The Impact of Subsidy Bidding Wars on the Optimal Investment Decisions of Multi-Establishment Firms

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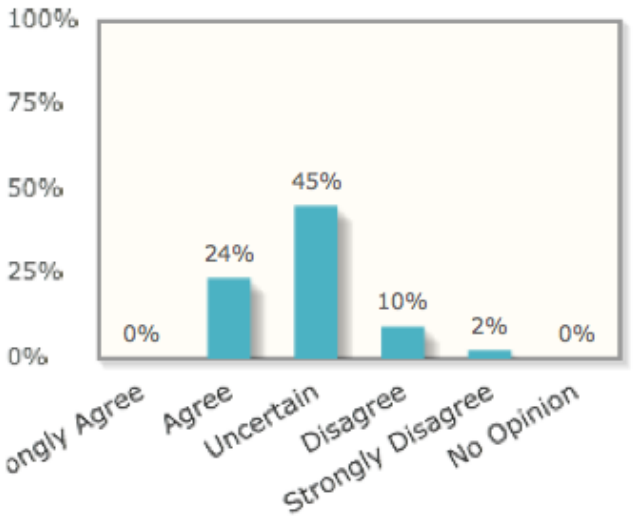
23 August 2017

Preliminary Version: Work in Progress.

Motivation

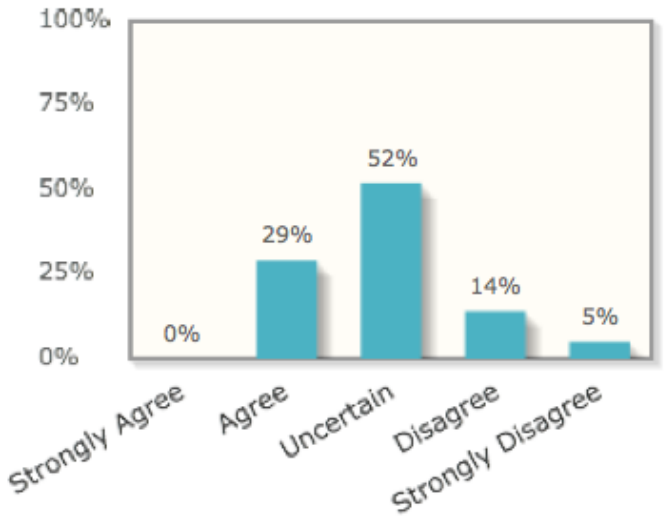
Question A: Giving tax incentives to specific firms to locate operations in a city or state typically generates local benefits that outweigh the costs to the city and/or state providing the incentives.

Responses



Source: IGM Economic Experts Panel
www.igmchicago.org/igm-economic-experts-panel

Responses weighted by each expert's confidence



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Motivation

- State and local governments in the US award approximately $80 billion in tax incentives each year to attract companies to their territory.
- These subsidies are often the result of bidding wars between regional governments.
- Are these subsidies good policy?
  - Some argue that these subsidies are a waste of resources.
  - However, they can allow firms to build new plants in regions that value their presence.
  - Greenstone and Moretti (2003) find that winning counties in the US actually benefit from the presence of the firm.

Motivation

an auction process

These bidding wars are similar to auctions, where a firm sells a production site to one of many regions.

- The bidding wars are not literal, formal auctions, but possible to apply the same theoretical tools (Klemperer, 2004; Cramton, 1998).
- Some authors used auction theory to study these bidding wars (e.g., Black and Hoyt, 1989; King et al., 1993; Martin, 2000; Menezes, 2003; Furusawa et al., 2010 ; Becker and Schneider, 2014). Keen and Konrad (2014) survey this literature on fiscal competition for a single large firm.

multinationals/multi-establishment

Nearly all models (except Haaparantaa, 1996) ignore the fact that these firms are multinationals/multi-establishment.

Motivation

- For example, Boeing received at least $327 million in incentives from 11 US states between 2007 and 2012. In the same period, Procter & Gamble received at least $128 million from 10 states.
- In 2014, Nevada offered approx. $1.5 billion in subsidies to Tesla for battery-producing factories : Outcome of a bidding war between counties in multiple states.
- Tesla publicly considered opening multiple plants, breaking ground in 2 locations (only one decided so far).

characteristics of these bidding wars

1. Often the result of competition between governments to attract the firm (similar to an auction).
2. Bidding wars for several plants of the same firm
3. Firm sets the rule of the bidding war

Research Questions

In this paper, we lift the restrictions of exogenous investment quantity and single establishment.

