How Competition Shapes Information in Auctions

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Connections Workshop

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Motivation

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Investment is only worth it if buyers have a fair chance to win:

- Incentivize buyers to inquire about the valuations of their competitors.
- A high-value bidder can discourage others from learning their own.

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Other participants bid cautiously…

…whereas they aggressively competed in Chicago.

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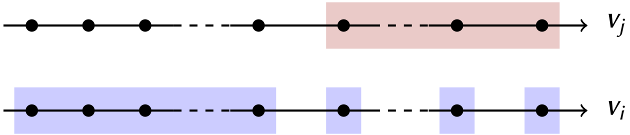
We study second-price auctions in which buyers can flexibly acquire information at some cost.

- ▷ Buyers' valuations are independently drawn.
- ▷ Valuations are **unknown** to buyers ex ante.
- ▷ Can acquire a signal about their own valuations as well as those of **others**.

How does competition shape buyers' information?

- Buyers do not **fully** learn their valuations.

Intuition: No need to learn your valuation if another has a higher one.



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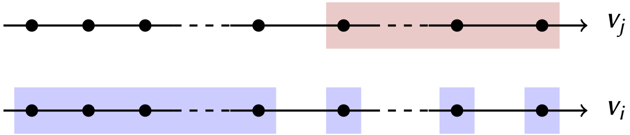

- Cheaper to first assess competition, and only learn own value if worth it.

How does buyers' information shape competition in return?

These learning incentives **hurt** the performance of the auction.

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- **Revenue loss** compared to standard model.

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Market design implications:

- An additional bidder is **less** valuable than optimizing the auction's design.
- Seller gains from maintaining **uncertainty** over competition (e.g., via NDAs).

Related Literature

We build on a previous paper Gleyze and Pernoud (2023):

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This Paper: focuses on second-price auctions to study interplay between *competition and learning incentives.*

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Learning and entry costs in auctions: Milgrom (1981), Haush and Li (1993), Levin and Smith (1994), Persico (2000), Bergemann and Välimaki (2002), Compte and Jehiel (2007), Shi (2012) Lu and Ye (2013), Quint and Hendricks (2018), Lu, Ye and Feng (2021), Bobkova (2021), Marquez (2021), ...

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▷ We propose a tractable model of *multidimensional* learning + isolate deterrence effect of competition on learning incentives.

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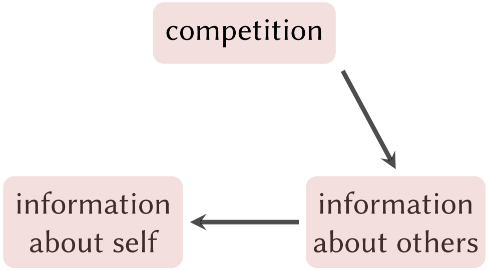
The value of competition—"Auctions vs. Negotiations": Bulow and Klemperer (1996, 2009), Aktas et al (2010), Roberts and Sweeting (2013), Gentry and Stroup (2019), …

▷ New focus on how competition affects what kinds of info buyers acquire.

Outline of Talk

1. The Model

2. How Competition Shapes Information



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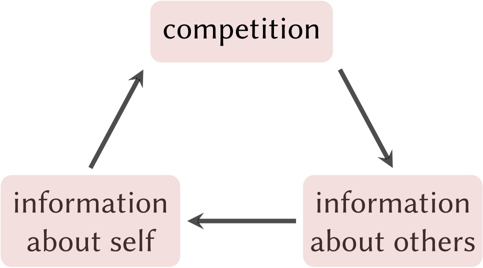
2. How Competition Shapes Information
3. How Information Shapes Competition
    - ▷ Revenue Distortions
    - ▷ Market Design Solutions



The Model

A unique, indivisible good is sold to one of N buyers via a **Second-Price Auction**.

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Utility of buyer i in state (ν_i, ν_{-i}) under bid profile $(b_j)_j$ is

$$U(\nu_i, b_i, b_{-i}) \equiv \left(\nu_i - \max_{j \neq i} b_j\right) \mathbb{1}\left\{b_i = \max_j b_j\right\}.$$

The Model – Information

Buyers have **no** private info ex-ante but, before bidding, can acquire **two signals**:

signal about valuations of others $(\tilde{v}_j)_{j \neq i} \in V^{N-1}$	signal about own valuation $\tilde{v}_i \in V$

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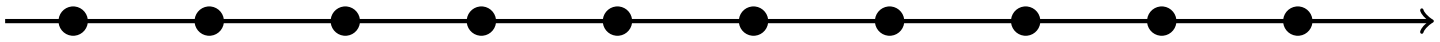

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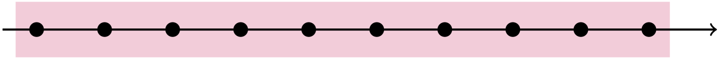

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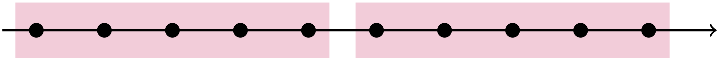

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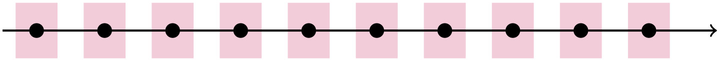

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Information is **costly**. Cost of signal $\propto$ how much signal moves buyer's belief.

