Persuasion by Cheap Talk

Archishman Chakraborty and Rick Harbaugh

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Cheap Talk

Expert has some private information of interest to Decision Maker

- Stock analyst knows value of stock
- Lobbyist knows value of a project
- Salesperson knows quality of a product

Communication is through simple “cheap talk”

- Not costly like in a signaling game (e.g., Spence, 1973)
- Not verifiable like in a disclosure/persuasion game (e.g., Milgrom, 1981)
- No commitment like in a screening game (e.g., Stiglitz, 1975)

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Crawford and Sobel (1982)

Crawford and Sobel provide canonical model

- Expert biased toward higher action than Decision Maker
- So exact communication breaks down
- If the bias b is not too large then coarse communication possible

Many, many variations and extensions

- Reputation (Sobel, 1985; Benabour and Laroque, 1992; Morris, 2001; Gentzkow and Shapiro, 2006, Ottaviani and Sorenson, 2006)
- Multiple experts (Gilligan and Krehbiel, 1989; Austen-Smith, 1993; Krishna and Morgan, 2001; Battaglini, 2002; Mullainathan and Shleifer, 2006; Ambrus and Takahashi, 2006; Gick, 2006; Visser and Swank, 2007)

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Multidimensional Cheap Talk

What if information on multiple dimensions?

- Stock analyst - multiple stocks
- Lobbyist - multiple projects
- Salesperson - multiple goods
- News network - multiple issues

Possibility raises lots of questions

- When can make credible tradeoffs across dimensions?
- Do players benefit from such tradeoffs?
- How much information can be revealed?
- Do asymmetries across dimensions make tradeoffs harder?s
- Does transparency of Expert's preferences make tradeoffs easier?

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- Does transparency of Expert's preferences make tradeoffs easier?

The Model

- Expert knows $\theta = (\theta_1, ..., \theta_N) \in \Theta$ where Θ is compact, convex subset of $\mathbb{R}^N$ - usually $[0,1]^N$
- Distribution F with density f has full support on Θ
- Expert sends message $m \in \mathbf{M}$
- Expert's communication strategy is a probability distribution over messages in **M** as a function of θ
- Assume all messages used in equilibrium - no surprises
- Decision maker action $a = (a_1, ..., a_N) = (E[\theta_1|m], ..., E[\theta_N|m])$ where expectations are updated from prior using Bayes Rule and communication strategy of expert
- Expert's preferences $U(a)$ continuous in a_i
- In (Perfect Bayesian) equilibrium Expert has no incentive to deviate from communication strategy - to "lie"

Key Assumptions

Decision maker preferences

- Action $a = (a_1, \ldots, a_N) = (E[\theta_1|m], \ldots, E[\theta_N|m])$
- Just like Crawford and Sobel (uniform) quadratic example
- We will give examples where these reduced form preferences are generated by underlying preferences of decision maker(s)
- Existence result generalizes well, but other results don't

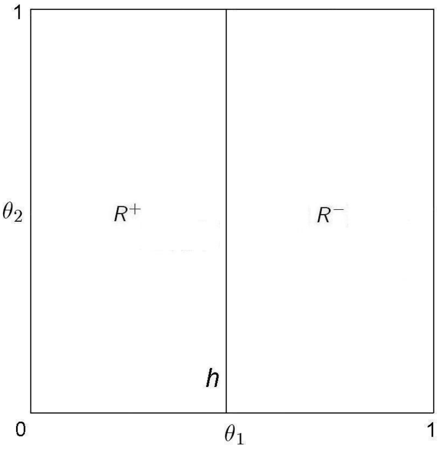
Expert's preferences

- Super simple - just $U(a)$ rather than $U(a, \theta)$ like CS
- Expert does not care directly about θ – state independence
- Standard assumption in persuasion games, signaling games – but not cheap talk games!
- In one dimension if U monotonic no room for cheap talk - always exaggerate as much as possible

Distribution of θ

- Distribution F with density f has full support on Θ - that's all!

Equilibrium



- A hyperplane h divides Θ into regions R^+ and R^-
- Message m indicates region θ is in
- Decision maker takes action $a^+ = E[\theta|\theta \in R^+]$ or $a^- = E[\theta|\theta \in R^-]$
- Different h possible
- PBE if h such that expert has no incentive to misreport the halfspace

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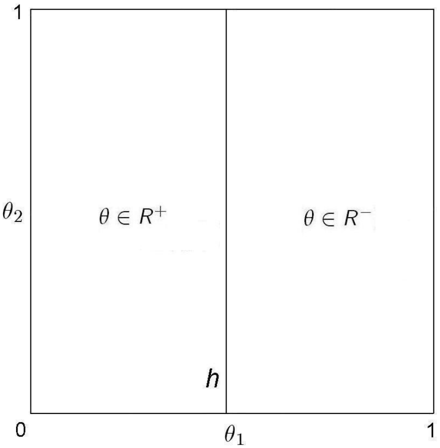

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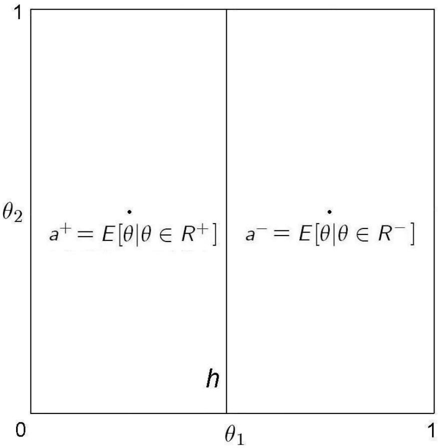

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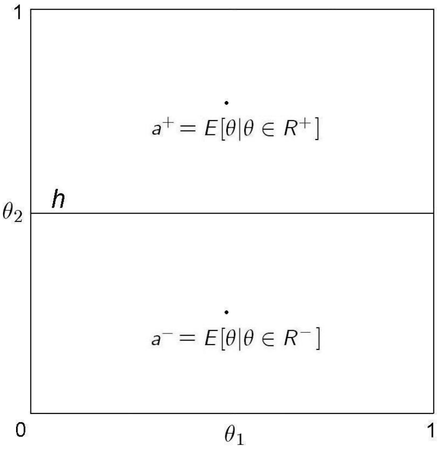

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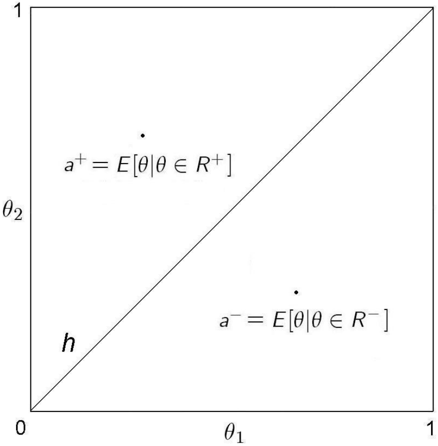

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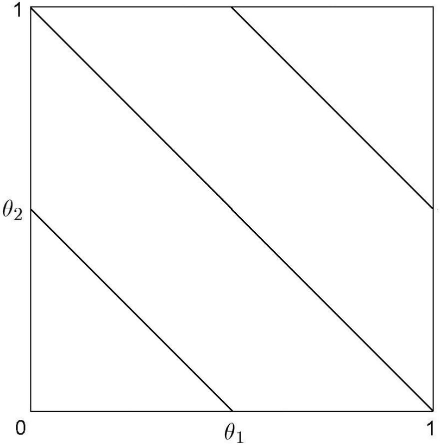
Example: Media Bias



