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Industrial blackmail: dynamic tax competition and public investment

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Abstract. A dynamic model of intergovernmental competition for a large plant is presented, when local productivity is uncertain. One firm determines the location of its plant in each period by conducting an auction, soliciting bids from local governments. Equilibrium subsidies from the local governments are derived. We also consider a two-stage game where local governments first choose a level of costly infrastructure then participate in the sequential auction. Even when costs are identical across locations, investing in different levels of infrastructure is a Nash equilibrium. Moreover, when infrastructure is endogenous in this manner, it is chosen efficiently.

Chantage industriel: concurrence fiscale dynamique et investissement public. Les auteurs présentent un modèle dynamique de concurrence intergouvernementale pour attirer une grande usine quand le niveau de productivité locale est incertain. Une firme détermine la localisation de son usine à chaque période par un mécanisme de mise à l'enchère et en demandant des soumissions de la part des gouvernements locaux. On dérive ainsi des subventions d'équilibre de la part des gouvernements locaux. Les auteurs considèrent aussi un jeu à deux étapes où les gouvernements locaux choisissent d'abord un niveau d'investissement dans des infrastructures coûteuses avant de prendre part à l'enchère séquentielle. Même quand les coûts sont identiques pour toutes les localisations, un investissement dans des infrastructures de niveaux différents constitue un équilibre à la Nash. De plus, quand les infrastructures sont endogènes de cette manière, elles sont choisies de manière efficace.

I. INTRODUCTION

Intergovernmental competition for private investment is a pervasive phenomenon.

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Local incentive programs, designed to attract investment, are common in most OECD countries.¹ When large investment projects are being considered, local governments will often go further by tailoring firm-specific tax/subsidy agreements. In Canada, for example, the Quebec provincial government provided \$5 million (Canadian) in subsidies to Hyundai Auto Canada Inc., in return for the company's building a new plant in that province (*Financial Post*, 5 July 1989, 3). The Saskatchewan government has reportedly supplied a \$35 million (Canadian) loan to Piper Aircraft Corporation to induce it to move its Florida plant to that province (*Globe and Mail*, 11 March 1992, B11). In recent years intergovernmental competition for such large capital projects has become fierce: in the United States, municipalities have been said to enter 'bidding wars' using firm-specific agreements to attract plants. For example, Mazda Motor Corp. actively solicited bids from various local governments in the United States when it was deciding where to locate its new plant. It finally accepted an offer from Flat Rock, Michigan, worth \$120 million (U.S.), prompting the mayor who negotiated the deal to denounce the process as 'industrial blackmail' (*ibid.*, 26 August 1989, B1). This paper presents a model that analyses this process, using the theoretical framework of sequential auctions.

Most of the existing literature on tax competition focuses on incentive programs that apply to any firm that is considering doing business in the region, rather than on firm-specific agreements for particular projects.² In a seminal paper, however, Doyle and van Wijnbergen (1984) modelled a firm that bargains with different governments sequentially in a bilateral monopoly setting. This model was used to provide an explanation of tax holidays. A similar approach was used by Bond and Samuelson (1986). Both these papers assume that the firm deals with only one local government at a time, rather than negotiating simultaneously with several governments. Black and Hoyt (1989) consider simultaneous negotiations, but their analysis is static, in that the location choice is a once-and-for-all decision. King and Welling (1992) present a two-period model in which two regions compete simultaneously in each period. In that model the firm conducts an auction in each period to decide the location of its plant. King and Welling find that firms would, in general, prefer an allocation in which all agents can commit to second-period actions. The regional governments, however, prefer the equilibrium allocation when no agent can commit. Moreover, the non-commitment equilibrium is more efficient than the commitment equilibrium when the relocation costs are sufficiently small that the threat of relocation is credible.

In this paper we generalize the environment considered in King and Welling (1992) by allowing for a continuum of possible productivity realizations in each location (rather than just two). As in King and Welling, the bidding process is modelled formally as an auction in each period and the firm may switch the location of its plant after some information about local productivity conditions has

1 Chandler and Trebilcock (1986) survey the regional incentive programs implemented in different OECD countries.

2 For a survey of the tax competition literature, see Wildasin (1986).

been revealed. This possibility of relocation is an important determinant of equilibrium pay-offs, even when it is not actually exercised.³ For this reason, and given the above result that local governments find it in their interest not to commit, in this paper we focus exclusively on non-commitment equilibria.⁴ This allows us to present a simple characterization of the size of government subsidies as a function of expected productivity differentials and sunk costs.

A second issue addressed here is local government investment in infrastructure. For example, government investment in roads, bridges, and ports can affect the expected profits available to firms locating plants in that region. Similarly, local regulations concerning trade union activity, environmental conditions, and land use by-laws, can affect private investment decisions.⁵ We consider a two-stage game in which local governments first choose a level of infrastructure (which is costly to build), then participate in the sequential auction described above. It is shown that, even if the costs of building the infrastructure are the same in each location, in the pure strategy Nash equilibrium the regional governments choose different levels of infrastructure and the region that chooses the highest level will be better off. Moreover, this equilibrium is efficient. Thus the productivity differentials assumed in the first section of the paper could arise endogenously. Further, when the level of infrastructure is endogenous in the manner described, federally administered programs designed to increase the level of infrastructure in the less attractive region will increase that region's expected pay-off but may decrease the sum of the pay-offs of the two regions even if the federal subsidy is not financed from within the regions.

The layout of the paper is as follows: section II presents the basic two-period model where a firm solicits bids, in each period, from local governments when deciding where to locate its plant. Section III extends the model by allowing the governments first to choose a level of infrastructure. Section IV uses the model to

3 While firms will likely establish that adequate trained labour and supplies of important inputs are present at each site considered, substantial residual uncertainty may exist about the ability to expand, or to obtain temporary workers, equipment, and transportation services. Volkswagen was reportedly unpleasantly surprised about the quality of the available labour force for its Pennsylvania plant and ultimately chose to close the plant. There have been, of course, numerous instances of firms' moving their plants. Piper Aircraft's dealings with the Saskatchewan government (cited above) is one example.

