable supply chain, Sustainable Development Goals, and so on. Meanwhile, Ping An leveraged its technology expertise and developed the Ping An AI-ESG platform, which can be used for both ESG performance management and investment applications.

We apply our AI driven indicators to analyze Ping An's sustainability disclosures and focus on climate risk dimensions that are relevant in the context of this report. Ping An performs very well relative to other firms along financial impact indicators, emission and energy use, whereas there is room for improvement in water use, land use, and capital and financing. According to the results presented in this report, high performance in financial impact disclosure is an important driver of higher valuation, thus confirming that Ping An's efforts are well placed. Our results also support the need to place greater emphasis on Target Setting and Location of Physical Risk Exposures going forward.

Figure 3: NLP analysis of main climate risk disclosure indicators for Ping An's sustainability report



During the last few years Ping An has worked toward improving its ESG disclosures and has encountered positive response from some external rating providers. For example, Ping An's MSCI rating has improved twice consecutively, from BB in 2018 to A in 2020. AI based indicators provide a consistent picture and identify key areas of current strength as well as directions for improvement.

4. How can investors and corporates leverage AI driven climate risk disclosure indicators

Help asset managers structure meaningful decarbonization strategies: The asset management industry has by now appreciated the importance of climate change and ESG compliance for a variety of stakeholders[13]. Managers often work under mandates specifying green or ESG compliance targets, are under increasing regulatory pressure to disclose the carbon footprint of their holdings and are acutely aware of reputational backlashes. However, portfolio decarbonization strategies are still in their infancy. Naive divestment approaches based on blanket policies driven by carbon emissions leave portfolios less diversified and prevent investors from engaging with some of those companies that may play a crucial role in transitioning to a low-carbon economy (e.g., Renelleau and Khan, 2019). As demonstrated by our analysis, differentiating companies based on traditional ratings may be ineffective or misleading; Berg et al. (2019), for example, document a sizeable dispersion of ESG ratings, which often results in divergent recommendations. AI driven indicators offer therefore a valuable addition to asset managers' toolkit to enhance and refine their investment screening process, as well as detect potential greenwashing that may be at play in particular companies.

13 See, for example, Benedetti et al. (2019), Renelleau and Khan (2019), Amel-Zadeh and Serafeim (2020).

Help investors inform and support portfolio tilts: The first objective of developing climate disclosure indicators is to extract more objective information on the climate risk exposure of firms, so as to better inform the **portfolio tilts** an investor may wish to implement in its portfolio. For example, our climate disclosure indicators enable portfolio optimization subject to constraints on **disclosure compliance** (understood in relation to the TCFD reporting framework) and **transparency** of particular metrics (e.g., climate or financial impact related). This approach vastly reduces the inefficiency associated with portfolios resulting from constrained optimization based on the application of blanket screens or restrictions driven by simplistic metrics such as carbon footprints (e.g., Benedetti et al., 2019; Renelleau and Khan, 2019). It also allows investors to articulate their views on the pace at which information on climatic exposures will be dynamically incorporated in market valuations. This is essential for expected returns considerations, which we now address.

Help investors better understand climate risk premiums beyond emissions. It is often claimed that ESG compliant firms should deliver higher risk-adjusted returns. However, if a sizeable portion of market participants prefer ESG compliant firms for ethical considerations, valuations of ESG compliant firms will increase at the expense of non-compliant firms, thus reducing the upside of compliant firms. It is exactly those investors who will be willing to invest in disliked firms that may end up earning higher returns as compensation for picking up the unwanted slack (e.g., Fama and French, 2007). Similar effects have been documented[14] for stocks of companies operating in the alcohol, tobacco, and gaming industry ("sin" stocks). These considerations, however, apply in equilibrium. Our results show that, although a carbon risk premium has been documented for high emission firms, the picture is more articulated once climate risk disclosure indicators are taken into account. We therefore take the view that the equilibrium outcome discussed above may still lie ahead of us, as we now discuss.

Help investors capitalize on the increase of climate awareness. As climate awareness gradually increases and climate risk information becomes more granularly available to investors, it is conceivable that we are witnessing the transition to a new equilibrium in which markets will eventually price in climate risk information and investors' preferences. Our findings therefore help investors position themselves to reap the benefits arising from such a transition. We find that **climate risk disclosures are associated with higher valuation of large cap companies**, after controlling for emissions, thus suggesting that the valuation dynamics discussed above are more mature for large firms. Although the scope for appreciation may still be considerable there, we find that **small and medium capitalization firms that engage in effective climate risk disclosure** may offer the greatest opportunities for superior risk-adjusted returns along the path to efficient climate risk pricing. AI driven indicators could therefore represent a valuable addition to investment policies aiming at making the most of forward-looking metrics of climatic change during the transition to a low carbon economy[15].

