Empirical Analysis and Auction Design

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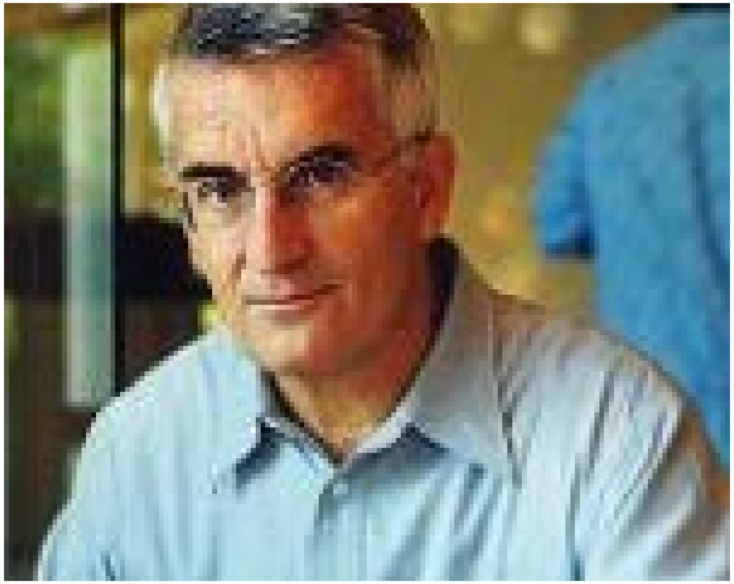
Inspired by …



Jean-Jacques Laffont, 1947-2004

Econometric Society President 1992

Introduction

Auctions are a widely used trading mechanism for both procurement and sales, in both the private and public sectors.

For convenience, consider a seller's auction.

Why use an auction, instead of posting or negotiating a price?

1. **Price discovery**: Buyers' willingness to pay is private information.

- Relevant when the item is unique, or market conditions are changing.
- Past sales of similar items may not be reliable indicators of current market conditions.
- Auctions reveal bidders' willingness to pay before the price is set.

2. **Efficient allocation**: Identity of highest value buyer is unknown.

- Relevant when it is difficult for the seller to determine the best use of the product.
- An auction lets the market decide how to allocate resources.

Imperfect and asymmetric information is central issue for optimal design.

Auction Design Issues

What are the objectives of the seller?

What are the characteristics of the item being sold?

- Product design
- Contractual terms governing *ex post* investments and use

Who can bid?

- Eligibility requirements
- Investments in information acquisition and other entry costs

What are the auction rules?

- Open outcry vs. sealed bid
- Reserve price; public or secret
- Differential treatment of bidders
- Entry fees or subsidies

The Role of Structural Analysis

In some instances, seller can run field experiments.

Online seller with many trading opportunities can experiment with auction rules and design.

Einav, Levin et al (AEJ: Micro 2015) compare identical goods sold on eBay by the same seller at approximately the same time.

Assess the impact of different reserve prices on sale probability and the sale price.

Elfenbein, Fisman & McManus (AEJ: Micro 2015) conduct a similar analysis of an eBay seller certification program.

However, experimentation to explore the set of possible rules and design parameters is not practical in many cases.

In these cases, structural analysis can play an important role.

Economic theory guides the interpretation of data.

The Laffont Program

Transform mechanism design from a theory about unobservables into a theory that is testable, implementable, and useful for policy makers.

Normative question: What is the optimal selling mechanism, from the perspective of the seller?

Optimal: Revenue maximizing, efficient, or some other criteria.

The answer depends on features of the economic environment, and hence empirical analysis can play an important role in auction design.

Here focus on structural analysis to recover primitives, such as the joint distribution of buyers' valuations and their information.

Positive analysis that sheds light on the preferences and behavior of the bidders also plays an important role.

E.g., is bidding consistent with some Bayesian Nash equilibrium?

Outline

Goal: To describe current state and challenges of the Laffont program.

