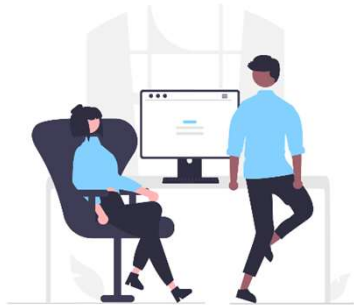
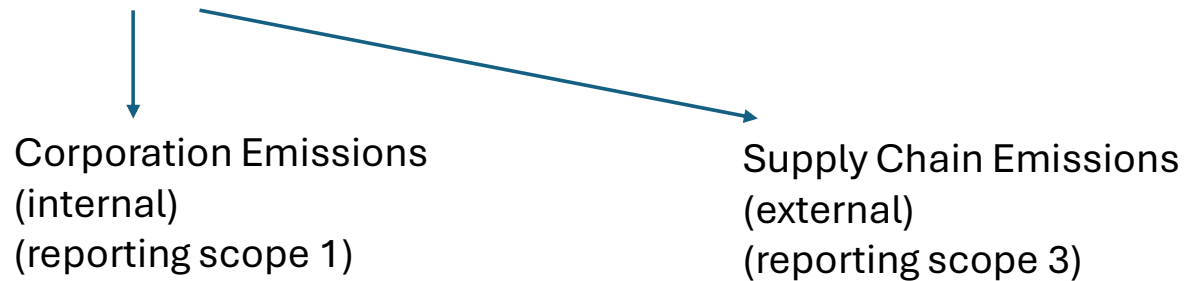


Supply Chain Carbon Footprinting and Climate Change Disclosures of Global Firms

Week 2 (11/13): Sustainable Supply Chains

Summary: Research Question

**CDP (formerly the Carbon Disclosure Project) – 2,003 firms worldwide
climate impact reporting**



Summary: Research Question

Research Question

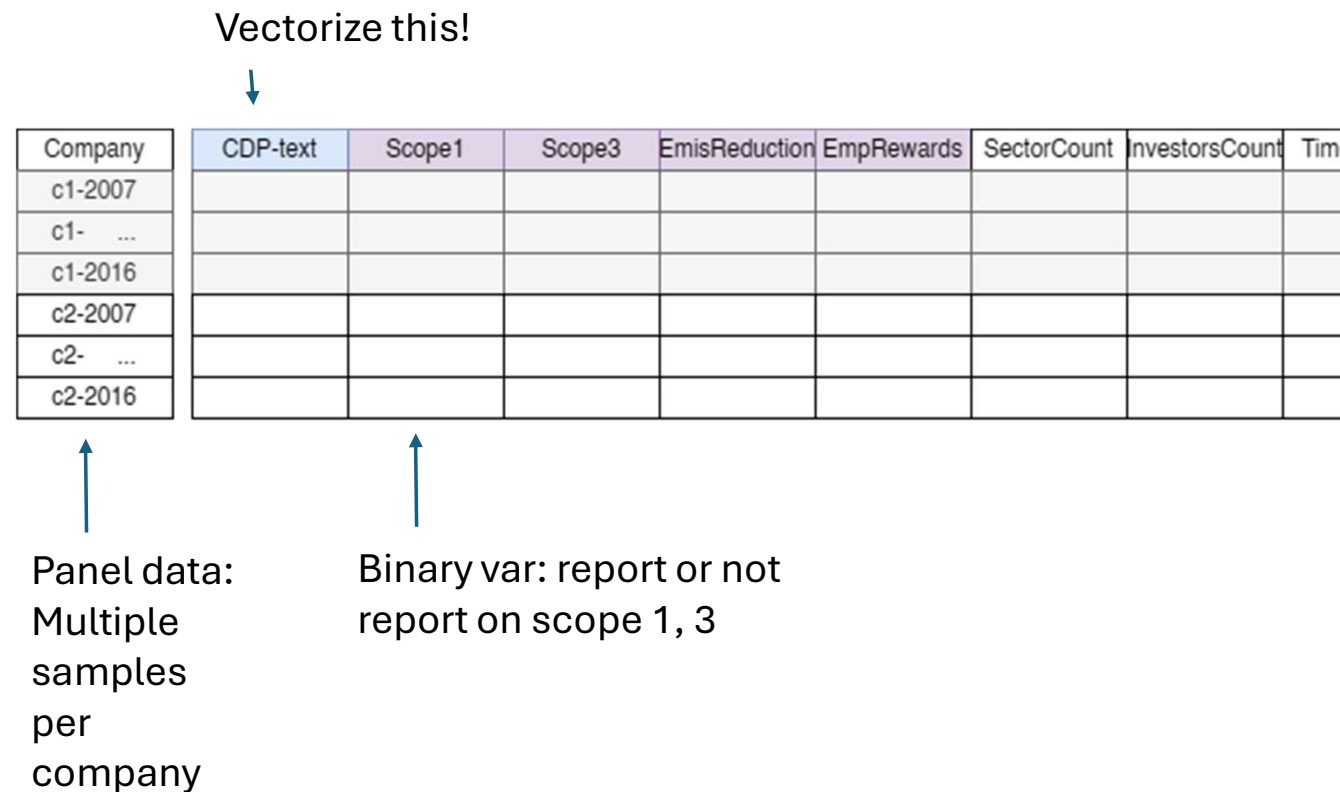
- *Does carbon footprint influence the nature and content of a firms disclosure on the climate change risks that are expected to affect it's business?*