Help investors better articulate their views on climatic risk-return trade-offs. We find that various dimensions of climate disclosure are associated with different firm characteristics and valuations. For example, a composite climate risk indicator is associated with lower valuations, whereas a composite TCFD financial impact disclosure indicator explains lower leverage and higher valuations. As such, investors could use AI based indicators to specify competing constraints in their portfolio optimization engines, so as to identify portfolios achieving desired risk-return trade-offs while delivering a certain degree of disclosure along particular dimensions. Granular AI indicators could further be used to articulate portfolio managers' views on how climatic risks will shape individual stock returns during the transition to a low carbon economy. Bayesian and Semi-Bayesian methodologies[16] a la Black and Litterman (1992), for example, could be enhanced by taking into account AI driven indicators. Applications in this direction are the object of future research.

Help companies understand how engaging in climate risk disclosures can add value to shareholders. Our results show that valuations take into account efforts made by firms in engaging in climate risk disclosures. They also show that some disclosure dimensions are associated with lower cost of capital and higher return on invested capital, thus suggesting opportunities to deliver value to shareholders both in terms of cost of equity and debt. Although understanding whether and how ESG compliance might affect firm value is notoriously difficult[17], both empirically and theoretically, our findings provide support for the role that climate disclosures can impact the cost of capital dimension of broader corporate valuation frameworks (see Cornell and Damodaran, 2020, for example). Further research will look into revenue, operating profit margin, as well as study the debt market in addition to the equity market focus adopted in this report.

14 See Hong and Kacperczyk (2009).

15 See Cormack et al. (2020), for example.

16 See, for example, Schöttle et al. (2010), Lai et al. (2011), Sim et al. (2016), and Benedetti et al. (2019).

17 See Cheng et al. (2014), Mitsuyama and Shimzutani (2015), Zhao and Murrell (2016).

5. Methodology

5.1 Weighting methodologies of composite indicators

To give an idea of how composite indicators are built, we illustrate different weighing methods that are used and tested in aggregating climate and financial impact indicators.

1. **Equal weighting:** Probability[18] of each indicator is weighted equally.

2. **Inverse mean weighting:** Indicators with lower scores are given higher weights, i.e. companies that disclose metrics that are less frequently disclosed or generally less likely to be disclosed are rewarded.

3. **Inverse document frequency weighting: probability of each indicator is weighted by inverse document frequency (idf).** This is similar in principle to inverse mean weighing, as idf of a rare term is high, while idf of a frequent term is low. Hence, less frequent metrics are given higher weights and companies that disclose them can be rewarded as a result.

4. **Industry-based weighing for financial impact metrics:** A composite financial impact disclosure indicator is obtained by using industry-based weights reflecting the fact that different financial impact dimensions are of relevance to different sectors. We follow TCFD's guidance as indicated in Table 9 below. For industries not covered in TCFD's sector classification, we rely on SASB guidance on convergence between reporting frameworks (SASB 2017a,b). For each sector, we use equal weights for the particular financial impact dimensions indicated by TCFD.

Baseline Indicators CM1 and FI1 are based on weighing methods three and four.

Table 9: Financial impact metrics mapping by sector (TCFD, 2017a)

Evidence of Financial Impact

Groups and Industries		Revenues	Expenditures	Assets and Liabilities	Capital and Financing
Financial	Banks	■		■	
	Insurers	■	■	■	
	Asset Owners	■		■	
	Asset Managers	■		■	
Energy	Oil and Gas	■	■	■	■
	Coal		■	■	■
	Electric Utilities	■	■		■
Transportation	Air Freight		■		■
	Passenger Air Transportation		■		■
	Maritime Transportation		■		■
	Rail Transportation		■		■
	Trucking Services		■		■
	Automobiles and Components	■	■		■
Materials and Buildings	Metals and Mining		■		■
	Chemicals	■	■		■
	Construction Materials	■	■		■
	Capital Goods	■	■		
	Real Estate Management and Development	■	■	■	■
Ag, Food and Forest	Beverages		■		■
	Agriculture	■	■	■	■
	Packaged Foods and meats		■	■	■
	Paper and Forest Products	■	■	■	■

18 The probability of each sub-metric is estimated by: 1-(1-sample precision) Number of matches at the company level

5.2 Sample scope and regression specifications

For panel regressions, we consider S&P500 firms that have climate risk disclosures, during the period 2010-19. For cross-sectional analysis, we focus on both S&P500 and CSI300 firms that have climate risk disclosures. We do not include CSI300 firms in the panel regressions because we distinguish between firms that disclose vs. firms that do not. Since very few CSI300 companies actually engage in climate risk disclosures, it would lead to an unbalanced panel. In addition to standard firms characteristics (revenues, total debt, leverage, earnings per share, price to book, return on assets, return on equity, return on invested capital, weighted average cost of capital), we consider total emissions and emissions broken down by scope (scope 1, 2, and 3), both logged and un-logged. We also consider time series of seven anonymized ESG ratings of common use in the marketplace.

Our analysis relies on pooled OLS regressions with and without year fixed effects. We use lagged explanatory variables to avoid look ahead bias. For robustness, we also consider contemporaneous information and the results are quite consistent. Although some findings are consistent with Bolton and Kacperczyk (2020), their analysis uses asynchronous data (monthly returns vs. yearly emissions), whereas we stick with synchronous data. We also use different data sources[19] for carbon emissions (Bloomberg, Reuters).