4 Because governments change periodically, it seems unlikely that local governments can commit to long-term contracts. Even if the local government agrees to a long-term contract, subsequent governments may be able to impose additional taxes. Moreover, because of verifiability problems, a local government may be able to undercut the original contract by supplying services of inferior quality.

5 One example was the 1979 amendment of the Nova Scotia Trade Union Act, which required that any unionization in a manufacturing company with two or more 'interdependent' manufacturing locations within the province must be done on a company-wide basis, rather than plant by plant. It has been alleged that this was done to encourage Michelin Tires to build a third plant in that province (Tupper 1986). More recently, the Piper Aircraft Corporation cited Saskatchewan's Foreign Judgements Act as a key factor in determining their decision to move. The act implies that judgments in liability lawsuits outside Saskatchewan are not enforceable within the province. Piper has several liability lawsuits pending in the United States, which makes the move to Saskatchewan more attractive (*Globe and Mail*, op. cit.)

analyse the effect of federal subsidies. Section v presents a conclusion and some suggestions for further research.

II. BIDDING WARS BETWEEN REGIONS

There are two regions (A and B) which compete for the firm's plant, in each of two time periods. Locating a plant in either region requires a sunk cost of k ; thus, if the firm relocates between periods, it incurs this cost twice. The surplus generated by the firm in either region, denoted y_i , $i = A, B$, is uncertain prior to actual production in that region.⁶ It is common knowledge, however, that

$$y_i = x_i + \epsilon_i \quad i = A, B, \quad (1)$$

where ϵ_A and ϵ_B are i.i.d. with common distribution function $F(\cdot)$ and associated density function $f(\cdot) = F'(\cdot)$. We assume

$$E\epsilon_i = 0 \quad \text{and} \quad F(0) \leq 0.5, \quad (2)$$

where E denotes expectations. All parties are risk-neutral, seek to maximize their own share of the available expected surplus, and have a common discount factor, β .

The sequence of decision-making and information revelation is as follows. At the beginning of the first period, $F(\cdot)$, x_A , and x_B are common knowledge; neither the firm nor either regional government has any private information about actual surpluses within either region. Based on the expectations about available surpluses, the regional governments participate in an oral (ascending bid) auction.⁷ The governments' 'bids' are offers of payments to the firm; an offer determines the division of the first period expected surplus between the firm and the regional government.⁸ Once the firm has chosen a location and incurred the fixed cost k , the actual surplus in the chosen region is revealed to all three decision-makers, production takes place, and the first-period surplus is split between the firm and the winning government. As the firm does not produce in the region that did not win the first-period auction, nothing is learned about the surplus available in that region. At the beginning of the second period the regional governments again enter an auction to determine the firm's second-period location. If the firm chooses not to move, no additional information is revealed; if it relocates, the surplus in the second region is revealed once

6 As in Bond and Samuelson (1986) and Wen (1992), the analysis is in terms of aggregate variables. Reformulating the model in per capita terms, as in Black and Hoyt (1989), would complicate the analysis, because regions with different populations could differ in both the sunk cost (per capita) and the benefit from winning the firm. This complication would increase the number of cases in the model without affecting the main thrust of the argument.

7 If the x values are private information at the start of the bidding process, an oral auction will reveal them, and the result will be identical to the full information case considered here. With no private information, the equilibria in an oral auction and a sealed bid auction coincide.

8 All agents are risk-neutral, so the actual form of the payment is not determined in this model – a number of combinations of lump-sum subsidies and tax rates are possible. See the discussion following Proposition 1.

the fixed cost has been incurred in that region. Once the firm's location decision has been made, production occurs and the second-period surplus is distributed.

Given the sequencing of actions and information revelation, first-period decisions are based on expectations of second-period decisions. Moreover, second-period decisions are based on a comparison of known with uncertain outcomes. In formulating the agents' first-period objective functions, it will prove convenient to define the following function:

$$\mu(z) = E \max \{ \epsilon, z \} = zF(z) + \int_z^\infty \epsilon f(\epsilon) d\epsilon, \tag{3}$$

where the expectation is taken with respect to the random component of production in the location chosen in the first period. Note that

$$\mu'(z) = F(z) \in [0, 1] \tag{4}$$

To interpret the function $\mu(z)$, suppose the firm locates in region A in the first period (as will occur in the equilibrium). Then at the beginning of period two, ϵ_A is common knowledge. If the firm remains in region A , second-period production yields a (certain) surplus of $y_A = x_A + \epsilon_A$; a move to region B would yield an *expected* net surplus of $E(x_B - k + \epsilon_B) = x_B - k$ (by (2)). Therefore relocation will not raise the expected surplus from production if $x_B - k < y_A$ or, rearranging, if $\epsilon_A > (x_B - x_A - k)$. Since all agents know that relocation is a possibility, an important determinant of the first-period decisions is $E \max \{ \epsilon_A, x_B - x_A - k \} = \mu(x_B - x_A - k)$.

Since no agent can commit to future actions, the model is solved recursively.