- Seriousness of two scandals θ_1 and θ_2, uniform i.i.d. on $[0, 1]$
- Network wants to push scandals to increase viewership
- $U = a_1 + a_2$ so biased within but not across dimensions
- Comparative cheap talk equilibrium

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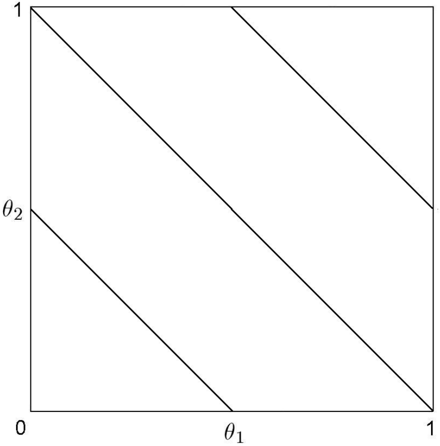

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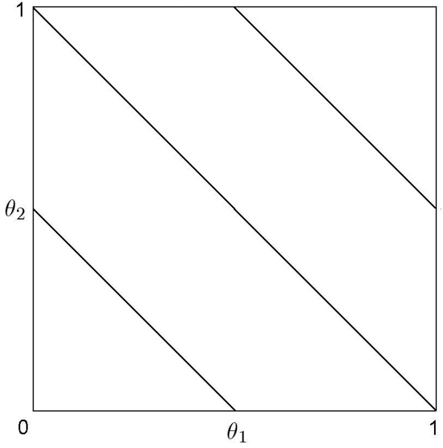

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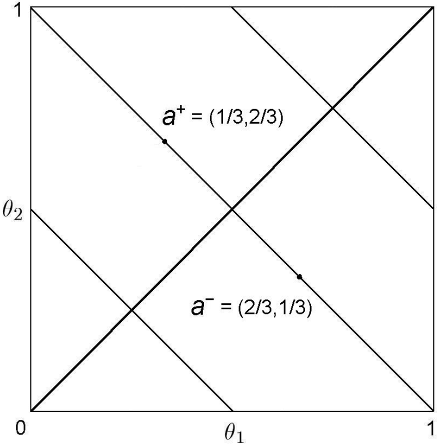

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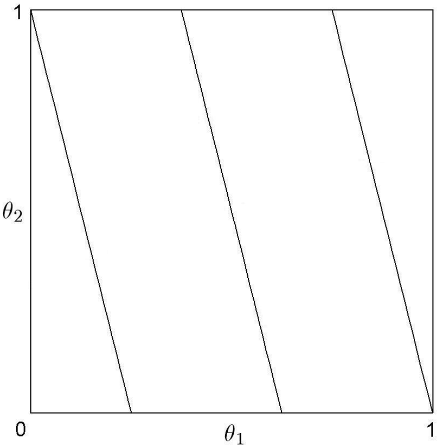

- Partisan network: $U = 4a_1 + a_2$
- Simple ranking of θ_1 and θ_2 not credible
- Can divide space with announcement line h to put actions on same indifference curve?

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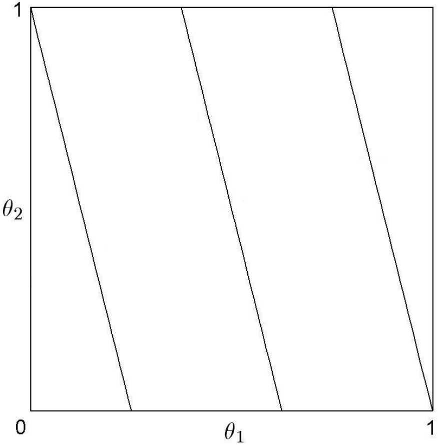

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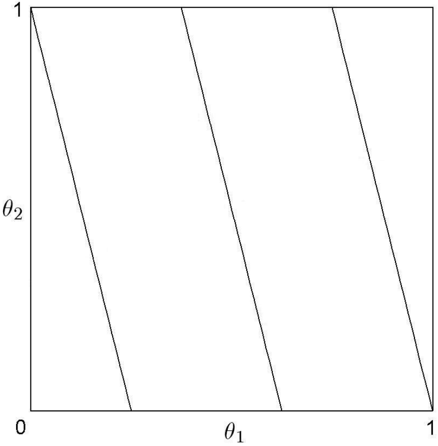

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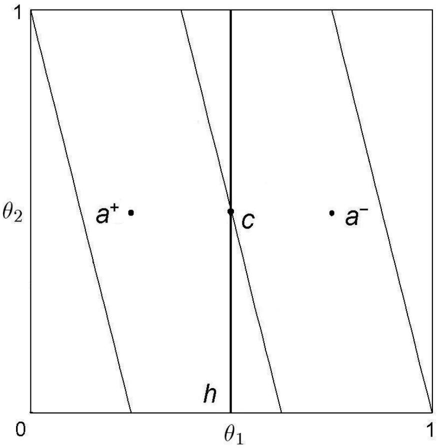

- Spin line around interior point c
- Actions continuously move around point
- Double back on each other when orientation of line is reversed
- For some orientation must have actions on same indifference curve

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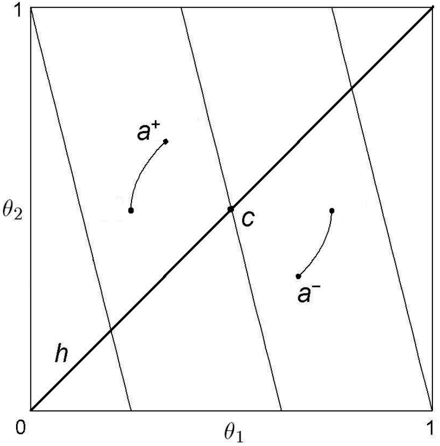

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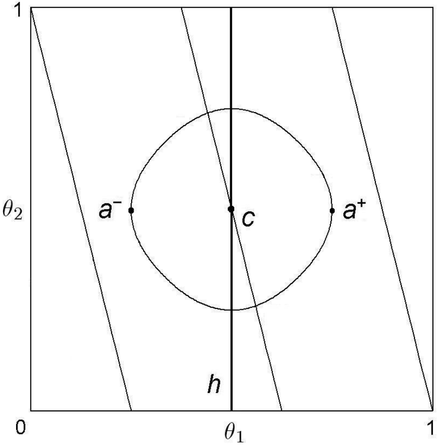

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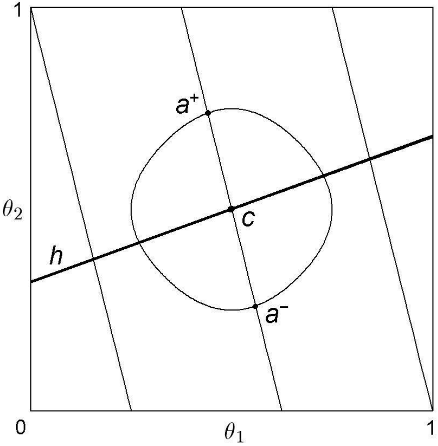

