Competition in persuasion

Matthew Gentzkow
Emir Kamenica

University of Chicago

Motivation

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- Long tradition in political and legal thought says: Yes
  - Media ownership regulation
  - First Amendment law
  - Adversarial judicial system

Example

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- $\omega_{ij} \in \{l, h\}$ is the quality of drug j for consumer i
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  - $\frac{1}{2}$ always buy the drug with higher expected quality
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  - $reveal_j$: fully reveals quality of own drug for all i

	$null$	$reveal_2$
$null$	$\frac{1}{4}, \frac{1}{4}$	$\frac{2}{5}, \frac{1}{5}$
$reveal_1$	$\frac{1}{5}, \frac{2}{5}$	$\frac{17}{50}, \frac{17}{50}$

Prisoners' dilemma

	null	*reveal*$_2$
null	$\frac{1}{4}, \frac{1}{4}$	$\frac{2}{5}, \frac{1}{5}$
reveal$_1$	$\frac{1}{5}, \frac{2}{5}$	$\frac{17}{50}, \frac{17}{50}$

- Prisoners' dilemma
  - revealing information beneficial for the firm's joint profits
  - revealing information unilaterally unattractive
  - *null* is a dominant strategy
- Unique equilibrium: $(null, null)$
- Unique collusive outcome: $(reveal_1, reveal_2)$
- Enhancing competition (blocking a merger) leads to less information

Framework and goal

- Symmetric information
- Number of senders simultaneously choose signals about the state
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- Competition can reduce information
- Competition can increase information
- Information environment specifies information available to each sender
- Goal: Find a condition on the information environment such that

Theorem

*Competition unambiguously increases information **if and only if** this condition is satisfied.*

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- n senders with a common prior

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  - sender i chooses signal $\pi_i \in \Pi_i$
  - strategy profile $\boldsymbol{\pi} = (\pi_1, ..., \pi_n)$
  - sender i's payoff: $v_i(\langle \boldsymbol{\pi} \rangle)$

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- Focus on **pure strategy** equilibria
- Assumption:
    - $\underline{\pi} \in \Pi_i \ \forall i$: $\langle P \cup \underline{\pi} \rangle = \langle P \rangle \ \forall P$
- Terminology:
    - τ is *feasible* if $\exists \boldsymbol{\pi} \in \boldsymbol{\Pi}$ s.t. $\tau = \langle \pi \rangle$

The Blackwell order

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- Partial order
  - $\tau \succeq \tau' \to \tau$ is *more informative* than τ'
  - $\tau' \not\succeq \tau \to \tau$ is *no less informative* than τ'

Key features of the set-up

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  - Arbitrary Π_i's allow some signals to be prohibitively costly
  - Allow for comparative advantage

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- Information generated directly observed
- Senders have no private information when they choose their signals
- All available signals are equally costly
  - Arbitrary Π_i's allow some signals to be prohibitively costly
  - Allow for comparative advantage
- No sender can down out information provided by others:
  - $P' \subset P \implies \langle P \rangle \succeq \langle P' \rangle$

Basic intuition

The sum game

- Each player i chooses $q_i \in \mathbb{N}$
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Any pure strategy equilibrium outcome is weakly greater than the collusive outcome.

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Any pure strategy equilibrium outcome is weakly greater than the collusive outcome.

- suppose $\tau^c > \tau^*$
- for at least one player $v_i(\tau^c) > v_i(\tau^*)$
- player i can profitably deviate to $q_i = q_i^* + (\tau^c - \tau^*)$

The sum game: key properties

- No downward deviation feasible: $q_i \geq 0$
  - Equilibria with excessively high outcomes possible
  - Information also has this feature
- Every upward deviation feasible: every i can deviate to *any* $\tau \geq \sum q_i$
  - Equilibria with excessively low outcomes not possible
  - Information does *not* always have this feature

The information environment

Information environment

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Definition

$\mathbf{\Pi}$ is *Blackwell-connected* if $\forall i$, $\forall \boldsymbol{\pi} \in \mathbf{\Pi}$, $\boldsymbol{\pi}' \in \mathbf{\Pi}_{-i}$ s.t. $\langle \boldsymbol{\pi} \rangle \succeq \langle \boldsymbol{\pi}' \rangle$, $\exists \pi_i \in \Pi_i$ s.t. $\langle \boldsymbol{\pi} \rangle = \langle \boldsymbol{\pi}' \cup \pi_i \rangle$.

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- i.e., given any strategy profile, any sender can unilaterally deviate to any feasible outcome that is more informative

Examples of environments

- *Number of draws*: given π, each sender chooses the number of independent draws
- *Precisions*: sender i generates an independent signal $\mathcal{N}\left(\omega, \sigma_i^2\right)$
- *Partitions*: each sender chooses a partition of Ω
- *Facts*: each fact in set F generates an $i.i.d.$ signal; each i chooses $F_i \subset F$
- *All-or-nothing*: each sender can say nothing or fully reveal everything
- *Rich:* each sender conducts any experiment, potentially correlated with others

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- All of these information environments are Blackwell-connected

Individual vs. aggregate feasibility

- Key implication of environment being Blackwell-connected:

Claim

Suppose $\mathbf{\Pi}$ is Blackwell-connected. Then, $\{\langle\pi\rangle|\pi \in \Pi_i\} = \{\langle\boldsymbol{\pi}\rangle|\boldsymbol{\pi} \in \mathbf{\Pi}\}$ $\forall i$.