1. Period 2

Assume the firm located in region i in period 1. The second-period surplus available in region i , y_i , is therefore known to all agents. Since no information has yet been gathered on the other region (region j), the common expectation of the surplus available there is $E y_j = x_j$. Relocating the plant in the second period means incurring the fixed cost k again, so the relevant pay-off in region j is the expected net surplus, $x_j - k$. Given these possibilities, the second-period auction ensures that the firm locates its plant in the region with the higher expected surplus. Since there will be no further moves, the losing region receives a zero pay-off, and the firm and the winning region split the surplus available in the second period. The firm's share is determined by the pay-off it could receive in the losing region, and the winning region retains any additional (expected) surplus.⁹ Thus the pay-offs to the firm and the two regional governments, respectively, are

$$\text{firm receives } \min \{ y_i, x_j - k \} \tag{5a}$$

$$\text{region } i \text{ receives } \max \{ 0, y_i - x_j + k \} \tag{5b}$$

$$\text{region } j \text{ receives } \max \{ 0, x_j - k - y_i \}. \tag{5c}$$

⁹ An ascending-bid auction has the article being purchased for a price equal to the second-highest value, by the bidder with the highest value; for a survey of auction theory, see McAfee and McMillan (1987). In this model each regional government is willing to offer a tax/subsidy package which allows the firm to retain at most the entire expected surplus generated by the firm in that region, net of the fixed cost.

The results of the second-period auction can now be used to derive the results of the first-period auction: the initial location choice of the firm, the overall pay-offs, and the first-period net subsidy offered by the winning region to the firm.

2. Period 1

Let b_A and b_B denote bids offered by regions A and B , respectively, in the first period. Also, let ϕ_A and ϕ_B denote the firm's overall two-period expected pay-offs if it locates the plant in the first period in regions A and B , respectively. In general, in the first period, any particular bid offered by region A will be valued differently by the firm than the same bid offered by region B . Using (5a), we obtain

$$\phi_A = b_A - k + \beta E \min \{x_A + \epsilon_A, x_B - k\}.$$

This implies¹⁰

$$\phi_A = b_A - (1 + \beta)k + \beta x_B - \beta \mu(x_B - x_A - k). \tag{6a}$$

Similarly,

$$\phi_B = b_B - (1 + \beta)k + \beta x_A - \beta \mu(x_A - x_B - k). \tag{6b}$$

We first establish certain properties of the equilibrium, in a series of lemmas.

LEMMA 1. *The firm will locate its plant in region A in the first period iff $b_A - b_B \geq \beta[\Delta + \mu(-\Delta - k) - \mu(\Delta - k)]$, where $\Delta \equiv x_A - x_B$.*

Proof. From (6a) and (6b), $\phi_A - \phi_B \geq 0$ iff the above inequality holds. ■

LEMMA 2. *If $0 \leq \Delta \leq k$, then the firm's valuation of any first-period bid from region A will be less than its valuation of the same bid from region B.*

Proof. If $b_A = b_B$, then (using (6a) and (6b)) we have

$$\phi_B - \phi_A = \beta[\Delta - [\mu(\Delta - k) - \mu(-\Delta - k)]].$$

Using (4), this implies¹¹

$$\phi_B - \phi_A = \beta \left[\Delta - \int_{-\Delta-k}^{\Delta-k} F(z) dz \right].$$

10 Note that the following rules apply for max and min operators (when a, b , and c are constants): $\max(a, b) = c + \max(a - c, b - c)$; $\min(a, b) = c + \min(a - c, b - c)$; $\min(a, b) = -\max(-a, -b)$; $\max(a, b) + \min(a, b) = a + b$.

11 Notice that $\Delta > \int_{-\Delta-k}^{\Delta-k} F(z) dz$ is necessary and sufficient for $\phi_B > \phi_A$. This amounts to either a restriction on F or a restriction on $\Delta - k$. Given (2), assuming $\Delta - k < 0$ is sufficient, though not necessary, for $\phi_B > \phi_A$.

If $\Delta - k \leq 0$, then (2) implies

$$\phi_B - \phi_A \geq \beta \left[\Delta - \int_{-\Delta-k}^{\Delta-k} (0.5) dz \right] = 0. \quad \blacksquare$$

Lemma 2 implies that, if the expected surplus in region *A* is greater than that in region *B*, it is possible that the firm will discriminate *against* region *A* in the bidding process. That is, region *B* could offer a smaller bid than region *A* and yet still win the plant in the first period. The reasoning behind this seemingly counter-intuitive result is as follows. In each period, in a second price auction, the firm's pay-off is determined by the highest bid that the *losing* region can make. If the firm locates in region *A* in the first period, then the highest bid that region *B* can make in the second period is $x_B - k$. If, alternatively, the firm first locates in region *B*, then the highest bid that region *A* can make in the second period is $x_A - k > x_B - k$ if $\Delta > 0$. Hence, if regions *A* and *B* make the *same* offers in the first period, then region *B*'s offer will be more attractive to the firm. This purely dynamic effect does not appear in single-period models.¹²

Consider now the bidding strategies of the regions in the first period. Region *A* would be willing to bid at most an amount, call it \bar{b}_A , which leaves it indifferent between winning and losing the first-period auction. If region *A* wins, then (using (5b)) its overall expected pay-off is

$$\begin{aligned} \pi_w^A &= x_A - b_A + \beta E \max \{0, x_A + \epsilon_A - x_B + k\} \\ &= x_A - b_A + \beta[\Delta + k + \mu(-\Delta - k)]. \end{aligned} \quad (7a)$$

If region *A* loses the first-period auction, then (using (5c)) its overall expected pay-off is

$$\begin{aligned} \pi_l^A &= 0 + \beta E \max \{0, x_A - k - (x_B + c_B)\} \\ &= \beta\mu(\Delta - k). \end{aligned} \quad (7b)$$

Since \bar{b}_A is that value for b_A for which $\pi_w^A = \pi_l^A$, from (7a) and (7b),

$$\bar{b}_A = x_A + \beta[\Delta + k + \mu(-\Delta - k) - \mu(\Delta - k)]. \quad (8a)$$

Similarly, region *B*'s maximum bid is

$$\bar{b}_B = x_B + \beta[-\Delta + k + \mu(\Delta - k) - \mu(-\Delta - k)]. \quad (8b)$$

¹² A similar result is derived in King and Welling (1992). In that setting the sunk cost of locating a plant is region specific. Proposition 2 in that paper states that the firm's valuation of any first-period offer from the low-cost region will be less than its valuation of the same offer from the high-cost region.