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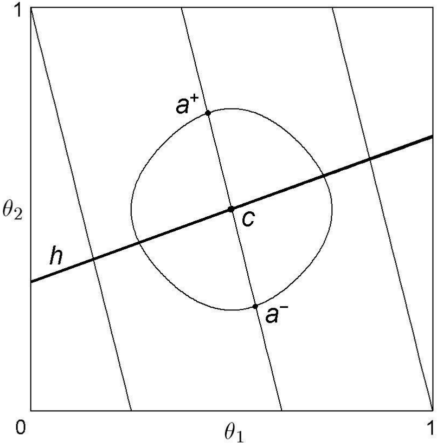

- Two actions not the same - equilibrium is influential
- Each action taken with positive probability - equilibrium is informative
- For any distribution can choose c so each action taken with probability $1/3$ or higher

Borsuk-Ulam Theorem

- For every continuous, odd mapping $G : \mathbb{S}^{N-1} \rightarrow \mathbb{R}^{N-1}$ there exists a point $s \in \mathbb{S}^{N-1}$ satisfying $G(s) = 0$.
- Odd mapping: $G(s) = -G(-s)$

- Consider any longitude on earth's surface
- Vector s identifies a point on circle formed by the longitude
- And $-s$ identifies the point's antipode
- Suppose temperature T continuous in s
- Is there an s such that $T(s) = T(-s)$?
- Let $G(s) = T(s) - T(-s)$, implying $G(s) = -G(-s)$
- So $G(s) = 0$ for some s, i.e., temperatures are the same at some antipodal points

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True Empirically?

- Longitude through 88 W
- Suppose $s = s'$ identifies Nashville at 36 N
- Then $s = -s'$ is antipode in Indian Ocean near Perth
- If $T(s') - T(-s') = 10$ then $T(-s') - T(s') = -10$
- So as move along longitude from Nashville to its antipode at some point s such that $T(s) = T(-s)$

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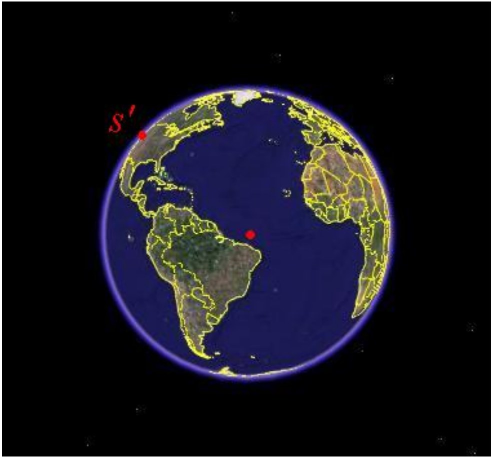

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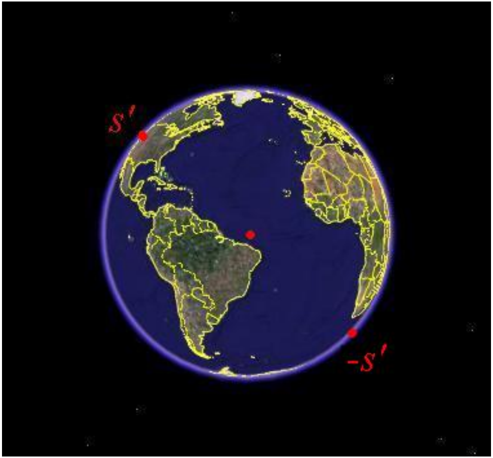

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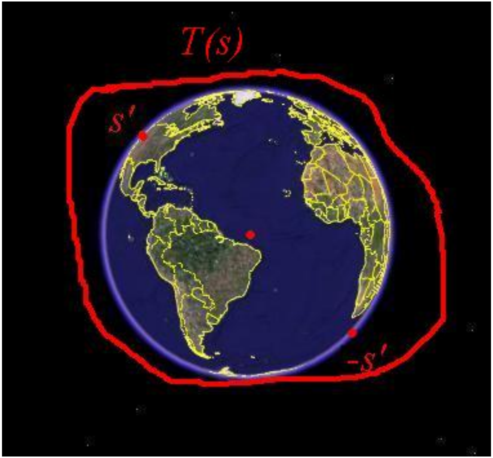

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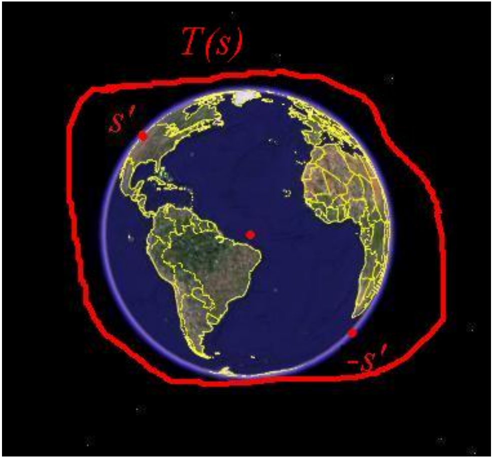

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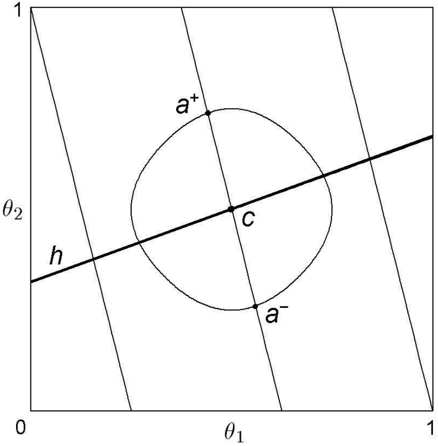

- Hyperplane has some orientation s
- Actions $a^+(s)$ and $a^-(s)$ are continuous
- So utilities $U(a^+(s))$ and $U(a^-(s))$ are also
- And difference $U(a^+(s) - U(a^-(s))$ is odd function

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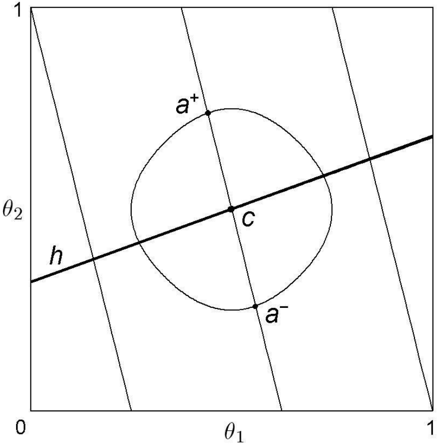

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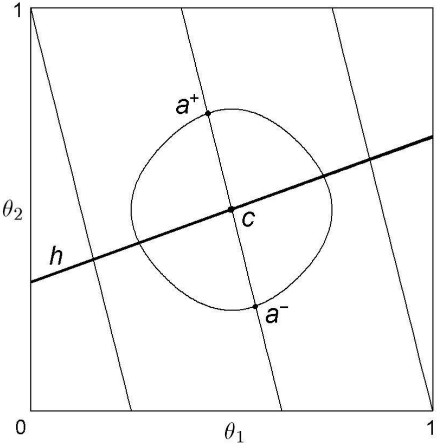

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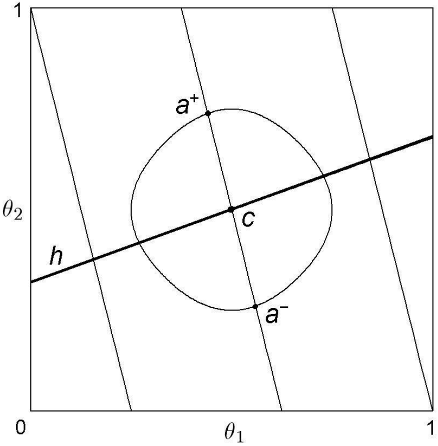

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Existence of Informative Cheap Talk

Theorem

An influential cheap talk equilibrium exists for all U and F.