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Overall cost is $\quad c\left(\Pi_i^{other}, \text{prior of} \max_j v_j\right) + \mathbb{E}_{\Pi_i^{self}|\pi_i^{other}}\left[c\left(\Pi_i^{self}, \text{prior of } v_i\right)\right] \quad .$

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After having acquired info, each buyer submits a bid $\sigma_i(\pi_i)$.

A **NE** is a strategy profile $(\Pi_i^{other}, \Pi_i^{self}, \sigma_i)_i$ s.t. i's eq strategy solves

$$\max_{(\widehat{\Pi}_i^{other}, \widehat{\Pi}_i^{self}, \hat{\sigma}_i)} \mathbb{E}_{\nu_i, \hat{\pi}_i, \pi_{-i}} \left[U\left(\nu_i, \hat{\sigma}_i(\hat{\pi}_i), \sigma_{-i}(\pi_{-i})\right) \,\middle|\, \hat{\pi}_i \right] - \lambda \operatorname{cost}\left(\widehat{\Pi}_i^{other}, \widehat{\Pi}_i^{self}\right) \quad \forall i.$$

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Equilibrium Selection: Focus on **symmetric** equilibria satisfying a trembling-hand-like refinement.

The Model – Key Assumptions

1. Measure of uncertainty H is **strongly** concave, and sufficiently so. ▸ details

   ≈ cost of signal is **sufficiently convex** in partition fineness.

2. Prior dist. of v_i is **sufficiently uncertain**.

   ≈ prior cannot put almost all weight on a couple of realizations.

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   $\approx$ prior cannot put almost all weight on a couple of realizations.

E.g., set H to be the **entropy** and suppose entropy of prior is not too small.

$$\left[\text{ entropy } H(\Pr(\cdot)) = -\sum_{v_i} \Pr(v_i)\log(\Pr(v_i))\right]$$

How Competition Shapes Information

Can Buyers Learn Their Valuations Fully?

Proposition

*There exist **no** sequence of equilibria* $\{(\Pi_\lambda^{other}, \Pi_\lambda^{self}, \sigma_\lambda)\}_\lambda$ *such that*

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- ▷ **Cost-efficient** to first get some info about v_{-i}, and only learn v_i when worth it.
- ▷ Competitive pressure between buyers makes info about v_{-i} valuable.
- ▷ If buyers can only learn about v_i, they become fully informed for λ small enough.

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Suppose that, for λ small enough, buyers do become fully informed in some eq.

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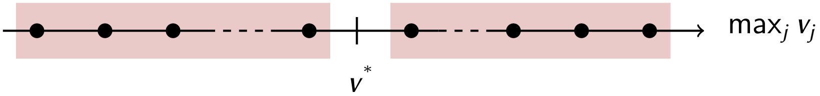

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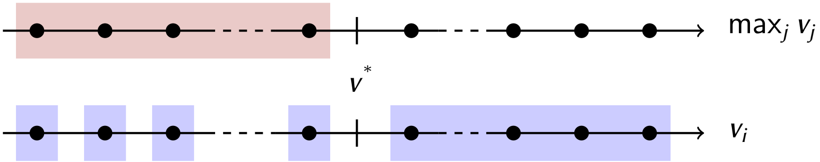

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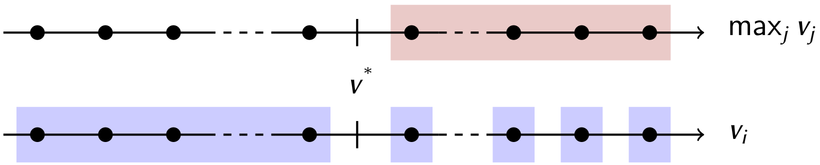

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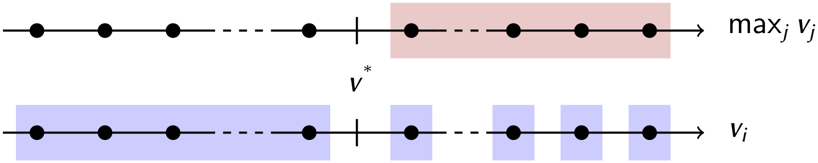

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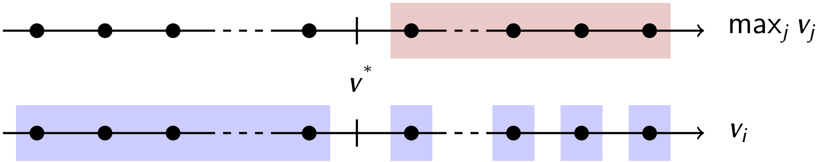

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Alternative strategy yields same **gross** payoff, but **strictly lower** info costs.

