Topic correlation networks inferred from open-ended responses reveal signatures of ideology behind carbon tax opinion

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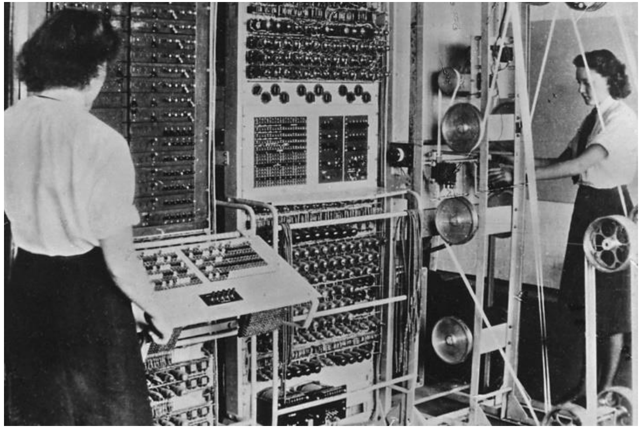
Stewardship of the Transition Zeitgeist

detect, *track*, and *intervene* on natural & engineered trends

Bletchley Park, 1941



Effectors (platform design, embedded agents, comms, etc.) supported by *social analytics*

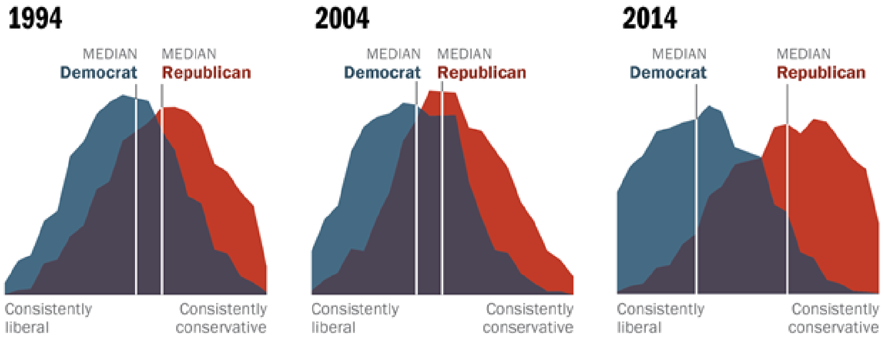
Stewarding transition policy

Policy development process:

iterate

- design policy
- deploy policy
- measure & analyze effectiveness
  – Public opinion: What do people think about it?
- …

Backdrop: Polarization



<u>Today's topic:</u>

Public opinion of carbon pricing in Canada

A case study in ideology-driven policy opinions

⟺

The ‘price on pollution’/‘carbon tax’

- In Canada:

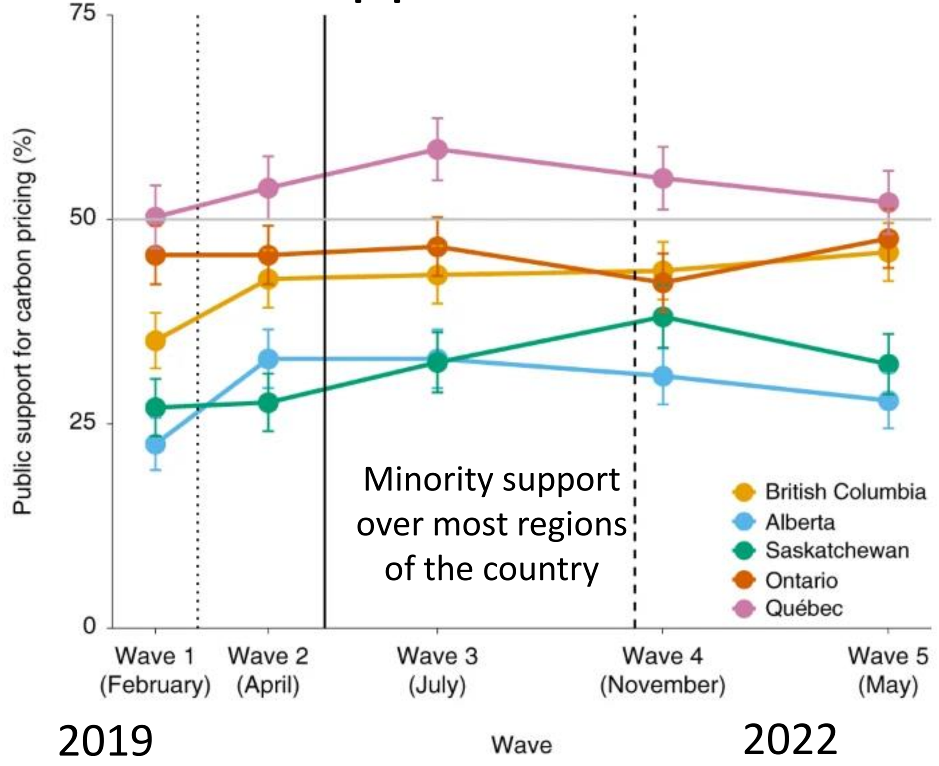
Polluters pay:
$20/ton 2019
$50/ton 2022
$170/ton 2030