1. Auction Rules under Revenue Equivalence

2. Auction Rules in More General Environments

3. Product Design

4. Ex Ante Investments

5. Ex Post Contingent Payments

6. Design in an Extended Model

7. Summary

1. Auction Rules: Basic Model

Some notation:

n number of (potential) bidders

X_i private signal of bidder *i*

$X = (X_1, \dots , X_n)$

V common payoff component

$U_i = u(X_i,V)$ bidder *i* incremental payoff if obtain one unit

F joint distribution function of (X,V)

$Y_i = \max\{X_j, j \neq i\}$ highest rival signal

W winning bid

$\beta_i(x)$ bidder *i*'s (monotone) bid strategy

$\eta_i(b)$ inverse bid function of bidder *i*

Main Assumptions

- Each bidder wants only one unit.
- Utility function u is non-negative, continuous, and increasing in each argument, and common across bidders.
- Bidders are risk neutral.
- F(X,V) is symmetric in the signals X (exchangeability).
- (X,V) are affiliated.
- X_i is real-valued.
- F, n and u are common knowledge.
- The losing bidders don't care who wins.

We will relax several of these assumptions later.

Special Cases

Private Values (PV):

$$u(X_i,V) = X_i$$

The important restriction here is:

$$E[u(X_i,V)| X] = E[u(X_i,V)| X_i]$$

Can normalize the signal X_i to be an unbiased estimator of valuation:

$$X_i = E[u(X_i,V)| X_i]$$

- Independent PV (IPV):

  X_i's i.i.d. with marginal distribution function F_x
- Affiliated PV (APV): X_i's are affiliated.

If not PV, then ***Common Values (CV)***.

Also known as interdependent values.

- Pure Common Value: $u(X_i,V) = V$, scalar V

Revenue Equivalence

Suppose bidders are risk neutral and symmetric, with IPV distributed according to d.f. $F_X(x)$, p.d.f. $f_X(x)$

Then the symmetric Bayesian Nash equilibria under first and second price auction formats yield equal expected revenues, given a reserve price r.

Empirical analysis of bidding data inform the reserve price choice.

If the seller's valuation is x_0, the efficient reserve price is x_0

The expected revenue maximizing reserve price r satisfies

$$r = x_0 + [1 - F_X(r)] / f_X(r)$$

This is the optimal take-it-or leave-it offer to a random bidder; doesn't depend on number of bidders.

To implement, need to estimate F_X

Can use the techniques of Guerre, Perrigne & Vuong (GPV, Ema 2000).

GPV for FPSB IPV

Expected profits from bidding b, given a signal x and rivals' strategy $\beta(.)$:

$$\pi(b,x) = (x - b) \Pr\{\text{win} \mid \text{bid } b\} = (x - b) F_X(\eta(b))^{n-1}$$

Differentiating with respect to b and imposing symmetry ($b = \beta(x)$):

$$(n-1)[x - \beta(x)] f_X(x) = \beta'(x) F_X(x) \quad \text{if } x \geq r; \quad r = \beta(r)$$

Laffont & Vuong (AER 1996) idea:

Let G denote the d.f. of a random rival bid, and g its p.d.f.

Then $F_X(x) = G(\beta(x))$ and $f_X(x) = g(\beta(x))\, \beta'(x)$.

Substitute into the FOC and evaluate at $b = \beta(x)$, to obtain the inverse bid function:

$$\eta(b) = b + G(b)/[(n-1)g(b)] = \xi(b,G) \text{ for } b \geq r$$

$\xi(b,G)$ must be monotone increasing in b, with $\lim \xi(b,G) = r$ as $b \downarrow r$.

Bidder type is obtained from best reply to empirical dist'n of rival bids.

Estimation

Suppose observe all bids. Estimation proceeds in two steps.

1. Choose a sub-sample with fixed n.

   Estimate G and g (parametric or non-parametric).

   Form valuation estimates:

   $x_{it} = \xi(b_{it}, G)$

   This yields a sample of pseudo-values.

2. Use the pseudo-values $\{x_{it}\}$ to estimate F_X

   If variation in n is exogenous, can pool across sub-samples with different n.

Advantages of the first-order approach:

- Need not compute equilibrium
- Need not rely on functional form assumptions
- Easy to implement computationally
- Can condition distributions on observable item characteristics

English Auctions

Haile & Tamer (JPE 2003) study oral, ascending auctions under IPV.

Likelihood function is not well-defined due to multiple equilibria problem.

There is no simple interpretation of losing bids.

Suppose b_i is *i*'s highest submitted bid. Assume:

A1. No bidder submits a bid greater than their value: $x_i \geq b_i$ for all *i*.

