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An Auction Theoretical Approach to Fiscal Wars

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Abstract

I examine a situation where a firm has to choose to locate a new factory in one of several jurisdictions. The value of the factory may differ among jurisdictions and it depends on the private information held by each jurisdiction. Jurisdictions compete for the location of the new factory. This competition may take the form of expenditures already incurred on infrastructure, commitments to spend on infrastructure, tax incentives or even cash payments. The model combines two elements that are usually considered separately; competition is desirable because we want the factory to be located in the jurisdiction that values it the most, but competition in itself is wasteful. I show that the expected total amount paid to the firm under a large family of arrangements. Moreover, I show that the ex-ante optimal mechanism – that is, the mechanism that guarantees that the firm chooses the jurisdiction with the highest value for the factory, minimizes the total expected payment to the firm, and balances the budget in an ex-ante

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sense – can be implemented by running a standard auction and subsidizing participation.
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1 Introduction

Competition among states for new businesses is nothing new. It is very likely a feature of any federative regime.[1] However, there is a public perception that such bidding wars are escalating and that government intervention may be called for.[2] Analysts point out that the costs of attracting businesses are increasing. Common examples include the construction of a new chip factory by Micron Technology in Utah at a cost of around $80 million and the Mercedes Bens new factory in Alabama at a cost for the state of about $250 million. Such competition is also common outside the U.S., both in developed and emerging economies.

The Region, a quarterly magazine of the Federal Reserve Bank of Minneapolis, reported on the proceedings of a conference on "The Economic War Among the States," held in 1996. Among several contributions, there was a specific proposal made by Burstein and Rolnick (1995) for congress to enact legislation to prevent states from using subsidies and tax incentives to compete with one another for businesses. Another example of a similar reaction to interstate competition can be found in the Memorandum of Economic Policies (1999), a document from the Brazilian government outlining major policy reforms. This document points out that one of the aims of the proposed tax reform that introduces a value added tax is to eliminate the scope for fiscal war among states.

[1] For example, interstate tax competition was discussed in the mid-80s in the context of the 1984 Treasury Department's proposal to former Presidente Reagan for tax reform. See, for example, Shannon (1986), McLure (1986) and Wildasin (1986).

[2] For example, see State Senator Charles Horn, Ohio, call for a State Legislative Conference on "Mitigating the Wasteful Economic Development Incentive Wars between the States, " in February 1996. Available at the site http://www.senate.state.oh.us/horn.

There are two opposing views of this competition among states. One view is that competition among states play a similar role of that played by competition among firms. A second opposing view is that incentives wars are a zero-(or negative) sum game. Both arguments on their own might be misleading. The latter presumes that the same amount of investment will have the same economic impact in any location. The former, ignores that competition among states for businesses may divert resources from other usages, such as education and health.

In contrast, in this paper I develop a framework that allows me to accommodate both views. In particular, I examine a situation where a firm has to choose to locate a new factory in one of several jurisdictions. The value of the factory may differ among jurisdictions and it depends on the private information held by each jurisdiction. This private information may take, for example, the form of a consultant's report. For simplicity we consider that jurisdictions offers are conveyed in dollar amounts. These offers may represent expenditures already incurred on infrastructure, commitments to spend on infrastructure, tax incentives or even cash payments.

Given that different locations have potentially different values for the factory, economic efficiency dictates that the factory should be located in the jurisdiction that values it the most. However, we model competition itself as wasteful. The idea is that the firm has already decided to build a new factory in one of the jurisdictions and will do so even if it has no tax incentives. For simplicity, we assume that any incentives paid by the firm by one or more jurisdictions represent a welfare loss (e.g., the firm's shareholders live outside the n jurisdictions).

We consider different types of competition such as an open auction-like mechanism where jurisdictions openly announce their offers, a sealed-offer competition where the winner is the jurisdiction that makes the highest offer, and an arrangement where jurisdictions invest simultaneously in infrastructure (that has no use if the factory is not located there) and the winning jurisdiction is the one that spends the most.