- ▷ Assumptions on the cost and prior are key. ‣ more

Equilibrium Information Structure

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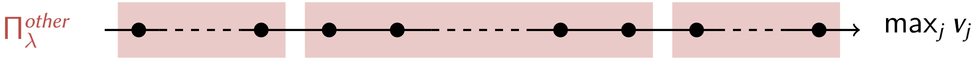
Theorem 1

*There exists $\overline{\lambda}$ such that, for all $\lambda \leq \overline{\lambda}$, in any equilibrium** $(\Pi_\lambda^{other}, \Pi_\lambda^{self}, \sigma_\lambda)$, *buyers*

*(1) acquire **some** info. about* $\max_j v_j$



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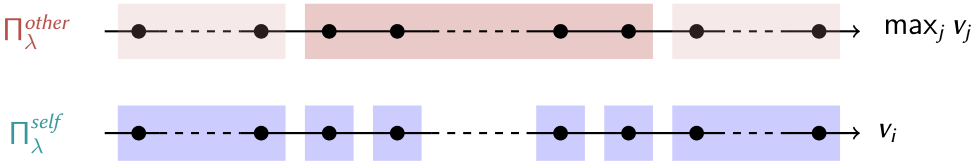
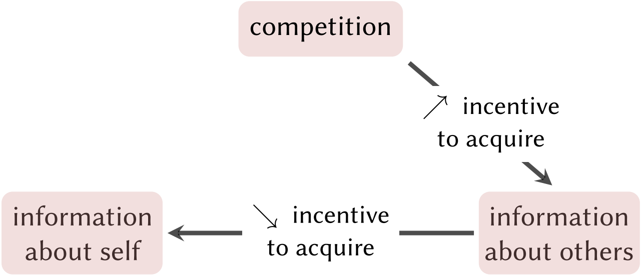


proof details

Takeaway


competition
↗ incentive
to acquire
information
about others
↘ incentive
to acquire
information
about self

Revenue Distortions

How does it affect the performance of the auction?

How does it affect the performance of the auction?

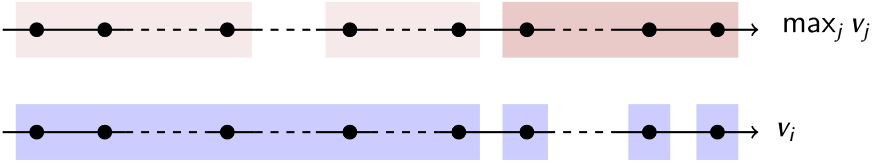
Theorem 2

Let $N \geq 3$. There exists $L > 0$ such that, for small enough information cost λ, the revenue generated in any equilibrium *is bounded away from the expected second-highest valuation:*

$$\mathbb{E}\left[\text{equilibrium revenue} \,\middle|\, \left(\Pi_\lambda^{other}, \Pi_\lambda^{self}, \sigma_\lambda\right)\right] < \mathbb{E}\left[\nu_{(2)}\right] - L.$$

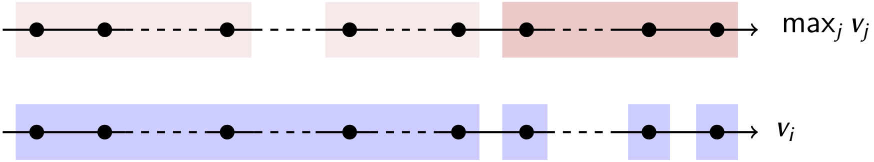
▷ Info acquisition **distorts revenue**, even for small information costs.