A2. Losing bidders are not willing to raise the winning bid by the minimum bid increment Δ:

$x_i \leq w + \Delta$ for all *i* except the winning bidder.

The two assumptions provide upper and lower bounds on F_X, without otherwise specifying equilibrium play.

Surprisingly, the bounds can be tight. The implied bounds on revenues under alternative reserve prices are also tight.

Caution: A2 may not be satisfied for equilibria with jump bidding.

2. Extensions

GPV framework can be adapted to many other settings:

- Asymmetric bidders: IPV with d.f. F_i for bidder *i*
- Affiliated private values (APV)
- Unobserved heterogeneity
- Common values
- Risk averse bidders
- Asymmetric equilibria
- Multiple units
- Departures from BNE; e.g., collusion

In the above settings, revenue equivalence no longer holds; optimal auction design entails more than choosing a reserve price.

Asymmetric Bidders

GPV is straightforward to adapt in case of FPSB with private values.

Let F_i denote the d.f. of bidder *i*'s valuation.

Bidder *i*'s inverse bid function is a best response to empirical distribution of its highest rival bid, denoted M(i), with d.f. $G_{M(i)}$ and p.d.f. $g_{M(i)}$

$$\eta_i(b) = b + (G_{M(i)}(b)/g_{M(i)}(b)) \text{ for } b \geq r$$

Here $G_{M(i)}(b) = \prod_{j\neq i} G_j(b) = \prod_{j\neq i} F_j(\eta_j(b))$, the probability that bidder *i* wins with bid *b*.

Require sufficient individual bidder data to estimate the bidder specific distribution function of bids, $G_i(b)$.

Or categorize bidders by observable types, consider type-symmetric BNE.

Given estimates of F_i, characterize optimal mechanism (Myerson 1981).

Typically, treat bidders asymmetrically.

Auction Heterogeneity: FPSB

If the distribution of IPV valuations depends on observable auction characteristics, Z, can estimate $F_X(x|Z)$ by GPV methods.

The inverse bid function is now:

$$\eta(b,Z) = b + G(b|Z)/[(n-1)g(b|Z)] \quad \text{for } b \geq r$$

Optimal reserve price depends on Z.

Suppose auction characteristics Z are not observed by the econometrician.

Then bids are correlated and, typically, inferred bidder markups too large.

Distribution of rival bids G(b) is mixture of G(b|Z) over dist'n of Z.

Solution, when heterogeneity is multiplicative:

Non-parametric: Krasnokutskaya (RES 2011)

For subsample with at least two bids, examine bid ratios.

Parametric: Athey, Levin & Seira (QJE 2011), Krasnokutskaya & Seim (AER 2010)

Affiliated Private Values: FPSB

Suppose instead correlation arises because valuations are affiliated.

Laffont & Vuong: Fix n and let $M = \beta(Y)$ denote the highest rival bid among n-1 rivals.

Let $G_{M|B}$ denote the distribution function of M, conditional on one's own bid B, and $g_{M|B}$ the conditional p.d.f.

Then $F_{Y|X}(y|x) = G_{M|B}(\beta(y)|\beta(x))$ and $f_{Y|X}(y|x) = g_{M|B}(\beta(y)|\beta(x))\,\beta'(y)$.

Substitute into the FOC and evaluate at $b = \beta(x)$ to obtain the inverse bid function:

$$\eta(b) = b + [G_{M|B}(b|b)/g_{M|B}(b|b)] \quad \text{for } b \geq r$$

$G_{M|B}(b|b)$ is the probability of winning with bid b ($M \leq b$).

For each value of n, use GPV methods to estimate the joint distribution of valuations.

GPV for Symmetric FPSB under CV

Expected profits from bidding b, given a signal x:

$$\pi(b,x) = \int^{\eta(b)} [w(x,y) - b]\, dF_{Y|X}(y|x)$$

where $w(x,y) = E[u(X,V)|\, X=x, Y=y]$ (= x if PV).