The novel feature of this analysis is that it combines two elements that are usually considered separately; competition is desirable because we want the factory to be located in the jurisdiction that values it the most, but competition in itself is wasteful. We resort to auction theoretical techniques [3] to show that the expected total amount paid to the firm under a large family of arrangements, including all three described above, is the same. This contrast with the view that the specific format of the competition may matter (see, for example, Taylor (1992)).

Moreover, we show that the ex-ante optimal mechanism – that is, the mechanism that guarantees that the firm chooses the jurisdiction with the highest value for the factory, minimizes the total expected payment to the firm, and balances the budget in an ex-ante sense – can be implemented by running a standard auction and subsidizing participation. This solution is similar in spirit to the proposal of Burstein and Rolnick (1995) to eliminate interstate competition by taxing real and imputed income from public spending. The distinction is that competition needs to take place to ensure that the factory is located efficiently.

[3] Klemperer (2000) provides an excellent exposition of the link between the theory of auctions and standard economics. Boylan (2000) applies the insighs from the optimal auction literature to examine lobbying.

2 The Model

A firm has decided to build a new factory and will choose to locate in one of the existing n local jurisdictions. Competition for the new business can take a number of different formats. For example, jurisdictions can offer tax incentives (such as abatements, exemptions, reductions and moratoria), tax-related incentives (such as investment and tax credits, research and development tax incentives, and accelerated depreciation of equipment) and non-tax incentives (such as creating infrastructure, financing subsidies and customized worker training). For simplicity we consider that any recourses spent on this competition are waisted. (For example, any incentives are fully translated into extra profits for the firm's shareholders who are located outside the n jurisdictions). The firm chooses to locate in the jurisdiction that offers the best deal.

Moreover, the contest itself can be organized in different ways. It may be the case that the competition consumes no resources as it takes the form of offerings of inducements that take effect only if the firm chooses to locate in the specific jurisdiction (e.g., as in Oates and Schwab (1988)). Alternatively, competition may also take the form of creating infrastructure (e.g., as in Taylor (1992)).[4]

Each jurisdiction i receives a private signal S_i where the S_i's are independent draws from a distribution $F(\cdot)$ with positive density $f(\cdot)$ in the support

[4] For the reader who is familiar with the theory of auctions, the former arrangement is equivalent to a first-price auction where the winner is the bidder with the highest bid and she pays her bid. The later arrangement is equivalent to an all-pay auction where the winner is the bidder with the highest bidder but all bidders pay their bids (even those who lost the auction).

$[0, \bar{S}]$. Jurisdictions are assumed risk-neutral and the value of the new factory for location i is given by[5]

$$v_i(S_1, ..., S_i, ..., S_n) = aS_i + b\sum_{i \neq j} S_j$$

with $\infty > a \geq b \geq 0$. We will denote by s^1 the highest actual signal, s^2 the second highest actual signal and so on. Although own's signal is private information, the value function is common knowledge. It is also known by all jurisdictions that the firm's reservation value is equal to zero, that is, it will choose to build the factory even when no jurisdiction offers any incentives. In this case, we assume for simplicity that the firm decides where to locate by using a lottery that assigns equal probability to each jurisdiction.

This formulation captures the notion that the true value of the new factory for each locality is not known with certainty at the time of the competition. The value of the factory for jurisdiction i is generally a function of its own signal and the signals of other jurisdictions. One can think of the signal as being a consultant's estimate of the income stream to be generated by the new factory.

Special cases include independent private values (when $v_i(S_1, ..., S_i, ..., S_n) = v_i(S_i)$ or $b = 0$) and pure common values (when $v_i(S_1, ..., S_i, ..., S_n) = v_j(S_1, ..., S_j, ..., S_n)$ or $a = b$). In the independent private values case the value of the factory for each jurisdiction is a function only of its own signal. In the pure common values case the value of the factory is the same for all players (for any given vector of private signals).

[5] This formulation is similar to that of Klemperer (1999), appendix D.

3 Equilibrium Behavior in the jurisdiction competition

We start by examining the jurisdictions' equilibrium behavior under the competition arrangement described below. This arrangement is simply an artifice to obtain the equilibrium behavior under the more standard competition arrangements mentioned in the previous section.