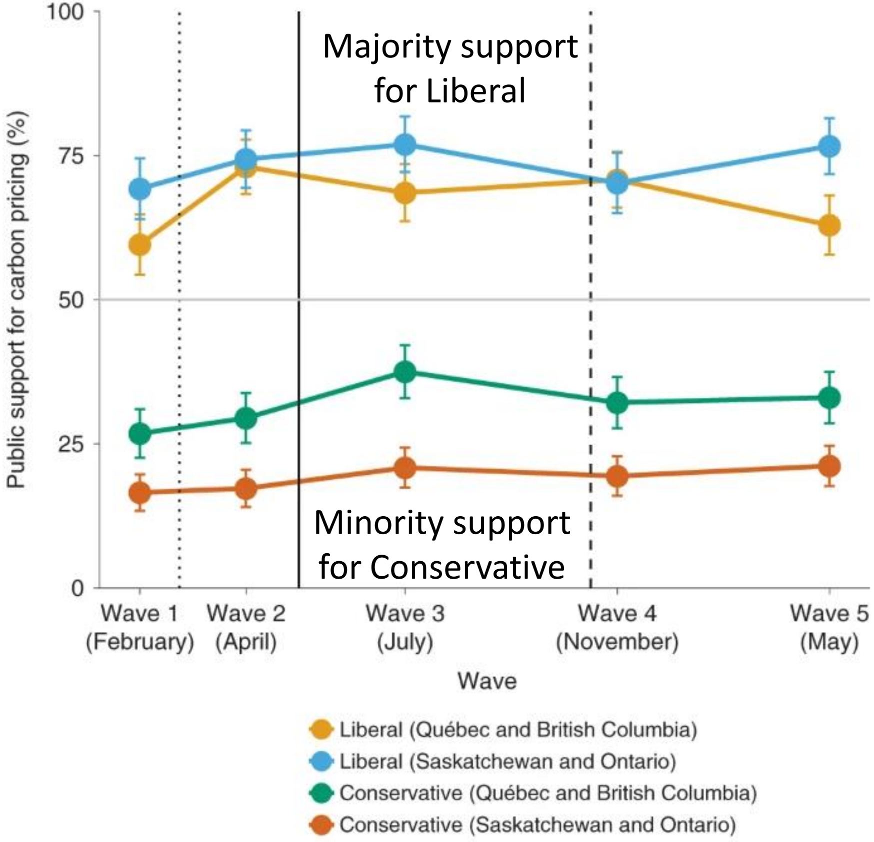
- carbon levy on fuel purchases
- “big emitters” program for industrial facilities
- rebate program for everyone:
  -$ in tax return to 8/10 households in Canada

- Many economists agree: *flexible*, *simple*, & *easy to ramp up*
- Yet, ***<u>popularity low</u>***—typically falling along political lines.

“Technology, not taxes, is the way forward to reduce emissions” –Conservative Party Leader

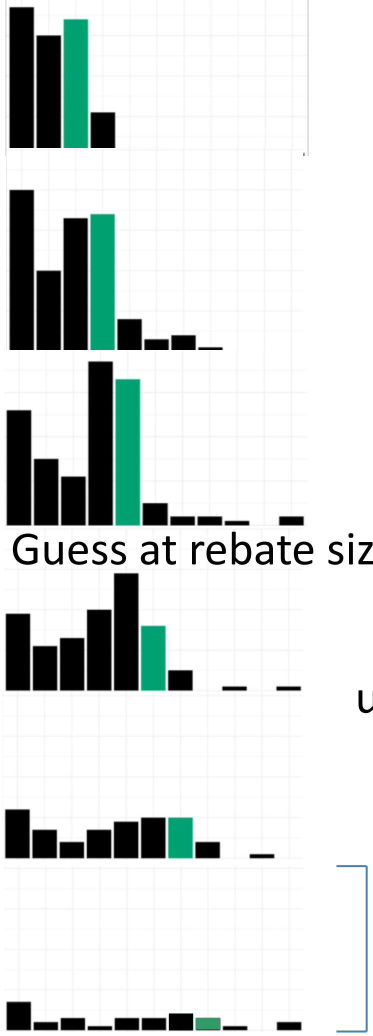
Public support for the carbon tax



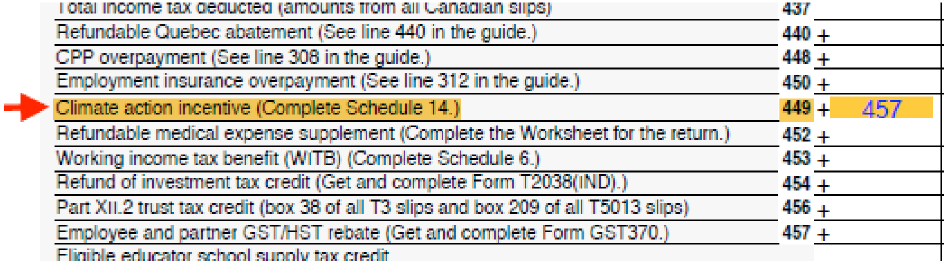


Mildenberger et al. *Nat. Clim. Change* (2022)

Intervening on beliefs with facts



Then just show them the data?