- If the firm has multiple sites, does she chooses quantities to invest strategically?
- Is the firm's investment decision distorted compared to a no-bidding-war situation?
- If so, what does this distortion look like, and what is its effect on the welfare properties of bidding wars?

Method: build models based in auction theory and mechanism design, where the seller is the firm and the buyers/bidders are the regional governments.

Model: The Firm

- The firm wants to build two new facilities in two of n regions.
- Can split investment in 2 establishments of potentially different sizes: $K_1 \geq K_2$.
- Production function $f(K_j, L_j)$.
  - $\frac{\partial f(K_j,L_j)}{\partial K_i} > 0$, $\frac{\partial f(K_j,L_j)}{\partial L_i} > 0$ and $\frac{\partial f^2(K_j,L_j)}{\partial K_i^2} < 0$, $\frac{\partial f^2(K_j,L_j)}{\partial L_i^2} < 0$.
- The firm's objective is to maximise the sum of operating profits (from production) and subsidies (from competing governments).

$$\Pi = s_1^* + s_2^* + \pi_1 + \pi_2 \tag{1}$$

Model: Regional Governments

- The regions receive some amount of private benefits (b_i) from hosting the firm.
  - Spillovers to local firms, hires unemployed citizens, political benefits, higher property values, affinity between firm and region.
- That amount is private information, but their distribution is publicly known (see Martin, 2000; Ferrett and Wooton, 2013).
  - i.i.d. according to $g(\cdot)$ on some interval $\left[\underline{b}, \overline{b}\right]$ (with $\underline{b} \geq 0$).
- If they win, they pay a subsidy of s_{ij} (total fiscal package and advantages offered to the firm).
- Payoffs:

$$V_{ij} = L_j \cdot b_i - s_{ij} \tag{2}$$

- Note: Apart from these benefits, regions are identical from the point of view of the firm (same wages, productive capacity).

Model: Timing

Stage 0: Regional governments privately learn their b_i.

Stage 1: The firm chooses and commits to an allocation of capital (K_1, K_2) with $K_1 \geq K_2$.

Stage 2: The multi-unit (open ascending) auction takes place. Winning regions offer subsidies s_1^* and s_2^*.

Stage 3: The firm invests capital K_1 and K_2, as determined in Stage 1, in the winning regions. She employs labour $L(K_j)$ according to profit maximisation.

How does the Bidding War Affect Allocation?

Equilibrium Subsidies

$$s_2^*(K_1, K_2) = L^*(K_2) \cdot b_{(3)} \tag{3}$$

$$s_1^*(K_1, K_2) = (L^*(K_1) - L^*(K_2))b_{(2)} + L^*(K_2)b_{(3)} \tag{4}$$

where $b_{(z)}$ is the z^{th}-highest signal among the n regions.

- Equilibrium subsidies determined by the stopping prices.
- For the largest establishment: infra-marginal competition between two remaining regions.
  - Region with second-highest benefits ($b_{(2)}$) will be indifferent between the two establishments when

$$L(K_1)b_{(2)} - s_1^*(K_1, K_2) = L(K_2)b_{(2)} - s_2^*(K_1, K_2)$$

Note: The subsidies depend on the firm's capital allocation decision.

How does the Bidding War Affect Allocation?

Differentiation

When the firm allocates her production units through a multi-unit auction, she always chooses to differentiate the two establishments ($K_1 \neq K_2$) in order to benefit from infra-marginal competition.

To understand why, look at first-order conditions for profit maximisation

$$p\frac{\partial f(K_1, L(K_1))}{\partial K_1} = L'(K_1)(w - E(b_{(2)})) + r \tag{5}$$

$$p\frac{\partial f(K_2, L(K_2))}{\partial K_2} = L'(K_2)(w + E(b_{(2)}) - 2E(b_{(3)})) + r \tag{6}$$

The sections in red correspond to the derivative of total subsidies w.r.t. the respective quantity.

