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Local Economic Development as a Game: We’re Caught in a Trap, I Can’t Walk Out …

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Abstract:

This paper uses game theory to analyze the practice of offering incentives to attract new firms to localities. It demonstrates that in trying to attract firms localities are faced with something like a prisoner's dilemma: they are compelled to offer incentives but would be better off if they could agree not compete for firms. The dilemma that localities face explains why the bidding war for firms continues to escalate despite calls by economists and politicians for disarmament.

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I. Introduction

Offering incentives to attract new firms is becoming increasingly popular local economic development strategy. Guskind (1990), for instance, estimates that state and local governments spend an $30 billion per year on development incentives [check precise estimate]. Despite the popularity of the practice, however, there is considerable concern among academics and policy makers about the wisdom of offering incentives. A fundamental worry is that incentives distort the economy. If incentives induce firms to move from best locations to less desirable locations**,** there will be an overall loss of efficiency. This criticism assumes that localities can influence businesses to move to suboptimal locations by offering incentives. Despite a large amount of research, however, there is no convincing evidence that incentives affect location decisions in this manner. Surveys of location decisions show that policy inducements enter into decisions only after basic factors of production are considered. Incentives only influence decisions if more than one location satisfies the basic investment criteria (Kieschnick, 1981). At best, incentives affect locational decisions at the margin and may only more influential at the local level. Economic development professionals are continually confronted and frustrated by the limited impact of development policies (Hansen, 1993).

Since incentives do not cause firms to move to sub-optimal locations, offering incentives may be a zero-sum game: for each winner there is a loser. If this is the case, however, offering incentives may actually cause an aggregate loss due to a misallocation of resources. Burstein and Rolnick (1995, 1996) argue that because resources are spent on targeting particular businesses too few public goods are provided. Our focus is not aggregate efficiency, however, but why localities seem compelled to compete for firms. Aggregate losses are no reason for particular localities to forego offering incentives. They still stand to gain for themselves by trying to win firms since offering incentives can influence a firm's decision among a group of localities that are similar with respect to the needs of the firm. Furthermore, there may be costs associated with not offering competitive incentives.

Even though offering incentives is rational at the local level, opponents cite other reasons to be concerned about the practice. One problem is that political actors tend to have short time horizons compared with the considerable time requirements for implementing and recouping the benefits of incentive policies (Rubin, 1988). Politicians, then, won't always offer incentives that are the best for the locality. Further, political interest groups may also influence deals so that private returns are not consistent with social returns. Even without political distortions, however, bad deals can happen. Due to poor accounting or a lack of information or expertise, localities may overvalue firms and as a result offer incentives that are too large. Firm behavior is also a concern. Firms may overstate their value to the locality in order to obtain larger subsidies. They also might produce less than expected or skip out after collecting short-term incentives, so that expected long term benefits are not realized by the locality. (Example from Pennsylvania Volkswagen Plant). These practical problems, caused by lack of public accountability, uncertainty, and asymmetric information, can undermine what might otherwise be a rational economic development policy.

The practical problems associated with offering incentives to firms are potentially vexing, but they might be overcome with good planning (and perhaps luck). Many remedies have been suggested, including clawback provisions, improved cost-benefit analysis, public accountability, and full disclosure. A more intrinsic concern is the ability of firms to shop for the best incentives. This forces localities to offer competing incentive packages and so to bid up the cost of attracting a firm. As a result, the benefits of winning a firm are eaten up. Jenn and Nourzad (1996) provide evidence that states tend to match the incentive offers of competing states. Competition for firms has been likened to an arms race. The escalation of incentive offers is feared by many to be out of control. There has been much discussion of the need to limit the incentives arms race. It is generally recognized that this must involve cooperation between localities, both within and across states. A moratorium on offering incentives has been suggested by a group of 100 Midwest economists and this sort of moratorium was a common theme from the Economic War Among the States Conference held in Washington, D.C. in May 1996. [For details see the web site at www.mnonline.org/mpr/econwar.htm, sponsored by the Minnesota Public Radio's Civic Journalism Initiative.]

