Subsidy Competition as an Auction

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Subsidy Competition in the U.S.

Governments have many policy levers at their disposal to attract firms, create jobs

- Regulatory policy, tax policy, investments in education and infrastructure
- One popular policy = discretionary subsidies for individual firms
  - Subsidy can be a function of tax abatement, grant, low-cost loan, land, infrastructure improvement, relaxed regulations

U.S. states have long history of offering discretionary subsidies to firms

- Volkswagen received $430M in 1976 to locate in PA, Mazda (MI, $125M), Mitsubishi (KY, $147M), Toyota (IL, $249M) follow
- 100s of discretionary deals in past 15 years
  - Notable examples include Amazon HQ2, Foxconn, GE, Tesla
  - States promise $6.6B to 33 firms in 2017

Evaluating Subsidy Competition: Challenges

Tax incentives seem to be a permanent part of the urban economic landscape. However, economists do not yet know why these incentives occur and whether they are in fact desirable.

"The Economics of Location-Based Tax Incentives" Glaeser (2001)

1. **Lack of comprehensive data**
   - Do not have data on all offers a firm receives (or even all components of the realized subsidy)
   - Lack of transparency in subsidy-setting process
2. **Subsidy is an equilibrium outcome**
   - Do not know where firms would locate without the subsidy
   - Do not how state and local governments deterine the subsidy offer

Example: Volkswagen receives subsidy to locate in Chattanooga in 2008

Subsidy for assembly plant worth approximately $558 million

- Property tax abatements ($200M), state job and investment tax credits ($200M), property ($81M), worker training ($30M), road construction ($43M) + rail line upgrades ($3.5M)

Location decision was "truly a very close competition"

- Runner-up in Huntsville, AL, subsidy offer at least $386 million

Site Selection Magazine reports:

> *A team of 25 people with Staubach worked on the project, helping VW consider an initial pool of more than 100 candidate sites, all located in the central or eastern U.S. because of time-zone proximity to Germany.*
>
> *"What you look for is mostly problems sites have – readiness, labor, logistics infrastructure," says Greg Lubar, project leader and senior vice president at Staubach. VW said it short-listed 25 sites. "It was then a dozen or so we were in discussions with until the three finalists," says Lubar.*

Observed Subsidies are an Equilibrium Outcome

We observe VW locating in Chattanooga for $558M, which is the result of:

- VW location decision: total payoff function of subsidy, profit
- TN willingness to pay (value) for VW
- # of competitors, and the payoffs they provide

Do not know VW location in no-subsidy counterfactual

- Does VW create more "value" in TN than in counterfactual choice?

We want to be able to evaluate how subsidies affect firm location choice **and** how state and local governments determine how much they are willing to pay for any given firm.

- Allows us to say something about allocative efficiency. Are subsidies reallocating firms to locations that will benefit more? (Then, are those benefits realized?)
- Compare effect of subsidies on firm location with changes in tax rate, other location chars

Proposed Framework: Subsidy Competition as an Auction

The New York Times

Amazon Plans Second Headquarters, Opening a Bidding War Among Cities

Sept. 7, 2017

Benefits of an Auction Approach

1. Auction can approximate negotiation between firm and multiple locations
2. Auction primitive of interest: valuation of bidders
   - Valuation = How much government is willing to pay for a firm
   - Policy relevant object: How do governments determine WTP? Does this WTP line up with realized benefits?
3. Can learn a lot from limited data
   - Winning price usually sufficient to recover distribution of bidder's valuations (will need more in case of scoring auction)
4. Counterfactuals
   - Simulate location of firms and corresponding govt valuations under alternative policy

An Auction Model of Subsidy Competition

Auction Background

Fundamentals: Bidders bid for object, given information on their valuation

- Auction rules allocate winners, payments

Objective of Empirical Auction Literature:

1. Recover bidders' valuations
   - Auction rules give way to optimal bidding strategy, given valuations
   - Equilibrium theory gives us a way to map from private information to bids
2. Infer welfare
3. Predict change in equilibrium if environment (rules, participation, etc.) were changed

What type of auction model is appropriate?

What do bidders know, how do bidders submit bids, and what does the winner pay?