- When the firm increases capital in Plant 1, it increases its value and the subsidy.
- When the firm increases capital in Plant 2, it has an ambiguous effect on total subsidies (due to infra-marginal competition).

How does the Bidding War Affect Total Investment?

Effect on K_1

The capital investment in the first establishment (K_1) is always greater under a bidding war than without a bidding war.

Effect on K_2

There exists some distribution of private benefits for which the firm invests less in the second establishment under a bidding war than without a bidding war.

In economic terms, this situation would occur when one region puts a great value on the firm's presence, but the majority of regions put little to no value (i.e., skewed distribution).

Mathematically: $E(b_{(2)}) - 2E(b_{(3)}) > 0$

How does the Bidding War Affect Total Investment?

Total Effect ($K_1 + K_2$)

Under conditions on the relative concavity of the production ($f(\cdot)$) and labour demand ($L(\cdot)$) functions, the total amount invested by the firm under a bidding war is always larger than the amount she would invest without a bidding war.

These conditions are somewhat technical, but we can look at an example:

Corollary: Cobb-Douglas

A Cobb-Douglas production function with decreasing returns to scale ($\alpha + \beta < 1$) respects these conditions.

Note: No assumption on distribution function!

Is it the Firm's Optimal Mechanism?

Are the results dependent on the choice of auction?

Proposition: Optimal Mechanisms

From the point of view of the firm, (if reserve subsidies are non-binding), the optimal mechanism results in the same allocation and subsidies as the multi-unit open ascending auction.

Keep the 2-stage nature of the game (commit to quantities, then implement a mechanism). Applying the Revelation Principle, the firm solves for an allocation function x^* and a payment rule s^*.

The equilibrium allocation rule is deterministic:

$$x^*(b) = (x_1^*(b), x_2^*(b)) = \begin{cases} (1,0) & \textit{if} \quad b = b_{(1)} \\ (0,1) & \textit{if} \quad b = b_{(2)} \\ (0,0) & \textit{otherwise} \end{cases} \tag{7}$$

Is it the Firm's Optimal Mechanism?

The optimal payment rule is

$$s_i^*(b) = b_i(x_i^*(b))L - \int_{\underline{b}}^{b_i} x_i^*(t, b_{-i})Ldt \tag{8}$$

In other words, the payment is the region's value *minus* some informational rent. We can use the definition of the allocation function to understand it better.

$$\int_{\underline{b}}^{b_i} x_i^*(t, b_{-i})Ldt = \int_{\underline{b}}^{b_i} (x_{i1}^*(t, b_{-i})L(K_1) + x_{i2}^*(t, b_{-i})L(K_2))dt =$$

$$\begin{cases} L(K_1)b_i - L(K_1)b_{(2)} + L(K_2)b_{(2)} - L(K_2)b_{(3)} & b_i > z_{i1}(b_{-i}) \\ L(K_2)b_i - L(K_2)b_{(3)} & z_{i1}(b_{-i}) > b_i > z_{i2}(b_{-i}) \\ 0 & \textit{otherwise} \end{cases}$$

with $z_{ij}(b_{-i})$ as the lowest value of private benefits that a region i can announce and still win establishment j.

Are Bidding Wars Desirable?

To better understand why bidding wars can improve social welfare, take a simple example.

Single Exogenous Investment

Assuming an exogenous investment of capital in a single plant, a subsidy bidding war is preferable to random allocation as long as the social cost of public funds is low enough.

To find this, compare the benefits in allocative efficiency

$$L(K_0)(E(b_{(1)} - E(b_{mean}))$$

to the social costs of public funds (to pay the subsidies)

$$\lambda s^*(K_0) = \lambda E(b_{(2)})L(K_0)$$

With a uniform distribution: $\lambda < \frac{1}{2}$

Are Bidding Wars Desirable (preliminary)?

Under endogenous investment, social welfare also takes into account the distortion in the firm's production:

$$\Pi(K^*) - \Pi(K_0) < 0$$

The conditions for the bidding war to surpass random allocation for social welfare thus also depends on the parameters of the production function.

Endogenous and Multiple Investments

The bidding war is preferable to random allocation even under endogenous and/or multiple investments (with different threshold λ)

Uninformed Social Planner

We showed that:

- The bidding war induces a strategic behaviour from the firm.
- Total investment is increased, and distorted compared to a random allocation.