Despite concerns about the incentives war, however, economic development professionals are poised to continue the competition. According to Gary Carlton, Director of Business and Industry Development for North Carolina, "You've got to have incentives to get your foot in the door" (Carlton, 1996). Offering incentives shows a willingness to promote growth and help businesses. "Governor Jim Folsum argues that, at least for his state, the Mercedes deal was [a] steal, if for nothing other than its symbolism—that is, to break through old stereotypes and announce to the corporate world that Alabama is open for business" (Mahtesian, 1995). Essentially, localities look bad if they don't offer sufficient incentives. Even if they don't help a locality get ahead, proponents suggest, incentives are necessary for self defense against 'firm poaching' by other localities.

The building consensus, among academics at least, is that the incentives arms race should be stopped. The practice of offering incentives can result in poorly structured deals with firms or deals where the locality must "give away the store" in order to attract a firm. Given the popularity of incentives as a local economic development strategy, local officials don't seem convinced. They argue that it is rational for localities to compete for firms. Localities want to increase local employment levels, send a pro business signal, and defend against losing the firms they have. The arguments of opponents and proponents of offering incentives are not contradictory, however. They both can be correct. Our position is that basically they are. Localities, we argue, are essentially in a prisoner's dilemma: it would be better if they did not compete against each other for firms and yet they are compelled to compete by the nature of their situation. To show that this is the case, we examine the competition among localities for a firm as a non-cooperative game and discuss the implications about how to de-escalate the incentives arms race.

To set up the game we focus on two key facts: (1) similar localities use incentives to compete for particular firms, and (2) localities incur costs if they fail to attract particular firms. Using a simple game theoretic construct we demonstrate that offering incentives in a competitive environment is paradoxical. Localities are compelled to offer incentives to attract firms: if no other locality offers incentives, a locality can win big by offering incentives because it can influence the firm's location decision at a minimal cost; if others are competing, a locality must offer incentives to avoid big losses. Still, the general practice of offering is bad for all localities, even in a world of full information, precise cost-benefit analysis, and social welfare maximization. If all localities are competing, then offering incentives does not increase a locality's chance of getting a firm. Furthermore, if a locality wins and attracts a firm, the nature of competition forces them to give the firm, in the form of incentives, all, or nearly all, of the benefit of the firm being in the locality. If a locality fails to attract a firm, then it sends a negative signal about its willingness or ability to help business. Consequently, localities do not gain by competing for firms.

The conclusions we draw from the game theoretic analysis may be important for developing strategies to end the "economic development wars." Unilateral disarmament by localities seems to be precluded since it is not individually rational. Due to the possibility of cheating, however, voluntary multilateral disarmament does not create a stable solution to the problem either. There is some hope that a cooperative solution could be attained under very specific conditions involving a repeated game scenario where the same localities bid against each other for similar firms an indefinite number of times. Such conditions, however, are rare. Given that voluntary solutions are not likely to be feasible, federal government mandates appear to be the only viable solution to the incentives arms race given the non-cooperative environment of economic development initiatives. Such mandates do not seem to be forthcoming. From a practical standpoint, then, it appears that the bidding war will continue.

II. The Local Economic Development Game

In this section we model the competition for firms as a game. In doing so, we abstract from some of the practical problems that localities face in offering incentives, e.g., lack of public accountability for local officials, uncertainty about the costs and benefits of having a particular firm in the locality, and information asymmetry between a locality and a firm or between localities. Thus, localities are assumed to be able to make the best deals for themselves. The idea is to show that even under circumstances where localities would be able to make the best deals they could, offering incentives would still have perverse consequences.

To begin, we assume that there is a particular firm and a set of localities where it might want to locate. The localities 1, …, I that the firm considers are the *players* in this game. The evidence suggests that firms consider basic location factors to identify potential locations before investigating incentives. Localities 1,…,I are therefore assumed to be equivalent with regard to basic location factors, at least with respect to the needs of the particular firm. For the sake of simplicity, we model the players as identical.[1] We assume that each locality knows what it will

[1] Our result does not rely on this assumption. Each locality can, for example, face different costs for failing to win the firm as long as those costs have the form outlined below.

gain if it attracts the firm and what it will lose if it fails to do so. We also assume that there is no information asymmetry between localities: each locality knows the identities of the other players, its legitimate competitors. Localities try to entice the firm by offering incentives. Incentives can come in many forms, but for the sake of simplicity we assume that localities offer cash subsidies. The cash subsidy can be seen as the monetary value of the combined incentive package that a locality offers. The players are otherwise identical so the firm moves to the locality that offers the highest subsidy. We assume that local officials are held accountable by the citizens of their localities. As a result, subsidy offers cannot exceed the benefit to a locality of attracting the firm. Let x be the discounted present value to a locality of attracting the firm.[2] Let $S_i = \{0, 1, \ldots, x\}$ be locality i's *strategy set*: the set of possible subsidies that locality i can offer the firm. Then s_i is a particular subsidy offer (*strategy*) from the set S_i. Let $s = (s_1, \ldots, s_I)$ be a *strategy profile* that lists a strategy for each locality, where $s \in \times_{i=1}^{I} S_i = S$.