- Allocation and payment rule
  - First-price sealed bid $\approx$ Descending-price open-outcry (Dutch)
  - Second-price sealed bid $\approx$ Ascending-price open-outcry (English)
  - Winner $=$ highest price (or lowest cost), or highest score (given scoring rule)
    - Scoring auction: multi-dimensional bid, auctioneer gives score

- Assumptions about bidders
  - Private values (PV): a bidder's valuation of the good is only a function of her own information; typically the bidder is fully aware of her own valuation.
  - Common values (CV): all bidders have the same valuation of the good, but each may only have an imperfect signal of the value.

Use institutional details to inform modeling approach

1. Firm cares about location characteristics and subsidy offer

   Scoring

   Wisconsin Was Outbid For Foxconn Factory, But Still Won

   By THE ASSOCIATED PRESS August 1, 2017

2. Multiple bids submitted: States go back and forth with firm

   Ascending

3. States know each others' offers [from firm, see above]

   General Electric Company ("GE")

   Nine states including North Carolina were considered for the project. South Carolina's incentive package was valued at $14.8 million while Virginia's totaled $11 million.

   Additionally, South Carolina had several local incentive packages worth over $30 million over a 10-year period.

   Calendar Year 2013 Legislative Report *17*

   Open Outcry

4. Information structure: Many firm characteristics observable
   - Allowing location-specific benefit of winning the firm

   Private Value

Developing a model

How to model the competition?

- **Private value English scoring auction**
- *with unknown (to econometrician) scoring rule*

Recent work on consumer loan and mortgage markets take a similar approach

- Consumers shop across banks for the best contract offer (Cuesta and Sepulveda, 2019)
- Signs the contract with the lowest cost bank, at the interest rate that leaves the second-lowest cost bank with zero profits

In our case, firms "shop" across locations for the highest payoff

- Payoff = location-specific profit + subsidy offer
- Can use other locations' offers to negotiate better subsidy deals

Model: Auction Details

(t=-1) **Firm** *i decides to expand/relocate and determines set of potential locations, S*

(t=0) **Firm** i contacts states $s \in S$ about possibility of expanding in their jurisdiction.

(t=1) **States** compete in private-value English Auction for firm i

State (county) s draws a profit level and a private valuation for firm i, $\{\pi_{is}, v_{is}\} \sim H(\pi, v|z)$

- Optimal strategy: bid subsidy b_{is} up to v_{is}

Firm i locates in state with highest payoff, p (profit + subsidy)

- $y_{is} = \mathbb{1}[\underbrace{\pi_{is} + b_{is}}_{p_{is}} \geq \underbrace{\pi_{ij} + b_{ij}}_{p_{ij}}] \; \forall \; j \in S$

Auction Example: Two States Bid for Firm A

State 1	State 2
Welfare$_{no-comp}$=13	Welfare$_{comp}$=14
$v_{A1} = 3,\ \pi_{A1} = 10$	$v_{A2} = 7,\ \pi_{A2} = 7$
$\vdots$	$b_2 = 3.1$
$b_1 = 1$	$\pi_{A2} + b_2 = 10.1$
$\pi_{A1} + b_1 = 11$	$\vdots$
$\vdots$	$b_2 = 5$
$b_1 = v_{A1} = 3$	$\pi_{A2} + b_2 = 12$
$\pi_{A1} + v_{A1} = 13$	$\vdots$
- - - - - - - - stop - - - - - - - -	$b_2 = 6 + \epsilon$
	$\pi_{A2} + b_2 = 13 + \epsilon$

Auction Example: Outcome

State 1	State 2
$v_{A1} = 3, \pi_{A1} = 10$	$v_{A2} = 7, \pi_{A2} = 7$

$\text{Welfare}_{no-comp}$=13
state 1 payoff $= 3$
state 2 payoff $= 0$
firm payoff $= 10$

Welfare_{comp}=14
state 1 payoff $= 0$
state 2 payoff $= 1 - \epsilon$
firm payoff $= 13 + \epsilon$

In this example, competition *increases* total "welfare"

- However, state payoffs higher without competition
- larger v_2 (negative correlation between v and π) $\rightarrow$ both state and firms gain
- smaller v_2 (positive correlation between v and π) $\rightarrow$ zero-sum game
- Welfare results depend on covariance of v and π, variance of v

Identification + Estimation

We have an auction model, now what?

We have an open-outcry ascending IPV auction

- We observe **winning bids** (realized subsidies) and the number of bidders

Suppose firms do not care about profits. Each firm locates in the highest subsidy location.