The definition of AI driven indicators rely on the study presented in Ping An Digital Economic Research Center (2020), although the composite indicators are new and rely on the weighting scheme discussed in section 1. When using baseline composite indices CM1 (climate related metrics) and FI1 (financial impact related metrics), we omit individual AI indicators from the regression to avoid multi-collinearity. The labelling of the composite indices reflect the fact that several composite indicators were developed based on different weighting schemes aiming at extracting slightly different information from climate risk disclosures. We only present results for CM1 and FI1.

In regression analysis we allow for different sets of controls, depending on the analysis at hand. These are typically classified into three groups: "Controls1" (firm's fundamentals, possibly excluding the one captured by the dependent variable), "Controls2" (firm's emissions), "ControlsTH" (AI driven theme indicators). In general, we control for log-emissions broken down by scope and indicated as LSCOPE1, LSCOPE2, and LSCOPE3; they are explicitly reported as part of the explanatory variables when the discussion of results requires it. Running the same regressions with un-logged emissions yields rather similar results, but logged values ensure greater consistency. As emissions are highly persistent, return on equity is included in the set of controls "Controls1". Further details are provided in the appendix.

19 We are grateful to Impax Asset Management for assistance in compiling the dataset.

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Appendix

Appendix 1

Results supporting Table 2.

	Overall rating 1						Controversy rating					
Climate risk disclosure		3.252***	2.845***	3.254***	2.778***	2.470***		-1.669**	-1.958***	-2.283***	-2.090***	-1.962**
		(0.581)	(0.567)	(0.673)	(0.669)	(0.658)		(0.678)	(0.702)	(0.800)	(0.787)	(0.911)
ESG rating 7 (GRI)	0.095***					0.095***	-0.030					-0.029
	(0.021)					(0.021)	(0.034)					(0.034)
Scope 1 emissions	-0.749***	0.865***			-0.005	-0.753***	0.329*	0.290**			0.246	0.333*
	(0.141)	(0.096)			(0.145)	(0.140)	(0.194)	(0.114)			(0.170)	(0.193)
Scope 2 emissions	2.174***		2.293***		1.854***	2.070***	0.568*		0.425**		0.500*	0.651*
	(0.247)		(0.152)		(0.243)	(0.247)	(0.344)		(0.193)		(0.285)	(0.346)
Scope 3 emissions	0.249*			1.040***	0.521***	0.190	-0.128			0.042	-0.313**	-0.081
	(0.132)			(0.115)	(0.137)	(0.132)	(0.181)			(0.134)	(0.158)	(0.182)
Constant	39.587***	51.026***	33.447***	50.587***	34.334***	40.300***	88.155***	92.539***	90.825***	96.154***	91.261***	87.512***
	(2.903)	(1.185)	(1.891)	(1.406)	(2.314)	(2.893)	(4.380)	(1.455)	(2.423)	(1.684)	(2.785)	(4.383)
	ESG scope						Environment score					
Climate risk disclosure		-0.120	0.151	0.495**	0.608***	0.792***		0.025	0.079	-0.042	0.018	0.018
		(0.178)	(0.178)	(0.218)	(0.218)	(0.260)		(0.059)	(0.059)	(0.072)	(0.072)	(0.072)
ESG rating 7 (GRI)	-0.021***					-0.021***	0.011**					0.011**
	(0.008)					(0.008)	(0.004)					(0.004)
Scope 1 emissions	0.238***	-0.083***			0.228***	0.237***	-0.056***	-0.034***			-0.036**	-0.056***
	(0.055)	(0.029)			(0.047)	(0.055)	(0.017)	(0.010)			(0.016)	(0.017)
Scope 2 emissions	-0.657***		-0.498***		-0.635***	-0.690***	-0.121***		-0.048***		-0.076***	-0.124***
	(0.098)		(0.047)		(0.079)	(0.098)	(0.030)		(0.016)		(0.026)	(0.031)
Scope 3 emissions	-0.171***			-0.301***	-0.238***	-0.190***	0.095***			0.026**	0.071***	0.093***
	(0.052)			(0.037)	(0.044)	(0.052)	(0.016)			(0.012)	(0.015)	(0.016)
Constant	16.450***	8.665***	13.673***	10.611***	14.909***	16.679***	5.051***	5.226***	5.395***	4.596***	5.369***	5.054***
	(1.146)	(0.360)	(0.580)	(0.450)	(0.742)	(1.144)	(0.491)	(0.123)	(0.196)	(0.151)	(0.248)	(0.491)
Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Appendix 2

Results supporting Table 3. Control variable set “Controls1” includes all financials with the exception of leverage.