What does it mean?

- *Carbon footprint = scope1, 3*
- *Nature and context of a firms disclosure... = Word distribution of CDP report. (what word pairs and how frequently mentioned)*
- *Simply: How does scope1 and 3, impact the word distribution of the CDP report?*

Summary: Methodology – Data

- Suppose we have a data-set looking something like this
- The CDP report is a long text of words, how do we measure how it changes, depending on if we report on scope 1 and 3?
- We need to make it a vector over what words are in the text and how frequently.
- Instead of just words we look at Bigrams for more context



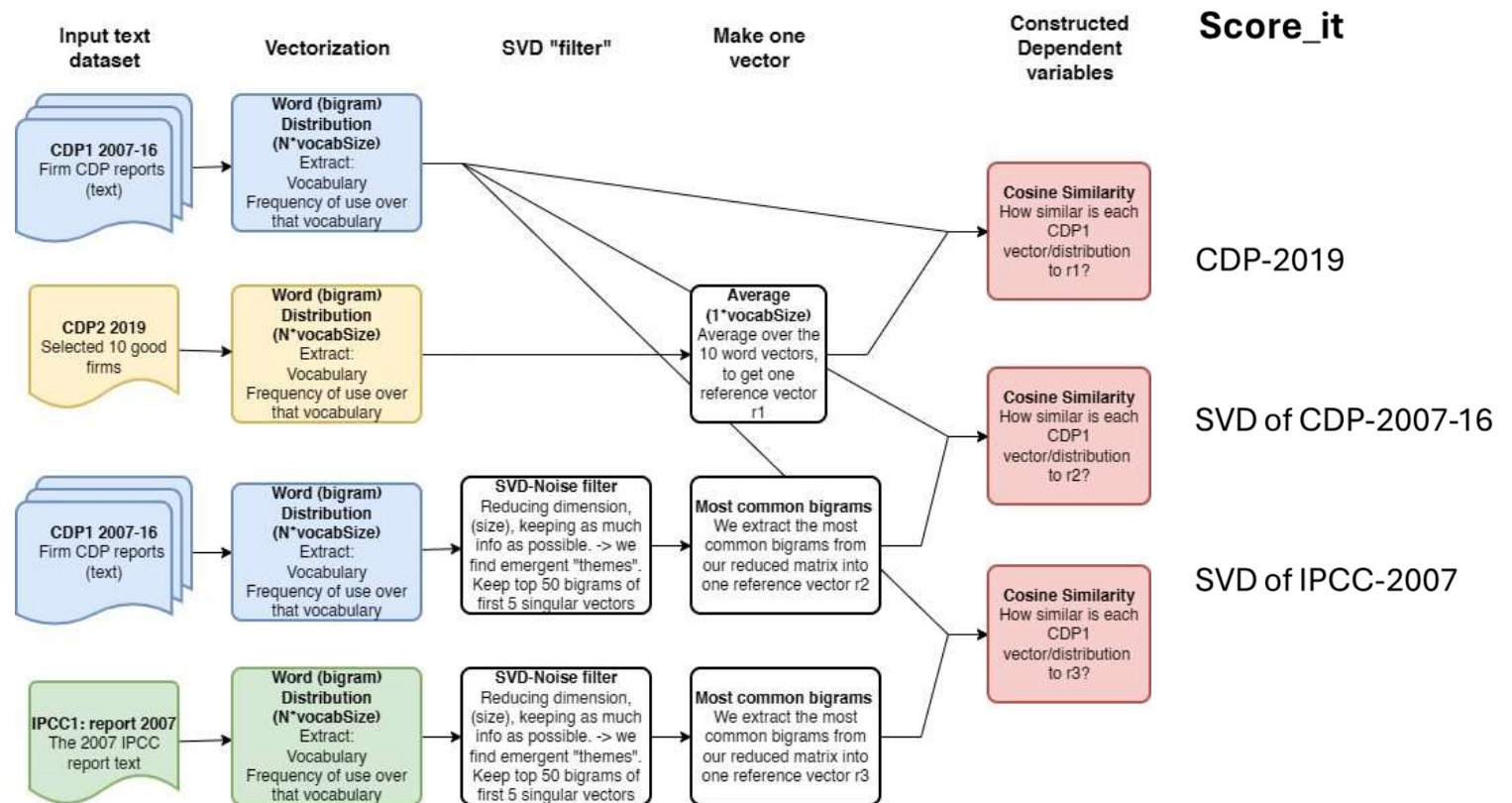
Summary: Methodology – 3 Dependent var

Compare against
(all companies CDP
vectors)

10 "good" companies
2019 (year exogenous)

Emergent themes from
SVD on CDP

Emergent themes
From SVD on IPCC



Summary: Method-Model: Fixed Effects

$$\begin{aligned}
 \text{Score}_{i,t} = & \alpha_i \\
 & + \beta_1 \cdot \text{Scope 1}_{i,t} \\
 & + \beta_2 \cdot \text{Scope 3}_{i,t} \\
 & + \beta_3 \cdot \text{Employee rewards}_{i,t} \\
 & + \beta_4 \cdot \text{Emissions reduction}_{i,t} \\
 & + \beta_5 \cdot \text{Sector count}_{i,t} \\
 & + \beta_6 \cdot \text{Investor count}_{i,t} \\
 & + \beta_7 \cdot \text{Times responded}_{i,t} \\
 & + \Omega_{i,t} \\
 & + \epsilon_{i,t}
 \end{aligned}$$

| Company | CDP-text | Scope1 | Scope3 | EmisReduction | EmpRewards | SectorCount | InvestorsCount | TimesResp |
|---------|----------|--------|--------|---------------|------------|-------------|----------------|-----------|