Under this arrangement, the firm announces that will locate the factory in the jurisdiction that offers the best deal – as summarized by a single dollar bid. The firm then organizes an ascending offer mechanism that works as follows; the firm announces a minimum acceptable offer (e.g., zero) and raises the minimum offer continuously in an electronic clock. Jurisdictions bid by pressing a button. A jurisdiction drops out from the competition by stopping to press the button. The winner of the competition is last the jurisdiction pressing the button and it has to offer the firm an incentive package worth the dollar amount at which the next-to-last jurisdiction has dropped out.

How will firms behave in the symmetric equilibrium of this competition? Can we predict the expected winning offer? Our starting point is the recognition that in a symmetric equilibrium each jurisdiction leaves the race where it would be indifferent between winning or losing. Therefore, the first jurisdiction to drop out from the competition will do so at offer

$$(a + (n-1)b)\, s^n$$

This would be the actual value to all jurisdictions if all had the lowest signal. The remaining jurisdictions can observe this so that the next jurisdiction leaves the competition when the offer reaches

$$bs^n + (a + (n-2)b)s^{n-1}.$$

This would be the actual value of the second to drop out; this jurisdiction's value is equal to the signal of the jurisdiction that was the first to drop out (times b) plus the value that arises when all other $n-2$ jurisdiction have the same signal. Similarly the third jurisdiction to drop out from the race will do so at the offer

$$bs^n + bs^{n-1} + (a + (n-3)b)s^{n-2}.$$

This process is now familiar to the reader who can predict that the next-to-last jurisdiction will drop out at offer

$$o^* = b(s^n + s^{n-1} + ... + s^3) + (a + b)s^2. \tag{1}$$

Note that 1 represents the final offer made by the winner to the firm in the symmetric equilibrium. We can now compute the expected value of the final offer to the firm by the winning jurisdiction. It is simply the expected value of o^*.

Now consider the following competition arrangement. All jurisdictions submit their offers simultaneously through a sealed bid. Although the winner is the jurisdiction with the highest offer, it pays the equivalent to the second highest offer. As in the ascending mechanism, each jurisdiction is willing to offer any amount up to its expected value conditional on winning the object and being tied with another jurisdiction with the same signal. However, under this arrangement the jurisdiction cannot observe the $(n-2)$ losing offers and, therefore, has to estimate them. Thus, jurisdiction i with signal s_i offers:

$$\hat{o}_i(s_i) = b(n-2)E[x \mid x < s_i] + (a+b)s_i.$$

Using the definition of the conditional expectation we obtain

$$\hat{o}_i(s_i) = b(n-2)\frac{\int_0^{s_i} xf(x)dx}{F(s_i)} + (a+b)s_i. \tag{2}$$

Using integration by parts we can write i's offer in a second-highest-offer mechanism as

$$\hat{o}_i(s_i) = (a + b(n-1))\, s_i - b(n-2)\frac{\int_0^{s_i} F(x)dx}{F(s_i)}. \tag{3}$$

We can now proceed to compute the expected winning offer and the jurisdiction's equilibrium behavior under the more conventional competition arrangements. We will do so by invoking one of the most celebrated results of auction theory, namely, the Revenue Equivalence Theorem (RET) . This result establishes that with risk-neutral agents any two mechanisms that in the symmetric equilibrium

1. allocate the good to the agent with the highest valuation; and

2. yields the same expected gain for the agent with the lowest possible signal.

This theorem was demonstrated by Vickrey (1961) for a special case and generalized later by, among others, Myerson (1981), Riley and Samuelson (1981) and Bulow and Klemperer (1996).

It is immediate that both the ascending and the second-highest-offer mechanisms described above satisfy the hypothesis of the RET. Moreover, the more familiar arrangements where jurisdictions offer inducements that takes effect only if the firm chooses to locate in the specific jurisdiction (pay-your-offer competition) and where competition take the form of creating infrastructure simultaneously and locating the factory at the jurisdiction with the highest amount invested (all-pay competition) also satisfy the conditions of the RET. In both cases, the jurisdiction with the highest offer wins the competition in the symmetric equilibrium and the expected profits of the jurisdiction with the lowest possible valuation is the same – the probability that this jurisdiction wins the competition is zero under both arrangements. In the following propositions we make use of the RET to characterize the equilibrium behavior in these mechanisms.