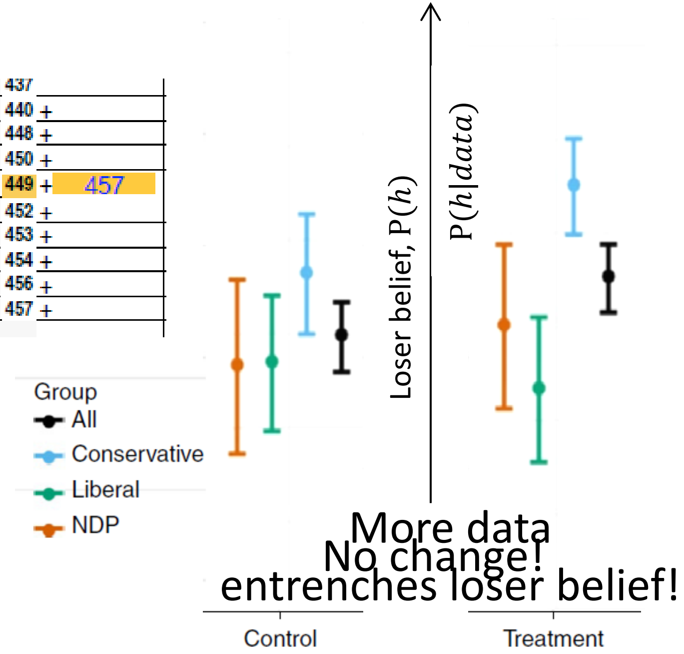
Total income tax deducted (amounts from all Canadian slips)	437		
Refundable Quebec abatement (See line 440 in the guide.)	440	+	
CPP overpayment (See line 308 in the guide.)	448	+	
Employment insurance overpayment (See line 312 in the guide.)	450	+	
Climate action incentive (Complete Schedule 14.)	449	+	457
Refundable medical expense supplement (Complete the Worksheet for the return.)	452	+	
Working income tax benefit (WITB) (Complete Schedule 6.)	453	+	
Refund of investment tax credit (Get and complete Form T2038(IND).)	454	+	
Part XII.2 trust tax credit (box 38 of all T3 slips and box 209 of all T5013 slips)	456	+	
Employee and partner GST/HST rebate (Get and complete Form GST370.)	457	+	
Eligible educator school supply tax credit			

Do they update their beliefs?

Systematic Underestimation

under-estimate the rebate size

for all **actual rebate sizes**



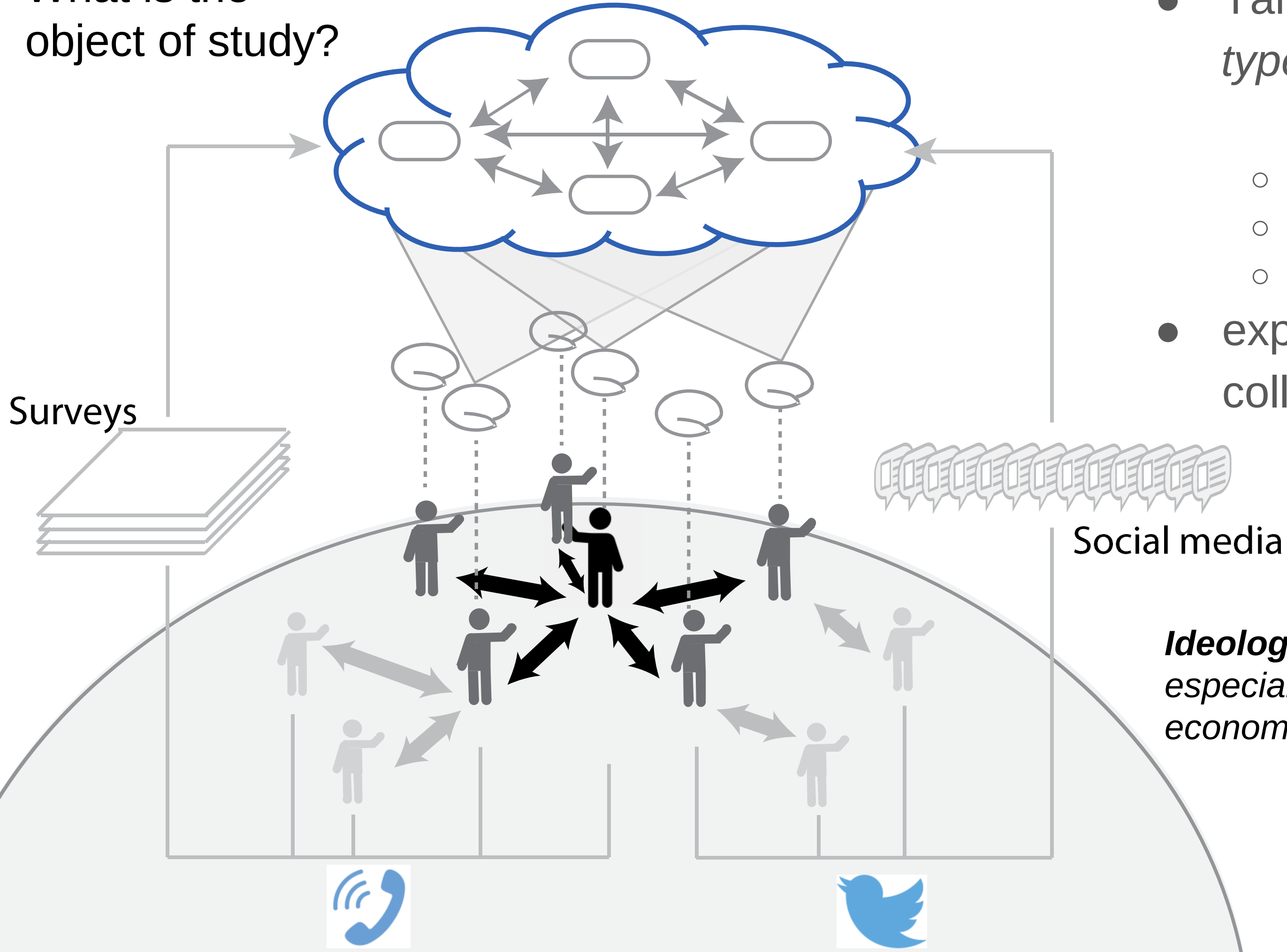
Not necessarily irrational!

strong prior for $h \Longrightarrow \mathrm{P}(h|data) \approx \mathrm{P}(h)$!

