Affecting Distributions of Opinions with Evidence

Antonio Jiménez   Isabel Melguizo

both @ CIDE, Mexico City

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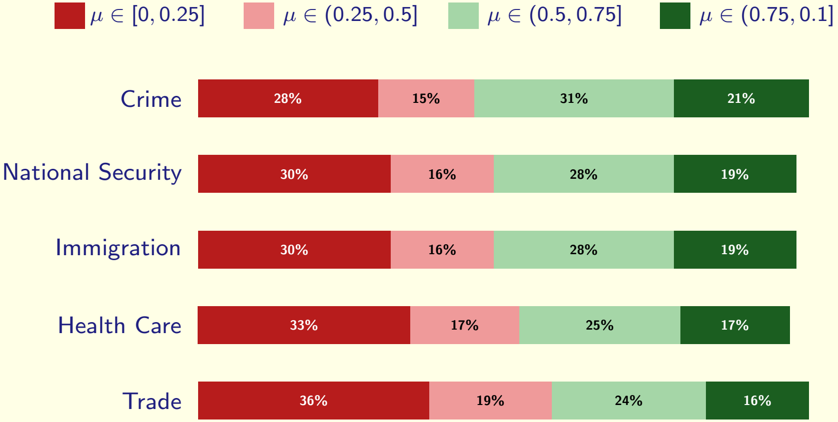
Motivation

How do evidence acquisition and disclosure affect distributions of opinions on unknown issues?

- Knowledge about communicator's efforts $\rightarrow$ audience's skepticism?
- Features of provision technology?
- Features of initial distributions of opinions?
- Welfare implications?

Motivation

Opinions $\mu = \mathbb{P}(\omega = 1)$ that Trump's policy-making is **good** $(\omega = 1)$
(Economist/YouGov Poll, Apr 25–May 2, 2025)



Motivation

Opinions on **good** ($\omega = 1$) effects of tariffs:

The New York Times **2024 ELECTIONS** | Cross-Tabs: September 2024 Times/Siena Polls in Michigan, Ohio and Wisconsin

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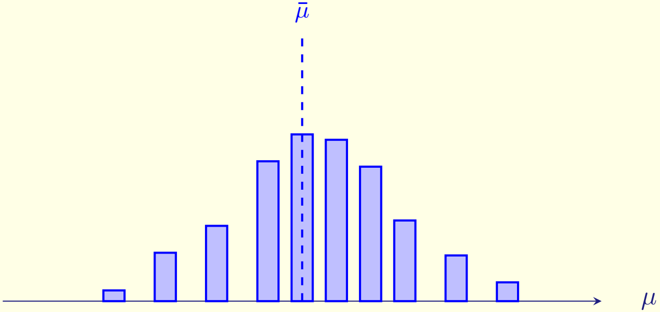
Expanding tariffs on products made outside the United States.	MI, OH AND WI LIKELY ELECTORATE	MI	OH	WI	MEN	WOMEN	18-29	30-44	45-64	65+	WHITE	BLACK	OTH.	B.A.+	NO B.A.	WHITE, COLLEGE	WHITE, NO COLLEGE	NON-WHITE, COLLEGE	NON-WHITE, NO COLLEGE	CITY
Strongly support	29%	33%	30%	25%	37%	22%	19%	24%	33%	32%	31%	15%	26%	20%	34%	20%	36%	20%	22%	20%
Somewhat support	25%	24%	27%	24%	22%	28%	36%	28%	23%	21%	26%	12%	24%	28%	24%	29%	25%	22%	17%	20%
Somewhat oppose	17%	16%	15%	20%	16%	18%	24%	20%	17%	13%	16%	28%	16%	22%	15%	22%	13%	21%	22%	21%
Strongly oppose	21%	20%	20%	22%	20%	22%	11%	19%	21%	27%	20%	32%	24%	23%	20%	22%	19%	28%	28%	25%
[VOL] Don't know/Refused	8%	7%	8%	9%	5%	10%	10%	10%	5%	8%	7%	12%	10%	7%	7%	7%	7%	10%	12%	14%
NET Support	54%	57%	57%	49%	59%	50%	55%	51%	56%	53%	57%	28%	51%	48%	58%	50%	61%	41%	39%	41%
NET Oppose	38%	36%	36%	42%	36%	40%	35%	39%	38%	40%	36%	60%	39%	44%	35%	44%	32%	49%	50%	45%
Number of respondents	1,690	557	567	566	800	865	261	338	589	457	1,370	133	147	731	950	592	775	122	158	302
Percentage of total electorate	100%	33%	33%	33%	47%	51%	13%	20%	34%	30%	83%	7%	8%	36%	63%	30%	53%	6%	9%	16%