Proposition 1 *A jurisdiction i with signal s_i offers*

$$\bar{o}_i(s_i) = a\left(s_i - \frac{\int_0^{s_i} F(x)^{n-1}dx}{F(s_i)^{n-1}}\right) + b(n-1)\left(s_i - \frac{\int_0^{s_i} F(x)dx}{F(s_i)}\right) \tag{4}$$

in a symmetric equilibrium of the pay-your-offer competition and offers

$$\tilde{o}_i(s_i) = a\left(F(s_i)^{n-1}s_i - \int_0^{s_i} F(x)^{n-1}dx\right) + b(n-1)F(s_i)^{n-2}\left(F(s_i)s_i - \int_0^{s_i} F(x)dx\right) \tag{5}$$

in a symmetric equilibrium of the all-pay competition.

Proof. An implication of RET is that a jurisdiction's expected payment is the same under any mechanism satisfying its hypothesis. Thus, we

first compute the expected payment of payment of jurisdiction i with signal s_i conditional on winning a second-highest-offer competition. Under this arrangement, i's expected payment is simply the expected value of the largest offer among its $(n-1)$ opponents conditional on s_i being the highest signal. Using (3), this expected payment is equal to

$$\frac{\int_0^{s_i}\left[(a+b(n-1))x - b(n-2)\frac{\int_0^x F(y)dy}{F(s)}\right](n-2)F(x)^{n-1}f(x)dx}{F(s_i)^{n-1}} \tag{6}$$

Note that integration by parts yields

$$\int_0^{s_i}\left[(a+b(n-1))x\right](n-2)F(x)^{n-1}f(x)dx = \tag{7}$$

$$(a+b(n-1))\left(F(s_i)^{n-1}s_i - \int_0^{s_i}F(x)^{n-1}dx\right)$$

and .

$$\int_0^{s_i}\left[b(n-2)\frac{\int_0^x F(y)dy}{F(s)}\right](n-2)F(x)^{n-1}f(x)dx = \tag{8}$$

$$b(n-1)\left(F(s_i)^{n-2}\int_0^{s_i}F(x)dx - \int_0^{s_i}F(x)^{n-1}dx\right)$$

Replacing (7) and (8 into (6) yields i's expected payment condition on winning a second-highest-offer competition:

$$a\left(s_i-\frac{\int\limits_0^{s_i}F(x)^{n-1}dx}{F(s_i)^{n-1}}\right)+b(n-1)\left(s_i-\frac{\int\limits_0^{s_i}F(x)dx}{F(s_i)}\right).$$

Given that in a pay-your-offer competition, each jurisdiction pays her offer conditional on winning, her offer is precisely her expected payment that is given by the expression above, which is equal to (4). Note that i's expected payment in a pay-your-offer competition is equal to its offer times the probability of winning (that is, the probability that i's has the highest signal $F(s_i)^{n-1}$.

Now we use the RET again to argue that i's offer in a all-pay competition is the expression above times $F(s_i)^{n-1}$. To see why, each jurisdiction pays her offer irrespectively of winning the all-pay competition. By the RET, its expected payment is fixed and equal to

$$\left[a\left(s_i-\frac{\int\limits_0^{s_i}F(x)^{n-1}dx}{F(s_i)^{n-1}}\right)+b(n-1)\left(s_i-\frac{\int\limits_0^{s_i}F(x)dx}{F(s_i)}\right)\right].F(s_i)^{n-1}$$

so this must be i's offer in a symmetric equilibrium, which coincides with (5) after cancellations. ■

Expression (4) has an intuitive explanation based on insights from auction theory. The first term of (4) represents the private component of i's offer. It suffices for i to outbid the opponent with the highest signal among her $(n-1)$ opponents. Therefore, i shades its offer by the difference between its signal and the expected value of the highest of the other signals (multiplied by a, the coefficient on the private value component). The second term (4) represents the public component of i's offer. In addition, Jurisdiction i also shades its offer by the difference between its signal and the other signals to take into account the winner's curse. Expression (5) has a similar interpretation along auction theoretical lines.