	LEVERAGE							
Climate risk disclosure					-0.264	-0.445***	-0.593***	-0.755***
					-0.187	-0.165	-0.229	-0.186
Overall rating 1					-0.01	-0.003	-0.019**	-0.008
					-0.008	-0.007	-0.009	-0.007
Controversy score					-0.038	-0.051**	0.003	-0.012
					-0.025	-0.022	-0.029	-0.023
ESG scope					0	-0.002	0.002	-0.005
					-0.006	-0.005	-0.007	-0.006
Overall rating 2					0.216**	0.194**	0.219*	0.212**
					-0.102	-0.089	-0.118	-0.097
Environment score					-0.024	0.001	0.018	0.055
					-0.058	-0.049	-0.064	-0.052
Climate change exposure score					0.028	0.003	-0.102*	-0.015
					-0.048	-0.041	-0.059	-0.051
Scope 1 emissions	0.074***			0.072*	0.116***			0.141***
	-0.025			-0.038	-0.034			-0.043
Scope 2 emissions		0.098***		0.069		0.127**		0.045
		-0.038		-0.064		-0.051		-0.07
Scope 3 emissions			0.083**	-0.027			0.114***	-0.029
			-0.034	-0.034			-0.04	-0.037
Constant	0.382	0.031	0.476	-0.005	-0.45	-0.56	0.579	-0.801
	-0.33	-0.467	-0.434	-0.621	-0.983	-0.963	-1.138	-1.071
Controls1	Y	Y	Y	Y	Y	Y	Y	Y
Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Obs	1507	1465	1036	1004	1151	1118	810	789
R-squared	0.025	0.022	0.052	0.053	0.112	0.112	0.26	0.306

Appendix 3

Results supporting Table 4. Control variable set “Controls1” includes all financials with the exception of earnings per share. Control variable set “Controls2” includes emissions by scope.

	EARNINGS PER SHARE										
Climate risk disclosure	0.510	0.895**	0.738**					0.638**	0.674**	0.785**	0.812**
	(0.331)	(0.362)	(0.367)					(0.291)	(0.296)	(0.363)	(0.371)
Overall rating 1	-0.028**		-0.024*					-0.017*	-0.013	-0.020	-0.021
	(0.012)		(0.013)					(0.010)	(0.010)	(0.013)	(0.013)
Controversy score	-0.009		0.057					0.008	0.008	0.042	0.047
	(0.037)		(0.041)					(0.033)	(0.033)	(0.041)	(0.042)
ESG scope	-0.002		0.001					0.004	0.005	0.001	0.002
	(0.009)		(0.010)					(0.007)	(0.007)	(0.010)	(0.010)
Overall rating 2		-0.155	-0.268					-0.017	-0.054	-0.261	-0.281
		(0.161)	(0.170)					(0.132)	(0.134)	(0.169)	(0.176)
Environment score		-0.072	-0.089					-0.054	-0.064	-0.072	-0.073
		(0.091)	(0.094)					(0.074)	(0.074)	(0.092)	(0.094)
Climate change exposure score		0.293***	0.346***					0.273***	0.298***	0.394***	0.384***
		(0.083)	(0.086)					(0.061)	(0.061)	(0.084)	(0.091)
Scope 1 emissions				-0.158***			-0.125**	-0.061			0.009
				(0.043)			(0.063)	(0.044)			(0.078)
Scope 2 emissions					-0.211***		-0.021		-0.176**		-0.125
					(0.074)		(0.108)		(0.076)		(0.126)
Scope 3 emissions						-0.053	0.017			-0.051	-0.028
						(0.046)	(0.057)			(0.056)	(0.066)
Controls1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Controls2	Y	Y	Y	N	N	N	N	N	N	N	N
Constant	6.177***	2.887***	4.194***	6.012***	6.616***	4.667***	5.562***	3.619***	4.680***	3.962**	5.183***
	(1.250)	(0.795)	(1.540)	(0.539)	(0.900)	(0.576)	(1.025)	(1.261)	(1.437)	(1.622)	(1.931)
Fixed Effects	N	N	N	N	N	N	N	N	N	N	N
Observations	910	874	792	1,507	1,465	1,036	1,004	1,151	1,118	810	789
	0.073	0.087	0.106	0.026	0.022	0.049	0.051	0.077	0.081	0.101	0.098

Appendix 4

Results supporting Table 5. Control variable set “Controls1” includes all financials with the exception of leverage.

	LEVERAGE							
	L	M/S	L	M/S	L	M/S	L	M/S
Climate risk disclosure	0.174	-0.885***	0.492	-0.927***	-0.277	-0.906***	0.106	-0.907***
	(0.282)	(0.182)	(0.298)	(0.201)	(0.319)	(0.182)	(0.345)	(0.202)
Overall rating 1			-0.012	0.006			0.002	-0.001
			(0.009)	(0.008)			(0.010)	(0.008)
Controversy score			0.121***	-0.040			0.110**	-0.031
			(0.032)	(0.026)			(0.050)	(0.026)
ESG scope			0.034*	-0.015**			0.071***	-0.004
			(0.017)	(0.006)			(0.022)	(0.006)
Overall rating 2					0.194	0.293***	-0.076	0.277**
					(0.126)	(0.096)	(0.137)	(0.108)
Environment score					0.254***	-0.010	0.354***	-0.022
					(0.093)	(0.054)	(0.106)	(0.058)
Climate change exposure score					-0.004	0.038	-0.060	0.037
					(0.124)	(0.049)	(0.120)	(0.054)
Controls1	Y	Y	Y	Y	Y	Y	Y	Y
Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Constant	-0.669**	1.678***	-4.044**	3.195***	-3.368***	-0.586	-10.081***	0.351
	(0.304)	(0.181)	(1.871)	(0.861)	(1.239)	(0.486)	(2.577)	(0.976)
R-squared	0.644	0.071	0.723	0.090	0.682	0.309	0.760	0.313

Appendix 5

Results supporting Table 6. Control variable set “Controls1” includes all financials with the exception of leverage. Control variable set “Controls2” includes CO2 emissions across scopes 1 to 3.