From Frequency to Theoretical Distributions

$\mu = \mathbb{P}(\omega = 1)$



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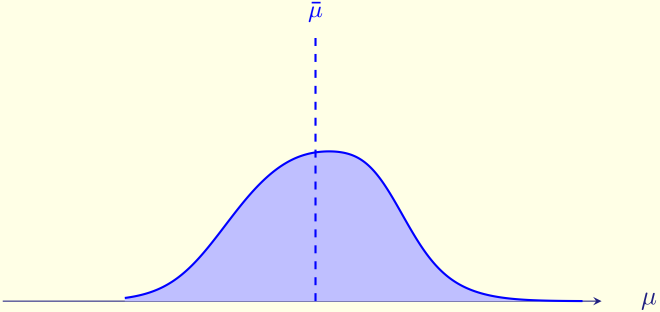


This Paper

Basic consideration: communicators care about features of distributions of opinions: Adams et al. (2024); Sommer-Topcu (2009); Lawrence et al. (2011); Pereira (2009); Monroe (1998); Walgrave et al. (2022); Durovic and Schanatterer (2025)

Beliefs elicited? theory for lab, **Brier 1950's elicitation**; in practice, opinion surveys, popular consultation, feedback from plebiscites

Interest in two goals of communicators in political scenarios:

- To shift the average opinion towards the communicator's preferred one
- To raise the dispersion of opinions: Iyengar et al., (2012); Iyengar and Westwood (2015); Iyengar et al. (2019); Reiljan et al. (2024); Bäck et al. (2023); Glaeser et al. (2005)

Use of evidence to affect distributions of opinions

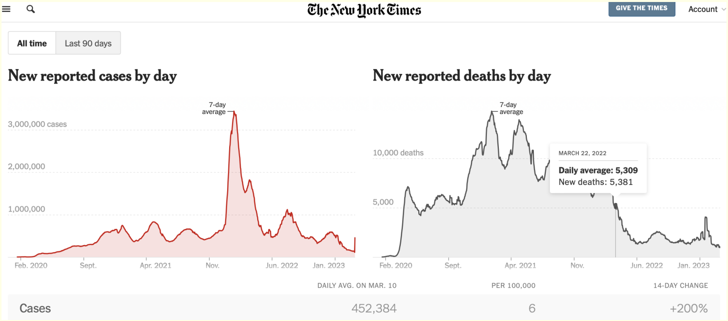
Political leaders, e.g., socioeconomic evidence to *affect opinions on* policy-making quality

Firm managers, e.g., earnings evidence to *affect opinions on* future shareholder returns

Government agencies, e.g., medical evidence to *affect opinions on* the state of a pandemic

How Does Evidence Look Like?

Example – evidence to *affect opinions on* the state of Covid pandemic:



Relevant state $\omega \in \Omega \equiv \{0, 1\}$ and generic prior $\beta \equiv \mathbb{P}(\omega = 1)$ of an audience of Receivers

β is not deterministic: $\boldsymbol{\beta} \sim F(\beta)$ with $\bar{\beta} = E[\boldsymbol{\beta}]$ and $\sigma^2 = \mathrm{Var}[\boldsymbol{\beta}]$

Interpretation 1: $F(\beta)$ approximates a frequency distribution (e.g., histogram from survey)

Interpretation 2: $F(\beta)$ theoretical distribution of unknown β

Each prior β revised upon observing **signal** $s \in \mathbb{R} \cup \{n\}$:

- $s \in \mathbb{R}$ is a **piece of evidence**
- $s = n$ is **no evidence**

The Game

A Sender chooses an observable **effort** $x \in [0, 1] = \mathbb{P}(s \in \mathbb{R}) \Rightarrow \mathbb{P}(s = n) = 1 - x$