Differentiating with respect to b and imposing symmetry:

$$[w(x,x) - \beta(x)]\, f_{Y|X}(x|x) = \beta'(x) F_{Y|X}(x|x) \quad \text{if} \quad x \geq x^*(r,n)$$

Apply the Laffont & Vuong transformation of variables:

$$F_{Y|X}(y|x) = G_{M|B}(\beta(y)|\beta(x)) \quad \text{and} \quad f_{Y|X}(y|x) = g_{M|B}(\beta(y)|\beta(x))\, \beta'(y).$$

Substitute into the FOC and evaluate at $b = \beta(x)$, to obtain the inverse bid function:

$$w(\eta(b),\eta(b)) = b + [G_{M|B}(b|b)/g_{M|B}(b|b)] = \xi(b,G) \text{ for } b \geq r$$

Here $\lim_{b\downarrow r} \xi(b,G) > r$.

Common Values

The distinction between PV and CV is important in mechanism design.

Laffont & Vuong (AER 1996): Any CV model is indistinguishable from an APV model, for a fixed number of bidders.

Many studies estimate PV model, or choose PV vs. CV based on prior.

But APV and CV models can be distinguished if there is exogenous variation in the number of bidders (Haile, Hong & Shum, 2006).

Or if the reserve price is binding (Hendricks, Pinkse & Porter, RES 2003; Hill & Shneyerov, J Ecm 2013).

CV model is also identified if observe measure of ex post value (HPP).

Or if observe factors that affect bidder value asymmetries (Somaini, 2015)

example: distance to job for highway repair contracts

Even absent identification, can predict revenues from change in auction format from FPSB to SPSB (Sheneyerov, RJE 2006) or bound revenues from change in reserve price (Tang, RJE 2011).

Affiliated Private Values: English Auctions

Suppose the winning bid in an English auction is the second highest valuation, so $W = X_{n-1:n}$

This assumption is stronger than Haile & Tamer's A2.

Aradillas-Lopez, Gandhi & Quint (Ema 2013):

In order to compute counterfactual revenues or bidder surplus under different reserve prices, it is sufficient to know the marginal distribution function of the second highest valuation (the winning bid), $F_{n-1:n}$, and the d.f. of the highest valuation, $F_{n:n}$

The former is observed, the latter can be bounded.

E.g., upper bound: $F_{n-1:n} = F_{n:n}$ when valuations are perfectly correlated.

Then can derive bounds on the optimal reserve price.

Risk Averse Bidders

Suppose bidders are risk averse.

If symmetric IPV, FPSB yields higher expected revenues than SPSB.

Suppose CRRA utility: $u(x) = x^{\lambda}$ where $0 < \lambda \leq 1$.

Then FPSB inverse bid function: $\eta(b) = b + \lambda G(b)/[(n-1)g(b)]$ for $b \geq r$

Lower FPSB markups than under risk neutrality.

In Vickrey auction (SPSB), $\beta(x) = x$ remains a dominant strategy.

Risk neutral seller prefers Vickrey auction.

Identification of risk preferences from FPSB data can be difficult (Campo, Guerre, Perrigne & Vuong, RES 2011): u(x) not non-parametrically identified, CRRA or CARA parameters are identified.

Estimation is straightforward if payoffs are observed.

E.g., Bajari & Hortacsu (JPE 2005) study experimental data.

Asymmetric Equilibria

Asymmetric equilibria?

The SPSB CV auction with 2 bidders has a continuum of asymmetric equilibria (Milgrom, Ema 1981).

E.g., if one bidder is aggressive, the other is relatively passive.

If there are multiple equilibria, then must either assume equilibrium selection as part of estimation, or take multiplicity into account, say via bounds (as in Haile & Tamer).

Sometimes concern expressed that a merger might eliminate "maverick."

In auction context, maverick might play aggressive strategy when there are multiple equilibria. A merger may affect both the number of bidders and which equilibrium is played.

Not much work on this to date.

Multiple Units

In many instances, multiple units are sold or procured simultaneously, rather than sequentially.

Examples: treasury bills, wholesale electricity, spectrum licenses.

Mechanism design choice for identical items:

Discriminatory auctions, in which winning bidders pay their own bids, vs. Uniform price auctions, in which winning bidders all pay the same price (such as the lowest winning bid, or the highest losing bid).

Ausubel & Cramton (2002) show that there is no clear ranking of the two auction formats according to expected seller revenues.

The revenue maximizing choice is an empirical issue.

Structural methods estimate the distribution of valuations, and so draw inferences about the consequences of changes in the selling procedure. Buyers may value more than one of the multiple units being sold.