| c1-2007 | | | | | | | | |
| c1- ... | | | | | | | | |
| c1-2016 | | | | | | | | |
| c2-2007 | | | | | | | | |
| c2- ... | | | | | | | | |
| c2-2016 | | | | | | | | |

| Company | r1-CDP2019 | Scope1 | Scope3 | EmisReduction | EmpRewards | SectorCount | InvestorsCount | TimesResp |
|---------|------------|--------|--------|---------------|------------|-------------|----------------|-----------|
| c1-2007 | | | | | | | | |
| c1- ... | | | | | | | | |
| c1-2016 | | | | | | | | |
| c2-2007 | | | | | | | | |
| c2- ... | | | | | | | | |
| c2-2016 | | | | | | | | |

| Company | r2-SVDCDP | Scope1 | Scope3 | EmisReduction | EmpRewards | SectorCount | InvestorsCount | TimesResp |
|---------|-----------|--------|--------|---------------|------------|-------------|----------------|-----------|
| Company | | | | | | | | |

| Company | r2-SVDIPCC | Scope1 | Scope3 | EmisReduction | EmpRewards | SectorCount | InvestorsCount | TimesResp |
|---------|------------|--------|--------|---------------|------------|-------------|----------------|-----------|
| Company | | | | | | | | |

| Company | r1-CDP2019 | Scope1 | Scope3 | EmisReduction | EmpRewards | SectorCount | InvestorsCount | TimesResp |
|---------------|------------|--------|--------|---------------|------------|-------------|----------------|-----------|
| c1_07-mean1 | | | | | | | | |
| c1_ ...-mean1 | | | | | | | | |
| c1_16-mean1 | | | | | | | | |
| c2_07-mean2 | | | | | | | | |
| c2_ ...-mean2 | | | | | | | | |
| c2_16-mean2 | | | | | | | | |