Effort cost $c : [0, 1] \to \mathbb{R}$, twice-differentiable, strictly increasing and convex, with $c(0) = 0$, and Inada conditions $c'(0) = 0$ and $c'(1) \geq 1$

Sender (privately) obtains $s \in \mathbb{R} \cup \{n\}$ and (publicly) reports $m \in \mathbb{R} \cup \{n\}$

Hard evidence: if $s = n \Rightarrow m = n$; if $s \in \mathbb{R} \Rightarrow m \in \{s, n\}$

The Game

Sender's **disclosure strategy**: $d : \mathbb{R} \cup \{n\} \to \{0, 1\}$ with $d(s) = \mathbb{P}(m = s \mid s)$ s.t. $d(n) = 1$. Sender's **overall strategy**: (x, d)

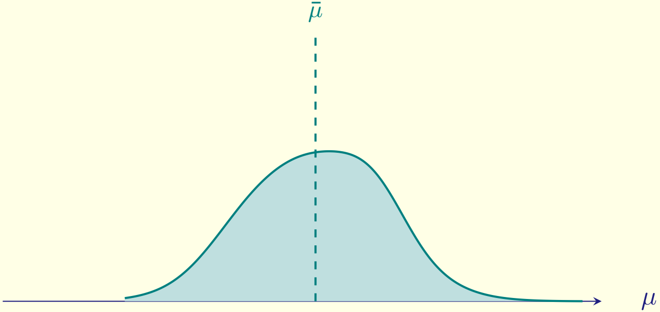
Receiver with prior β updates to $\mu_m^x(\beta) = \mathbb{P}(\omega = 1 \mid m; x, d)$. Strategy (x, d) induces **distribution of posteriors** $G_m^x(\mu)$ for $\mu = \mu_m^x$

Sender's interim payoff: $v(G_m^x)$

Shifting Average Opinion

Normalization consideration: Sender prefers audience to believe that $\omega = 1$

Motivation I: $v(G_m^x) = E[\mu_m^x]$



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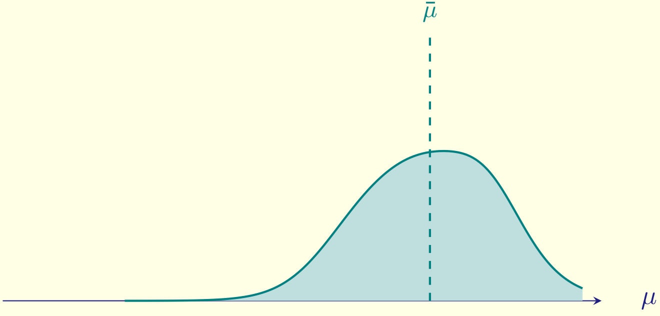
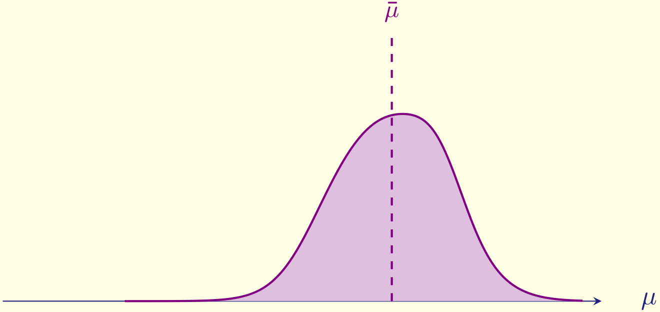


Raising Dispersion of Opinions

Motivation II: $v(G_m^x) = E[(\mu_m^x)^2]$



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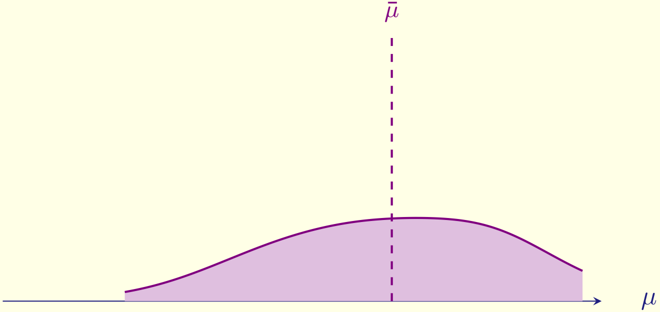