How any particular locality fares in the competition for a firm depends on the subsidies offered by each of the players. Suppose a locality is not among the high bidders. It doesn't pay the cost of the subsidy, but it doesn't get the benefit of having the firm either. Localities that fail to attract a firm also look bad compared to a locality that does. By not winning the firm, the locality sends a negative signal to its citizens, other firms, etc., about its business climate. The strength of that negative signal depends on how the locality's subsidy offer compares to the highest bid(s). The greater the difference, the stronger the signal. Suppose a locality has the sole high bid. It gets x, the benefit of having the firm. It also has to pay out s_i, the subsidy offered. The net benefit of being the sole high bidder is, therefore, $x - s_i \geq 0$. Suppose a locality shares the high bid with another locality. We'll assume that the firm chooses one of the high bidders at random, so each high bidder has an equal chance at the net benefit of having the firm. If a player that offers the highest subsidy doesn't win the firm then there might be some small doubt about its business climate, which implies some cost c(0). The expected value of sharing the high bid with another locality, therefore, equals the chance of getting the firm multiplied by the value of getting the firm plus the chance of not getting the firm multiplied by the cost of doubt: $.5(x-s_i) + .5c(0)$.

[2] For ease of presentation we'll assume that $x \geq 2$. The results for x = 1 and x = 2 are a special case of the results (below) concerning the bids x - 1 and x.

To put all of this formally, let $H = \{s_j \mid s_j \geq s_k \text{ for } k = 1, \ldots, I\}$ be the set of high bids, and h equal the number of elements in H, i.e., the number of high bids. The cost of sending a negative signal about the locality's business climate, $c(\cdot)$, is a function of the difference between a high bid and a locality's bid, $(s_j - s_i)$. The farther a locality is from the high bid, the larger the cost of doubt. Define $c(\cdot)$, then, as a strictly increasing function from the set $\{0, 1, \ldots, x\}$ into $\Re$, the set of real numbers, such that $c(0) > 0$. The probability that a player with a high bid wins the firm equals 1/h. The payoff to a bid depends on the bids of all of the players. Define the payoff for player i as a function $p_i(\cdot)$ from the set of strategy profiles, S, into $\Re$ such that

if $s_i \in H$ then $p_i(s) = \frac{1}{h}(x - s_i) - (1 - \frac{1}{h})c(0)$, and

if $s_i \notin H$ then $p_i(s) = -c(s_j - s_i)$ for $s_j \in H$.

In other words, if player i offers a high bid, $s_i \in H$, then its payoff equals the probability of getting the firm multiplied by the net benefit of getting the firm minus the cost of doubt associated with offering the high bid and not getting the firm. If player i does not have a high bid, $s_i \notin H$, then its payoff is negative and equals the cost of doubt about its business climate, which, depends, in turn, on how low its bid is relative to the high bid(s).

What subsidies will localities offer? We start with a simple two-locality case. The two player version of the game, in its normal form, is shown in Figure 1. Player 1 chooses the rows and player 2 chooses the columns. The cells represent the payoffs given the offers of both players. The payoff to player one is shown in the upper left and the payoff to player two is shown in the lower right. Note that it is always better for each locality to offer a subsidy of 1 rather than 0. To see this, suppose are player one and your opponent bids 0. If you offer 0 you get a 50% chance at x and a 50% chance at -c(0), but if you offer 1 you get x for sure. In Figure 1, these are the payoffs in the upper left corner of the first and second columns in the first row. Now suppose your opponent bids 1. If you offer 0 you lose the firm and get -c(1), but if you offer 1 you get a 50% chance at x - 1 and a 50% chance at -c(0). (Compare the payoffs to player one in the first two rows of column two). As long as x is greater than or equal to 1, you would want to bid 1 since c(1)>c(0) by assumption. Suppose your opponent bids 2 or more. You lose the firm if you offer 0 or 1, but you send a stronger negative signal with an offer of 0 rather than 1. [You could be either locality, so the argument shows that a bid of 1 is better than 0 for both players.] Since we can rule out 0 bids, it is always better for each locality to offer a subsidy of 2 rather than 1. Again, suppose your opponent bids 1. If you offer 1 you get a 50% chance at x - 1 and a 50% chance at -c(0), but if you offer 2 you get x - 2 for sure. Suppose your opponent bids 2. If you offer 1 you lose the firm, but if you offer 2 you get a 50% chance at x-2. Suppose your opponent bids 3 or more. You lose the firm if you offer 1 or 2, but you send a stronger negative signal with an offer of 1 rather than 2.