Revenue Loss—Cont'd



▸ uniform example ▸ entry

Revenue Loss—Cont'd



For every interval of the eq. partition:

▷ If $v_{(1)}$, $v_{(2)}$ fall in same interval, then price $\approx v_{(2)}$. (*Same as in standard model.*)

▸ uniform example ▸ entry

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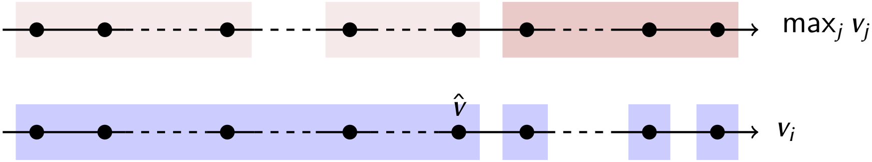

For every interval of the eq. partition:

- If $v_{(1)}, v_{(2)}$ fall in same interval, then price $\approx v_{(2)}$. (*Same as in standard model.*)
- If not, losing buyers fail to learn v_i and bid $\approx \mathbb{E}[v_i | v_i \leq \hat{v}] < \mathbb{E}[v_{(2)} | v_{(2)} \leq \hat{v}]$.

▸ uniform example ▸ entry

Implications for Market Design

The Value of Competition

Why do sellers use auctions? Competitive pressure between buyers helps sellers find a good **price**.

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Bulow & Klemperer (1996) show the value of competition is significant:

revenue of second-price auction with $N+1$ buyers	$>$	revenue of opt. mechanism with N buyers

▷ Careful design of markets may not be that important absent additional frictions.

Extra Buyer vs. Reserve Price

Learning frictions reduce value of competition between buyers.

Theorem 3

There exists $\overline{N}$ such that, for all $N \geq \overline{N}$ and for λ small enough:

revenue with $N + 1$ buyers and no reserve price	$<$	revenue with N buyers and optimal reserve price

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- ▷ Reserve price even **more valuable** as more likely to trim low bids.
- ▷ Opt. reserve price depends on number of buyers N.

▸ uniform example

Maintaining Uncertainty Over Competition

The seller is hurt by buyers' incentives to learn about the competition.

Solution: **Randomize** access to the auction to maintain **uncertainty** over who will be competing:

- $\widetilde{M}$ random set of selected buyers.
- Only bids of buyers in M are considered in the auction.
- Buyers do not know M when acquiring information.

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Buyers do not know M when acquiring information.

- ▷ Relates to the use of NDAs in practice.
- ▷ Might result in **misallocation** of the good if highest-valuation buyer is excluded.

Theorem 4

There exists $\overline{N}$ such that, for all $N \geq \overline{N}$ and for λ small enough:

revenue with opt. random access and no reserve price	$>$	revenue with full access and optimal reserve price

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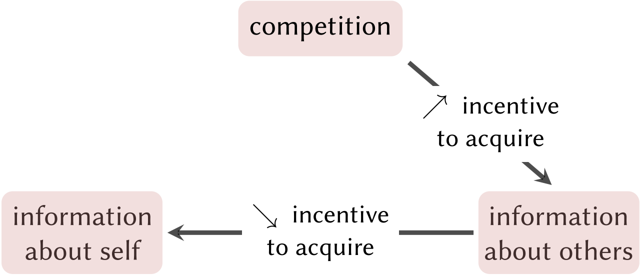
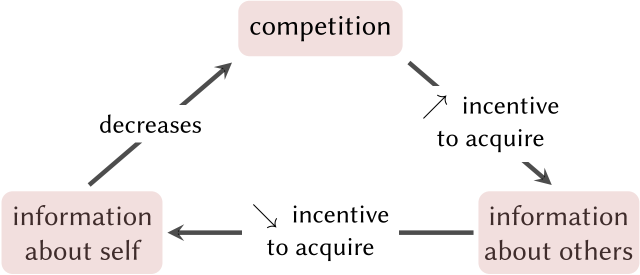
Seller wants buyers to sign NDAs. Buyers want to disclose or signal a high value.

Conclusion



When info is shaped by competition, buyers do not **fully** learn their valuations…

Concluding Remarks



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Take Away: competition more effective if *designed* (w/ reserve price) or *uncertain*.

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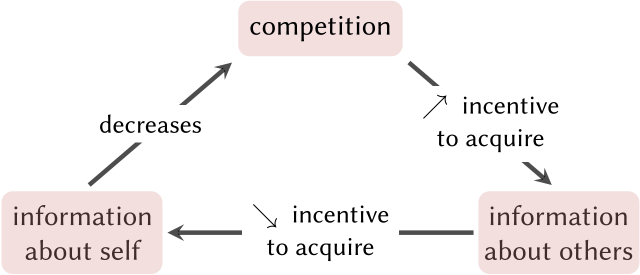

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Take Away: competition more effective if *designed* (w/ reserve price) or *uncertain*.

Thank you! (agathep@stanford.edu)

Additional Material

The Model – Key Assumptions

A1. H is sufficiently concave $\approx$ cost is **sufficiently convex** in partition fineness.