(Bayesian confirmation theory)

Mildenberger et al. *Nat. Clim. Change* (2022)

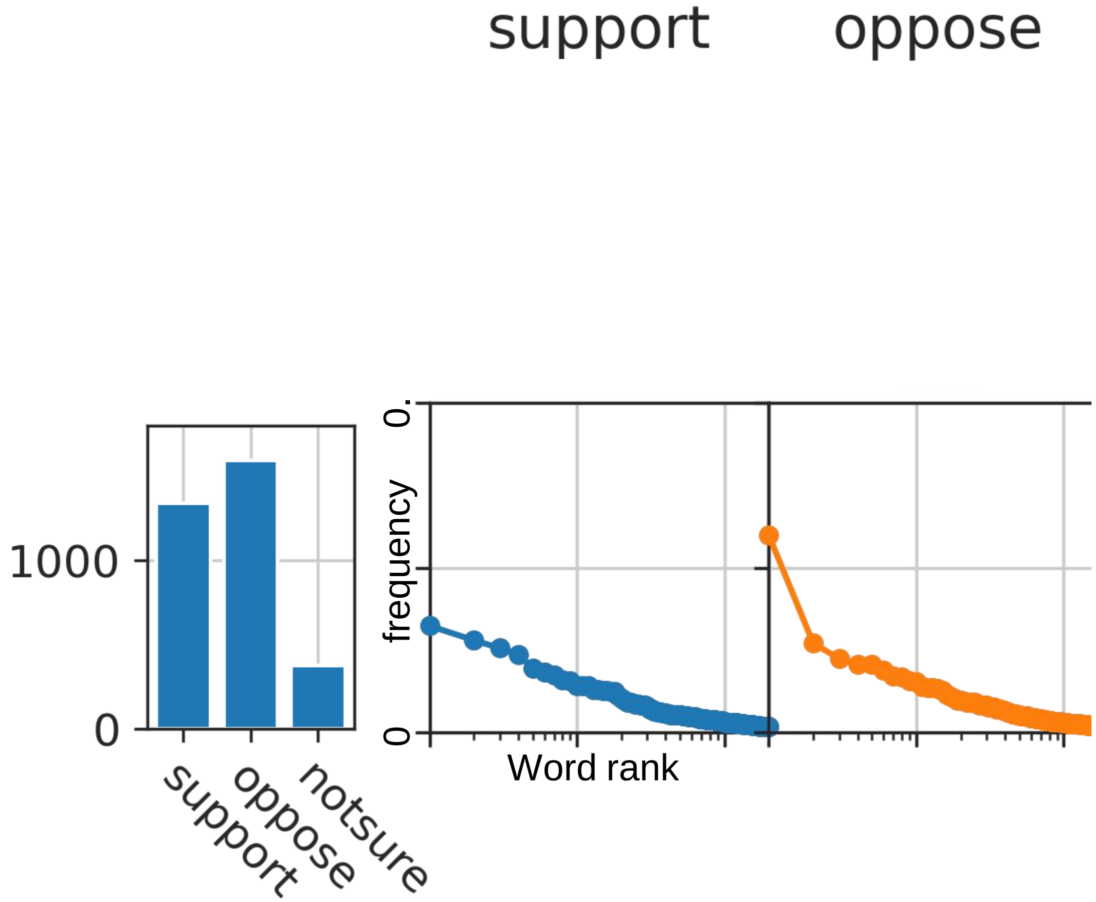
What is the object of study?



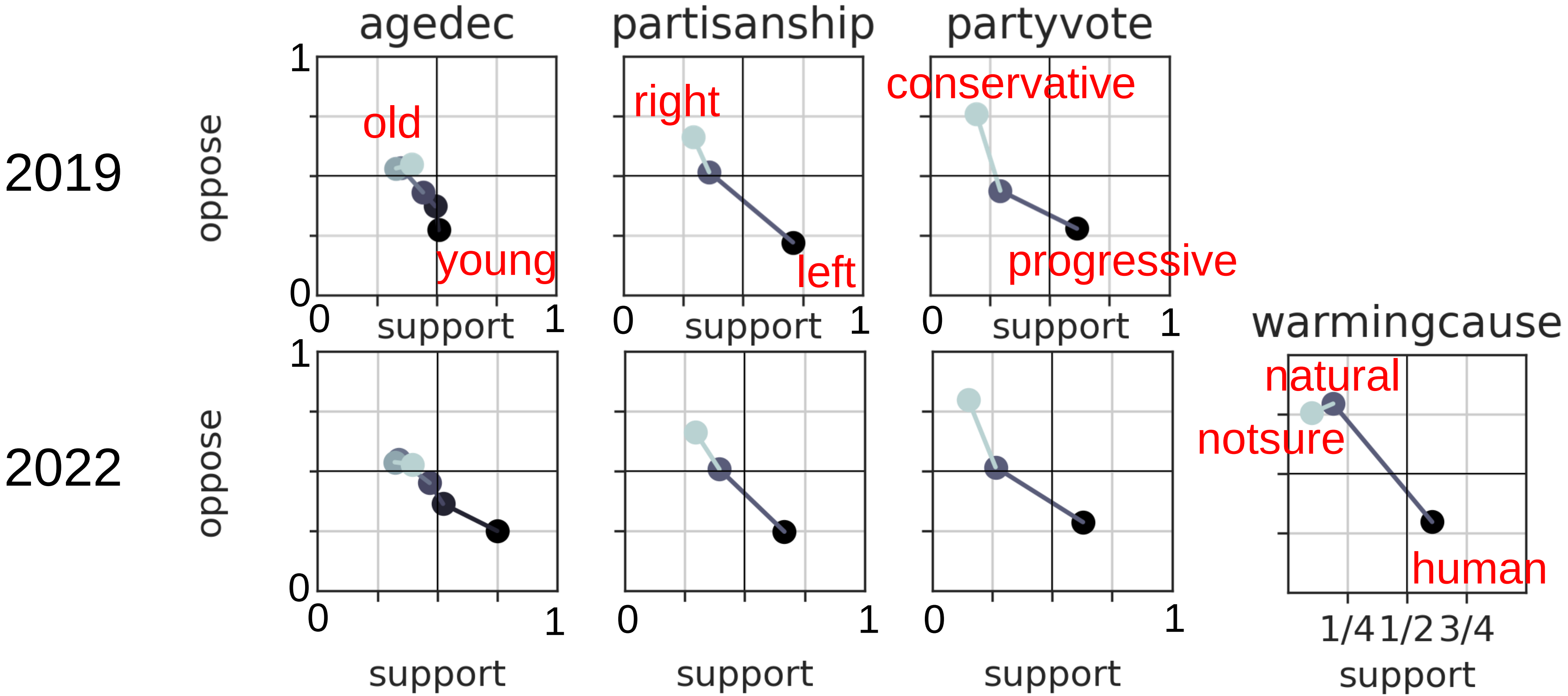
- Target Object:
  type-conditioned distribution over a belief network
  - Inter-connected
  - Highly dynamic
  - Driven by many objectives
- expressed in what we collectively say and do