Figure 1

	0	1	…	x - 1	x
0	.5(x - c(0)) .5(x - c(0))	-c(1) x - 1	…	-c(x -1) 1	-c(x) 0
1	x - 1 -c(1)	.5(x - 1 - c(0)) .5(x - 1 - c(0))	…	-c(x-2) 1	-c(x-1) 0
	…	…		…	…
x - 1	1 -c(x - 1)	1 -c(x- 2)	…	.5(1 - c(0)) .5(1 - c(0))	-c(1) 0
x	0 -c(x)	0 -c(x-1)	…	0 -c(1)	-.5c(0) -.5c(0)

The pattern suggested here continues until the only bids left are x - 1 and x: if we also rule out 1, 3 is always a better bid than 2; if we also rule out 2, 4 is always a better bid than 3; etc. If c(0), the cost of not winning even though you share the high bid, is low enough (c(0) $\leq$ 1) then x is not always a better bid than x - 1 after you rule out all of the other bids. If your opponent bids x - 1 then you will want to bid x - 1 as well: this way you preserve some chance of winning the firm with an expected gain, .5(x - (x - 1)) = .5, that is greater than the expected loss of not getting the firm, .5c(0). If you were to bid x then you would win the firm but wouldn't gain anything. If c(0) > 1 and your opponent bids x - 1, you should bid x, since in this situation the payoff to bidding x, 0, is greater than the payoff to bidding x - 1, .5(1 - c(0)). In any case, if your opponent bids x then your best response is to bid x as well in order to avoid the cost, -c(1), associated with not bidding as much as the high bid.

The upshot is that each locality has an incentive to bid high. To entice a firm to a locality, the locality must give the firm (almost) all of the benefit of having the firm locate there in the first place. Each locality would do better if they could all refuse to offer subsidies and let the firm choose at random. That isn't a feasible outcome, however, since there is a huge benefit to cheating in such a system: even a very small subsidy wins the firm.

The two-locality results generalize substantially to the multi-locality case. Again, for each player, it is always better to offer 1 than 0; if 0 is eliminated then 2 is always a better bid than 1; if 1 is eliminated then 3 is always a better bid than 2; etc. As before, each locality has an incentive to outbid the others (see Appendix A). The result is a race to "give away the store." Each locality bids up to x, the whole benefit of having the firm.

III. Implications for Ending the Competition

Is there any way to reign in incentive giveaways? A unilateral moratorium on incentives is not feasible. Any locality that tried it would be at a competitive disadvantage - they wouldn't attract much business. Other localities have no incentive to follow suit. Again, this is the essence of the prisoner's dilemma: everyone cooperating is better for each of the parties but the cooperative solution is impossible to attain voluntarily since there is much to be gained from cheating. "Such unilateral action has not worked in the past and offers limited future prospects" (Toft, 1995-96).

A voluntary multilateral moratorium on incentives is a popular proposal. Politicians, economists, academics, and planners have called for such a moratorium. The resolution by 100 midwestern economists issued on September 20, 1995, for example, called for "an end to state-sponsored selective business incentive programs such as direct grants and targeted tax abatements." There is no reason, however, to be optimistic about this approach. Multilateral agreements have been tried in the past with no success. The non-competition compact between New York, New Jersey, and Connecticut, for example, lasted just four days (Reich, 1996). The compact among the Great Lakes states also failed. [Provide more detail on this, with cite.]

Basically, there is no reason for a locality to abide by a voluntary moratorium on incentives. As we saw before, a locality has much to gain by offering incentives. In particular, the officials of a locality want everyone else to stop offering incentives so they can offer smaller subsidies and realize greater gains. They have an incentive to sign compacts but not to abide by them.