Evidence Provision Technology

$(\mathbb{R}, \mathcal{B})$, measurable space of pieces of evid. with a σ-finite reference measure

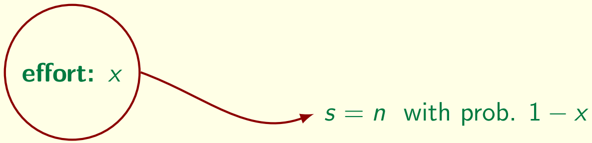
For $\omega \in \{0, 1\}$, prob. measure $\mathbb{P}_\omega$ over space $(\mathbb{R}, \mathcal{B})$ (absolutely continuous w.r.t. to reference measure $\Rightarrow$ $\mathbb{P}_\omega$ admits Radon-Nikodym derivatives): densities $\pi_\omega(s) > 0$ and cdfs $\Pi_\omega(s) = \int_0^s \pi_\omega(t)dt$

$\xi \equiv (\mathbb{P}_0, \mathbb{P}_1)$, an evidence provision structure $\equiv$ a Blackwell experiment

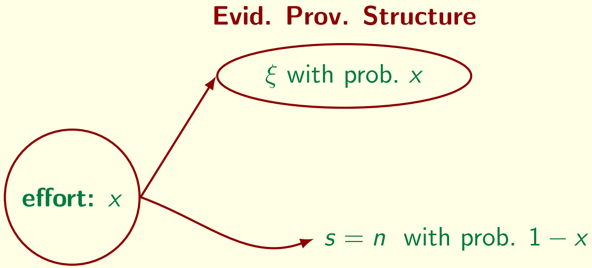
Time Line

effort: x

Time Line



Time Line



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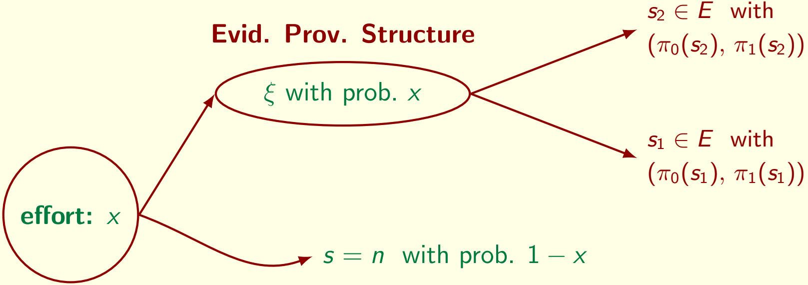

Evid. Prov. Structure
ξ with prob. x
$s_2 \in E$ with
$(\pi_0(s_2), \pi_1(s_2))$
$s_1 \in E$ with
$(\pi_0(s_1), \pi_1(s_1))$
effort: x
$s = n$ with prob. $1 - x$

Equilibrium

Interim stage: Sender discloses $s \in \mathbb{R}$ whenever $v(G_s^x) \geq v(G_n^x)$

Ex ante stage: Sender chooses $x \in [0,1]$ to maximize:

$$V(x;d) = E_{\beta\sim F}\Big\{(1-x)v(G_n^x) + xE_{\boldsymbol{s}\sim Q_{\boldsymbol{\beta}}}\big[[1-d(\boldsymbol{s})]v(G_n^x) + d(\boldsymbol{s})v(G_{\boldsymbol{s}})\big]\Big\} - c(x)$$

$$Q_\beta \equiv \beta\Pi_1 + (1-\beta)\Pi_0$$

Skepticism and threshold disclosure

$$\mu_s^x(\beta) = \frac{\beta}{\lambda(s)\beta + (1-\beta)} \quad \text{with} \quad \lambda(s) \equiv \frac{\pi_1(s)}{\pi_0(s)} \quad \text{for} \quad \pi_0(s) > 0$$