Ideology: *"a system of ideas and ideals, especially one which forms the basis of economic or political theory and policy"*

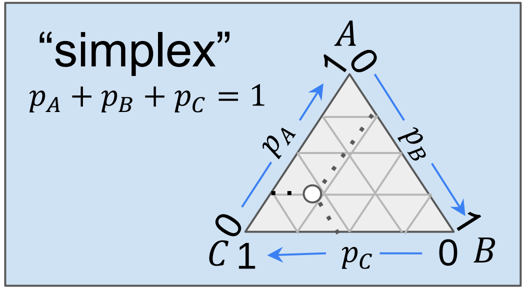
2019 Response statistics



Support shifts strongly with political views/voting



Topic Models are generative models

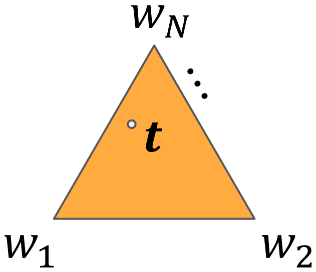


Vocabulary—an indexed set of words $\{w_1, \dots, w_N\}$

Topic, $\boldsymbol{t} = (p_1, \dots, p_N)$—sample probabilities over a vocabulary

Topic mixture, $\boldsymbol{\theta} = (q_1, \dots, q_K)$—sample probabilities over K given topics

Topic mixture prior, $P_s(\boldsymbol{\theta})$—a distribution on $\boldsymbol{\theta}$, given respondent type s

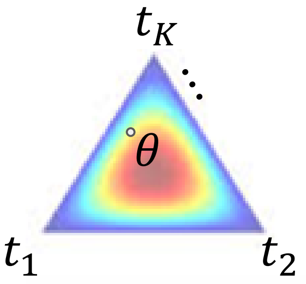


Process to generate a response:

Step 1: Sample a topic mixture $\boldsymbol{\theta}$, given s

Step 2: Sample a topic id, given $\boldsymbol{\theta}$

Step 3: Sample a word id, given $\boldsymbol{t}$

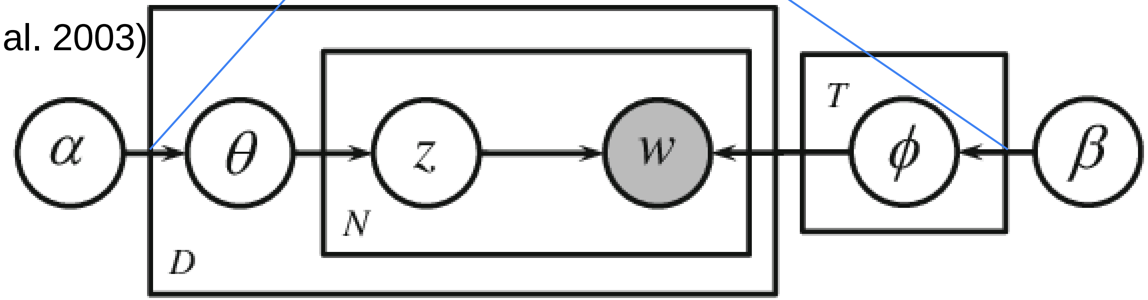


["____ ____ ____ ____ ____ ____"]

Generative Topic Models

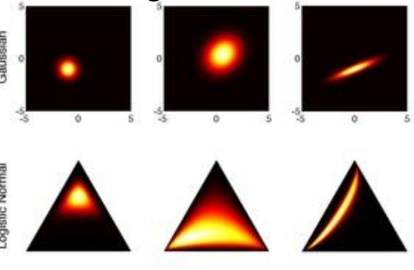
Latent Dirichlet Allocation (LDA) (Blei et al. 2003)