LEMMA 3. Region A wins the first-period auction if $\Delta \equiv x_A - x_B > 0$.

Proof. From lemma 1, region A is capable of making a large enough bid iff

$$\bar{b}_A - \bar{b}_B > \beta[\Delta + \mu(-\Delta - k) - \mu(\Delta - k)].$$

(Notice that region A strictly prefers to win if it wins with a bid below \bar{b}_A ; for, at such a bid, region A obtains a higher surplus from winning than from losing.) Using (8a) and (8b), this condition is satisfied if

$$\nu(\Delta) \equiv \Delta + \beta[\Delta - \mu(\Delta - k) + \mu(-\Delta - k)] \geq 0$$

Recall $\Delta \equiv x_A - x_B$. Then $\nu(0) = 0$ and

$$\begin{aligned} \nu'(\Delta) &= 1 + \beta - \beta F(\Delta - k) - \beta F(-\Delta - k) \\ &= 1 - \beta + \beta[1 - F(\Delta - k) + 1 - F(-\Delta - k)] > 1 - \beta > 0. \end{aligned}$$

So $\nu(\Delta) > 0$ if $\Delta > 0$, and therefore region A can win. ■

Lemma 3 implies that the region with the larger expected surplus wins the plant in the first period. Without loss of generality, in the remainder of the paper we let $x_A > x_B$, so $\Delta > 0$, and therefore the firm initially goes to region A. The actual bid that region A makes, however, need not be as high as \bar{b}_A . Region A need bid only the smallest amount, so that (by lemma 1),

$$b_A - \bar{b}_B = \beta[\Delta + \mu(-\Delta - k) - \mu(\Delta - k)].$$

Using (8b) we obtain

$$b_A = x_B + \beta k. \tag{9}$$

We can now summarize the equilibrium expected overall pay-offs in the first period.

PROPOSITION 1. *If $\Delta \equiv x_A - x_B > 0$, then the firm will locate its plant in region A in the first period, and the pay-offs will be*

$$\text{region A : } \pi_A = (1 + \beta)\Delta + \beta\mu(-\Delta - k) \tag{10a}$$

$$\text{region B : } \pi_B = \beta\mu(-\Delta - k) \tag{10b}$$

$$\text{firm : } \phi_A = (1 + \beta)x_B - k - \beta\mu(-\Delta - k). \tag{10c}$$

Proof. (10a) follows directly from (7a) and (9). (10b) follows from (5c). (10c) follows from (6a) and (9). ■

Notice that, in the equilibrium, $\pi_A > \pi_B$ iff $\Delta > 0$.

3. Subsidies and taxes

We can now characterize the subsidies paid by the winning region to the firm in the first period. Let σ denote the expected net first-period transfer to the firm – the difference between the winning bid and the expected surplus. That is,

$$\sigma \equiv b_i - x_i \quad (11)$$

With $\Delta > 0$, (9) and proposition 1 imply that, in equilibrium,

$$\sigma(\Delta, k) = \beta k - \Delta. \quad (12)$$

Properties of this subsidy are summarized in the following corollary to proposition 1.

COROLLARY . *In the first period*

- i) *region A will pay the firm a positive subsidy iff $\Delta < \beta k$;*
- ii) *if $\Delta = 0$, so ex ante the regions are identical, then the firm receives an equilibrium subsidy of βk ;*
- iii) *the more disparate the regions, the greater must be the fixed cost for the firm to receive a subsidy.*

Proof. Follows directly from (12). ■

The intuition behind the corollary is as follows. The bid the firm receives in the first period from A, the winning region, is given in equation (9). Notice that A's bid is independent of x_A , the expected surplus in the winning region, but is increasing in both the expected surplus in the *other* region, x_B , and the discounted value of the sunk cost. The subsidy, defined to be the difference between the winning region's bid and the expected surplus in that region, is therefore *decreasing* in Δ . Once the firm locates its plant in the first period, it loses some of its future bargaining power (the discounted cost of re-building the plant in the next period, βk). The winning region must compensate the firm for this loss, which is why higher values of βk require a higher winning first-period bid. If $\Delta = 0$, so the two regions are identical ex ante, then the firm can capture the entire discounted value of the sunk cost as a subsidy. If the winning region has a higher expected productivity (i.e., $\Delta > 0$), however, then the subsidy will be smaller. The firm will receive a positive subsidy in the first period if the expected productivity differential is less than the discounted value of the sunk cost.

Notice that, from part (ii) of the above corollary and from lemma 2, when $\Delta < \beta k$ the firm receives a positive subsidy in the first period *and* region A is

discriminated against in the first-period decision: it must bid significantly more than region *B* to win.¹³

Because we have modelled this as a two-period game and concentrated on the division of the surplus from the production of a single plant, the firm can never expect to receive an ex ante net subsidy in the second (final) period. However, ex post net subsidies to newly attracted firms are consistent with our model. This model makes no predictions about the form of the net subsidy granted to the firm; in particular, a given level of expected taxes could be obtained by a number of combinations of lump-sum subsidies and tax rates. If the firm does move to region *B* in the second period, it pays expected net taxes of T_{2B} , where $T_{2B} = x_B - k - x_A - \epsilon_A$ (calculated from (5a)). This could be achieved by any combination of a lump-sum (L) and a marginal component (τ) such that the region's total expected revenues were equal to $T_{2B} = \tau(x_B - k) - L$. The taxes actually paid by the firm would be equal to $\tau(y_B - k)$; if realized productivity in region *B* turned out to be low, the ex post subsidy to the firm could be positive.¹⁴

4. Relocation in the second period

Although the fixed cost is a barrier to mobility in the second period, it is not absolute: once the actual surplus available in region *A* is revealed, the firm must decide where to produce in the second period. If ϵ_A is high, the firm will not move, but a low realized surplus in period 1 may cause the firm to switch locations in the second period. The probability of moving to region *B* in period 2 is¹⁵

$$\text{Prob}(x_A + \epsilon_A \leq x_B - k) = \text{Prob}(\epsilon_A \leq -\Delta - k) = F(-\Delta - k). \quad (13)$$

Provided the support of $F(\cdot)$ is large enough, there is a positive probability that the equilibrium to this model will involve the firm's switching locations in the second period. This probability is strictly decreasing in both k and Δ : ex ante, relocation is less likely the higher is the fixed cost of building a plant and the greater is the disparity between the mean surpluses in the two regions. We state this as a proposition.