Individual vs. aggregate feasibility

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- Each sender can provide as much information as many senders can provide together

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- Each sender can provide as much information as many senders can provide together
- Necessary but not sufficient for environment to be Blackwell-connected
  - $\boldsymbol{\Pi}$ can also be too 'coarse'
  - e.g., each sender chooses $n_i \in \{0, 2, 3, ...\}$ independent draws

Main result

Competition vs. collusion

- An outcome τ^c is *collusive* if it maximizes $\sum_i v_i(\tau)$

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  - results generalize to all monotone social welfare functions
- Expositional ease: assume collusive outcome is unique
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- Compare equilibrium outcomes with the collusive outcome

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Every equilibrium outcome is no less informative than the collusive outcome (regardless of preferences) if and only if the information environment is Blackwell-connected.

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- Let $\boldsymbol{\pi}^*_{-i} = \left(\pi^*_1, \ldots, \pi^*_{i-1}, \pi^*_{i+1}, \ldots, \pi^*_n\right) \in \mathbf{\Pi}_{-i}$
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- We have $\tau^c \succeq \langle \boldsymbol{\pi}^* \rangle \succeq \langle \boldsymbol{\pi}^*_{-i} \rangle$
- $\mathbf{\Pi}$ Blackwell-connected $\Rightarrow \exists \pi^d_i \in \Pi_i$ s.t. $\tau^c = \langle \boldsymbol{\pi}^*_{-i} \cup \pi^d_i \rangle$

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Every equilibrium outcome is ***more*** *informative than the collusive outcome (regardless of preferences) if and only if the information environment is Blackwell-connected* ***and*** *any two feasible outcomes are comparable.*

- With mixed strategies, the environment is never Blackwell connected
  - mixed strategy equilibria are not unambiguously more informative than collusive outcomes

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- Scenario B:
  - each firm can only generate information about its own drug
  - informational environment is not Blackwell-connected
  - impact of merger will depend on demand
  - for some demand structure, merger will make consumers more informed

Equilibrium characterization

Characterizing the equilibrium set

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- Outcome τ is *unimprovable* for i if for any feasible $\tau' \succeq \tau$, we have $v_i(\tau') \leq v_i(\tau)$

Characterization result

Proposition

Suppose $\Pi_i = \Pi \ \forall i$, $\mathbf{\Pi}$ *is Blackwell-connected, and* $n \geq 2$. *A feasible outcome is an equilibrium outcome if and only if it is unimprovable for each sender.*

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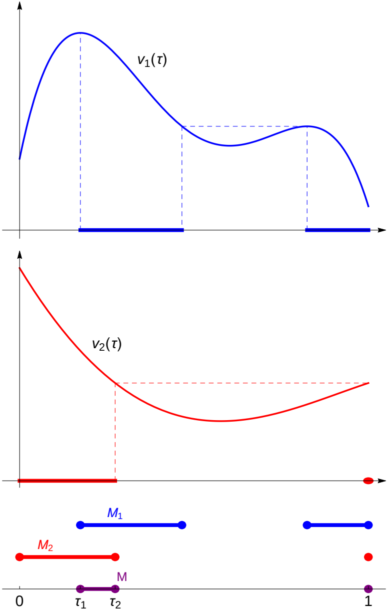
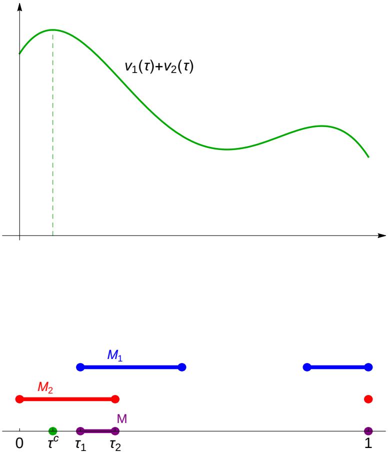
- Suppose some feasible τ is unimprovable for each sender
- Consider $\pi \in \Pi$ s.t. $\langle \pi \rangle = \tau$
- Strategy profile $(\pi, ..., \pi)$ is an equilibrium
  - i can only deviate to $\tau' \succeq \tau$
  - τ unimprovable implies $v_i(\tau') \leq v_i(\tau)$

Characterization result illustrated



Comparative statics illustrated



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  - Equilibrium outcomes vs. collusive outcomes
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  - adding senders cannot lead to less information
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Thank you

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- Suppose τ and τ' are two equilibrium outcomes and $\tau' \succ \tau$
- Then, $v_i(\tau) \geq v_i(\tau')$ for all senders i
- Say τ is a *minimal equilibrium outcome* if there is no equilibrium outcome τ' s.t. $\tau' \succ \tau$

Adding senders

- Compare minimal equilibria when
  - set of senders is J
  - set of senders is $J' \subset J$

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Proposition

Suppose $\Pi_i = \Pi$ for all i. If the information environment is Blackwell-connected, then (regardless of preferences) any minimal equilibrium outcome when the set of senders is some set J is no less informative than any minimal equilibrium outcome when the set of senders is some set $J' \subset J$.

Preference misalignment

- Suppose there are two senders j and k with

$$\begin{aligned} v_j(\tau) &= f(\tau) + bg(\tau) \\ v_k(\tau) &= f(\tau) - bg(\tau) \end{aligned}$$

- Parameter $b \geq 0$ measures misalignment of preferences

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Proposition

Suppose $\Pi_i = \Pi$ for all i. If the information environment is Blackwell-connected, then any minimal equilibrium outcome when the level of misalignment is b is no less informative than any minimal equilibrium outcome when the level of misalignment is some $b' < b$.