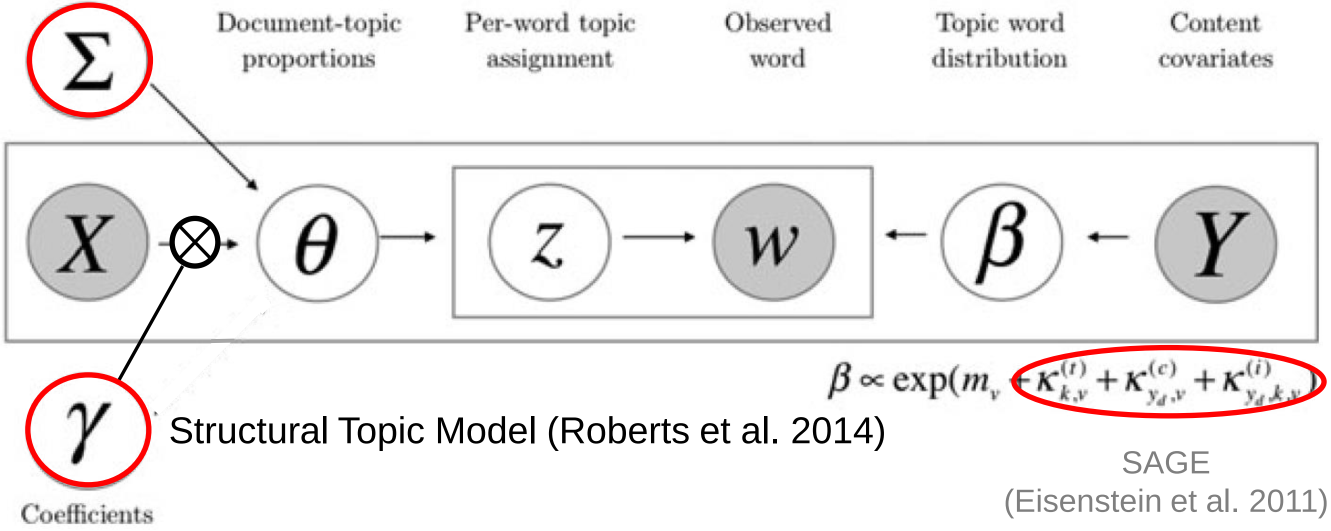
Dirichlet



Correlated Topic Model (CTM)
(Blei & Lafferty, 2005)

LogisticNormal





Structural Topic Model (Roberts et al. 2014)

SAGE
(Eisenstein et al. 2011)

Topic Quality Assessment

Exclusivity

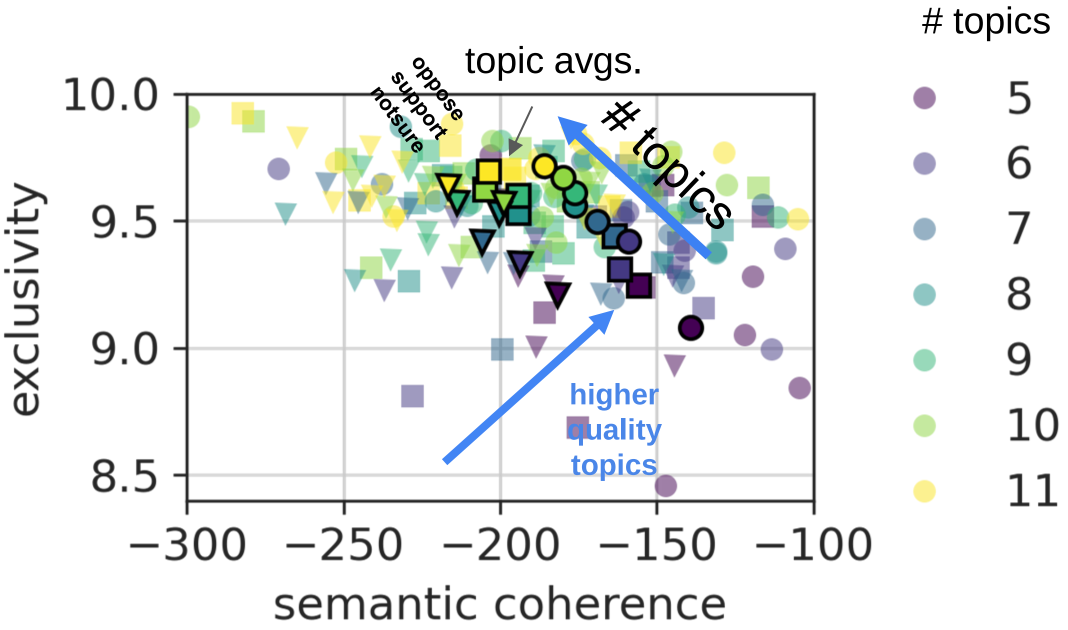
High when a topic's frequent words are exclusive to that topic

$$\text{FREX}_{k,v} = \left(\frac{\omega}{\text{ECDF}(\beta_{k,v} / \sum_{j=1}^{K} \beta_{j,v})} + \frac{1-\omega}{\text{ECDF}(\beta_{k,v})} \right)^{-1}$$

Semantic Coherence

High when a topic's frequent words co-occur often

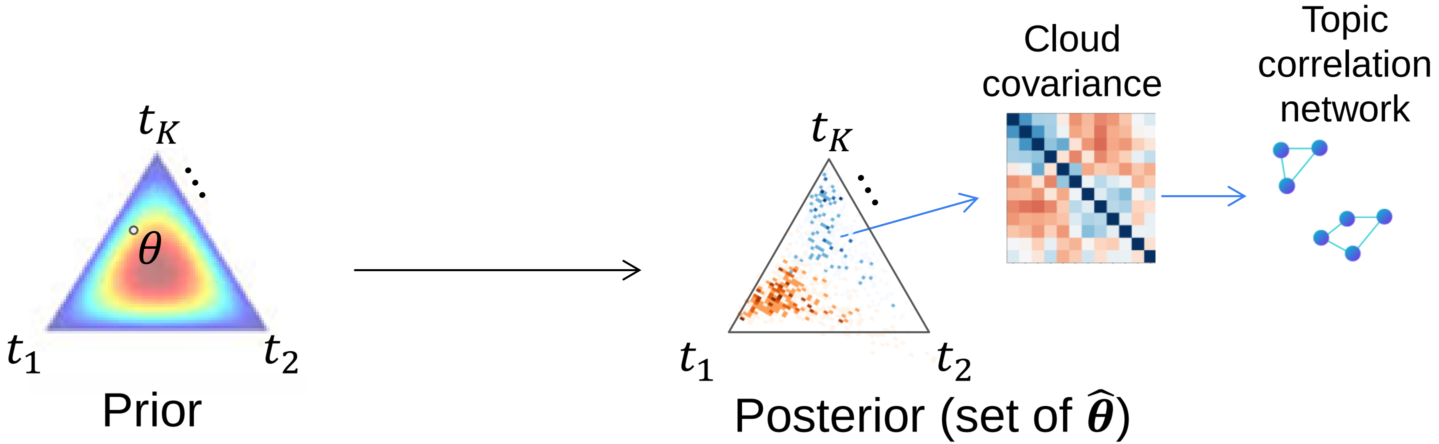
$$C_k = \sum_{i=2}^{M} \sum_{j=1}^{i-1} \log \left(\frac{D(v_i, v_j) + 1}{D(v_j)} \right)$$