LEVERAGE												
	Extractives & Minerals Processing				Infrastructure				Resource Transformation			
Climate risk disclosure	0.469	-0.495	-0.361	-1.202	-0.572***	-0.886***	-0.547**	-0.807***	-1.106***	-0.983***	-1.373***	-1.092***
	(0.544)	(0.837)	(0.728)	(1.315)	(0.207)	(0.226)	(0.253)	(0.266)	(0.265)	(0.338)	(0.349)	(0.401)
Overall rating 1		0.003		0.004		-0.026***		-0.029***		-0.016		-0.017
		(0.004)		(0.007)		(0.010)		(0.011)		(0.011)		(0.012)
Controversy score		0.157***		0.188**		-0.057		-0.063		-0.029		-0.064
		(0.057)		(0.087)		(0.039)		(0.039)		(0.035)		(0.043)
ESG scope		-0.013		-0.018		-0.009		-0.007		0.007		0.013
		(0.009)		(0.013)		(0.006)		(0.007)		(0.007)		(0.009)
Overall rating 2			-0.085	-0.127			-0.042	-0.022			-0.023	0.158
			(0.111)	(0.118)			(0.168)	(0.178)			(0.220)	(0.266)
Environment score			-0.027	0.077			0.198	0.219*			-0.069	-0.087
			(0.091)	(0.098)			(0.125)	(0.128)			(0.133)	(0.142)
Climate change exposure score			-0.022	-0.043			-0.000	0.003			0.069	0.052
			(0.033)	(0.038)			(0.085)	(0.085)			(0.101)	(0.112)
Controls1	-0.000	-0.000	0.000	-0.000	-0.000**	-0.000	-0.000	-0.000	0.000	0.000	-0.000	-0.000
Controls2	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-0.284	-0.060	1.235	1.202	1.498***	4.856***	0.056	3.023**	1.535***	2.104**	1.507**	0.958
	(0.569)	(1.216)	(0.990)	(2.270)	(0.267)	(1.046)	(0.906)	(1.396)	(0.318)	(0.988)	(0.697)	(1.357)
R-squared	0.705	0.836	0.753	0.877	0.623	0.652	0.635	0.671	0.610	0.598	0.676	0.685

Appendix 6

Results supporting Table 7. Control variable set “Controls1” include all financials, whereas “Controls2” include CO2 emissions across scopes 1 to 3.

RETURN								
	L	M/S	L	M/S	L	M/S	L	M/S
Climate risk disclosure	-0.082*	0.023	-0.112**	0.027	-0.082*	0.008	-0.114*	0.013
	(0.045)	(0.016)	(0.052)	(0.017)	(0.049)	(0.018)	(0.060)	(0.019)
Overall rating 1			0.004**	-0.001			0.003	-0.001
			(0.002)	(0.001)			(0.002)	(0.001)
Controversy score			0.002	0.002			0.001	0.004*
			(0.006)	(0.002)			(0.009)	(0.002)
ESG scope			-0.002	0.001			-0.003	0.000
			(0.003)	(0.001)			(0.004)	(0.001)
Overall rating 2					0.005	-0.014	0.003	-0.012
					(0.020)	(0.009)	(0.024)	(0.010)
Environment score					-0.018	-0.008	-0.021	-0.011**
					(0.015)	(0.005)	(0.020)	(0.005)
Climate change exposure score					0.001	-0.005	-0.001	-0.002
					(0.019)	(0.005)	(0.021)	(0.005)
Controls1	0.000	0.000	-0.000	0.000	0.000	0.000	-0.000	0.000
Controls2	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-0.019	-0.075***	-0.075	-0.120	0.037	0.076	0.253	0.028
	(0.049)	(0.017)	(0.327)	(0.073)	(0.198)	(0.048)	(0.486)	(0.089)

Appendix 7

Results supporting Table 8. Control variable set “Controls1” include all financials, whereas “ControlsTH” include all six theme indicators identified via the unsupervised approach to topic detection introduced in Ping An Digital Economic Research Center (2020). “ControlsSC1” to “ControlsSC3” include log-emissions by scope 1 to 3.