Formally—there exists $m > 0$ such that , for all $q, q' \in \Delta V$ and all $t \in [0, 1]$,

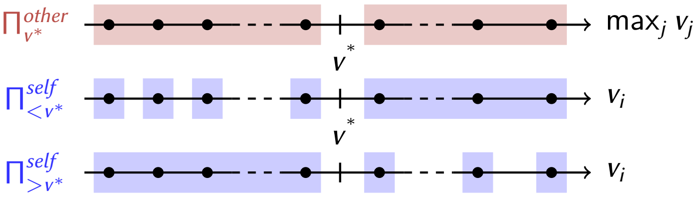
$$H(tq + (1-t)q') - tH(q) + (1-t)H(q') \geq mt(1-t)||q - q'||^2,$$

and m is sufficiently large.

A2. *Prior* is sufficiently uncertain, i.e., $\sum_{v_i} \Pr(v_i)^2$ is small enough.

▸ back

When is it Cost-Efficient?



Lemma

There exists $\overline{\Sigma}$ *and* $\overline{m}$ *s. t. if* $\sum_v [p(v)]^2 \leq \overline{\Sigma}$ *and* $m \geq \overline{m}$*, then*

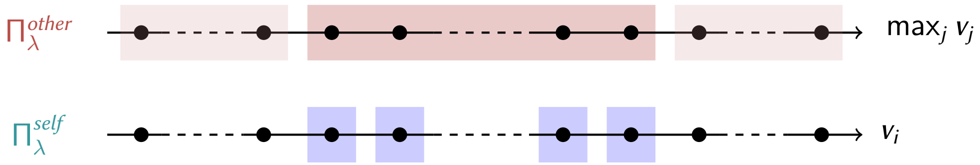
$$c\left(\Pi_{v^*}^{other}, p_{1:N-1}\right) + \Pr\left(\max_j v_j < v^*\right) c\left(\Pi_{<v^*}^{self}, p\right) + \Pr\left(\max_j v_j > v^*\right) c\left(\Pi_{>v^*}^{self}, p\right)$$

is ***strictly lower*** *than choosing* $\Pi^{self} = \{\{v_i\}_{v_i \in V}\}$ *for some* $v^* \in V$.

back

Eq. Information Structure – Proof Outline

Step 1. Info partition about self $\Pi_\lambda^{self}(\pi^{other})$ **cannot** bundle two $v_i', v_i'' \in \pi^{other}$.



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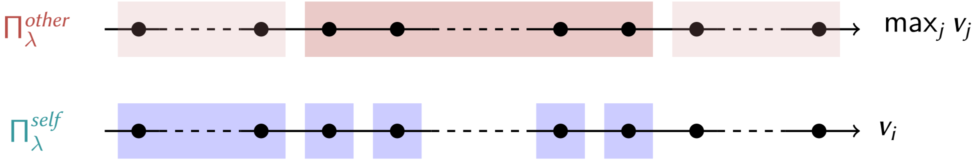

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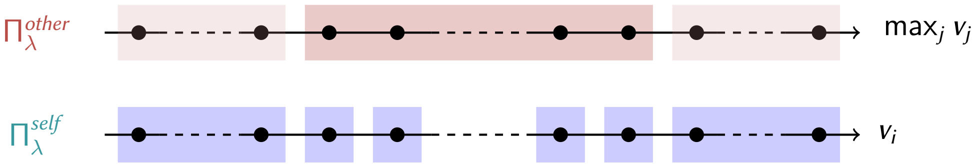

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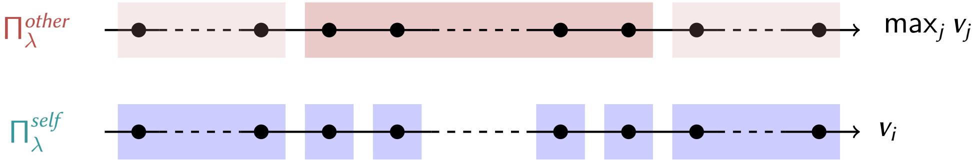
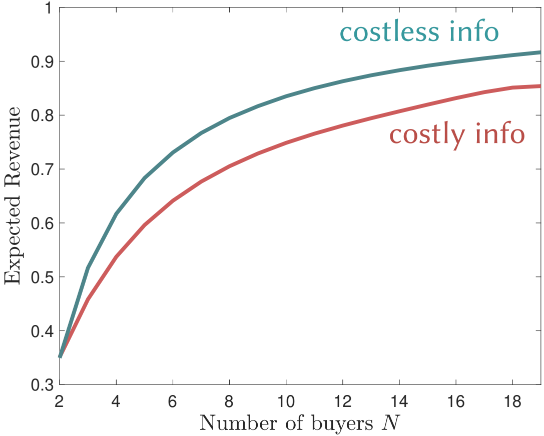


STEP 4. Info partition about others **must** be informative $\Pi_\lambda^{other} \neq \{V\}$.