Conclusion: No *single* number of topics stands out.

Posterior Inference of STMs

- Given parameters, compute the most probable topic mixture, $\hat{\boldsymbol{\theta}}$, for each response

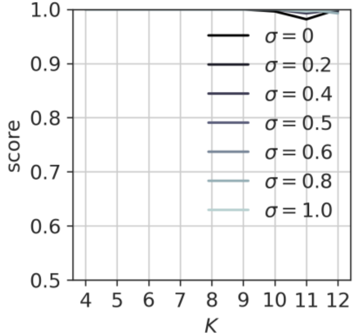


How to analyze these type-conditioned $\hat{\boldsymbol{\theta}}$-data clouds?

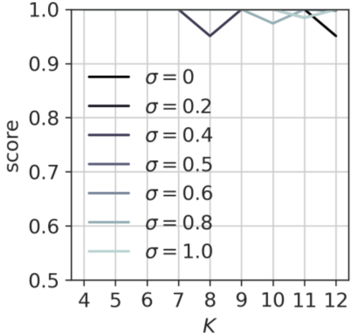
Predictive power of mixture space

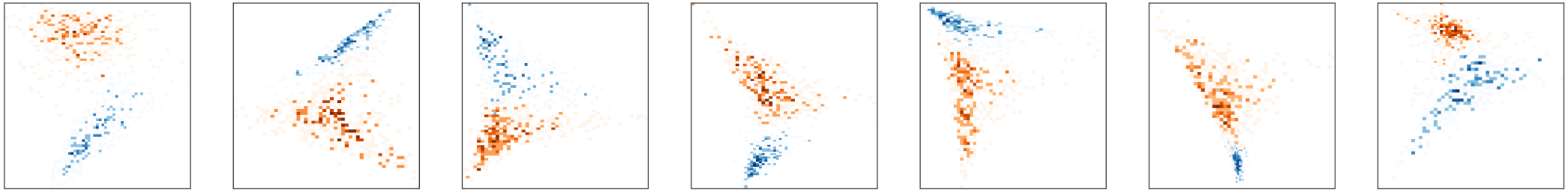
- How well does a linear classifier do?

Left-learning/
Right-leaning



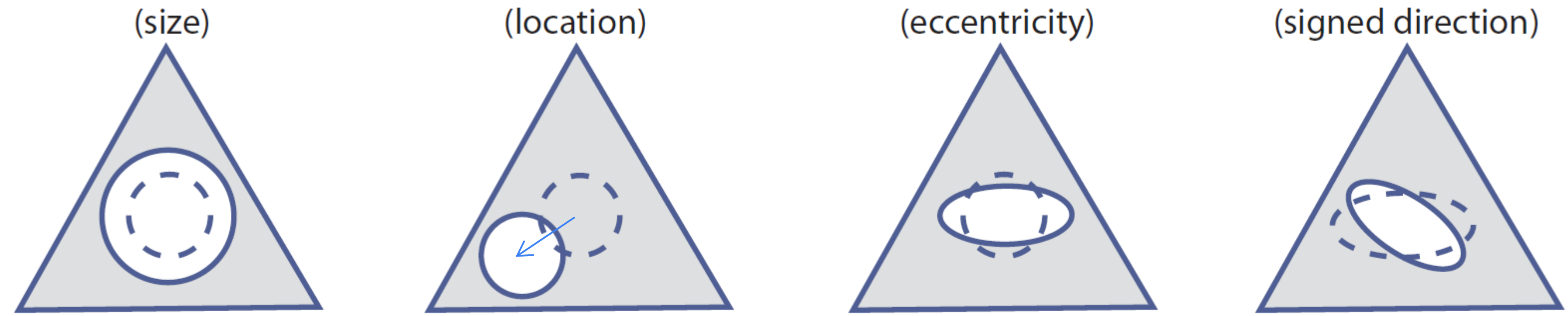
Progressive Voting/
Conservative Voting





Characterizing Ideology

- Previously: subjective labelling of topics from interpreting top words.
- But, “ideological” strength *should be* independent of topic semantics…
- Solution: *geometry of mixture data cloud*