- For instance, suppose $N = 2$
- $s \in \mathbb{S}$ is orientation of line h dividing plane into two regions, R^+ and R^-
- $a^+(s) = (E[\theta_1|\theta \in R^+(s)], E[\theta_2|\theta \in R^+(s)])$
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Relation to Chakraborty and Harbaugh (JET, 2007)

- Suppose Expert and Decision Maker payoffs additively separable and supermodular in a, θ
- And environment sufficiently symmetric
- Then "comparative cheap talk" is credible, informative even if strong incentive to exaggerate within each dimension
- Supermodularity, separability, symmetry also used in multidimensional bargaining (Chakraborty and Harbaugh, *Econ. Letters*, 2003) and multi-object auctions (Chakraborty, Gupta, and Harbaugh, *RAND*, 2006)
- Here we have weak supermodularity, but don't need separability and symmetry

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Effect on payoffs - is cheap talk "persuasive"

More info always better for a single decision maker

Does cheap talk induce a more desired action?

- Communication induces a mean-preserving spread in actions taken by decision maker
- In general expert benefits if preference are convex
- In equilibrium expert benefits if preferences are quasiconvex

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Relative to no communication, any informative cheap talk equilibrium benefits the expert if U is quasiconvex and hurts the expert if U is quasiconcave.

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Quasiconvex?

U is a (strictly) quasiconvex function iff every lower contour set $W(x) = \{a | U(a) \leq U(x)\}$ is (strictly) convex

- That is, for all $x', x'' \in W(x)$, $x' \neq x''$ and $\lambda \in (0,1)$, $U(\lambda x' + (1-\lambda)x'') < U(x)$
- That is, indifference curves are "bowed outward" or "concave to the origin"
- Opposite of Econ 101 indifference curves!

How check quasiconvexity?

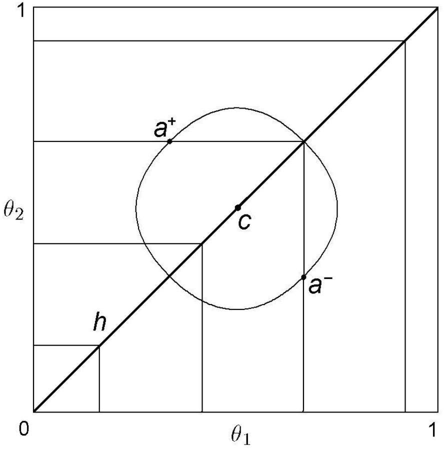
- Any monotonic transformation of a convex function is quasiconvex - weaker condition than convexity!
- U is quasiconvex iff $-U$ is quasiconcave
- If U is twice-differentiable then can check bordered Hessian
- If two-dimensions just check shape of indifference curves

Example: Persuasive Recommendations

Buyer walks into a store...

- N products that buyer might purchase one of
- Value of product i to buyer is v_i, an increasing linear function of quality θ_i
- Utility from not buying is ε with independent distribution G
- Seller knows θ, buyer knows ε, seller sends m
- Seller just wants to make a sale
- Probability of a sale is $U = \Pr[\varepsilon \leq \max_i\{v_i(E[\theta_i|m)\}] = G(\max_i\{v_i(a_i)\})$
- U continuous so cheap talk is credible
- U is quasiconvex so cheap talk is persuasive

Example: Persuasive Recommendations (N=2)



- Assume $v_i = \theta_i$
- Without communication $E[\theta_i] = 1/2$ so $U = 1/2$
- With cheap talk $E[\max_i\{\theta_i\}] = 2/3$ so $U = 2/3$
- So cheap talk is persuasive

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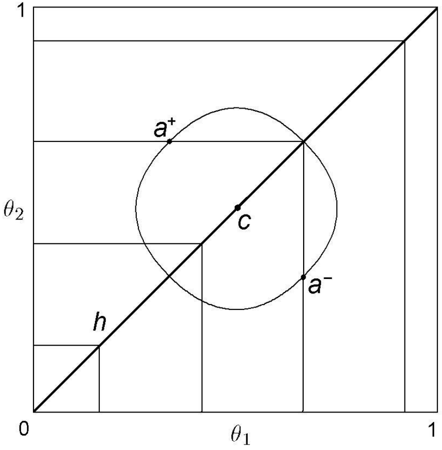

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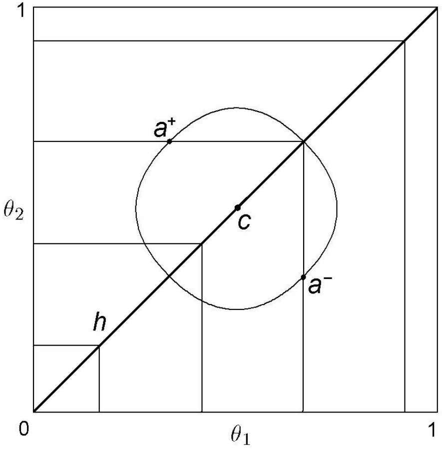

- Assume $v_i = \theta_i$
- Without communication $E[\theta_i] = 1/2$ so $U = 1/2$
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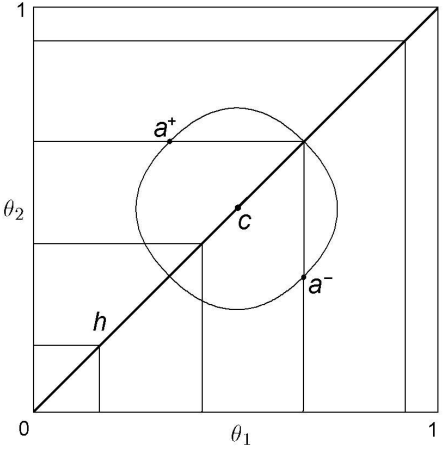

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Example: Persuasive Recommendations

Extends to standard discrete choice models

- Utility from each good is $v_i(\theta_i) + \varepsilon_i$
- Utility from walking away is ε
- ε's known by buyer, follow Type 1 extreme value dist.
- Probability good i purchased: $e^{v_i(a_i)} / (1 + \sum_i e^{v_i(a_i)})$
- So probability any good purchased:
  $U = 1 - 1/(1 + \sum_i e^{v_i(a_i)})$
- U is monotonic transformation of sum of strictly convex monotonic transformations of linear functions, so U is quasiconvex
- Pretty general applicability...

Example: Voting

N jurors care about N different issues

- Juror i votes guilty if $\theta_i > \tau_i$, where $\tau_i \in [0, 1]$, i.i.d. uniform
- θ also i.i.d. uniform so a_i is probability juror i votes guilty
- $p(a)$ is probability of conviction

Cheap talk to jurors?