For non-identical items, there is also an issue of whether and how to bundle items, or allow package bids, to reflect complementarities.

Treasury Bill Auctions

Hortacsu & McAdams (JPE 2010) study discriminatory Turkish auctions.

Model based on Wilson's (QJE 1979) analysis of share auctions, in which bid schedules are continuous.

Assume private values, real valued signals.

(Euler-LaGrange) necessary condition to demand q units at bid price b:

$$v_i(q,x) = b + G_i(b,q)/(\partial G_i(b,q)/\partial b)$$

where $v_i(q,x)$ is the marginal value at q given signal x, and $G_i(b,q)$ is the probability that the bid point (b,q) is accepted.

Here $v_i(q,x)$ is smooth, decreasing in q and increasing in x.

Analogous to the inverse bid equation in the single item case.

Kastl (RES 2011) studies uniform price Czech auctions.

Explicit recognition of bids as step functions, not continuous.

Bidders choose the number of bid points, and (b,q) for each point.

Multiple Units: Estimation

Inverse bid equation for discriminatory auctions given signal x:

$$v_i(q,x) = b + G_i(b,q)/(\partial G_i(b,q)/\partial b)$$

where $G_i(b,q)$ is the probability that the bid point (b,q) is accepted.

Hortacsu & McAdams propose resampling method to estimate $G_i(b,q)$:

For each bidder *i*, randomly draw with replacement from the set of rival bid functions n-1 times.

If bidders are asymmetric, draw from sets of types to maintain number of rivals of each type.

Sum bid functions to obtain estimate of aggregate rival demand function.

Given aggregate supply and *i*'s bid function, obtain estimate of market clearing price p, and hence whether $b \geq p$.

Repeat, to estimate frequency of $b \geq p$, and hence $G_i(b,q)$ for each (b,q) on *i*'s bid function.

Require large number of bidders, or pooling across auctions.

Bayes Nash Equilibrium?

BNE play can require considerable sophistication.

Alternatives might entail less sophisticated bidding (e.g., simple rules of thumb, such as linear or proportional bidding strategies) or systematic biases (e.g., winner's curse in common value auctions).

Hendricks & Porter (AER 1988): pre-1980 oil & gas drainage auctions

- Bidding consistent with BNE of pure CV auction in which neighbors are better informed and collude, non-neighbors are uninformed (also Hendricks, Porter & Wilson, Ema 1994).

Hendricks, Pinkse & Porter (RES 2003): pre-1980 wildcat auctions

- Bidding consistent with BNE of symmetric pure CV auction

Another alternative is collusion.

Collusion: Detection

Auctions can be an effective price discovery process.

But sellers are at an information disadvantage, and may be vulnerable to price manipulation by a buyer cartel.

There will be a welfare loss from collusion relative to the non-cooperative outcome if potential gains from trade are foregone.

E.g., if average bid prices are low, and potential sellers opt out of market; or if the auction outcome is inefficient.

Would like to determine when collusion is present, to inform antitrust policy or optimal auction design.

Porter & Zona (JPE 1993, RJE 1999): reduced form tests, showing how behavior of subset of bidders deviated from BNE.

Kawai & Nakabayashi (2015): suspicious patterns of bids across re-auctioned projects, focusing on rank reversals.

Aradillas-Lopez, Haile, Hendricks & Porter (2015): test affiliation of participation and bid decisions by owners of neighbor leases.

Collusion: Auction Design

Suppose identify a subset of bidders who collude in a PV setting.

Can estimate the value dist'n of the representative bidder for the cartel and that of the non-cartel bidders, assuming they compete as in BNE.

Use GPV methods for asymmetric bidders.

Then can derive the optimal mechanism.

Caveat: This takes cartel membership, and the valuation distribution of the cartel bidder, as given.

Under efficient collusion, cartel value is maximum conspirator value.

But if cartel allocation of bidding privileges depends on auction rules (e.g. if conspirators are asymmetric), the cartel value is endogenous.

Example: Asker's (AER 2010) structural analysis of behavior in stamps auction and preceding cartel knockout auction by bidding ring.

Under CV, similar logic, complicated by cartel information aggregation.

If mechanism design affects cartel information aggregation, it also alters the degree of winner's curse faced by non-cartel bidders.