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$$\mu_n^x(\beta) = \frac{\left[(1-x) + xE_{s\sim\Pi_1}[1-d(s)]\right]\beta}{\left[(1-x) + xE_{s\sim\Pi_1}[1-d(s)]\right]\beta + \left[(1-x) + xE_{s\sim\Pi_0}[1-d(s)]\right](1-\beta)}$$

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$$(1-x) + xE_{\boldsymbol{s}\sim\Pi_\omega}[1-d(\boldsymbol{s})]]$$

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$(1-x) + xE_{\boldsymbol{s}\sim\Pi_\omega}[1-d(\boldsymbol{s})]\big]$ =prob. of reporting n given ω under (x, d)

Skepticism and threshold disclosure

$$G_s(\mu) = \mathbb{P}(\mu_s^x \leq \mu) = F\left(\overbrace{\frac{\mu}{\mu + (1-\mu)\lambda(s)}}^{\beta_s(\mu)}\right)$$

$$G_n^x(\mu) = \mathbb{P}(\mu_n^x \leq \mu) = F\left(\overbrace{\frac{\mu}{\mu + (1-\mu)m(x,d)}}^{\beta_n^x(\mu)}\right)$$

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$$\lambda(s) \equiv \frac{\pi_1(s)}{\pi_0(s)} \quad \text{and} \quad m(x,d) \equiv \frac{(1-x) + xE_{\boldsymbol{s}\sim\Pi_1}[1-d(\boldsymbol{s})]}{(1-x) + xE_{\boldsymbol{s}\sim\Pi_0}[1-d(\boldsymbol{s})]}$$

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iff $\beta_{\boldsymbol{s}}^{x}(\mu) \geq \beta_{\boldsymbol{n}}(\mu)$ for any $\mu = \beta$

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iff $\quad G_n^x(\beta) = F(\beta_n^x(\beta)) \geq F(\beta_s(\beta)) = G_s(\beta)$

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iff $G_s(\beta)$ FOSD $G_n^x(\beta)$ iff

1. $E[\mu_s^x] \geq E[\mu_s^x]$ and 2. $E[(\mu_s^x)^2] \geq E[(\mu_s^x)^2]$

Skepticism and threshold disclosure, what we have shown:

Thm.
d^* discloses piece of evidence $s \in \mathbb{R}$ such that $\pi_0(s)\pi_1(s) > 0$ iff

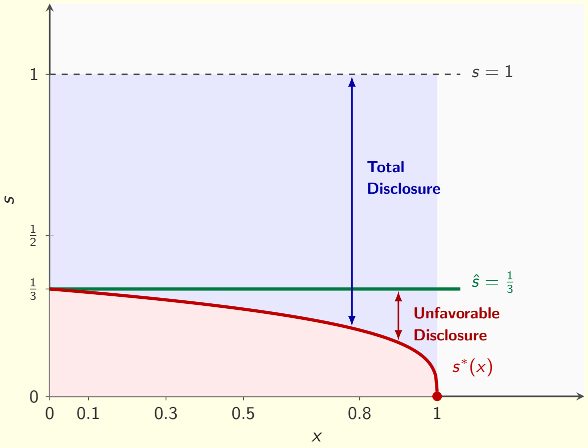
$$\lambda(s) \equiv \frac{\pi_1(s)}{\pi_0(s)} \geq \frac{(1-x) + xE_{\boldsymbol{s}\sim\Pi_1}[1 - d^*(\boldsymbol{s})]}{(1-x) + xE_{\boldsymbol{s}\sim\Pi_0}[1 - d^*(\boldsymbol{s})]}$$

Under regularity conditions, **unique threshold** $s^*(x)$ characterized by:

$$(1-x)[\lambda(s^*(x)) - 1] + x\int_{\underline{s}}^{s^*(x)} \pi_0(s)[\lambda(s^*(x)) - \lambda(s)]ds = 0$$

Beta Technology

$\pi_\omega(s) = (\omega+2)(\omega+1)s^\omega(1-s),\ s \in [0,1]\ \Rightarrow \lambda(\hat{s}) = 1$ for $\hat{s} = 1/3$