▸ back

A Uniform Example

$V = \left\{ \frac{1}{K}, \frac{2}{K}, \ldots, \frac{K-1}{K}, \frac{K}{K} \right\}$ with $\Pr(v_i) = \frac{1}{K}$ for all v_i. Cost is based on entropy.



▸ equilibrium partitions ▸ back

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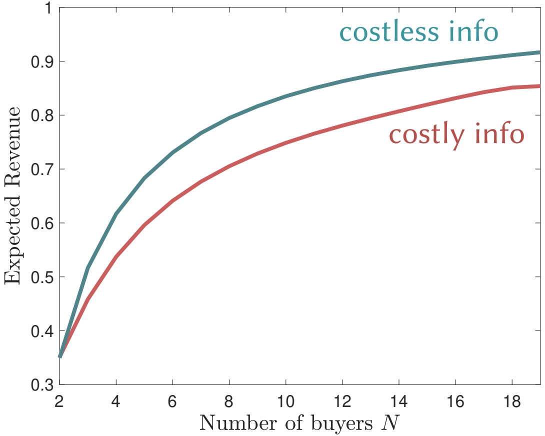

For λ small, eq. leads to efficient allocation. Revenue loss means buyers get **more surplus**.

equilibrium partitions
back

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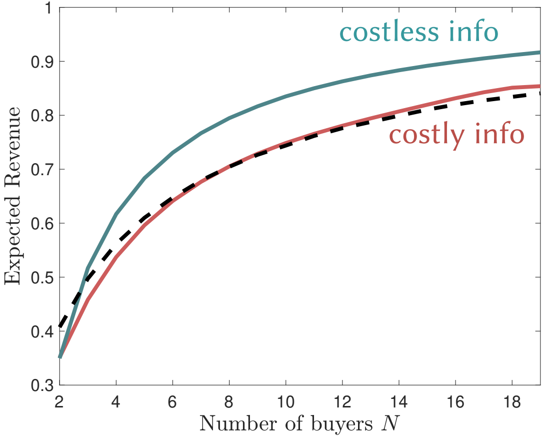

For λ small, eq. leads to efficient allocation. Revenue loss means buyers get **more surplus**.

- - *Posted price:* seller chooses a **fixed** price; if multiple buyers want to buy, one is chosen randomly.

▸ equilibrium partitions ▸ back

Entry Distortions

So far, participation in the auction was *free*. Now suppose buyers must incur an entry cost $\kappa > 0$ to bid. Entry decision occurs at the end of info acquisition stage.

- If learns that another has a higher valuation, might not want to enter at all…
- …which *worsens* the revenue loss.

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- ▷ …which *worsens* the revenue loss.

Standard model: For small entry cost κ, almost all buyers enter.

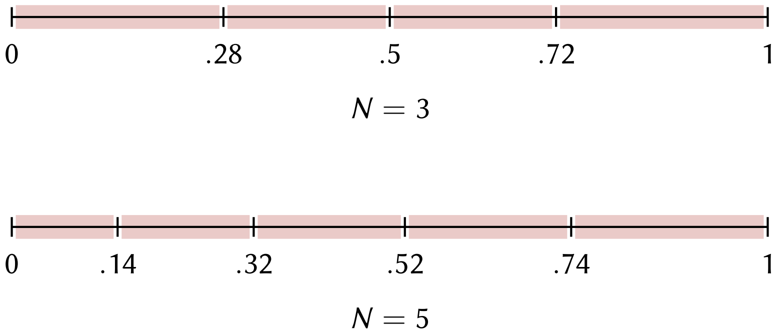
Our model: Several buyers enter only if their valuations fall in a similar range.

- ▷ Presence of high-value buyer **deters entry** of lower-value buyers.

▸ back

A Uniform Example

Equilibrium signal about $\max_j v_j$ partitions V into:



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Extra Buyer vs. Reserve Price—Cont'd

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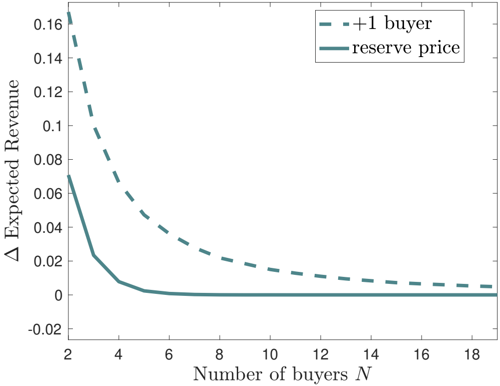
back