$$\begin{aligned}
 (\text{Score}_{i,t} - \bar{\text{Score}}_i) = & \beta_1 \cdot (\text{Scope 1}_{i,t} - \bar{\text{Scope 1}}_i) \\
 & + \beta_2 \cdot (\text{Scope 3}_{i,t} - \bar{\text{Scope 3}}_i) \\
 & + \beta_3 \cdot (\text{Employee rewards}_{i,t} - \bar{\text{Employee rewards}}_i) \\
 & + \beta_4 \cdot (\text{Emissions reduction}_{i,t} - \bar{\text{Emissions reduction}}_i) \\
 & + \beta_5 \cdot (\text{Sector count}_{i,t} - \bar{\text{Sector count}}_i) \\
 & + \beta_6 \cdot (\text{Investor count}_{i,t} - \bar{\text{Investor count}}_i) \\
 & + \beta_7 \cdot (\text{Times responded}_{i,t} - \bar{\text{Times responded}}_i) \\
 & + (\Omega_{i,t} - \bar{\Omega}_i) \\
 & + (\epsilon_{i,t} - \bar{\epsilon}_i)
 \end{aligned}$$

$$\alpha_i - \bar{\alpha}_i = \alpha_i - \alpha_i = 0.$$

Summary-Result

Alpha=1-95=0.05

All values significant

Both scope 1 and 3

Are highly significant std err

0.005 and 0.003 respectively,

Beta Scope 1 0.003 is much smaller than scope 3; 0.020 for CDP 2019

They also do robustness checks with lagged variables (dynamic completeness) and instruments (AR), but these does not significantly change the main conclusion, that scope 1,3 is significant and that scope3 is larger

If we ignore companies Not with data for all years

Table 3 Regression Results of the Similarity Scores and Carbon Footprinting

| | Dependent variable: Similarity distance of disclosure to reference text | | | | | |
|-----------------------------|---|-----------------------------|-------------------------|----------------------|-----------------------------|-------------------------|
| | Unbalanced sample | | | Balanced sample | | |
| | CDP 2019 (1) | SVD of CDP 2007-2016 (2) | SVD of IPCC 2007 (3) | CDP 2019 (4) | SVD of CDP 2007-2016 (5) | SVD of IPCC 2007 (6) |
| Scope 1 | 0.003 (0.005) | 0.002 (0.006) | 0.002 (0.003) | -0.003 (0.008) | -0.011 (0.009) | -0.001 (0.005) |
| Scope 3 | 0.020*** (0.003) | 0.028*** (0.004) | 0.013*** (0.002) | 0.016*** (0.006) | 0.022*** (0.006) | 0.015*** (0.004) |
| Employee rewards | 0.015*** (0.003) | 0.024*** (0.003) | 0.010*** (0.002) | 0.016*** (0.006) | 0.022*** (0.006) | 0.011*** (0.003) |
| Emissions reduction | 0.005** (0.002) | 0.013*** (0.002) | 0.005*** (0.001) | 0.004 (0.004) | 0.007 (0.005) | 0.002 (0.003) |
| Sector count [†] | -0.019*** (0.006) | -0.008 (0.007) | -0.001 (0.004) | -0.033*** (0.010) | -0.022* (0.011) | -0.007 (0.006) |
| Investor count [†] | -0.016** (0.007) | -0.019** (0.008) | -0.011** (0.005) | -0.021* (0.011) | -0.033** (0.014) | -0.027*** (0.008) |
| Liabilities/Assets | -0.009 (0.006) | -0.004 (0.004) | -0.001 (0.003) | -0.029 (0.026) | 0.017 (0.028) | 0.029 (0.020) |
| Firm size | 0.006 (0.004) | 0.000 (0.006) | 0.003 (0.003) | 0.003 (0.008) | -0.001 (0.012) | 0.012** (0.006) |
| RoA | 0.001** (0.000) | 0.000 (0.000) | 0.001*** (0.000) | -0.003 (0.021) | -0.052* (0.031) | -0.016 (0.013) |
| Tangibility | -0.000 (0.000) | -0.000 (0.000) | -0.000 (0.000) | 0.000 (0.000) | 0.000* (0.000) | 0.000* (0.000) |
| Leverage | -0.000 (0.000) | -0.000 (0.000) | 0.000 (0.000) | -0.000 (0.000) | -0.000** (0.000) | -0.000 (0.000) |
| Times responded | 0.004 (0.003) | 0.010*** (0.003) | 0.001 (0.002) | - | - | - |
| Firm fixed effects | Included | Included | Included | Included | Included | Included |
| Year fixed effects | Included | Included | Included | Included | Included | Included |
| Observations | 10,925 | 10,925 | 10,925 | 2,850 | 2,850 | 2,850 |
| R ² | 0.821 | 0.866 | 0.825 | 0.736 | 0.806 | 0.663 |
| Adjusted R ² | 0.780 | 0.835 | 0.785 | 0.704 | 0.783 | 0.623 |