- Unanimity rule: $p(a) = a_1 a_2 ... a_N$
- Prosecution utility $U = p(a)$ (quasiconcave)
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Helps defense and hurts prosecution

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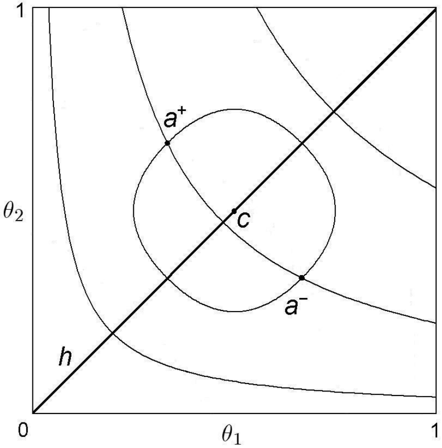

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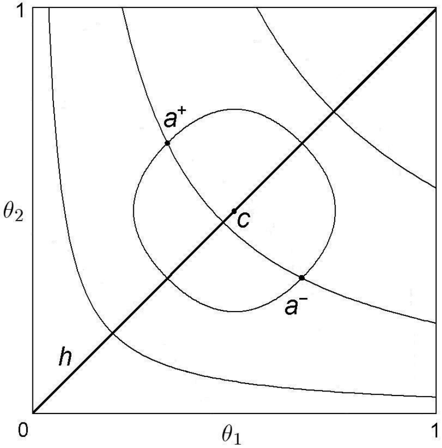

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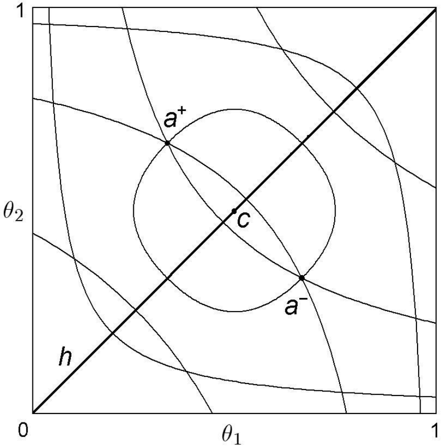

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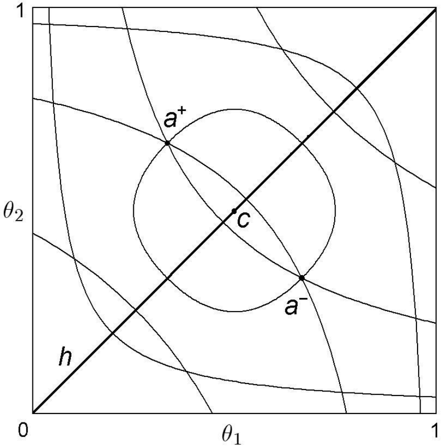

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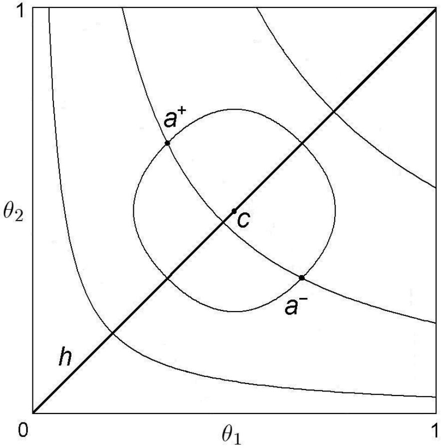

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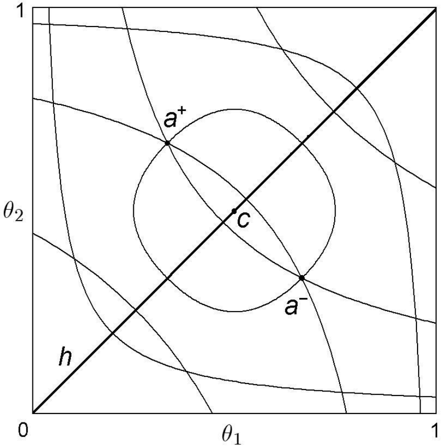

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Example: Private Value (Second Price) Auction

Good's two attributes valued differently by buyers $j = 1, ..., n$

- $E[v_j] = \lambda_j E[\theta_1] + (1 - \lambda_j) E[\theta_2]$
- Weights λ_j private buyer info
- Seller knows θ - uniformly distributed for calculations
- No communication $E[\theta_i] = 1/2$, so revenue is $1/2$

Cheap talk spreads out buyer valuations

- Allocational efficiency rises
- But competition falls

Net effect depends on number of buyers

- If two bidders second highest bid is now $1/3 < 1/2$
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- In limit as bidders increase revenue is $2/3 > 1/2$

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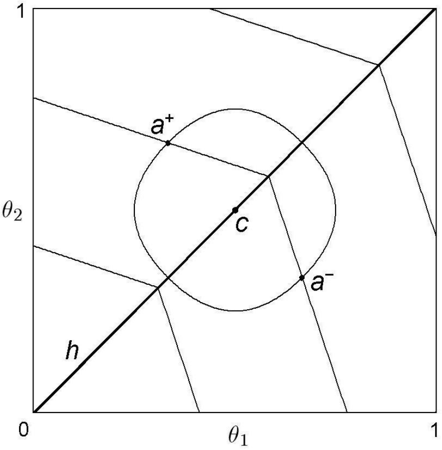

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- $a_1 = 2/3$ and $a_2 = 1/3$ or vice versa
- Expected value of second highest bid is $(2/(n+1))(2/3) + ((n-1)/(n+1))(2/3)$
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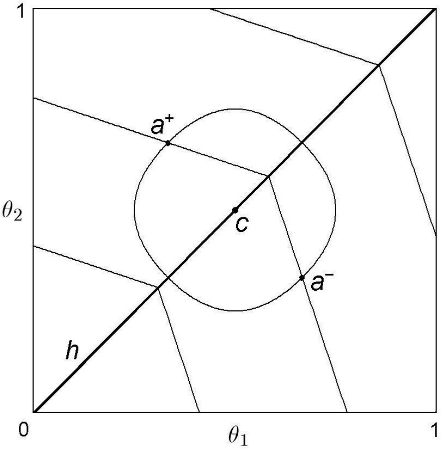

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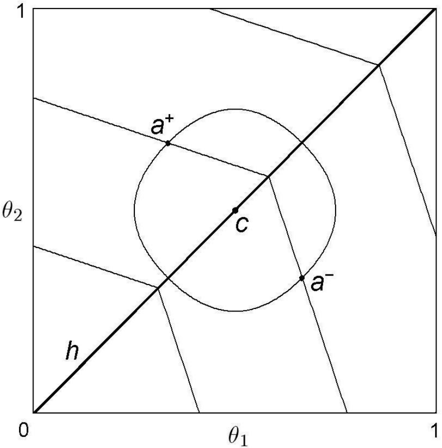

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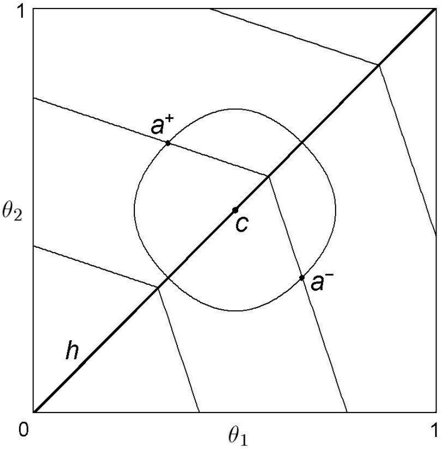