There is a glimmer of hope for ending the bidding war. Under certain conditions, localities might be able to develop a stable cooperative scheme. The idea is for communities to divide a series of firms among themselves by taking turns offering small subsidies. A locality might have to wait for its turn to court a firm, but when its turn arrives, the locality will realize most of the benefit of acquiring the firm. This strategy can be incentive compatible. Localities will restrain themselves for future benefits if the expected benefits are substantial enough, certain enough, and not too far off. The conditions for this sort of cooperation are quite rare. The set of localities must be stable. A locality outside of the compact won't abide by its constraints, forcing the other localities to offer incentives to match. There must be a continuous supply of firms, arriving on the scene sufficiently often. If there are no more firms or if potential firms arrive too far in the future then a locality will not have an incentive to leave the field to other localities. Localities have to take the long run view. They have to value the future highly or they will have an incentive to cheat and go for the immediate gain. This condition is problematic for politicians who stand to gain from short term success and may not get credit for success in the future (after their term ends). These conditions are likely to be met, if ever, only among a small number of localities with regard to a highly specialized sector of the economy. These results follow from an analysis of an indefinitely repeated version of the game in figure 1 (see Appendix B).

Another possible solution to the incentive bidding war is a government enforced moratorium. As we saw before, a moratorium works only if everyone actually stops offering incentives. As a practical matter, this implies federal action. Economists from the Federal Reserve Banks of Minneapolis have suggested such a moratorium.. How might this sort of policy be implemented? It might come in the form of a total ban on economic development incentives targeted at particular companies. An alternative to a total moratorium could take the form of general constraints on subsidies, such as spending limits, "luxury taxes," limits on the form that incentives can take, or limits on which localities can offer incentives. Some individuals argue that certain places can benefit more from attracting new firms than other places. From a national perspective, it might make sense to limit the number of localities that can offer incentives to a limited group of poor areas which would lag the rest of the nation. With this approach, incentives would only be made by those localities that would benefit the most. All of these federal solutions to the problem of incentive bidding wars come at the price of limiting state power to influence firm location and attract new employment. Moratoriums and mandated limitations, however, are unlikely in this era of new federalism since such legislation would directly reduce a state's ability to promote economic development within its borders.

IV. Conclusion

Our analysis demonstrates the paradox of offering incentives from a locality's perspective. There are good reasons why a locality would not want to offer incentives. Once localities start to compete for firms, however, a bidding war is inevitable. Consequently, communities give away all, or almost all, the benefit of attracting a new firm. It is clear that localities would be better off if the unbridled competition could be ended. Unfortunately, coordination between places to that end is difficult because each locality benefits by attracting firms.

The question is whether we have the political will to pass legislation that would eliminate or substantially reduce the bidding war. Given the political climate, the apparent answer is "no." Thus we are left with the dismal prediction that 'place-eat-place' bidding wars will probably continue for some time. In fact, because of practical difficulties, some localities will offer a firm more than its true value to the locality. Given the inevitability of the competition between places, at least in the immediate future, the discussion about how to safeguard against such bad deals becomes increasingly important. Economic development professionals should realize, however, that even in a perfect planning world, the best outcome they can obtain may be to give away almost all of the benefit of attracting a new firm.

Appendix A

This appendix provides some technical results for the I player game, along with a brief explanation of what they might mean to someone trying to understand the practice of offering incentives to firms.

Result 1: For each player, strategies 0, 1, …, x - 2 are eliminated by iterated elimination of dominated strategies.

Proof: For any player and k = 1, …, x - 1, if strategies k - 2, k - 3, … are already eliminated then k dominates k - 1. (Without loss of generality, we look at player 1.) There are three cases:

(1) *Show* $p_1(k, k - 1, \ldots, k - 1) > p_1(k - 1, k - 1, \ldots, k - 1)$

$p_1(k, k - 1, \ldots, k - 1) = x - k$

$p_1(k - 1, k - 1, \ldots, k - 1) = (1/I)(x - (k - 1)) - ((I - 1)/I)c(0)$

$p_1(k, k - 1, \ldots, k - 1) - p_1(k - 1, k - 1, \ldots, k - 1) = x - k - (1/I)(x - (k - 1)) + ((I - 1)/I)c(0)$