3. Product Design

"The scope and terms of spectrum licenses can be even more important than the auction rules for determining the allocation."

Milgrom (2004), *Putting Auction Theory to Work*

In many auction environments, the item being sold is a contract.

e.g., spectrum license, oil & gas lease, timber lease, procurement.

Contract terms can affect both *ex ante* decisions of the bidders and *ex post* decisions by the winning bidder, and hence the value of contract.

In timber and oil & gas auctions, the product is a lease. Design aspects:

- Obligation (timber) vs. Option (oil & gas)
- Duration – number of years
- Scope – geographical coverage, tasks
- Terms – royalty payments, incentive payments
- Restrictions – preferred buyers

Henceforward, use timber and oil & gas auctions to illustrate tradeoffs.

Lease Rights

Oil & gas lease confers the right, but not the obligation, to explore.

If exploratory drilling is successful, then the lease holder also has the right to develop and extract the oil & gas (as long as the lease is productive).

Under these option contracts, many leases are not drilled.

In some cases, drill only if nearby tracts are productive or prices increase.

Congress has expressed concern over low drill rates ("speculative" buying, "hoarding"), argued for stricter work requirements.

This argument ignores the value of the option not to drill.

If lease holders were required to drill, even if they receive bad news (dry holes on neighboring tracts, falling prices), the value of leases is lower.

Bid levels are then lower, and firms bid for fewer tracts, lowering development rates and auction revenues.

Timber lease holder has the obligation to harvest.

Less of an information externality, option not to cut valued primarily because of price uncertainty. Smaller impact from obligation to cut.

Lease Size

Oil & gas leases pertain to a tract, approximately 9 square miles.

Tracts too small to internalize information externalities from exploration.

If adjacent tracts have multiple owners, private information inhibits efficient exploration plans (Hendricks & Porter, AER 1996).

One solution would be to define leases on bundles of tracts.

Problems with bundling:

- Efficient combinations are not obvious *ex ante*
- Bidding may be less competitive, if capital requirements limit entry

Timber leases also pertain to tracts.

Might be economies of scope with respect to packages of leases associated with road building, but government subsidizes road building costs.

Question is whether tracts are of efficient size, in terms of economies of scale of harvesting.

Lease Tenure

Oil & gas lease tenure depends on water depth (5, 8 or 10 years).

Tenure is longer than necessary to drill wells; many tracts drilled in first year.

Longer tenure may lead to inefficient strategic delay.

If tenure is too short, cannot explore adjacent tracts sequentially; simultaneous search is inefficient when there are information externalities.

Under symmetric BNE, lease holders have highest valuations at sale date.

Ownership transfer may be efficient given subsequent information arrival.

Resale market suffers from adverse selection, due to private information.

Potential buyers then wait for lease to expire and the tract to be re-auctioned.

Argues for shorter lease terms, but not too short.

Timber lease tenure is typically 1 to 5 years.

Incentive to harvest when prices high; option value from waiting.

Short lease term to expedite development conflicts with revenue goals.

Lease Payments: Oil & Gas

Oil & gas leaseholder makes three kinds of payments:

- Bonus bid, payable at time of sale
- Annual rental fees until lease expires or production begins
- Royalty payments; fixed fraction of revenues from production (1/6 in shallow waters, 1/8 in deep)

Bonuses depend on bidder's *ex ante* value, royalties on *ex post* value.

Bonus bids are now relatively low; government captures smaller share of value (Haile, Hendricks & Porter, IJIO 2010).

Rentals were small until recently, now increase with age of lease.

High rental rates reduce option value, but encourage transfers.

Majority of revenues since early 1980s have been from royalty payments.

What is the optimal royalty payment? Is it positive?

Lease Payments: Timber

In scaled sales, bids are vectors of per-unit prices.

For each species on tract, bid is amount per volume harvested.

Forest Service scoring rule evaluates bids based on their estimate of relative volumes of each specie; estimate is announced prior to sale.

Payments by winning bidder are based on actual amounts harvested.

Insures bidders against total volume uncertainty, but incentive to skew bids.

- Bid more for species whose relative volume is overestimated by the Forest Service, bid less if underestimated.

Risk with respect to species composition is exacerbated by bid skewing.

Payoffs have common value component.

Athey & Levin (JPE 2001) provide theory and evidence.