Notes: *p < 0.1; **p < 0.05; ***p < 0.01. Robust standard errors are in parentheses. We do not include the number of times firms respond for the balanced sample because that number is a constant. [†]This is per 100 sector or investor counts.

Summary-Result Conclude

Simply: How does scope1 and 3, impact the word distribution of the CDP report?

- Carbon emissions, scope1 is highly significant for word distributions r1,r2,r3 but has small impact
- Scope 3 is also highly significant and has a much larger impact on the word distributions r1,r2,r3.

Does carbon footprint influence the nature and content of a firms disclosure on the climate change risks that are expected to affect it's business?

- Yes, we see significant standard errors in all models for scope 1,3.
- When a company start reporting on scope 3, it significantly impacts the content of the report. Making them f.ex more like good 2019 reports (r1) in word bigram distribution.

Key Trade-off

- **Quantitative significance vs Qualitative meaning:** We ignore the literal meaning of the reports, and reduce them to word distributions, in order to fit it to our statistical method. (which is the main smart innovative idea of the paper)
- **Pro:** The large CDP dataset is great for statistical analysis, the selected method helps us achieve that
- **Con:** We lose the rich qualitative data from the reports. In cosine similarity the vectors [no,climate,adaptation] and [great,climate,adaptation] are going to be very similar, despite opposite meaning.


Pros and Cons (Strength and Weakness)



- **Original empirical contribution:**

Large-scale longitudinal dataset and first to link operational measurement with disclosure change

- **Methodological rigor:** Integration of test analytics with econometrics
- **Substantive relevance:** Demonstrates that measuring emissions enhances corporate learning and transparency
- **Cross-disciplinary value:** Extends OM research towards sustainability disclosure

- 
- **Causality:** Potential self-selection bias; proactive firms are more likely to measure Scope 3
 - **Sample composition:** CDP* firms are large, listed and sustainability-oriented companies → limited generalizability
 - **Mechanistic opacity:** Internal change not directly observed
 - **Outcome boundary:** No link to emission reduction or financial outcomes
 - **Temporal scope:** Data ends 2016 before TCFD** and net-zero initiatives

* Carbon Disclosure Project ** Task Force on Climate-related Financial Disclosures

Implications/ Managerial Insights

- **Measure to manage:** Firms must quantify Scope 3 to understand true exposure
- **Supply-chain engagement:** Carbon data enable collaboration and risk control
- **Disclosure as capability:** Transparency strengthens investor relations
- **Learning process:** Climate maturity develops over time, not instantly
- **Policy relevance:** Voluntary reporting can advance sustainability beyond regulation

Scholarly Significance

- Measurement reshapes organizational cognition and disclosure
- Carbon footprinting as an operational lever for corporate accountability
- OM field's focus on rigor and relevance in addressing global challenges

Improvement Idea

- Identify causal effects via regulatory or policy shocks
- Extend dataset beyond 2016 (Paris Agreement, TCFD)
- Link disclosure evolution to real decarbonization or valuation outcomes
- Compare across sectors and supply-chain structures
- Study digital tools (AI, blockchain) for efficient Scope 3 tracking
- Combine econometrics with case studies to explore learning mechanisms

Conclusion

- Measuring supply-chain emissions transforms how firms perceive and report climate risks
- Scope 3 serves as a catalyst for transparency and strategic adaption
- Operational measurement precedes strategic awareness
- Sustainability becomes a central, data-driven component of modern OM