PROPOSITION 2. *Given sufficient uncertainty about the available surplus, there is a positive probability that the firm will move in the second period to the other region.*

13 In a single-period model region *A* could win with a bid that was marginally higher than region *B*'s best bid. This is not the case here, when relocation in the second period is possible (recall the discussion following lemma 2).

14 In 1987 the Newfoundland government offered a \$15 million (Canadian) package to the Sprung Environponics cucumber greenhouse (*Calgary Herald*, 12 May 1987, C1). The company accepted this offer and left Calgary for St John's. The firm proved no more successful in Newfoundland than it had been in Calgary, and the December 1988 crop failure precipitated a political upheaval in Newfoundland. The analysis in this paper, as in King and Welling (1992), suggests that the Newfoundland government's offer may have been rational ex ante. In the King-Welling paper there is uncertainty about the firm's type. We show here that this sort of uncertainty is not necessary to generate such a result.

15 Recall that by assumption $\Delta \equiv (x_A - x_B) > 0$, so the firm chooses region *A* in period 1.

Switching locations is less likely the greater is the fixed cost and the larger is the difference between the expected surpluses in the two regions.

III. INVESTMENT AS A STRATEGIC VARIABLE

It was assumed in the previous section that the expected surplus in each region was exogenously determined. In practice, however, we observe regional governments' creating legal and capital infrastructures that are intended to improve the climate for business in their regions.¹⁶ In this section we add a prior stage to the two-period game above and allow regions to make costly investments which increase x_i .¹⁷ We show that the assumed difference between the regions can arise endogenously, and the regions' equilibrium decisions break ex ante symmetry.¹⁸

Suppose that the regions are initially identical; for notational convenience, we ignore the initial exogenous level of the surplus and concentrate on the additional surplus created by the regions' investments. Before the first-period bidding begins, region i can create (additional) x_i at cost $\gamma(x_i)$, where $\gamma(\cdot)$ is increasing and strictly convex. Suppose the other region will invest x_j . Then region i , $i \neq j$, obtains the pay-off:

$$\pi(x_i|x_j) = \begin{cases} (1 + \beta)(x_i - x_j) + \beta\mu(x_j - x_i - k) - \gamma(x_i) & \text{if } x_i > x_j \\ \beta\mu(x_i - x_j - k) - \gamma(x_i) & \text{if } x_i < x_j \end{cases} \quad (14)$$

Hence, region i 's reaction function¹⁹ is given by

$$\frac{\partial \pi(x_i|x_j)}{\partial x_i} = \begin{cases} 1 + \beta - \beta F(x_j - x_i - k) - \gamma'(x_i) = 0 & \text{if } x_i > x_j \\ \beta F(x_i - x_j - k) - \gamma'(x_i) = 0 & \text{if } x_i < x_j \end{cases} \quad (15)$$

LEMMA 4. *There does not exist a symmetric pure strategy equilibrium to the infrastructure game.*

Proof. From (15), a symmetric pure strategy equilibrium would require

$$\left. \begin{aligned} 1 + \beta - \beta F(-k) - \gamma'(x_i) &\leq 0 && \text{if region } i \text{ does not wish to increase } x_i \\ \beta F(-k) - \gamma'(x_i) &\geq 0 && \text{if region } i \text{ does not wish to decrease } x_i \end{aligned} \right\}$$

16 Black and Hoyt (1989) cite examples of offers of a public school and a robotics institute. See also footnote 5, above.

17 In this section we assume that the bidding game is the same as before. In a related paper we show that in a single-period model where local governments can make unobservable investments that affect local productivity, the firm would prefer a sealed-bid first-price auction, but the regions are better off under the second-price auction (see King et al., 1992).

18 The interpretation of x_i as 'infrastructure' may seem too broad because x_i is a private good, and infrastructure is usually thought of as being a public good. In this paper we abstract away from any other concerns that the local governments may have, including the productivity of other local firms in order to isolate the dynamic influences on behaviour. The 'infrastructure' that we have in mind is therefore of a restrictive nature: it will only affect the productivity of the newly attracted plant. Future work that considers more sophisticated objectives for the local governments (e.g., along the lines of Black and Hoyt 1989) in a dynamic setting seems warranted. See section v for a further discussion.

19 This section assumes that the second-order conditions are satisfied. Notice that $\beta \max_{z \leq -k} f(z) \leq \min_{z \geq 0} \gamma''(z)$ ensures that $\pi(x_i|x_j)$ is globally concave in x_i .

Together, these imply $1 + \beta - \beta F(-k) \leq \gamma'(x_i) \leq \beta F(-k)$, or $1 - \beta + 2\beta[1 - F(-k)] \leq 0$, which is false. ■

A symmetric pure-strategy equilibrium does not exist in this model because of the discontinuity in the regions' pay-off functions at $\Delta = 0$. When the regions make equal investments, if each region wins with some probability within $(0, 1)$, a small additional increase by one region brings a large increase in its pay-off, since it then captures the firm with probability one. If, on the other hand, one region wins with probability one when $\Delta = 0$, then the losing region can significantly reduce its losses by choosing zero investment.