Estimates indicate that information rents are bid away in English auctions, but not FPSB.

Open outcry auction is preferable for mitigation of winner's curse.

Revenues vs. Efficiency

The auction solves an adverse selection problem.

Typically, there is a tradeoff between efficiency and revenue (e.g., when optimal reserve price exceeds seller's valuation).

Contract design can help solve a moral hazard problem or a problem of economies of scale or scope, enhancing the value of the contract.

Seller's efficiency and revenue maximizing motives are often aligned.

Caveat: design could lower revenues through its impact on competition

Empirical analysis can inform contract design choices.

Bajari & Lewis (QJE 2011, RES 2014): Measure the effect of deadlines and penalties on work rates and bids on highway contracts.

Bajari, Tadelis & Houghton (AER 2014): Study how renegotiation over work changes affects costs and bids on highway contracts.

Kransakutskaya, Song & Tang (2014): Examine a multi-attribute procurement auction where buyers care about price and quality.

4. *Ex Ante* Investments

Bidders often have to invest resources to learn about the value of the contract or asset being sold.

e.g., timber cruises, seismic studies, due diligence in M&A.

The set of bidders, their valuations or their information may not be fixed.

If auction design extracts all bidder rents, no incentive to invest.

Seller pays investment costs indirectly via lower participation and bids.

Simultaneous entry and bid mechanism is typically not optimal.

Restricting entry can be both revenue and efficiency enhancing.

The tradeoffs across entry/auction formats are largely an empirical issue.

Theoretical literature on CV auctions and *ex ante* information acquisition:

Matthews (1984), Hausch & Li (ET 1993), Persico (Ema 2000), Bergemann & Valimaki (Ema 2002)

Persico: stronger incentive to acquire information in FPSB than SPSB

Two Models of Entry Under PV

Value Learning Model: Bidders have no private information about their values prior to entry, and must pay a cost to learn them.

Entry is random with respect to values.

Bulow & Klemperer (AER 2009): Sequential bidding process is more efficient than auction, but the auction usually generates more revenue.

Value Updating Model (Ye (GEB 2007)): Bidders have a private signal about their values and must pay a cost to learn more about them.

Also known as selective entry model.

Sellers want to screen buyers to ensure higher value buyers enter.

Lu & Ye (2014): Two-stage mechanism where bidders bid for rights to enter a second-price auction with bidder-specific handicaps is optimal.

Hendricks & Quint (2015): Sellers can use indicative bids to screen buyers and "thin the field;" efficiency and revenue higher than in simultaneous entry and bid.

Economic Environment: Timber

Uncertainty prior to harvesting:

- Timber volume and species composition, harvesting costs, future prices
- Harvesting costs and valuation of timber may differ

Private information concerns own valuation, perhaps volume and species composition, not future prices.

Spatial correlation of common value components less important.

Costly information gathering.

- Cruises: *ex ante* assessment of tract volume and species composition

No consensus in literature whether value learning or value updating.

Potential competition:

- Mills: differentiated by distance to tract, efficiency, specialization
- Loggers: subcontract with mills; akin to a competitive fringe

Timber: Value Learning

Athey, Levin et al (QJE 2011, AEJ: Micro 2013): asymmetric IPV

- Use parametric GPV to estimate distributions of values of loggers and mills in timber auctions.
- Use the estimates to calculate expected profits from bidding and apply zero profit condition to identify entry costs (or entry cost thresholds).
- Sealed bid is less efficient than open auction but attracts more weak bidders (loggers) and can generate higher revenues.
- Set-asides lower efficiency and revenue; subsidies for weak bidders can eliminate most of those losses and achieve allocation goals.

Li & Zheng (RES 2009, JEcm 2012): Estimate both entry models for timber and highway contracts using MCMC methods; find that value learning model fits the data better than the value updating model.

Timber: Value Updating

Marmer, Shneyerov & Xu (JEcm 2013): Propose non-parametric tests of the two entry models.

Gentry & Li (Ema 2014): Provide conditions under which the joint distribution of signal and values is identified.

Bhattacharya, Roberts & Sweeting (AER 2013, RJE 2014, IJIO 2015): Estimate selective entry (value updating) model for timber and highway procurement; nests value learning as special case.

If bidders are asymmetric, selective entry dampens the value of bid preference programs.

