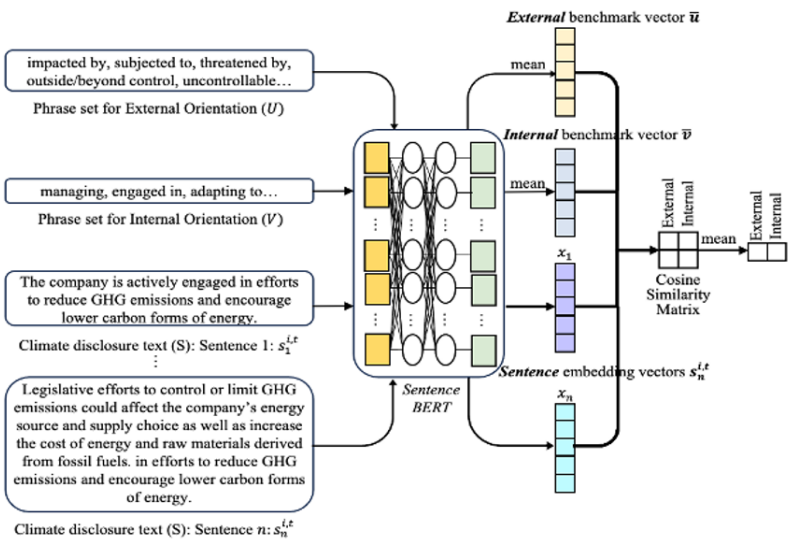
Language-based Measure of External/Internal Orientation: An Overview

Left Pane: Methodological Framework for Orientation Measurement
Right Pane: Illustrative Examples of Internal and External Orientation
Bottom: Formal Representation of Semantic Orientation Calculation



Sentence 1: **The company** is actively engaged in efforts to reduce GHG emissions and encourage lower carbon forms of energy.

internal: 0.19, external: 0.12

Sentence 2: **Legislative efforts** to control or limit GHG emissions could affect the company's energy source and supply choice as well as increase the cost of energy and raw materials derived from fossil fuels.

internal: 0.18, external: 0.24

internal: 0.185
external: 0.18

Climate risk disclosure often includes a mix of elements indicating internal and external orientation. Our language-based measure leverages sentence BERT's capability to represent the meaning of the sentence as a whole to better capture each sentence's overall orientation score. We first assess the internal and external scores of each sentence, take an average, and then calculate the overall internal orientation relative to the external orientation.

For instance, in sentence 1, the phrase "actively engaged in efforts to reduce" indicates an internal locus of control, while "lower carbon forms of energy" implies something beyond the company's control. Overall, sentence BERT gives a higher internal score because the emphasis of the sentence is more internal.

In sentence 2, the phrases "legislative efforts" and "the cost of energy" are beyond the company's control, while "energy source and supply choice" is more within management's control. Sentence BERT gives a higher external score because the sentence's overall emphasis is more external due to the phrase "legislative efforts" at the beginning.

When a company's climate risk disclosure has an equal number of sentences like sentence 1 and sentence 2, the overall orientation will be neutral. If there are more sentences like sentence 1, the overall orientation will be internal, and if there are more sentences like sentence 2, the overall orientation will be external.

Let $U = \{u_m\}_1^{|U|}$ and $V = \{v_k\}_1^{|V|}$ be the internal and external orientation related phrase sets, the internal embeddings $\bar{u}$ and external embeddings $\bar{v}$ can be computed by:

$\bar{u} = \frac{1}{|U|}\sum_{m=1}^{|U|} \text{BERT}(u_m)$, $\bar{v} = \frac{1}{|V|}\sum_{k=1}^{|V|} \text{BERT}(v_k)$.

Similarly, let $S^{i,t} = \{\hat{s}_n^{i,t}\}_1^N$ be the sentences of company i in year t where N is the number of sentences, the n-th sentence embeddings is $s_n^{i,t} = \text{BERT}(\hat{s}_n^{i,t}), \forall n \in \{1, \dots, N\}$.

Hence, the cosine similarity between company i in year t and internal/external embeddings are:

$$\text{Internal orientation} = \cos(\theta_1) = \frac{1}{N}\sum_{n\in N} \frac{s_n^{i,t}\cdot\bar{u}}{||s_n^{i,t}||\cdot||\bar{u}||} \qquad \text{External orientation} = \cos(\theta_2) = \frac{1}{N}\sum_{n\in N} \frac{s_n^{i,t}\cdot\bar{v}}{||s_n^{i,t}||\cdot||\bar{v}||}$$

Then, the difference (overall internal orientation) is defined as:

$$\text{Overall internal orientation} = d\big(\cos(\theta_1), \cos(\theta_2)\big) = \frac{1}{N}\sum_{n\in N} \frac{s_n^{i,t}\cdot\bar{u}}{||s_n^{i,t}||\cdot||\bar{u}||} - \frac{s_n^{i,t}\cdot\bar{v}}{||s_n^{i,t}||\cdot||\bar{v}||}$$