$= ((I - 1)/I)(x - k) - (1/I) + ((I - 1)/I)c(0)$

$x - k \geq 1$ and $I - 1 \geq 1$ implies $(I - 1)(x - k) - 1 > 0$ so $((I - 1)/I)(x - k) - (1/I) \geq 0$

$c(0) > 0$ so $((I - 1)/I)c(0) > 0$

therefore $((I - 1)/I)(x - k) - (1/I) + ((I - 1)/I)c(0) > 0$

(2) *Show* $p_1(k, \ldots, k, \ldots) > p_1(k - 1, \ldots, k, \ldots)$ where $k \in H$ and s^{-1} (the strategy profile s without s_1) has (h - 1) k bids, for h = 2, …, I

$p_1(k, \ldots, k, \ldots) = (1/h)(x - k) - ((h - 1)/h)c(0)$

$p_1(k - 1, \ldots, k, \ldots) = -c(1)$

$p_1(k, \ldots, k, \ldots) - p_1(k - 1, \ldots, k, \ldots) = (1/h)(x - k) + c(1) - ((h - 1)/h)c(0)$

$x - k \geq 1$ so $(1/h)(x - k) > 0$

$c(1) > c(0)$ so $c(1) - ((h - 1)/h)c(0) > 0$

therefore $(1/h)(x - k) + c(1) - ((h - 1)/h)c(0) > 0$

(3) *Show* $p_1(k, \ldots, k + m, \ldots) > p_1(k - 1, \ldots, k + m, \ldots)$ where $m \in \{1, \ldots, x - k\}$, $k + m \in H$, and s^{-1} has (h - 1) k + m bids, for h = 2, …, I

$p_1(k, \ldots, k + m, \ldots) = -c(k + m - k) = -c(m)$

p_1 (k - 1, …, k + m, …) = -c(k + m- (k - 1)) = -c(m + 1)

p_1(k, …, k + m, …) - p_1 (k - 1, …, k + m, …) = -c(m) + c(m + 1) = c(m + 1) - c(m)

c(m + 1) > c(m)

therefore c(m + 1) - c(m) > 0

A strategy s^*_i *dominates* another strategy s'_i for player i if and only if i does better playing s^*_i rather than s'_i no matter what anyone else does (for any s^{-i}, $p_i(s^*_i, s^{-i}) > p_i(s'_i, s^{-i})$ where s^{--i} is the strategy profile s without s_1). A rational player never plays a dominated strategy because she always does better by playing the dominant strategy.

Result 1 underwrites our main thesis. It shows that if localities compete for firms then the only incentive offers that make sense are x - 1 and x: 1 is always better than 0; if no one will bid 0 then 2 is better than 1; if no one will bid 0 or 1 then 3 is better than 2; etc. The upshot is that when localities care about development the best they can do for themselves is pretty poor. They must give away most, if not all, of the benefit of attracting firms in the first place.

Result 2: It is always better to play x if anyone else is playing x, so (x, …, x) is always a Nash equilibrium.

Proof: From Result 1 we know that each player has, at most, two undominated strategies: x and x - 1. Each player's best strategy is x when any of the other players bids x. (Without loss of generality, we look at player 1.)

Show p_1(x, …, x, …) > p_1(x - 1, …, x, …) where s^{-1} (the strategy profile s without s_1) has (h - 1) x bids, for h = 2, …, I

p_1(x, …, x, …) = -((h - 1)/h)c(0)

p_1(x - 1, …, x, …) = -c(1)

p_1(x, …, x, …) - p_1(x - 1, …, x, …) = -((h - 1)/h)c(0) + c(1) = c(1) - ((h - 1)/h)c(0)

0 < ((h - 1)/h) < 1 and c(1) > c(0) so c(1) > ((h - 1)/h)c(0)

therefore c(1) - ((h - 1)/h)c(0) > 0

Since each player's best strategy is x when a*ny* of the other players plays x, it follows that each player's best strategy is x when *all* of the other players play x. The strategy profile (x, …, x) is, therefore, a Nash equilibrium.

Result 2 shows that if *any* other locality bids x, a locality does its best when it also offers as a subsidy *all* of the benefit a firm would provide to the community. A Nash equilibrium is a strategy profile where each player does the best she can given what every other player does. The outcome of a game with rational players will be a Nash equilibrium unless some player has false beliefs about what some other player will do. Result 2 shows, then, that one likely outcome of competition for firms by rational localities is that each locality bids x and ends up with a negative expected payoff, -((I - 1)/I)c(0).