Return on Invested Capital (ROIC)																	
Overall rating 1								-0.001		0.000	-0.001		0.000	0.001		0.001	0.000
								-0.001		-0.002	-0.001		-0.002	-0.002		-0.002	-0.002
Overall rating 2									-0.011	-0.013		-0.015	-0.018		-0.018	-0.022	
									-0.033	-0.035		-0.034	-0.036		-0.041	-0.043	
Environment score									0.004	0.002		0.006	0.003		0.009	0.007	
									-0.019	-0.021		-0.018	-0.021		-0.021	-0.023	
Climate change exposure score									0.007	0.007		0.007	0.008		0.006	0.009	
									-0.007	-0.007		-0.007	-0.007		-0.008	-0.008	
Emissions	-4.757					1.390	3.523	2.424	9.767	14.640	5.295	8.323	13.573	12.491	9.789	14.147	10.967
	-4.029					-11.109	-11.421	-14.520	-9.677	-13.541	-14.472	-10.131	-14.298	-13.795	-8.953	-13.153	-13.887
Energy use	4.722					-1.576	-3.884	-2.641	-11.093	-16.535	-5.787	-9.445	-15.315	-14.170	-11.055	-15.978	-12.514
	-4.038					-12.194	-12.533	-15.918	-10.640	-14.876	-15.868	-11.154	-15.728	-15.159	-9.852	-14.45	-15.257
Water use	0.047					0.113*	0.115*	0.090	0.040	0.014	0.093	0.033	0.011	0.059	0.012	-0.02	0.053
	-0.059					-0.066	-0.064	-0.075	-0.067	-0.073	-0.077	-0.076	-0.079	-0.082	-0.076	-0.077	-0.082
Asset location	0.051	0.093				0.130	0.144	0.178	-0.109*	-0.085	0.169	-0.141*	-0.111	0.232	-0.081	-0.052	0.238
	-0.146	-0.150				-0.189	-0.184	-0.187	-0.065	-0.067	-0.196	-0.072	-0.074	-0.196	-0.069	-0.069	-0.188
Revenues		0.026				0.023	0.023	0.014	0.120	0.113	0.009	0.106	0.105	0.044	0.11	0.104	0.064
		-0.061				-0.077	-0.083	-0.092	-0.081	-0.085	-0.096	-0.084	-0.087	-0.095	-0.098	-0.099	-0.093
Expenditures		-0.047				-0.018	0.169	0.041	0.460	0.837	0.321	0.380	0.777	0.586	0.539	0.81	0.374
		-0.070				-1.105	-1.144	-1.429	-0.944	-1.237	-1.430	-0.970	-1.288	-1.320	-0.893	-1.188	-1.326
Assets & Liabilities		-0.015				-0.021	-0.012	0.036	-0.012	0.066	0.052	-0.025	0.056	0.082	-0.011	0.068	0.074
		-0.066				-0.080	-0.078	-0.117	-0.057	-0.107	-0.115	-0.063	-0.114	-0.106	-0.058	-0.112	-0.112
Capital & Financing		2.850***				3.151	3.667	3.424	6.469**	8.290**	4.155	5.822**	7.816**	7.997**	6.424***	8.351**	7.766**
		-0.467				-2.743	-2.821	-3.571	-2.588	-3.532	-3.561	-2.783	-3.821	-3.581	-2.368	-3.461	-3.603
Scope 1 emission (AI indicator)			0.105			-0.220	-0.208	-0.240	-0.012	-0.053	-0.251	-0.025	-0.067	-0.398	-0.027	-0.083	-0.421
			-0.132			-0.253	-0.245	-0.248	-0.110	-0.120	-0.261	-0.124	-0.132	-0.309	-0.171	-0.181	-0.296
Scope 2 emission (AI indicator)			0.033			0.290	0.261	0.264	0.024	0.060	0.295	0.028	0.070	0.422	0.059	0.109	0.421
			-0.094			-0.263	-0.254	-0.257	-0.088	-0.102	-0.270	-0.103	-0.114	-0.281	-0.119	-0.124	-0.265
Scope 3 emission (AI indicator)			0.138			0.040	0.054	0.061	-0.042	-0.074	0.052	-0.026	-0.066	-0.091	-0.111	-0.157*	-0.089
			-0.107			-0.115	-0.117	-0.149	-0.065	-0.082	-0.154	-0.070	-0.088	-0.137	-0.071	-0.088	-0.133
Target setting			-0.180**			0.027	0.012	0.004	0.783***	0.967***	-0.030	0.687***	0.887**	0.964*	0.658*	0.955**	1.068*
			-0.081			-0.143	-0.147	-0.204	-0.254	-0.363	-0.206	-0.260	-0.356	-0.513	-0.39	-0.473	-0.551
Composite climate indicator				-0.018	-0.020												
				-0.055	-0.046												
Composite financial impact indicator				-0.434*	-0.424												
				-0.229	-0.267												
Controls1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Controls TH	N	N	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Controls SC1	N	N	N	N	N	N	N	Y	Y	Y	N	N	N	N	N	N	Y
Controls SC2	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	N	N	N	Y
Controls SC3	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y
Constant	0.158***	0.161***	0.160***	-10.383**	-10.383**	0.164***	-3.433	-4.53	-4.578	-6.549	-4.545	-4.487	-6.454	-6.664	-4.311	-7.346	-6.769
	-0.022	-0.021	-0.022	-4.856	-4.856	-0.022	-3.515	-4.072	-4.851	-5.231	-3.851	-4.888	-5.318	-4.441	-5.299	-5.727	-4.933
R-squared	0.153	0.18	0.149	0.351	0.351	0.19	0.203	0.234	0.252	0.269	0.228	0.252	0.268	0.246	0.252	0.281	0.254