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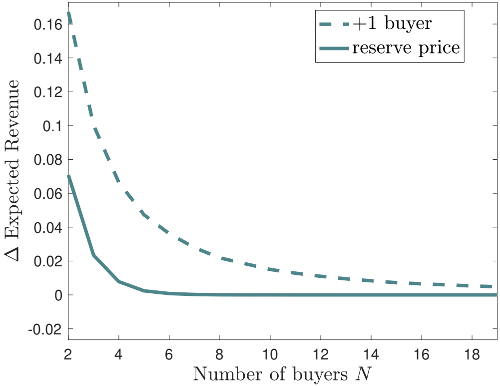

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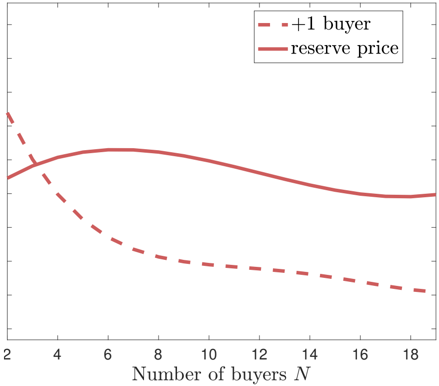

Costly Info ($\lambda > 0$)

Optimal Reserve Price

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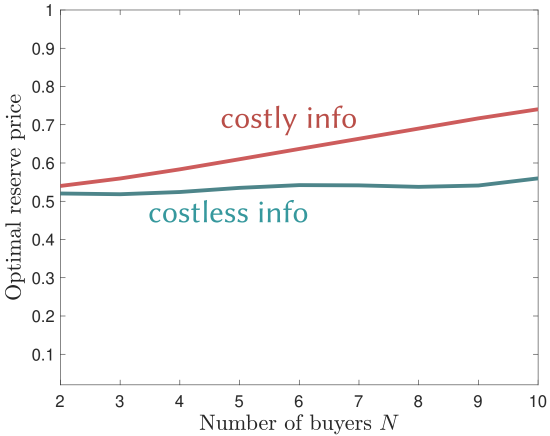
back



First-Price Auction

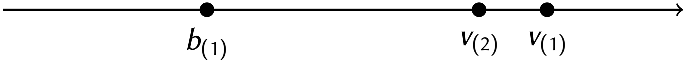
Buyers have an additional *strategic* reason to learn about their competitors:

- Winning buyer wants to bid just above the 2^{nd}-highest bid.

Proposition

The Revenue Equivalence Theorem no longer holds in our model.

If it held, revenue loss in SPA $\implies$ in some states, winning bid $b_{(1)} << v_{(2)}$:



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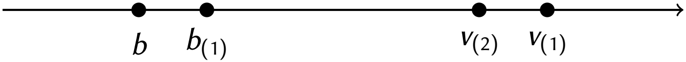

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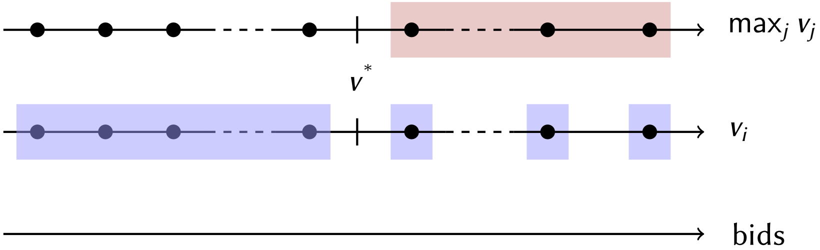

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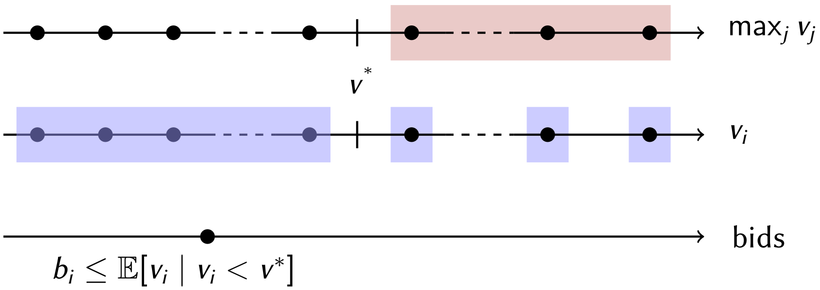

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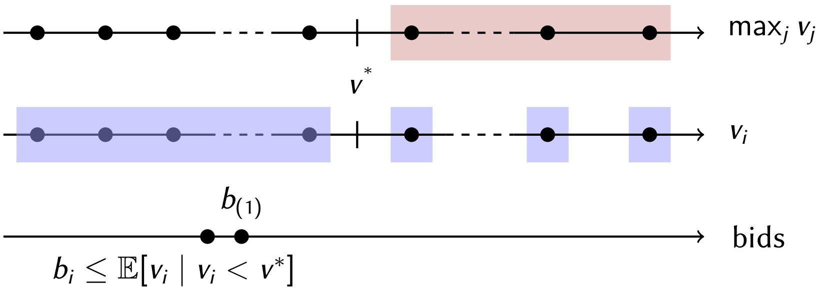