Result 3: If c(0) is large enough (> 1/(I - 1)) then x dominates x - 1 for each player and the *only* Nash equilibrium is (x, …, x).

Proof: From Result 1 we know that each player has, at most, two undominated strategies, x and x - 1. If c(0) > 1/(I - 1) then x dominates x - 1 for every player. (Without loss of generality, we look at player 1).

From Result 2 we know that x is a player's best strategy if anyone else plays x. Here we show that x is a player's best strategy even if everyone plays x - 1.

Show p_1(x, x - 1,…, x - 1) > p_1(x - 1, x - 1, …, x - 1)

p_1(x, x - 1,…, x - 1) = 0

p_1(x - 1, x - 1, …, x - 1) = (1/I) - ((I - 1)/I)c(0)

p_1(x, x - 1,…, x - 1) - p_1(x - 1, x - 1, …, x - 1) = ((I - 1)/I)c(0) - (1/I)

((I - 1)/I)c(0) - (1/I) > 0 if and only if c(0) > (1/(I - 1))

therefore ((I - 1)/I)c(0) - (1/I) > 0

Since x is the only undominated strategy for each player, it is the unique best strategy for each player. The strategy profile (x, …, x), then, is the unique Nash equilibrium.

Result 3 shows that if c(0) (the cost of not attracting a firm with a high bid) is more than negligible then a rational locality can never do better than to give away, in the form of incentives, all of the benefits of attracting a firm. Since each locality can figure out that x dominates x - 1, no locality will have false beliefs about the strategies of other localities. The unique outcome of a competition for a firm under these conditions is that all localities end up with negative expected payoffs.

Result 4: If $c(0) \leq (1/(I - 1))$ then $(x - 1, \ldots, x - 1)$ is the only other pure strategy Nash equilibrium.[3]

Proof: From Result 1 we know that each player has, at most, two undominated strategies: x and x - 1. We know from Result 3 that it is always better to play x if anyone else is playing x. If all of the other players play x - 1 and $c(0) \leq (1/(I - 1))$, however, a player's best response is x -1. (Without loss of generality, we will look at player 1.)

Show $p_1(x - 1, x - 1, \ldots, x - 1) > p_1(x, x - 1, \ldots, x - 1)$

$p_1(x - 1, x - 1, \ldots, x - 1) = (1/I) - ((I - 1)/I)c(0)$

$p_1(x, x - 1, \ldots, x - 1) = 0$

$p_1(x - 1, x - 1, \ldots, x - 1) - p_1(x, x - 1, \ldots, x - 1) = (1/I) - ((I - 1)/I)c(0)$

$(1/I) - ((I - 1)/I)c(0) \geq 0$ if and only if $c(0) \leq (I/(I^2 - I)) = (1/(I - 1))$

therefore $(1/I) - ((I - 1)/I)c(0) \geq 0$

Result 4 shows that there is a Nash equilibrium with positive expected payoffs. This equilibrium is only attainable if c(0) (the cost of not attracting a firm with a high bid) is sufficiently small and each locality is sure that the other localities are bidding x-1. If any player has doubts about what the other players are bidding then the equilibrium where everyone plays x automatically occurs (Result 3).

[3] There is also a mixed strategy equilibrium where each player randomizes over x - 1 and x, but I won't derive that here.

Appendix B

Playing the same game over an indefinite number of times can make certain series of actions optimal even though none of those actions would be optimal with respect to the unrepeated game. In other words, repeated play can lead to new equilibrium actions. Modeling economic development as a repeated game might be appropriate in some situations.