Given lemma 4, we focus on asymmetric pure strategy equilibria²⁰ and, as before, adopt the convention that the region with the larger expected surplus is region A, so $x_A > x_B$.²¹

PROPOSITION 3. *Provided $\gamma'(0) = 0$ and the investment required to 'drive out' region B is prohibitively costly,²² a unique asymmetric pure-strategy equilibrium (x_A^*, x_B^*) exists, where x_A^* and x_B^* satisfy*

$$i) \quad x_A^* > x_B^* > 0$$

$$ii) \quad 1 + \beta - \beta F(x_B^* - x_A^* - k) - \gamma'(x_A^*) = 0 \tag{16a}$$

$$iii) \quad \beta F(x_B^* - x_A^* - k) - \gamma'(x_B^*) = 0. \tag{16b}$$

Proof. See appendix.

Even though region A wins the firm in the first period, region B may choose $x_B^* > 0$, since higher values of x_B raise the probability that the firm will choose to switch locations in the second period.

In equilibrium, region A wins the firm in the first period, but does so as a consequence of greater expenditures to attract the firm. Despite these greater costs, there is no ambiguity in the ranking of the expected rewards: the region that makes the greater investment to attract the firm has the larger expected pay-off. To see this, let $\pi_i(x_i|x_j)$ denote the expected pay-off of region i as a function of x_i , given region j has chosen x_j . Then,

$$\pi_A(x_A^*|x_B^*) - \gamma(x_A^*) \geq \pi_A(x_B^*|x_B^*) - \gamma(x_B^*) > \pi_B(x_B^*|x_A^*) - \gamma(x_B^*).$$

20 In King et al. (1992) we demonstrate that when regions can make unobservable investments in infrastructure prior to engaging in a once-and-for-all auction to determine the location of a firm, the investment decisions depend on the type of auction. If the firm runs a sealed-bid *second-price* (or oral) auction, there is an asymmetric pure strategy equilibrium; with a sealed-bid *first-price* auction there is no pure strategy equilibrium but there is a symmetric mixed strategy equilibrium.

21 Since the purpose of this section is to demonstrate that the asymmetry assumed in the previous section can arise endogenously, we do not address the issue of how it is that regions determine which of them will undertake the larger investment and become region A.

22 This restriction is made precise in the proof.

The first inequality follows because region A chooses x_A^* optimally, given x_B^* , while the second holds because region B's pay-off is strictly decreasing in x_A and $x_A^* > x_B^*$.

The results of this analysis are summarized in proposition 4.

PROPOSITION 4. *If regional governments are able to make costly investments which increase the expected surplus available from locating a plant in their regions, and this investment is equally costly in each region, then it is an equilibrium for the regions to choose different levels of investment. Hence, the regions will not be equally attractive to firms, and the region that makes the higher expenditure will be better off.*

The competition between the regions leads to investment in infrastructure which may remain idle, given the uncertainty about the plant's location in the second period. The following proposition shows that the regions' choices could not be improved upon by coordination.

PROPOSITION 5. *The unique pure strategy equilibrium of the infrastructure game is efficient.*

Proof. For any choice of $\{x_A, x_B\}$ where $x_A \geq x_B$ (so the firm initially enters region A), the expected net surplus at the beginning of the first period is

$$\begin{aligned} S &= x_A - k + \beta E \max \{x_A + \epsilon, x_B - k\} - \gamma(x_A) - \gamma(x_B) \\ &= (1 + \beta)x_A - k + \beta\mu(x_B - x_A - k) - \gamma(x_A) - \gamma(x_B). \end{aligned}$$

First-order conditions for a maximum are

$$\begin{aligned} \partial S / \partial x_A &= (1 + \beta) - \beta F(x_B - x_A - k) - \gamma'(x_A) = 0 \\ \partial S / \partial x_B &= \beta F(x_B - x_A - k) - \gamma'(x_B) = 0. \end{aligned}$$

These are identical to (16a) and (16b) in the equilibrium. ■

To understand this result, notice first that the expected net surplus is simply the sum of the expected pay-offs given in proposition 1, net of the costs of building the infrastructure. Changes in the levels of (either or both of) x_A and x_B will affect both the size of the available surplus and its distribution. Because of the sequential decision structure of the equilibrium, however, these two effects are quite separate. Consider equations (10a)–(10c) in proposition 1. A change in x_A will alter π_A but will leave the *sum* of $\pi_B + \phi_A$ unchanged. Thus, in the infrastructure game, region A has an incentive to choose an efficient level of x_A because all of the net change in the social surplus accrues to A. The individual pay-offs going to region B and the firm are affected by A's choice, but the *net* pay-off going to these two agents is independent of the level of x_A . The same is true for B: when B alters its choice of

x_B , all of the changes in the size of the (expected) surplus accrue to B , and region A and the firm merely redistribute a constant sum. Since all of the net effects of a choice of either region's infrastructure are internalized by the investing region, the Nash equilibrium to the infrastructure game is efficient.

IV. REGIONAL SUBSIDIES

The analysis of the previous section showed that competition between the regions for large capital investment could generate a situation in which the region that made the greater effort to attract a firm would be better off. A common feature of federal states is some form of equalization grants and/or regional incentive program, through which the federal government transfers wealth across lower levels of government in order to encourage the development of regional industrial bases. Clearly, proposition 5 implies that there is no efficiency basis for redistribution policies in this model.²³ Although the model in this paper cannot provide a full analysis of federal programs, some consequences of regional subsidies can be examined.

Consider amending the model of the previous section to incorporate subsidization of region B . For the sake of argument, suppose that the subsidy is not financed within the model (i.e., it is 'manna from heaven'). We assume that region B receives a lump-sum grant which increases the size of x_B without increasing the cost to the region.²⁴ Region A 's reaction function is implicitly defined in (16a) above; totally differentiating this condition with respect to x_A and x_B , and rearranging, yields the slope of the reaction function

$$\frac{dx_A}{dx_B} = \frac{\beta f(x_B - x_A - k)}{\beta f(x_B - x_A - k) - \gamma''(x_A)} < 0. \tag{17}$$

Assuming the second-order condition for a maximum is satisfied, this expression is negative. As long as region B is not subsidized enough to reverse the sign of Δ in the equilibrium, the subsidization reduces the disparity of x values between the regions. We now consider the effects of such a policy on the welfare of the different agents in the model.