Value of evidence acquisition and disclosure to Sender

Equilibrium Sender's Return

$$V(x; s^*(x)) = v(G_{s^*(x)}) + xE_{s \sim Q_{\bar{\beta}}}\left[v(G_s) - v(G_{s^*(x)}) \,\middle|\, s \geq s^*(x)\right]$$

Equilibrium Sender's Marginal Return: $MR(x; s^*(x)) \equiv \partial V(x; s^*(x))/\partial x$

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Equilibrium Sender's Marginal Return: $MR(x; s^*(x)) \equiv \partial V(x; s^*(x)) / \partial x$

Key implications: $s^*(x)$ is 1. invertible and 2. common for both Motivations of Sender $\rightarrow MR(s) \equiv MR(y(s); s)$

with $y(s) \equiv (s^*(x))^{-1}$ inverse function of $s^*(x)$

Value of evidence acquisition and disclosure to Sender

Given s, Sender's marginal return linear on measure of likelihood that ξ provides her pieces evidence more favorable than s

Using **Hazard Rate Dominance (HRD) size**:

$$\rho_\xi(s) \equiv \frac{1-\Pi_1(s)}{\pi_1(s)} - \frac{1-\Pi_0(s)}{\pi_0(s)},$$

we can write

$$MR(s) = A(s) + B(s)\rho_\xi(s),$$

where $A(s)$ and $B(s)$ depend on $\xi(s)$ and on features of $F(\beta)$

What affects $MR(s)$?

Under certain conditions, higher efforts x incentivized by

- Higher HRD sizes $\rho_\xi(s)$
- Initial average opinion less aligned with Sender's goal
- Higher dispersion of initial opinions

Preferred motivation for the Sender?

Lower HRD sizes $\rho_\xi(s)$ make it easer for Sender to benefit more under the goal of raising the dispersion of opinions (compared to shifting the average opinion)

The marginal return to the Sender $MR(s)$ is higher under Motivation II iff

$$q_{\bar{\beta}}(s)E[\boldsymbol{\mu}_s(1-\boldsymbol{\mu}_s)(2\boldsymbol{\mu}_s-1)]\rho_\xi(s) \leq Q_{\bar{\beta}}(s)E[\boldsymbol{\mu}_s(1-\boldsymbol{\mu}_s)]$$

Condition above always satisfied if $\rho_\xi(s) < 1$

Welfare of the Audience?

Each Receiver chooses $a \in A = [0,1]$ and obtains $u(a,\omega) = -(a-\omega)^2$

Measuring ex ante welfare of audience (**in equilibrium**),

$$W(\mu_s) \equiv E_{\boldsymbol{\beta}\sim F} E_{\mu_s(\boldsymbol{\beta})}[u(a^*(\mu_s(\boldsymbol{\beta})),\omega)] = -E_{\boldsymbol{\beta}\sim F}\left[\mu_s(\boldsymbol{\beta})[1-\mu_s(\boldsymbol{\beta})]\right]$$

Derived measure of welfare of audience:

$$W(x; s^*(x)) = xE_{\boldsymbol{s}\sim Q_{\bar{\beta}}}\left[W(\mu_s)\,\middle|\, s \geq s^*(x)\right] + [(1-x)+xQ_{\bar{\beta}}(s^*(x))]W(\mu_{s^*(x)})$$

Welfare of the Audience?

$W(x; s^*(x))$ increases in $x \Leftrightarrow$ Sender obtains higher $MR(x; s^*(x))$ when she wants to raise dispersion of opinions relative to when she wants of shift average opinion

Policy recommendations on evidence acquisition efforts depend on the goal of the communicator

Mandatory minimum efforts benefit audiences if communicators want to raise dispersions; harm audiences if communicators want to shift average opinions

Partial provability:

- Exogenous evidence: Dye (1985); Jung and Kwon (1988); Shin (1994); Acharya, DeMarzo, and Kremer (2011)
- Endogenous information acquisition: Che and Kartik (2009); Kartik, Lee, and Suen (2017)

Uncertainty about Receivers' preferences: Bond and Zeng (2022)

Pricing of acquired evidence: Ali, Lewis, and Wasserman (2023)

Bayesian persuasion with heterogeneous Receivers: Alonso and Camara (2016); Manili (2024)

Thank you