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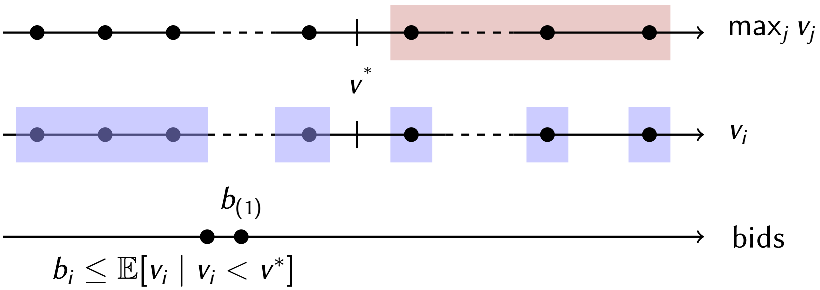

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Role of Price Discovery—Model Extension

$\omega \in \Omega$, with Ω finite, is the common component (*what the seller wants to learn*).

Buyers' valuations are drawn i.i.d. from full-support $p_\omega \in \Delta V$, given ω.

▸ back

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# of buyers N impacts number of bids *and* equilibrium strategies.

Proposition

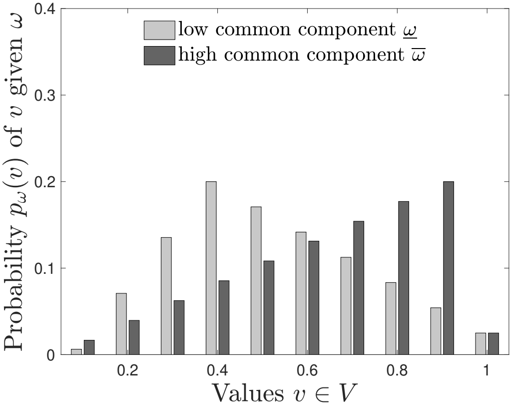
There exist environments $\{p_\omega\}_\omega$ with $p_\omega \neq p_{\omega'}$ for all ω, ω', s. t. the auction ***does not*** *reveal the common component as $N \longrightarrow \infty$, even when λ is arbitrarily small.*

▸ back

Does the Auction Reveal ω?

back

Let $\Omega = \{\underline{\omega}, \overline{\omega}\}$ and $\mu_0(\overline{\omega}) = 0.5$.



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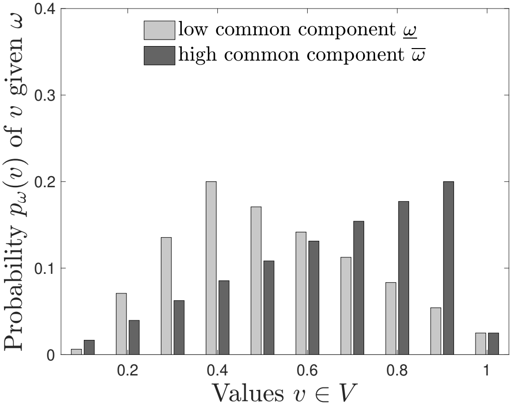

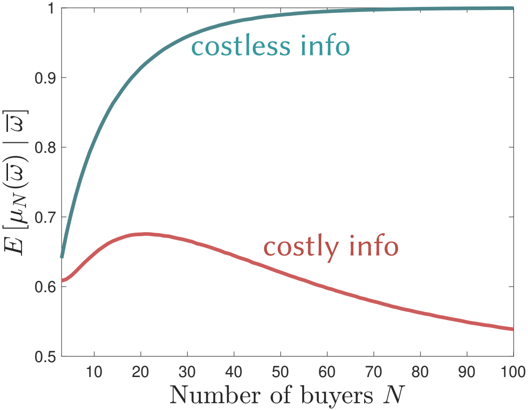

Price Converges More Slowly

In previous lit., price discovery often thought of as *price* $\longrightarrow \nu_{(1)}$ as $N \longrightarrow \infty$.

[Wilson (1977), Milgrom (1979), Pesendorfer & Swinkels (1997, 2000),...]

In our model, price converges **more slowly** because losing buyers often fail to learn and price $\ll \nu_{(2)}$.

▸ uniform example

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▸ uniform example

- Can be problematic if auction prices serve as benchmarks.
- Need larger auctions to find a "correct" price.

▸ back

Price Converges More Slowly

Same example as before.

back