4 The ex-ante optimal mechanism

In addition to being able to compute equilibrium behavior under any competition arrangement satisfying the RET, we are also able to compute the expected total payment (ETP) to the firm across all such arrangements. It suffices to compute the expected value of the highest offer for example in a pay-your-offer competition:[6]

$$ETP = \int_0^{\bar{S}} \left[a\left(s_i - \frac{\int_0^{s_i} F(y)^{n-1}dy}{F(s_i)^{n-1}} \right) + b(n-1)\left(s_i - \frac{\int_0^{s_i} F(y)dy}{F(s_i)} \right) \right] (n-1)F(x)^{n-1}f(x)dx$$

A natural question to ask is then what is then whether a social planner can choose a mechanism where the factory will be located at the jurisdiction with the highest value for it, minimizes the total amount spent on the competition and at the same time balances the budget in the ex-ante sense. By the revelation principle, it suffices to examine direct revelation mechanisms satisfying incentive compatibility and individual rationality constraints.

We what follows I pursue an approach similar to that in Bulow and Klemperer (1996). Define $P_i(s_1, ..., s_i, ..., s_n)$ as the probability that jurisdiction i

[6] By the RET, this should yield the same expected winning offer as in a second-highest-offer competition (obtained by computing the expected value of the second highest offer) or in a all-pay competition (obtained by computing the expected value of the sum of all offers).

wins the competition in any such mechanism as a function of the jurisdictions' realized signals . The individual rationality constraint requires that locations are not worse off from participating in the mechanism, that is, every location i's expected surplus as a function of its signal, for all possible signals, must satisfy:

$$\pi_i(s_i) \geq 0 \ \forall i, \forall s_i \tag{IR}$$

The incentive compatibility constraint requires that i's expected surplus as a function of its signal, $\pi_i(s_i)$,to satisfy for all realized signals s_i and s_i' and for all i, $i = 1, ..., n$:

$$\pi_i(s_i) \geq \pi_i(s_i')+$$
$$\int \cdots \int_0^{\bar{S}} \left(as_i + b\sum_{i\neq j} S_j - as_i' - b\sum_{i\neq j} S_j \right) \times \tag{IC}$$

$$P_i(S_1, ..., s_i', ..., S_n) f(S_1)...f(S_{i-1}) f(S_{i+1})...f(S_n) dS_1...dS_{i-1}dS_{i+1}...dS_n$$

This constraint simply guarantees that it is in jurisdiction i's best interest to truthfully reveal its signal. The (IC) constraint implies that

$$\frac{d\pi_i(s_i)}{ds_i} =$$
$$\int \cdots \int_0^{\bar{S}} aP_i(S_1, ..., s_i, ..., S_n) f(S_1)...f(S_{i-1}) f(S_{i+1})...f(S_n) dS_1...dS_{i-1}dS_{i+1}...dS_n \tag{9}$$

Integrating (9) we obtain:

$$\pi_i(s_i) = \pi_i(0)+$$
$$\int_0^{s_i} \int \cdots \int_0^{\bar{S}} aP_i(S_1, ..., S_i, ..., S_n) f(S_1)...f(S_{i-1}) f(S_{i+1})...f(S_n) dS_1...dS_i...dS_n.$$

This is jurisdiction i's expected surplus in equilibrium conditional on its signal being s_i. Therefore, from the point of view of the central planner, who does not know i's signal, the total expected surplus from the n jurisdictions is equal to:

$$\sum_{i=1}^{n} \int_0^{\bar{S}} [(\pi_i(0)+$$

$$\int_0^{s_i} \int \cdots \int_0^{\bar{S}} aP_i(S_1, ..., S_i, ..., S_n) f(S_1)...f(S_{i-1}) f(S_{i+1})...f(S_n) dS_1...dS_i...dS_n] f(s_i) ds_i$$

After integration by parts, we can write the expected total surplus of the n jurisdictions as :

$$\Pi = \sum_{i=1}^{n} \pi_i(0)+$$

$$\sum_{i=1}^{n} \int \cdots \int_0^{\bar{S}} (1 - F(S_i))\, aP_i(S_1, ..., S_i, ..., S_n) f(S_1)...f(S_i)...f(S_n) dS_1...dS_i...dS_n \tag{10}$$