PROPOSITION 6. *Any marginal lump-sum subsidy to region B will*

- i) increase the welfare of region B*
- ii) decrease the welfare of region A*
- iii) decrease the aggregate welfare of regions A and B, provided that x_A is not extremely responsive to changes in x_B .*

23 The analysis in this paper assumes that the only benefit from winning the firm is the expected surplus received from that particular firm, and the result on subsidies must be viewed in this narrow framework. Broadening the model to allow for externalities (as in Black and Hoyt 1989) or embedding this bidding game in a more complex model of fiscal federalism could alter this result.

24 A 'matching grant' program yields results similar to those discussed in this section.

Proof.

- i) From (14), a marginal increase in x_B , which is paid for by another source, will have the following effect on B 's welfare:

$$d\pi_B/dx_B = \beta F(x_B - x_A - k)[1 - dx_A/dx_B] > 0.$$

- ii) Also from (14) and (15):

$$\frac{d\pi_A}{dx_A} = \frac{\partial\pi_A}{\partial x_A} \frac{dx_A}{dx_B} + \frac{\partial\pi_A}{\partial x_B} = \frac{\partial\pi_A}{\partial x_B} = -[1 + \beta(1 - F(x_B - x_A - k))] < 0.$$

- iii) From (i) and (ii).

$$\begin{aligned} d\pi_A/dx_B + d\pi_B/dx_B &= -(1 + \beta) + \beta F(x_B - x_A - k)[2 - dx_A/dx_B] \\ &\leq -2\beta + 0.5\beta[2 - dx_A/dx_B] \\ &< 0 \text{ if } dx_A/dx_B > -2. \quad \blacksquare \end{aligned}$$

The reasoning behind the first two results is straightforward: an increase in x_B raises the probability that the firm will switch locations between periods. Since we are assuming that the increase in x_B is not large enough to coax the firm to locate its plant in region B in the first period, this can only raise the welfare of region B and decrease that of region A . The relative size of these two effects determines the impact on the aggregate welfare of the two regions.²⁵ It is possible that a subsidy to the poorer region will reduce aggregate welfare even if this subsidy is not financed by taxes in either region (that is, if the subsidy is manna from heaven), because the subsidy distorts the equilibrium infrastructure choices from their efficient levels.

V. CONCLUSION AND EXTENSIONS

In this paper we present a two-period model in which local governments compete via auctions for a plant being built by a single firm. Since a sunk cost is incurred when the plant is built in the first period, mobility in the second period is limited, giving the first-period winner a second-period advantage. This allows the region in which the firm initially locates to extract a share of the surplus produced in subsequent periods, without fear of the firm's being bid away to another region. The firm trades these future tax payments for current subsidies and tax concessions. The magnitude of the subsidy is increasing in the level of the sunk cost and decreasing in the disparity between the regions.

²⁵ Without imposing further restrictions, the effect on the profits of the firm cannot be determined.

Using this framework we also analyse regional governments' incentives to invest in infrastructure to make their regions more attractive to outside capital. We show that differences between the regions can emerge endogenously, and that the asymmetric equilibrium allocation is efficient. Attempts (by a federal authority, say) to reduce these differences may reduce aggregate welfare across the regions, even if these subsidies are financed outside the system.

An obvious extension of this analysis is to increase the number of firms that are available for bidding. Firms could appear simultaneously, or sequentially. In the former case, the outcome would depend crucially on the assumed bargaining game between the firms and the regional governments, but the existence of rivals should diminish any given firm's bargaining power. Since in our framework each firm generates a non-negative expected net revenue stream, however, the regions would still have an incentive to bid for each firm.

If firms appeared sequentially, a multi-period extension of the current model would be applicable. Infrastructure built but not used in any particular period may be used in subsequent periods by other firms. If the firms can be of different types, then one possible equilibrium would have the regions specializing in the type of infrastructure that they build. Vernon, California, seems a good candidate for a city that has specialized in being attractive to business by investing heavily in distant hydroelectric power, with low marginal cost, and installing the local grid.

Black and Hoyt (1989) present a one-period model in which local governments' bids for capital projects are financed by a reduction in the tax burden of current citizens. In their model the local governments provide public goods that have relatively large fixed costs. With declining average costs for the public good, the larger labour force attracted by the investment lowers the per capita tax of the citizens, and the subsidy to the firm does not require an increase in net taxes. Although Black and Hoyt do allow for some uncertainty about the relative productivity of the firm in a particular location, they do not consider the complications introduced by the possibility of plant relocation once actual productivity is revealed. The contemporaneous financing of any subsidy makes relocation irrelevant in their model. In our model externalities are assumed away, but the possibility of relocation is an important determinant of the price actually paid by the winning region in the first period, and there is a positive probability that a firm that experiences a low outcome in the first period will be courted and won by another region. Future research that combined these two models would allow for a richer description of the consequences of intergovernmental competition and analysis of the effects of various policies within federal states.

In this paper we do not consider the possibility that winning the firm may generate negative externalities for a region, but our framework is easily adapted to analyse such cases. The incorporation of a lump-sum externality is straightforward: if this externality is large enough, the firm's choice of location in the dynamic game is determined by the lowest subsidy the *firm* must pay to induce a region to accept its presence. Thus the infrastructure game in our model can be reinterpreted as one in which regions compete by, for instance, setting environmental standards with

which firms must comply.²⁶ If the negative externality cannot be contained within a single region – if, for example, the damage is airborne rather than confined to the land site on which the plant is built – then the game becomes more complicated, but this framework still provides a useful starting point for analysis.