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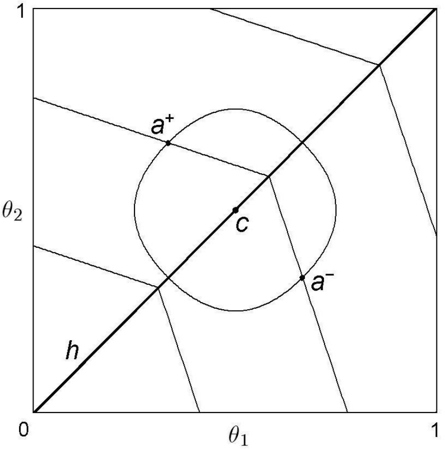

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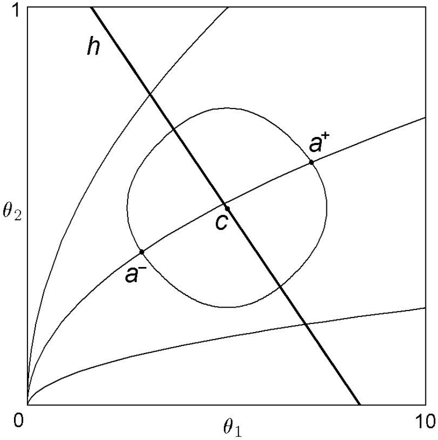

- Monopolist firm at 0 faces unit mass of consumers uniform on $[0, 1]$
- Consumer at x values product at $\theta_2 - \theta_1 x - p$
- Quality θ_2 and nicheyness θ_1 firm's private info
- Firm says good (and nichey) or broad appeal (and ok)

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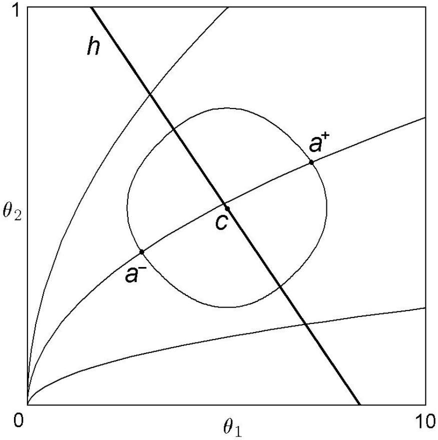

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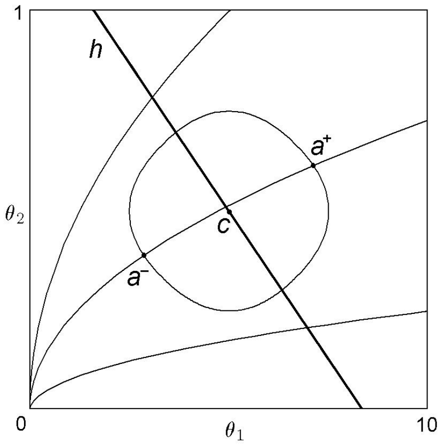

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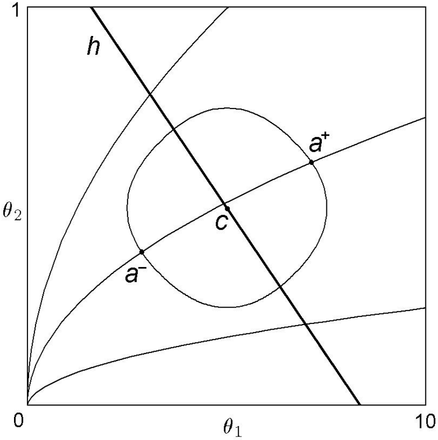

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Informative?

Sure that equilibrium is informative?

- Maybe both messages have almost same meaning?
- Or one message rarely sent?

Not a problem

- Messages are always distinct - convex regions
- If c is centerpoint then each message sent with probability at least $1/(N+1)$
- If density f logconcave then probability at least $1/e$
- If $N > 2$ can make each message probability $1/2$

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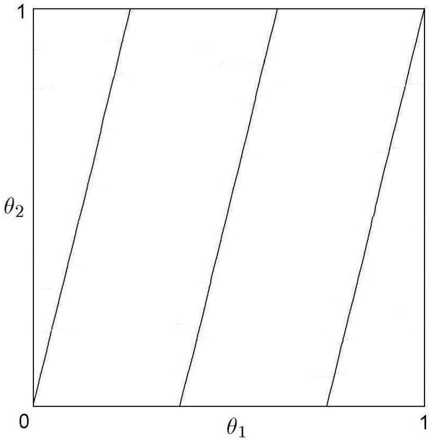

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- $U = 4a_1 - a_2$
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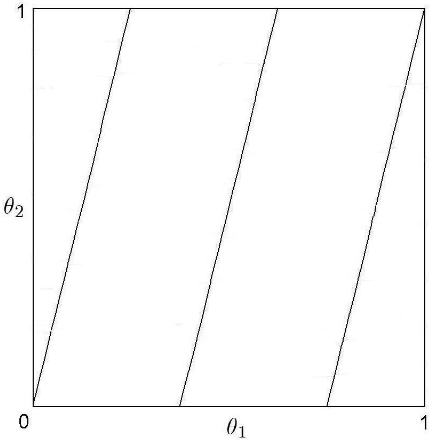

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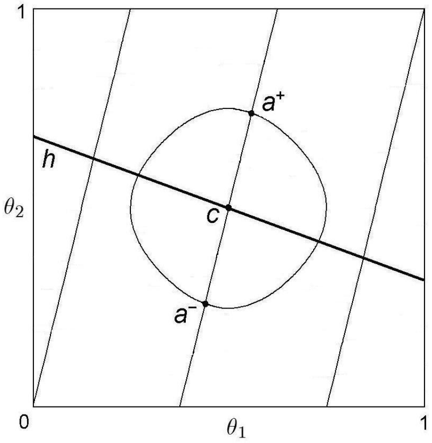

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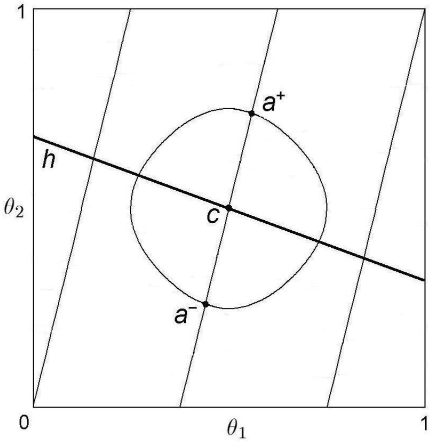

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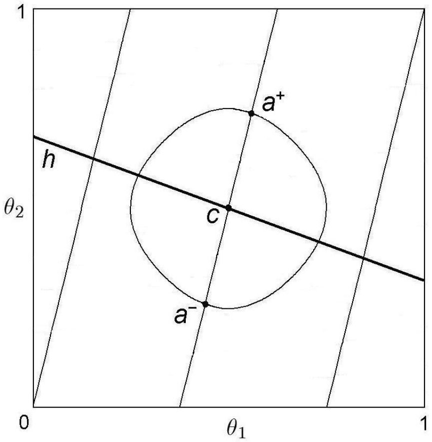

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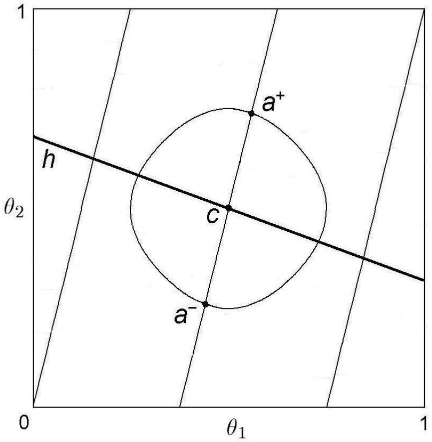