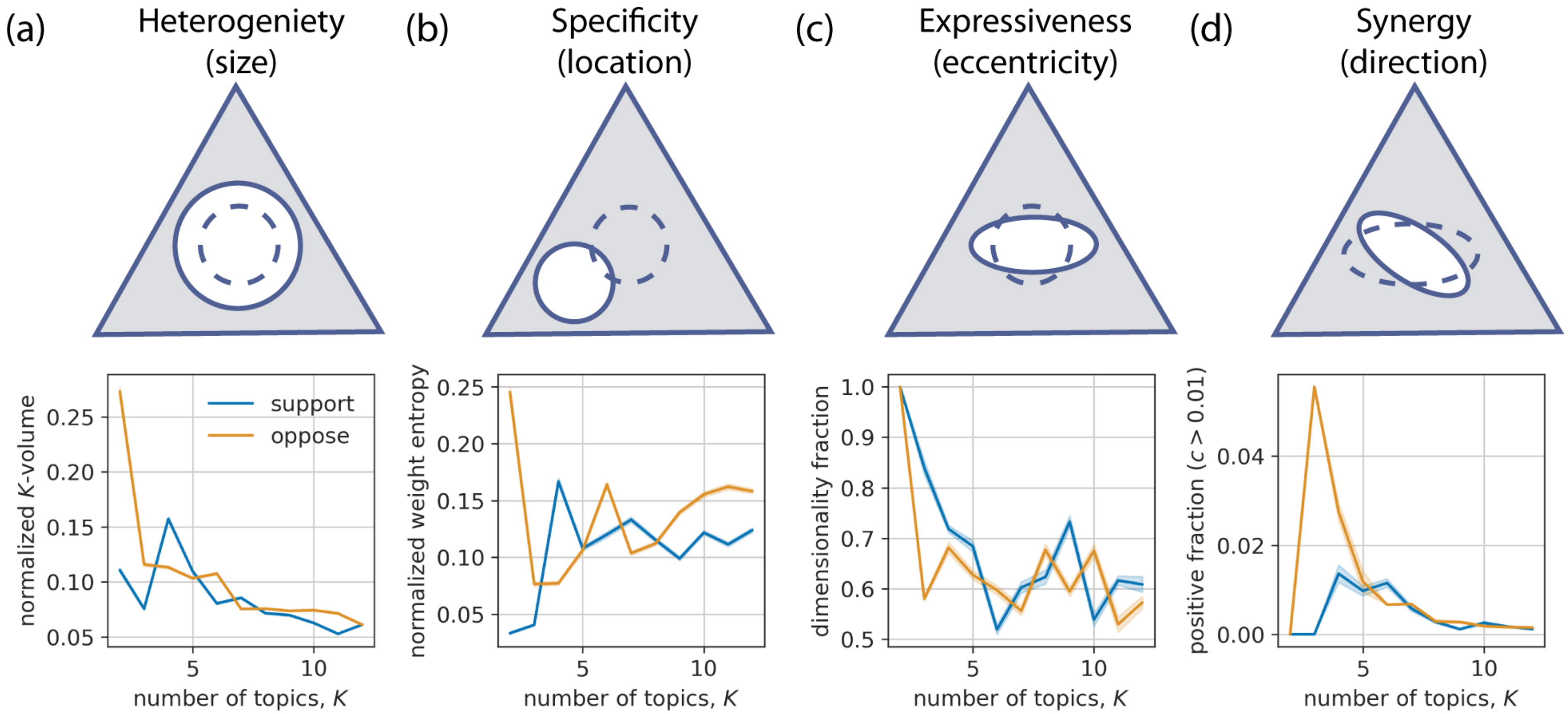


(K-1)-dim. Volume from covariance

Distance to center $\langle H(\hat{\boldsymbol{\theta}})\rangle / H_{\max}$

Intrinsic dimensionality from covariance

Fraction of positive pairwise correlations



Oppose types are more similar to each other

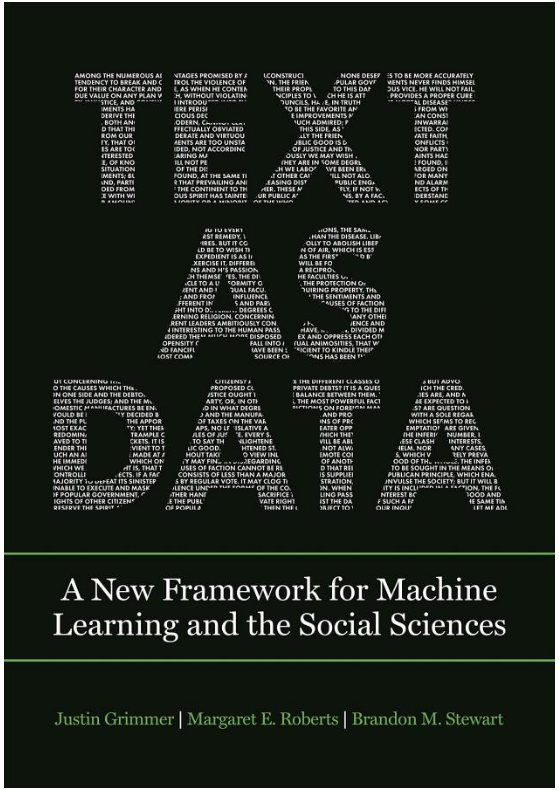
inconclusive (with this distance metric)

oppose types mix in fewer ways

oppose types recruit more mutually enforcing topics

Quantitative social science

- *Datastreams*: [text, behaviour,…] *as data*
  – social media, news media, transcripts, internet,
- *Models*: Multiscale, many-agent system models
  – e.g. Sociophysics with neural network components
- *Infra*: pipelines for now-casting/data management
- *Methods*: statistical inference/deep learning
- *Mathematical theory*:
  – Control theory/reinforcement learning theory
  – Game theory (esp. mechanism design)
  – evolutionary game theory/statistical mechanics
- *Disciplines*: psychology/public policy/political science/economics/sociology



Policy Implications

- Better design/better communication
  - Meet people where they are.
- A response to “no one is driving the bus”
  - discourse evolving in unintended ways
  - Many trying to sculpt the narrative
- Stewardship ethics best developed in open science setting

Acknowledgements

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