Evaluate different entry/auction formats including entry auctions.

Quantify efficiency and expected seller revenue gains if move from a mechanism with simultaneous entry and bidding to a sequential mechanism.

Economic Environment: Oil & Gas

Considerable uncertainty prior to drilling.

- Deposit size, drilling costs, future prices
- Similar drilling costs and valuation of deposits

Private information concerns deposit size, not future prices or costs.

Spatial correlation of deposits and their characteristics.

- Drilling outcomes informative about neighboring tracts

Costly information gathering.

- *Ex ante*: Collection and interpretation of seismic data (value learning or updating?)
- *Ex post*: Exploratory drilling

Potential competition: In shallow waters, many potential bidders.

Large oil & gas companies dominate bidding in deep waters.

Barriers to entry in deep water: Capital requirements, expertise

Open question: Extend entry theory and empirics to CV environment.

5. *Ex Post* Payoff Contingent Payments

Royalty payments are substantial in oil & gas auctions.

Royalties are fixed fraction of revenues from *ex post* production.

Arguments for positive royalty:

- Shares risk if bidders are risk averse
- Reduces asymmetries in common value auctions, intensifies bidding (Riley, RES 1988)
- Rent extraction if too little competition in auction
- Original motivation: Encourage participation by financially constrained bidders

But positive royalty distorts *ex post* investment incentives of leaseholders.

- Drilling decisions based on profits net of royalties; marginal tracts not drilled
- Leases abandoned too soon

A non-zero royalty is optimal for a fixed information structure:

Moral hazard distortion is locally second order, revenue gain first order (McAfee & McMillan, RJE 1986; Skrzypacz, IJIO 2013).

Ex ante information acquisition incentives may be dampened.

Effect of Deepwater Royalty Relief

1995 DRRA provides some evidence on effects of royalty payments.

Royalty exemption up to production cap, which depends on water depth.

Consider outcomes of sales in 2 years before DRRA, in comparison with 2 following years.

DRRA clearly had a large impact:

	No. of Tracts Sold		Average Winning Bid (1982$)		Drilling Rate		Hit Rate	
Water Depth	Before	After	Before	After	Before	After	Before	After
0 - 200	1,012	1,187	478,869	497,314	.31	.27	.60	.54
200-400	63	112	360,646	626,104	.27	.23	.53	.46
400-800	115	228	353,640	795,300	.17	.19	.55	.27
>800	262	1,851	196,834	495,286	.13	.07	.34	.51

6. Auction Design: Oil & Gas

Key issues for lease and auction design of oil & gas sales:

1. Information externalities across nearby tracts.
2. Winner's curse (common values).
3. Financial constraints.

Complementarities associated with externalities argue for package or combination bidding. But optimal bundling is unknown, number of possible combinations too large to be practical.

Winner's curse argues for release of as much information as possible.

Proposed solution: Simultaneous multi-round auction, as in spectrum auctions.

Easier to assemble packages to realize complementarities.

Financially constrained bidders are potential competitors on more tracts.

Potential concern: Open auctions are more susceptible to bidder collusion.

Auction Design: Timber

Key issues for timber:

1. Bidder asymmetries.
2. Common values associated with scaled sales.
3. Potential collusion.

Forest Service uses both FPSB and English auctions.

Winner’s curse argues for release of as much information as possible.

Proposed solution: Open outcry auction

If bidders are asymmetric, more likely to achieve efficient allocation.

Potential concern: FPSB can achieve higher revenues for asymmetric bidders, also less susceptible to collusion.

Athey, Levin & Seira (QJE 2011) use outcomes in FPSB auctions to test whether there is collusion in English auctions.

In their sample, evidence of some collusion.

7. Summary

Laffont program has resulted in a rich empirical literature, with a close connection between theory and empirics.

GPV methods are widely adopted; a flexible estimation method to recover the primitives relevant for mechanism design.

A recent empirical literature examines environments where *ex ante* investments matter.

This literature is promising, but more remains to be done, e.g. for CV environments.

There is less research on situations where both *ex ante* and *ex post* actions are affected by the design of the contract being offered for sale, and by the auction rules.

In some contexts, these considerations can be of first order importance.

The optimal design depends on the features of the economic environment, and empirical analysis can indicate which features are salient.