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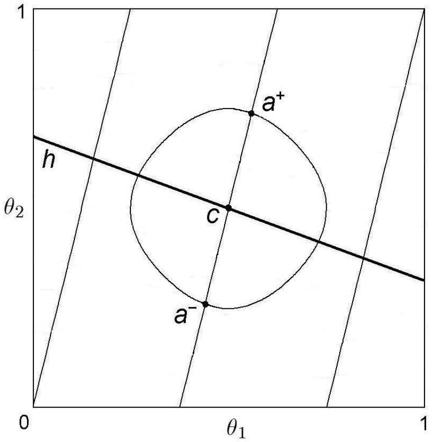

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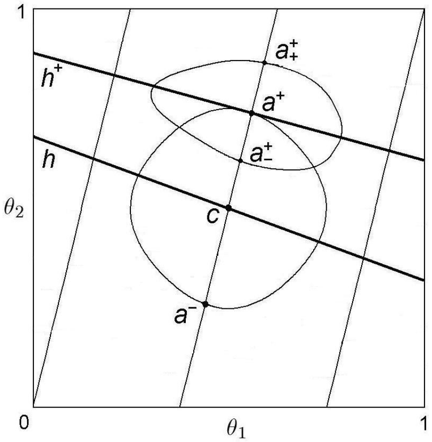

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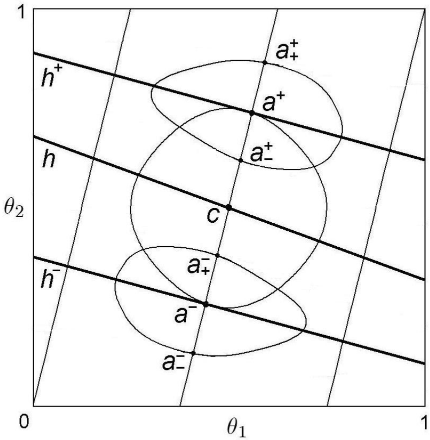

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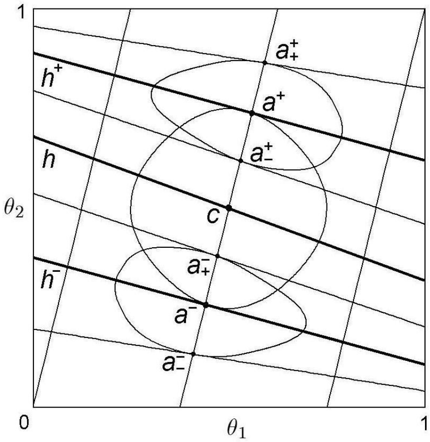

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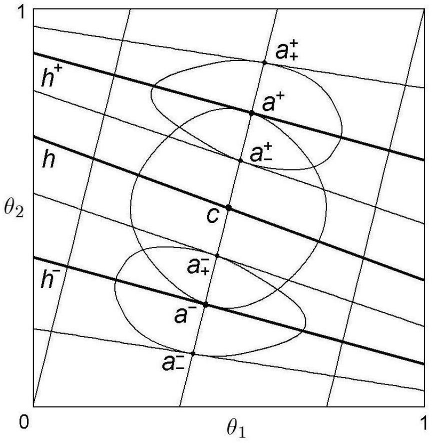

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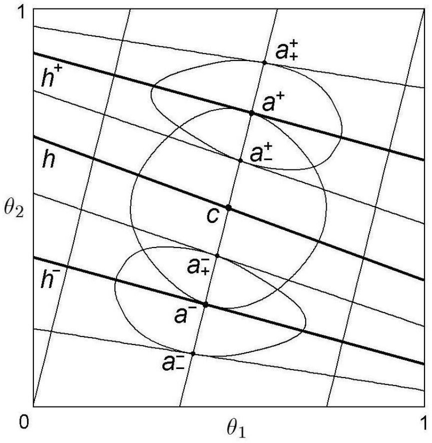

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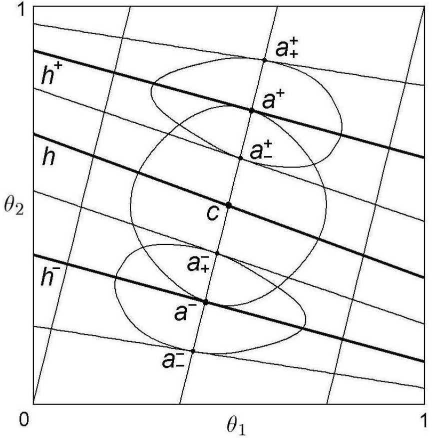

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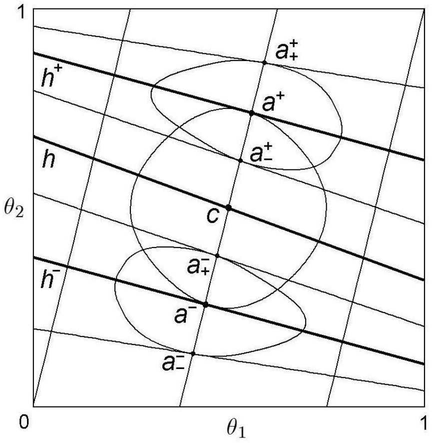

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Very Informative Cheap Talk with Linear Preferences

$$U(a) = \lambda_1 a_1 + ... + \lambda_N a_N$$

Theorem

An informative cheap talk equilibrium revealing almost all information on $N-1$ dimensions exists if U is linear.

- Expert and decision maker have no conflict on $N-1$ dimensions
- Can keep slicing and dicing space so only the one dimension of disagreement is not revealed
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If preferences are not linear then expectations for different subregions won't in general be on same indifference curve

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Robustness checks

But are these results robust to "small" lack of transparency?

1. Expert is almost certainly one type – but not 100%
2. Expert certain to be one of a few types – biased or not
3. Expert preferences fully state-dependent – but small influence on utility

Assume $U(a, t)$ where $t \in \mathbf{T}$ is the type of the expert and prior over $\mathbf{T}$ is Φ

1. Suppose almost certain expert is some type t^* – apply IFT to show existence with mild conditions
2. Suppose $\mathbf{T} = (1, ..., T)$ and $T < N$ – everything still works
3. Suppose $\mathbf{T} = \theta$ and in particular expert has Euclidean preferences – existence for any $\varepsilon > 0$ cost of lying if biases large enough

Robustness checks

But are these results robust to "small" lack of transparency?

1. Expert is almost certainly one type – but not 100%
2. Expert certain to be one of a few types – biased or not
3. Expert preferences fully state-dependent – but small influence on utility

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Robustness 1. Almost certainly one type

Prior Φ strongly weighted toward type t^*

For instance, pretty sure expert not biased

- $U(a, 1) = a_1 + a_2$ and $U(a, 2) = 4a_1 + a_2$
- $\Pr[t = 1]$ close to 1

Consider equilibrium for degenerate case Φ^* where $\Pr[t = t^*] = 1$

If single-crossing like condition (S) on preferences then equilibrium exists for $\Pr[t = t^*]$ sufficiently close to 1

Proposition

Suppose U satisfies condition (S) and $N = 2$. Then, generically there exists $\varepsilon > 0$ such that for each Φ with $||\Phi - \Phi^*|| < \varepsilon$ an influential cheap talk equilibrium exists.