- Then, we can recover the distribution of valuations (Athey and Haile; 2002)[1]
- Winning bids are equivalent to the valuation of the 2nd place bidder
  → Winning bids = 2nd order statistic for distribution of valuations
  → Can recover parent distribution, given number of bidders (Arnold et al.; 1992)

[1] Similarly, you only need winning bids to recover the distribution of valuations in the first-price IPV auction (Guerre, Perrigne, and Vuong; 2000). Relevant if we think the states submit one bid, and there is no negotiation.

Complication with the Scoring Auction

However, we know firms care about profits. That is why we have a scoring auction.

- The first step is to recover the scoring rule (*how do location characteristics affect profits?*)

The model tells us that the winning state gives payoff of runner-up:

$$\underbrace{\pi_{\text{winner}} + b_{\text{winner}}}_{\text{payoff in winning state}} \approx \underbrace{\pi_{\text{runner-up}} + v_{\text{runner-up}}}_{\text{payoff in runner-up state}}$$

Assume profits are a function of location chars, x, ($\pi = \beta x$ for simplicity)

$$\begin{aligned} \beta x_{\text{winner}} + b_{\text{winner}} &= \beta x_{\text{runner-up}} + v_{\text{runner-up}} \\ b_{\text{winner}} &= \beta(x_{\text{runner-up}} - x_{\text{winner}}) + v_{\text{runner-up}} \end{aligned}$$

- Identify β with variation in winning and **runner-up location** chars, winning bids

Identification + Estimation: Outline

Step 1. Recover profit parameters, correlation between runner-up π and v Details

- Using variation in winning bids, winning, runner-up location characteristics

Step 2. Identify distribution of welfare (profits + valuation) Details

- Predict welfare in runner-up state: $\hat{w}_{i2} \rightarrow F^{2:n}(w|z)$
- Use order statistic identity to recover full distribution of welfare: $F(w|z)$

Step 3. Invert welfare to recover marginal distribution of state valuations Details

→ Use for counterfactual simulations

$$Welfare: \; w_{is} = \boxed{v_{is}} + \underbrace{\pi_{is}}_{\text{Step 1}} \sim \underbrace{F(w|z)}_{\text{Step 2}}$$

Counterfactual Policy Regimes

1. Subsidy Ban (or truce): Restrict states and local governments from offering discretionary subsidies
    - Firms choose location where they are most profitable (predict using $\hat{\beta}$)
    - Given π, simulate valuation of winning location, v, from joint distribution $\hat{H}(\pi, v)$
    - Compare total welfare ($\pi + v$) with and without subsidy competition
2. Some intermediate, regional truce
    - Subset of locations do not offer discretionary subsidies
    - Do they still win firm locations?
3. State makes investment in location characteristics
    - Simulate subsidy game, quantify change in number of firms won

Potential Model Extensions

- Sequential auction
  - Some states have budget constraint
  - Valuation depends on wins in past, as well as expectation of arrival of future firms
- Common value auction
  - Amazon HQ2 will create similar benefit in any city
  - Differences in bids driven by differences in estimates of that benefit

The Dallas Morning News

OPINION › COMMENTARY

Could landing Amazon also summon the winner's curse?

There is a great deal of uncertainty as to how valuable Amazon is likely to be.

- Incorporate entry decision
  - Bid preference programs for certain regions

Conclusion and Avenues for Future Work

Evaluating subsidy competition is difficult due to data limitations, and lack of exogenous variation in policy space

- Auctions provide a convenient framework to evaluate competition
- Model allows us to learn about primitives of interest even with limited amounts of data

Future work can continue to leverage these models

- Incorporate dynamics with sequential auctions
- Distinguish between competition across and within states
- Settings where subsidy competition is allowed, but limited (EU)
- Trade-offs between subsidy-giving and changes in tax base, rates

Thank you!