A natural question is then: Is this mechanism optimal in terms of social welfare?
Assume same setup, but the "seller" is a social planner, with (simplified) SWF:

$$E(W) = \int_B \left[\gamma \sum_{i=1}^{n} (x_i(b) b_i L) + (\alpha - \gamma - \lambda) \sum_{i=1}^{n} s_i(b) + \alpha \sum_{j=1}^{2} x_{ij}(b) \cdot \pi(K_j) \right] g(b) db$$

Social Planner Allocation

For a given K_1 and K_2 and conditional on allocating the plant, an uninformed social planner cannot do better than using a similar auction process to locate the plants in the same regions as the firm.

Uninformed Social Planner

The social planner acts differently with respect to reserve subsidies.

Social Planner Reserve Subsidies

For any distribution such that $\beta(\underline{b}) < 0$, $\overline{K}' > \overline{K}$. In other words, the social planner allocates the plants more often.

With $\beta(\cdot)$ defining virtual valuations.

- In the optimal mechanism, the firm sells the plants to the regions with the highest *virtual valuations*.
  - In some cases, the firm might decide not to allocate the plant, even if some regions receive positive benefits (not efficient).

Uninformed Social Planner

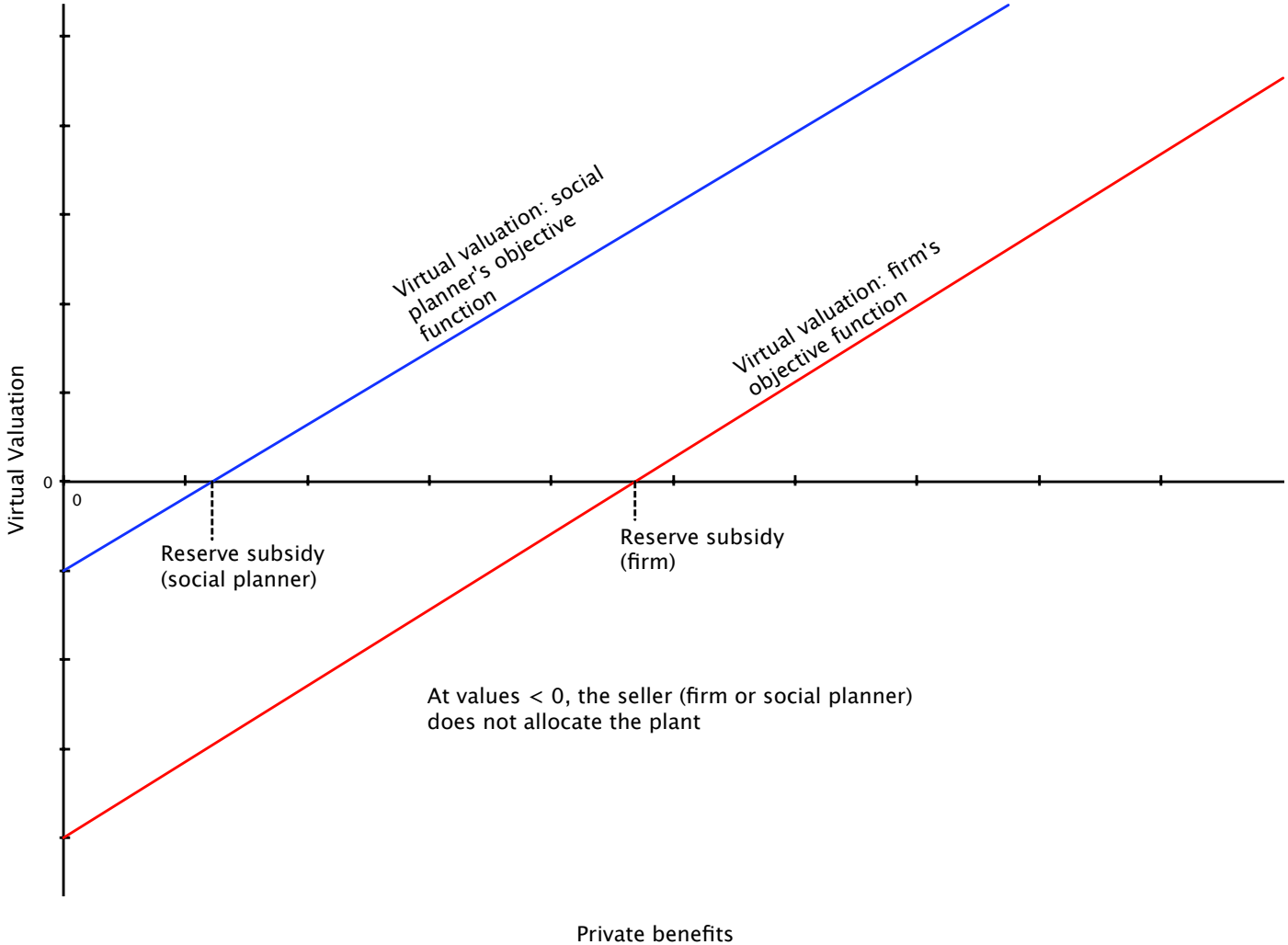

Figure: Stylized Illustration of Virtual Valuations

The Role of Commitment

So far, we assumed that the firm commits to the level of investment before implementing a selling mechanism. What if the quantities are determined endogeneously?

Modify the mechanism design problem to find investment functions instead:

$$E(\Pi) = \sum_{i=1}^{n} \int_B \left[x_{i1}(b)\pi(k_{i1}(b)) + x_{i2}(b)\pi(k_{i2}(b)) + \beta_i(b_i) \left(x_{i1}(b)L(k_{i1}(b)) + x_{i2}(b)L(k_{i2}(b)) \right) \right] g(b) \tag{9}$$

Commitment

The firm invests, in expected value, a greater quantity of capital when she does not commit to an investment decision before the regions announce their signals than when she commits.

Without commitment, the firm reduces informational rents conceded to the regions.

The Role of Commitment

We can also look at the social planner problem without commitment, by adapting the previous equation:

$$E(W) = \int_B \left[\gamma \sum_{i=1}^{n} (x_i(b) b_i L(k_i(b)) + (\alpha - \gamma - \lambda) \sum_{i=1}^{n} s_i(b) + \alpha \sum_{i=1}^{n} \sum_{j=1}^{2} x_{ij}(b) \cdot \pi(k_{ij}(b)) \right] g(b) db \tag{10}$$

We find the following:

Commitment: Social Planner

When observing the same signals from the regions, a social planner that is under no commitment obligation might choose a larger or lower equilibrium level of investment than the firm in the same conditions, depending on the weights of the SWF.

The Role of Commitment

For k_1^* (when observing a given $b_{(1)}$), the social planner invests less under the following condition:

$$w - \left(\frac{\alpha - \lambda}{\alpha}\right)\left(b_{(1)} - \left(\frac{\alpha - \gamma - \lambda}{\alpha - \lambda}\right)\frac{1 - G(b_{(1)})}{g(b_{(1)})}\right) > w - \left(b_{(1)} - \frac{1 - G(b_{(1)})}{g(b_{(1)})}\right) \tag{11}$$

- If $\gamma = 0$ and $\lambda > 0$, then the social planner invests less.
- If $\gamma > 0$ and $\lambda > 0$, then the answer is ambiguous.
- In other words, if we place no weight on the regions' welfare, then the firm was investing too much; she did not take the social cost of the subsidies into account.
- However, if we increase the weight on the regions' welfare, then it is possible that the firm was *under-investing*.
- In general, the value of γ could reflect how much of the regions' private benefits (b_i) is derived from political benefits (accruing to politicians, for example), and how much is public benefits (jobs, higher tax revenues, etc.).

Conclusion

This paper discusses the strategic behaviour of the firm in subsidy bidding wars. It shows:

- The bidding war induces some strategic behaviour from the firm.
  - The firm invests differentiated amounts across sites, and more in total.
  - The open ascending auction is optimal from the viewpoint of the firm.
- Despite these distortions, the bidding war remains socially efficient
  - A social planner would choose the same mechanism
- However, there could be a role for higher levels of government to ensure commitment to plant sizes prior to the bidding war.
  - This depends on the nature of the benefits accruing to regions.