RETURN																	
Scope 1 emissions	0.004*							-0.002	-0.004	-0.005				0.002	0.001	-0.000	
	(0.002)							(0.006)	(0.007)	(0.008)				(0.010)	(0.011)	(0.012)	
Scope 2 emissions		0.009***									-0.007	-0.020*	-0.023*	-0.034**	-0.038**	-0.039**	
		(0.003)									(0.010)	(0.011)	(0.012)	(0.014)	(0.015)	(0.016)	
Scope 3 emissions			-0.000											0.005	0.010	0.008	
			(0.003)											(0.009)	(0.009)	(0.011)	
Overall rating 1								0.000		0.001	0.001		0.001	0.001		0.002	
								(0.002)		(0.002)	(0.002)		(0.002)	(0.002)		(0.002)	
Overall rating 2									0.008	0.007		0.014	0.009		0.019	0.022	
									(0.024)	(0.026)		(0.024)	(0.025)		(0.025)	(0.027)	
Environment score									0.009	0.010		0.012	0.014		0.025*	0.025	
									(0.013)	(0.015)		(0.013)	(0.015)		(0.014)	(0.017)	
Climate change exposure score									-0.017	-0.020*		-0.017	-0.021*		-0.021*	-0.021*	
									(0.011)	(0.011)		(0.011)	(0.011)		(0.011)	(0.012)	
General emissions				4.583**			35.363**	40.926***	50.482***	51.708***	40.877***	46.377***	48.246***	41.367***	46.023***	50.642***	
				(2.298)			(14.219)	(14.434)	(13.460)	(15.329)	(14.086)	(13.738)	(16.096)	(13.132)	(14.024)	(16.701)	
Energy use				-4.227*			-37.645**	-43.879***	-54.468***	-55.890***	-43.826***	-49.830***	-52.000***	-44.160***	-49.326***	-54.576***	
				(2.329)			(15.619)	(15.838)	(14.789)	(16.825)	(15.455)	(15.104)	(17.669)	(14.395)	(15.524)	(18.441)	
Water use				-0.147			-0.043	-0.104	-0.010	-0.020	-0.100	-0.034	-0.039	0.018	0.166	0.173	
				(0.111)			(0.152)	(0.143)	(0.216)	(0.221)	(0.143)	(0.220)	(0.228)	(0.118)	(0.166)	(0.175)	
Land use				0.642***			4.047***	4.862***	5.800***	5.861***	4.884***	5.487***	5.631***				
				(0.120)			(1.526)	(1.629)	(1.627)	(1.846)	(1.577)	(1.628)	(1.913)				
Asset location				-0.124			-0.035	-0.054	-0.023	-0.008	-0.058	-0.064	-0.054	-0.020	0.074	0.079	
				(0.117)			(0.136)	(0.128)	(0.178)	(0.179)	(0.130)	(0.187)	(0.191)	(0.128)	(0.184)	(0.191)	
Revenues							-0.007	0.016	-0.028	-0.029	0.008	-0.038	-0.046	-0.042	-0.052	-0.060	
							(0.081)	(0.083)	(0.073)	(0.082)	(0.083)	(0.071)	(0.083)	(0.097)	(0.098)	(0.118)	
Expenditures							2.789**	3.483**	4.218***	4.296***	3.496***	3.902***	4.050**	3.592***	3.751***	4.055***	
							(1.311)	(1.369)	(1.328)	(1.500)	(1.330)	(1.340)	(1.566)	(1.280)	(1.230)	(1.481)	
Assets & Liabilities							0.012	0.047	0.054	0.069	0.038	0.015	0.033	-0.040	-0.126	-0.106	
							(0.090)	(0.108)	(0.144)	(0.158)	(0.108)	(0.145)	(0.161)	(0.101)	(0.096)	(0.125)	
Capital & Financing							8.034**	9.351**	11.991***	12.532***	9.258***	10.419***	11.158**	8.943**	10.137**	11.785**	
							(3.588)	(3.627)	(3.756)	(4.231)	(3.547)	(3.874)	(4.443)	(3.585)	(4.288)	(4.968)	
Scope 1 emissions (AI indicator)					-0.393***		-0.131	-0.064	-0.016	-0.036	-0.071	-0.029	-0.048	-0.128	-0.134	-0.130	
					(0.126)		(0.180)	(0.171)	(0.231)	(0.232)	(0.172)	(0.244)	(0.247)	(0.246)	(0.335)	(0.342)	
Scope 2 emissions (AI indicator)					0.509***		0.413	0.385	0.465*	0.477*	0.383	0.428	0.449	0.414	0.472	0.502	
					(0.125)		(0.278)	(0.245)	(0.276)	(0.275)	(0.247)	(0.296)	(0.299)	(0.259)	(0.340)	(0.349)	
Scope 3 emissions (AI indicator)					-0.262*		-0.298	-0.359*	-0.411**	-0.432**	-0.358*	-0.366**	-0.398**	-0.285	-0.311*	-0.366*	
					(0.143)		(0.207)	(0.191)	(0.166)	(0.170)	(0.192)	(0.175)	(0.180)	(0.184)	(0.175)	(0.189)	
Target setting					0.301***		-0.323**	-0.307	-0.116	0.017	-0.302	-0.246	-0.082	-0.575	-0.299	0.022	
					(0.111)		(0.155)	(0.191)	(0.763)	(0.811)	(0.185)	(0.764)	(0.818)	(0.821)	(0.859)	(0.916)	
Composite climate indicator						0.135***											
						(0.040)											
Composite financial impact indicator						-0.858***											
						(0.250)											
Controls1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
ControlsTH	N	N	N	N	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	
Constant	-0.084***	-0.144***	-0.051	-0.035	-0.030	5.633	-0.032	-2.159	3.242	2.852	-1.610	2.816	2.834	-1.956	0.610	1.393	
	(0.026)	(0.042)	(0.032)	(0.026)	(0.027)	(7.734)	(0.027)	(4.635)	(4.607)	(4.844)	(4.500)	(4.519)	(4.701)	(5.215)	(4.922)	(5.120)	