Bonus Slides

Step 1: Profit Parameters

Observed: location choice, winning bid, and runner-up location
Primitives: firm profit, state valuations

Let 1 denote winner, 2 denote runner-up:

$$\text{From the model:} \quad \underbrace{\pi_{i1} + b_{i1}}_{\text{firm i's payoff in 1}} = \underbrace{\pi_{i2} + v_{i2}}_{\text{firm i's payoff in 2}}$$

Parameterization x,z **:**

(1) $\pi_{ics} = \beta z_i \times x_{cs} + \xi_{ics}$

x_{cs} observed location characteristics, ξ location-firm productivity match

(2) $v_{i2} = \alpha x_2 + \gamma z_i + \phi(x_2 \times z_i) + \epsilon_{i2}$

z_i observed firm characteristics, ϵ firm-location value match

Step 1: Identification of π and runner-up v

Plug in for π, v, and rearrange terms:

$$b_{i1} = \underbrace{\beta z_i(x_2 - x_1) + (\xi_{i2} - \xi_{i1})}_{\pi_{i2}-\pi_{i1}} + \underbrace{\alpha x_2 + \gamma z_i + \phi(x_2 \times z_i) + \epsilon_{2i}}_{v_{i2}}$$

Intuition: Imagine 2 subsidy deals for auto manufacturing facilities of identical size

- 1 locates in AL for \$100M, 1 in OH for \$140M, runner-up is SC in both cases
- AL and OH have almost all same location chars
  - Same tax rates, same wages, same skilled work force
  - Only difference is AL is right-to-work and OH is not (runner-up, SC, is right-to-work)

→ \$40M difference between 2 observed subsidy deals attributed to how much automobile manufacturers prefer to locate in a right-to-work state

Step 1: Taking Stock Back

We have the parameters for the firms' profit function

- Will use to predict profits across potential locations

$\rightarrow$ runner-up location profits $\pi^{n-1:n}$

$\rightarrow$ empirical marginal distribution $\hat{H}_{\Pi}$

We have the runner-up locations' valuations for firms $v^{n-1:n}$

$\Rightarrow$ We can estimate the relationship between profits and valuations for runner-up locations.

Step 1 $\rightarrow$ 2: Predict runner-up welfare

Given the OLS estimates I can predict welfare in runner-up location $\hat{w}_{i2}$

$$\hat{w}_{i2} = \underbrace{\hat{\beta} z_i x_2 + \xi_{i2}}_{\pi_{i2}} + \underbrace{\hat{\alpha} x_2 + \hat{\gamma} z_i + \hat{\phi} z_i x_2 + \epsilon_{i2}}_{v_{i2}}$$

Residual from OLS defined in the structural model: $\theta_i = (\xi_{i2} - \xi_{i1}) + \epsilon_{i2}$

Can't simultaneously pin down ξ and ϵ, do one of two things

1. All residual attributed to measurement error $\Delta\xi, \epsilon = 0$
2. Joint normal, with correlation $\hat{\rho}$, and fit to distribution of $\hat{\theta}$

Step 2: Distribution of welfare across locations $\hat{F}(w|z)$

Recover $\hat{F}(w|\cdot)$ from order statistic identity (Athey and Haile 2002)

Assumption: Welfare across locations, w, is distributed i.i.d. $F(w|z)$

We know the i-th order statistic from an arbitrary F has distribution :

$$\hat{F}^{(i:n)}(w|\cdot) = \frac{n!}{(n-i)!(i-1)!} \int_0^{\hat{F}(w|\cdot)} t^{i-1}(1-t)^{n-i} dt$$

where n is the number of bidders (Arnold, Balakrishnan, Nagaraja 1992)

$\Rightarrow$ Full distribution of welfare $\hat{F}(w|\cdot)$

Back

Step 3: Recover marginal distribution of gov't valuations, H_V

Recall the definition for welfare: $w_{is} = v_{is} + \underbrace{\beta x_s + \xi_s}_{\pi_{is}} \sim F(w|\cdot)$

$$
\begin{aligned}
H_V(t) = \Pr(v < t) &= \Pr(w - \pi < t) \\
&= \Pr(w < t + \pi) \\
&= \int F(t+\pi) h(\pi|t) d\pi
\end{aligned}
$$

- I can represent the relationship between π and v as a copula, $H(v, \pi) = C(H_V, H_\Pi)$
- Use $corr(\hat{v}^{n-1:n}, \hat{\pi}^{n-1:n})$ to define dependence structure C

  $\rightarrow$ Sklar's Theorem: $h(\pi|t) = c(H_V(t), H_\Pi(\pi)) h_\Pi(\pi)$

Solve for H_V: $H_V(t) = \int F(t+\pi) c(H_V(t), H_\Pi(\pi)) h_\Pi(\pi) d\pi$

Back