APPENDIX

Proof of proposition 3. Existence of an asymmetric pure strategy equilibrium to the infrastructure game: Let $x_A \geq x_B$. The first-order conditions determining the optimal infrastructure levels are

$$1 + \beta - \beta F(x_B - x_A - k) - \gamma'(x_A) = 0 \tag{A1}$$

$$\beta F(x_B - x_A - k) - \gamma'(x_B) = 0. \tag{A2}$$

Define x^0 to be the level of A 's infrastructure for which B 's optimal choice is zero, so x^0 satisfies $\beta F(-x^0 - k) = \gamma'(0)$ if this yields $x^0 \geq 0$, and is equal to zero otherwise.

Case 1: Suppose $1 + \beta - \beta F(-x^0 - k) - \gamma'(x^0) \geq 0$. Then $x_B = 0$, and x_A satisfies $1 + \beta - \beta F(-x_A - k) - \gamma'(x_A) = 0$. Then $x_A \geq x^0$.

Case 2: Suppose $1 + \beta - \beta F(-x^0 - k) - \gamma'(x^0) < 0$. (So A would choose a level of infrastructure sufficiently high that $x_B^* = 0$.) Define x^1 to be B 's choice of infrastructure when $x_A = x_B$, so $\beta F(-k) = \gamma'(x^1)$. By construction, (A2) is satisfied at both (x^1, x^1) and $(x^0, 0)$. At (x^1, x^1) , the LHS of (A1) is

$$1 + \beta - \beta F(-k) - \gamma'(x^1) = 1 + \beta - 2\beta F(-k) > 0.$$

Since the LHS of (A1) is decreasing in x_B , for (A1) to hold at $x_A = x^1$, $x_B < x^1$. At $(x^0, 0)$, LHS of (A1) is $1 + \beta - \beta F(-x^0 - k) - \gamma'(x^0) < 0$ by assumption. So $x_B > 0$ for (1) to be satisfied at $x_A = x^0$.

The intermediate value theorem establishes an equilibrium (see figure 1).

To show $x^1 < x^0$, notice that at these two values for x_A , (A2) is satisfied as $\beta F(-k) - \gamma'(x^1) = 0$ and $\beta F(-k) - \gamma'(0) = 0$, respectively. Consider the function $\alpha(x, y) = \beta F(-k - x) - \gamma'(y)$, with $\alpha(x^0, 0) = \alpha(0, x^1) = 0$.

$$\left. \frac{dy}{dx} \right|_{\alpha(x,y)=0} = -\frac{\beta f(-k-x)}{\gamma''(y)} > -1$$

so long as the second-order conditions for a maximum are satisfied. Therefore, as x increases from 0 to x^0 , y decreases from x^1 to 0 at a rate *greater* than -1 , so $x^1 < x^0$.

26 Markusen, Morley, and Olewiler (1992) consider a similar problem in a static model.

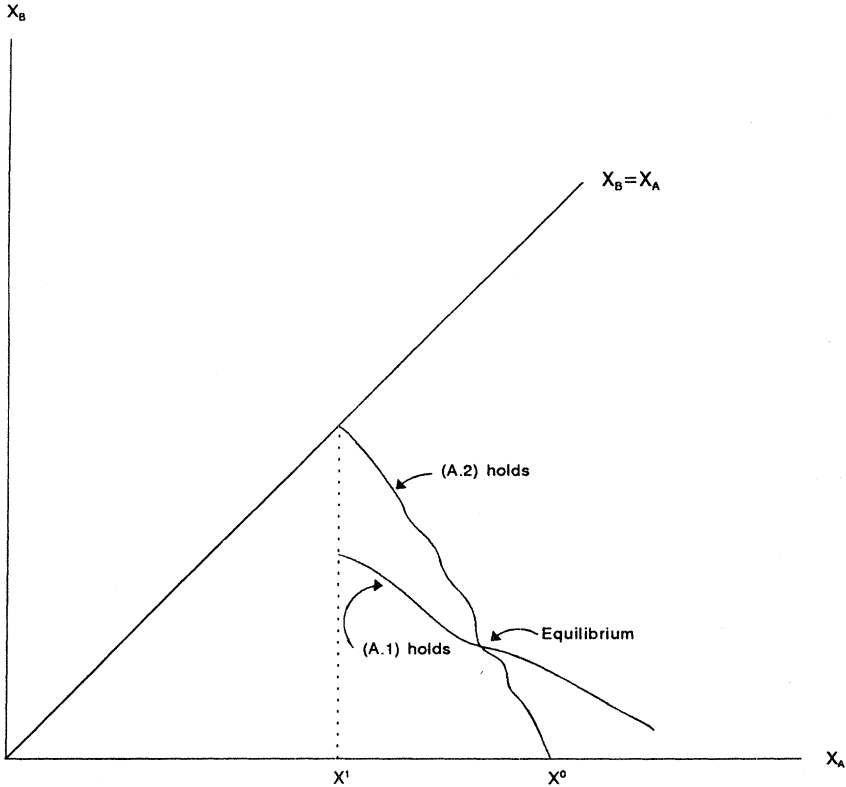


FIGURE 1

Notice that case 2 does not arise if $x^0 = 0$, that is, if $\beta F(-k) - \gamma'(0) \leq 0$. If $x^0 = 0$, then $1 + \beta - \beta F(-k - x^0) - \gamma'(x^0) = 1 + \beta = \beta F(-k) - \gamma'(0)$; if this expression is negative, then the equilibrium is $(x_A, x_B) = (0, 0)$: investment is too costly.

Case 1 never arises if $\gamma'(0) = 0$ and, given $\bar{\epsilon} = \sup \{\epsilon | F(\epsilon) = 0\}$, we have $(1 + \beta) < \gamma'(-\bar{\epsilon})$. Then the cost of driving out the other region is prohibitive. If $\gamma'(0) = 0$ and the support of $F(\cdot)$ is $(-\infty, \bar{\epsilon})$, an interior solution must occur. ■

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