	WACC							
Scope 1 emissions		-0.001			-0.001	-0.002	-0.002	-0.002
		-0.002			-0.002	-0.002	-0.002	-0.002
Scope 2 emissions			0.002		0.000	0.001	0.001	0.001
			-0.003		-0.005	-0.004	-0.004	-0.004
Scope 3 emissions				0.000	0.001	0.001	0.001	0.000
				-0.002	-0.002	-0.002	-0.002	-0.002
Overall rating 1		0.000	-0.001	0.000	0.000	0.000	0.000	0.000
		0.000	0.000	0.000	-0.001	0.000	0.000	0.000
Overall rating 2		0.001	0.002	0.004	0.002	-0.003	-0.003	-0.002
		-0.005	-0.004	-0.004	-0.006	-0.004	-0.004	-0.005
Environment score		0.002	0.002	0.003	0.003	0.002	0.002	0.002
		-0.002	-0.002	-0.002	-0.003	-0.002	-0.002	-0.002
Climate change exposure score		-0.004**	-0.004**	-0.004*	-0.005*	-0.004*	-0.004*	-0.004*
		-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
General emissions		0.038**	0.033**	0.041**	0.041*			
		-0.017	-0.016	-0.018	-0.023			
Asset location		-0.005	-0.001	0.037	0.036			
		-0.024	-0.021	-0.024	-0.034			
Revenue		0.049*	0.067***	-	-			
		-0.025	-0.021					
Expenditure		-0.070*	-0.088**	-0.073***	-0.070**			
		-0.041	-0.033	-0.022	-0.027			
Composite climate indicator	0.008**	0.025**	0.024*	-0.011	-0.012	-0.002		-0.007
	-0.003	-0.011	-0.013	-0.010	-0.011	-0.002		-0.010
Composite financial impact indicator	-0.035*	-0.114***	-0.109**	0.084	0.091		-0.008	0.050
	-0.020	-0.038	-0.043	-0.079	-0.094		-0.020	-0.078
Controls1	Y	Y	Y	Y	Y	Y	Y	Y
ControlsTH	Y	Y	Y	Y	Y	Y	Y	Y
Constant	-0.670	-0.526	-0.526	-0.291	-0.378	-0.089	-0.106	-0.075
	-0.586	-0.871	-0.766	-0.838	-0.936	-0.834	-0.827	-0.833
R2	0.244	0.573	0.581	0.484	0.526	0.456	0.453	0.461

About Ping An Group

Ping An Insurance (Group) Company of China, Ltd. ("Ping An") is a world-leading technology-powered retail financial services group. With over 214 million retail customers and nearly 579 million Internet users, Ping An is one of the largest financial services companies in the world.

Ping An has two over-arching strategies, "pan financial assets" and "pan health care", which focus on the provision of financial and health care services through our integrated financial services platform and ecosystems. Our "finance + technology" and "finance + ecosystem" strategies aim to provide customers and internet users with innovative and simple products and services using technology. As China's first joint stock insurance company, Ping An is committed to upholding the highest standards of corporate reporting and corporate governance. The Group is listed on the stock exchanges in Hong Kong and Shanghai.

In 2020, Ping An ranked 7th in the Forbes Global 2000 list and ranked 21st in the Fortune Global 500 list. Ping An also ranked 38th in the 2020 WPP Kantar Millward Brown BrandZ™ Top 100 Most Valuable Global Brands list. For more information, please visit group.pingan.com.

About Ping An Digital Economic Research Center

Ping An Digital Economic Research Center utilizes more than 50 TB high frequency data points, more than 30 years of historical data and more than 1.5 billion data points to drive research on the "AI + Macro Forecast" and provide insights and methods towards precise macroeconomic trends.

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