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Robustness 2. Limited type space

Number of possible types T smaller than number of dimensions N

For instance newspaper bias is uncertain

- Could be either liberal or conservative ($T = 2$)
- And it reports on many different issues ($N > 2$)

Can use extra freedom from $N > 2$ dimensions to spin announcement hyperplane different ways, keep everyone happy

- [If temperature and barometric pressure vary continuously around globe then there must be two antipodal points on globe with same temperature and same barometric pressure!]

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Suppose U satisfies $T < N$. Then an influential cheap talk equilibrium exists for all $\mathbf{T}$ and Φ.

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Robustness 3. Euclidean Preferences

$$U(a,\theta) = -\left(\sum_{i=1}^{N}(a_i - (\theta_i + b_i))^2\right)^{1/2}$$

- $b = (b_1, ..., b_N) \in \mathbb{R}^N$ is bias in each dimension
- $(\theta_1 + b_1, ..., \theta_N + b_N)$ is Expert's ideal point

- Interested in arbitrarily large biases: $b = (\rho_1 B, ..., \rho_N B)$ for $B \geq 0$ and $\rho = (\rho_1, ..., \rho_N) \neq 0$
- Suppose there is some $\varepsilon > 0$ cost to lying

Proposition

Suppose U is Euclidean. Then for all F and all k, an announcement strategy is a k-message ε–cheap talk equilibrium for large biases if and only if it is a cheap talk equilibrium for the limiting linear U with $\rho = \lambda$.

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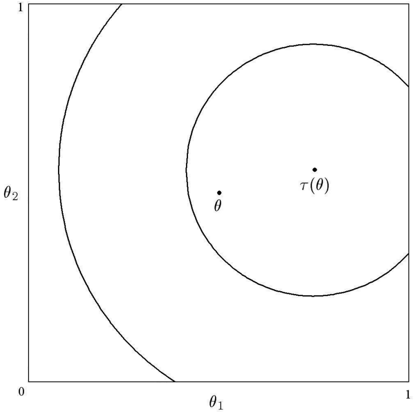
Convergence to Linear Preferences



$$U = -\left((a_1 - (\theta_1 + 4B))^2 + (a_2 - (\theta_2 + B))^2\right)^{1/2}$$

- $B = 1/16$ indifference curves very curved
- $B = 1/8$ become straighter
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- Also becoming more similar for each θ
- Converge uniformly to linear preferences as $B \to \infty$
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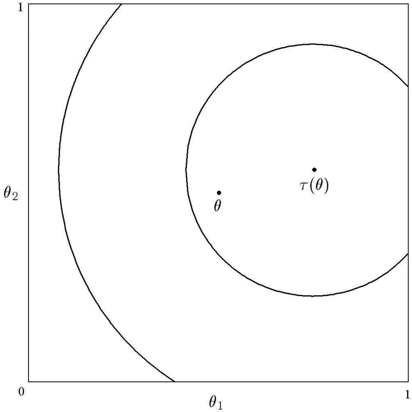

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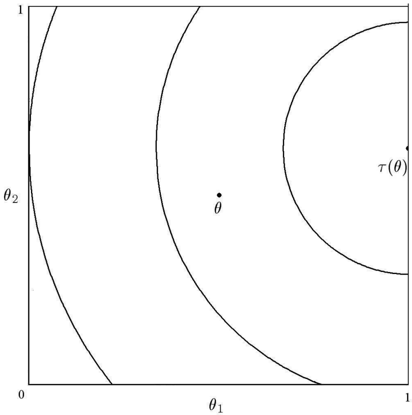

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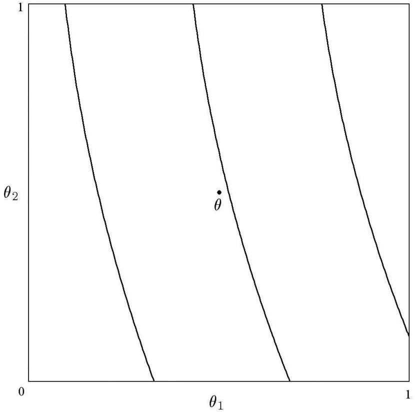

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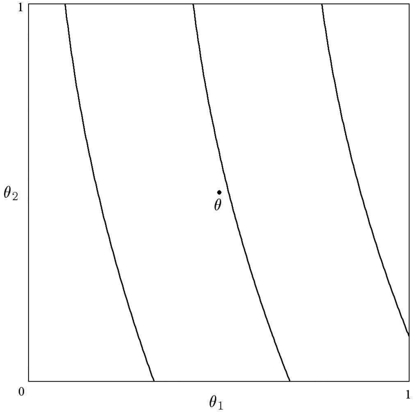

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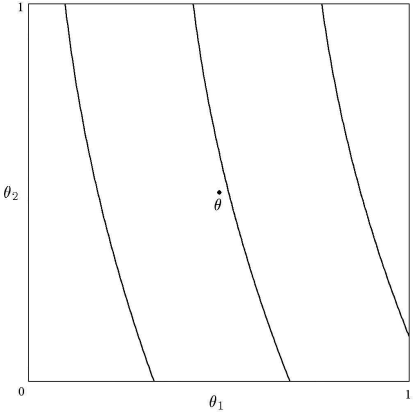

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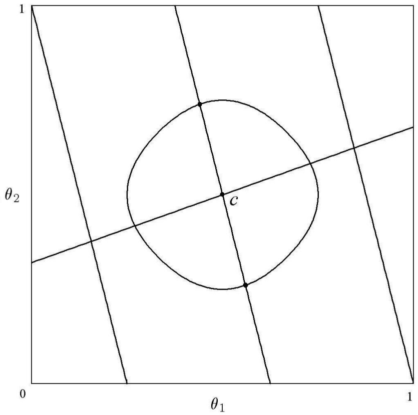

$U = 4a_1 + a_2$

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Cheap Talk vs Delegation

Rely on a biased expert for cheap talk advice?

Or instead just delegate the decision to the expert?

Flexibility from full delegation or information from cheap talk?

- One dimension: Delegation better in standard uniform-quadratic example (Dessein, 2002)
- Multiple dimensions: Cheap talk better in symmetric such model for sufficiently large biases (Chakraborty and Harbaugh, 2007)

Euclidean result implies epsilon cheap talk better than full delegation for sufficiently large biases even if asymmetric

Open question what form of partial delegation is best when such delegation is possible

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Related to models of "transparency"

Previous analyses closely follow one-dimensional CS model

- Does Decision Maker know Expert's bias b?
- Transparency helps or hurts depending on size of b that is revealed (Morgan and Stocken, 2003; Dimitrakas and Sarafidas, 2004)
- If uncertainty over sign of large b then transparency better (Li and Madarasz, 2006)
- Note that preferences are state-dependent even if b is common knowledge

We model transparency as common knowledge of Expert's preferences

- Can allow lots of communication in cheap talk model
- So more consistent with intuition that transparency promotes communication
- But we do not have any comparative results about "more transparency"

Conclusion

Sufficient "transparency" of preferences (state independence) implies existence of cheap talk equilibria

State independence standard in persuasion and signaling literatures

So can just look at most any situation where used persuasion or signaling game, make realistic assumption of multiple dimensions of information, and can find cheap talk equilibrium

Doesn't matter if asymmetries in preferences

Just check for quasiconvexity to see if gain from communication