The total expected payment to the firm can also be computed as it is the difference between the expected total surplus in this economy (that is, the expected value of the factory) and the total expected surplus of the n jurisdictions:

$$-\Pi+$$

$$\sum_{i=1}^{n} \int \cdots \int_0^{\bar{S}} \left(aS_i + b \sum_{i \neq j} S_j \right) P_i(S_1, ..., S_i, ..., S_n) f(S_1)...f(S_i)...f(S_n) dS_1...dS_i...dS_n \tag{11}$$

Replacing (10) into (11) we obtain that the total expected payment to the firm from any competition satisfying (IC) and (IR) is equal to

$$-\sum_{i=1}^{n}\pi_i(0)+\sum_{i=1}^{n}\int\cdots\int_0^{\bar{S}}\left(aS_i+b\sum_{i\neq j}S_j-(1-F(S_i))\,a\right)\times$$
$$P_i(S_1,...,S_i,...,S_n)f(S_1)...f(S_i)...f(S_n)dS_1...dS_i...dS_n \tag{12}$$

The central planner's problem is to choose a mechanism satisfying the (IC) and (IR) constraints to minimize (12) subject to

C1 firm's expected profits are greater or equal to zero.

C2 locate the factory at the jurisdiction with the highest signal; and

C3 balance its budget.

The following proposition characterizes the optimal mechanism satisfying the conditions above.

Proposition 2 *The optimal mechanism is such where the central planner runs any standard competition (e.g., a pay-your-offer competition), imposes a tax on the firm equal to total expected payment to the firm and pays a subsidy to each one of the* n *jurisdictions that is equal to:*

$$\frac{1}{n}\sum_{i=1}^{n}\int\cdots\int_0^{\bar{S}}\left(aS_i+b\sum_{i\neq j}S_j-(1-F(S_i))\,a\right)\times \tag{13}$$
$$F_i(S_i)^{n-1}f(S_1)...f(S_i)...f(S_n)dS_1...dS_i...dS_n$$

Proof. We concentrate on mechanisms satisfying the (IC) and (IR constraints. Any such mechanism that locates the factory at the jurisdiction with the highest signal must be such that the probability that i wins the competition is equal to the probability of i being the highest signal, namely, $F_i(S_i)^{n-1}$. From inspection of (12), the above subsidy implies that the central planner just balances its budget and that the firm's total expected profits are equal to zero. To implement this mechanism the central planner runs any standard competition, e.g., a pay-your-offer competition. It is straightforward to check that in any such competition the factory is located at the jurisdiction with the highest signal and the constraints (IC) and (IR are satisfied. The subsidy does not change jurisdiction i's behavior as it does not depend on i's private information. ■

There are several features of this mechanism that deserves our attention. First, one needs to run a competition among jurisdictions, that may take any of the formats mentioned earlier, in order to ensure that the factory is located in the jurisdiction that values it the most. Note that the result is quite general as it indicates that *any competition arrangement* will work as long as in such arrangement the factory is allocated in the jurisdiction that makes the highest offer (and subject to the technical condition that the jurisdiction with the lowest possible valuation has zero probability of being chosen by the firm).

Second, the tax on the firm and the subsidy paid to the jurisdictions cannot be based on the actual signals observed by the jurisdictions and should instead based on expected values. This implies that the firm might lose money ex-post. Depending on the competition arrangement (e.g., an all-pay competition), jurisdictions might lose money ex-post as well. Therefore, it might not be feasible to implement such mechanism.

5 Conclusion

This paper examines the competition among jurisdictions for a new business when the value of this new business is not known at the time that the competition takes place. The analysis combines the notion that competition might be desirable for the location of the factory in the jurisdiction that values it the most with the idea that competition in itself might be wasteful. Using the Revenue Equivalence Theorem, I argue that the expected total amount paid to the firm under a large family of arrangements is the same. Using the revelation principle and the tools developed by Bulow and Klemperer (1996), I show that the ex-ante optimal mechanism can be implemented by running a standard auction and subsidizing participation. The emphasis is in that competition needs to take place to ensure that the factory is located efficiently.

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