Formally, an indefinitely repeated game consists of a series of *stage games*. The stage games we are interested in are each just like the game outlined above: the players are 1, …, I; the sets of actions for each player at each stage are the strategy sets S_i; and the payoffs at each stage are determined by the payoff functions $p_i(\cdot)$. Let $s(t) = (s_1(t), \ldots, s_I(t))$ be the action profile for the t period of the game, where t = 1, 2, 3, …. The history of play up to t is given by $\lambda(t) = (s(0), s(1), \ldots, s(t))$, where $\lambda(t)$ is a particular history of play from the set of all possible histories, $\lambda(t) \in \Lambda(t) = \times_t S$. A strategy for player i in the full game, σ_i, is a sequence of functions from histories into actions, $\sigma_i: \Lambda(t) \rightarrow S_i$. $\sigma_i \in \mathsf{S}_i$, the set of all such possible strategies. A strategy profile of the full game is σ which is an element of the set of all strategy profiles, $\sigma = (\sigma_1, \ldots, \sigma_I) \in \mathsf{S} = \mathsf{S}_1 \times \ldots \times \mathsf{S}_I$. The payoff to player i of strategy profile σ is $\sum_{t=0}^{\infty} (wd)^t p_i(s(l(t)))$ where $w \in (0, 1]$ is the chance that the game will continue to the next stage and $\delta \in (0, 1]$ is the discount factor. This payoff is, roughly, the discounted sum of the expected values of the stage payoffs given the actions implied by the strategy profile.

Let σ^*_i be the strategy of bidding 0 at each stage until the first player bids more and bidding x after that. $\sigma^* = (\sigma^*_1, \ldots, \sigma^*_I)$. This strategy profile is symmetric (every player plays the same strategy) and provides pareto-efficient payoffs (no locality can increase its payoff without decreasing the payoff of another locality). The players are cooperating when they play σ^*: they refrain from bidding in order to avoid having to offer incentives. According to the folk theorem of repeated games, σ^* is a Nash equilibrium (optimal for each player if the other players go along) if and only if wd is large enough.[4] (Without loss of generality, we will be treating player 1 as a representative player.) How large does wd have to be in order to support σ^* as a Nash equilibrium? Suppose player one were to defect from σ^*, she would bid 1 at the first stage game, before the gain from defecting could be discounted. Let σ^D_1 be a strategy where she does just that. Player one plays σ^D_1 when everyone else plays their part of σ^* only if $\pi_1(\sigma^D_1, \sigma^{*-1}) \geq \pi_1(\sigma^*)$ where σ^{*-1} is the strategy profile of all players except player one. Player one won't defect if wd is large enough as shown below.

$$\pi_1(\sigma^*) = \sum (wd)^t [(1/I)x - ((I - 1)/I)c(0)] = (1/(1 - wd))[(1/I)x - ((I - 1)/I)c(0)]$$

$$\pi_1(\sigma^D_1, \sigma^{*-1}) = x - 1 + \sum (wd)^t [-((I - 1)/I)c(0)] = x - 1 - (wd/(1 - wd))[((I - 1)/I)c(0)]$$

$$(1/(1 - wd))[(1/I)x - ((I - 1)/I)c(0)] \geq x - 1 - (wd/(1 - wd))[((I - 1)/I)c(0)] \text{ implies that}$$

$$wd \geq 1 - (x/[I(x - 1) + c(0)(I - 1)])$$

Let $\underline{wd} = 1 - (x/[I(x - 1) + c(0)(I - 1)])$. $\underline{wd}$, therefore, is the smallest level of wd that supports cooperation among localities. How does $\underline{wd}$ change as I, x, and c(0) change?

(B1) $\partial\underline{wd}/\partial I = (\partial/\partial I)[1 - (x/[I(x - 1) + c(0)(I - 1)])] = (x^2 + c(0) - x)/(I(x - 1) + c(0)(I - 1))^2 > 0$

so $\underline{wd}$ increases as I increases.

(B2) $\partial\underline{wd}/\partial c(0) = (\partial/\partial c(0))[1 - (x/[I(x - 1) + c(0)(I - 1)])] = (x(I - 1))/ (I(x - 1) + c(0)(I - 1))^2 > 0$

so $\underline{wd}$ increases as c(0) increases.

(B3) $\partial\underline{wd}/\partial x = (\partial/\partial x)[1 - (x/[I(x - 1) + c(0)(I - 1)])] = (I + c(0) - c(0)I)/ (I(x - 1) + c(0)(I - 1))^2$.

$I + c(0) - c(0)I > 0$ if and only if $c(0) < (I/(I -1))$

so $\underline{wd}$ increases as x increases where $c(0) < (I/(I -1))$, and

$\underline{wd}$ decreases as x increases where $c(0) > (I/(I -1))$.

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[4] See page 150-160 of Fudenberg and Tirole, 1991 for an explanation of the folk theorem.

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