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Discussion Paper No. 01-4

April 2001

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Fiscal Competition and Regional Differentiation*

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First draft June 2001; this draft June 2004.

Abstract

Regions can benefit by offering infrastructure services that are differentiated. Competiton between regions over potential investors is then less direct, allowing them to realize greater benefits from external investors. The two polar cases of full and incomplete information about investors' needs are studied. In both cases, there is regional differentiation. However, fiscal competition is efficient in the former case but not in the latter. Finally, it is shown that free entry in the location market calls for some regulation because of the excessive number of competing regions that would prevail in equilibrium.

*We thank P. Pestieau, K. Stahl and two referees for helpful comments and suggestions. We are also grateful to the Ministère de l'éducation, de la recherche et de la formation (Communauté française de Belgique), Convention 00/05-262, for funding.

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Keywords: fiscal competition, regional development, infrastructure, horizontal differentiation.

JEL Classification: R58, R12, H73, O38.

1 Introduction

The globalization of trade and investment has increased competition among regions vying to attract outside investments that create jobs, boost local income and raise property values, forcing them to compete internationally. Such competition often takes the form of tax reductions or subsidies. In one recent example, Israel successfully outbid Ireland and other rival locations in persuading Intel to locate a new fabrication plant in a struggling development town, by awarding the company a specially earmarked subsidy of $600 million. Subsidies like this are often augmented by local investments in infrastructure, which may be as important as financial incentives in attracting new investments. The European Union's regional development policy recognizes this, and has greatly increased its budget for building transportation infrastructure in the last decade with the purpose of reducing large inter-regional disparities in infrastructure quality (Martin, 1999). The competitive supply of infrastructure and investment subsidies can become a trap in which regions sink excessive resources that outweigh the gains they are able to realize from new investment (Taylor, 1992; Brueckner, 2000).[1] The typically strategic nature of this competition, and the negative fiscal and pecuniary externalities that often characterize it, leave little reason to expect it to yield the benefits that Tiebout (1956) associated with "perfect" fiscal competition (Oates, 1972).[2]

Specialization in infrastructure services offers a promising solution to this quandary. *By differentiating the infrastructure services they provide, regions can create niches in which they are protected from the ravages of excessive competition.* The scope for such differentiation is increasing. The revolution in information and communication technologies that is a concomitant

[1]Here we assume that regions have full information regarding the value that may be gained from their efforts. When bidders for a new project hold incomplete information regarding its actual value, the "winner's curse" may well result in the winning bid exceeding the value of the project (Thaler, 1992).

[2]See Wilson (1999) for a recent survey of theories of tax competition.

of the globalization of world markets shifting firms' infrastructure needs to less tangible, more specialized investments (Teubal et al., 1996). Such infrastructure typically incorporates, in addition to key physical elements of communications and transportation, intangible elements of human, social and organizational capital that are highly specialized. These have created well-documented nodes of attraction for such diverse activities as the ceramic-tile industry in Italy's Emilia Romagna region (Porter, 1990) or the data security software industry in Israel (Teubal et al., 2000), among many others.

This paper analyzes a formal model of horizontal differentiation of infrastructure by regions tailoring the services they provide to the needs of specialized industry segments.[3] Using a two-region model to highlight the strategic dimension of rivalry, we show how such *differentiation moderates fiscal competition between regions and reduces the pressure on regional budgets.* This supports Porter's (1998) recommendation that regional development strategies should identify areas of specialization that exploit local sources of uniqueness rather than engage in head-to-head fiscal competition with well-established rival locations. Moreover, we show that such differentiation strategies can be implemented unilaterally, without explicit coordination, as the optimal response of rival regions to a strategy of increased differentiation will be to similarly specialize their infrastructure in a manner that increases differentiation. We show that when regions are able precisely to identify firms' needs fiscal competition yields an efficient outcome but when regions only have a general knowledge of the statistical distribution of these needs, fiscal competition leads to excessive differentiation.[4]

There is generally scope for regulating or coordinating the number of regions actively competing for outside investment. When the number of participating regions is determined by the trade-off between the cost of supplying specialized infrastructure and its value for the region we find that *the*

[3] Horizontal differentiation arises when firms split themselves among several regions, which all supply different types of infrastructure whereas charging the same tax.

[4] Thus, we differ from King et al. (1993) in which firms' information about the quality of regional infrastructure is imperfect.

number of regions actively competing for the location of firms may be inefficiently large, at least when regions have incomplete information about firms' needs, as individual regions fail to take into account their negative external effect on the surplus of other regions. This suggests coordinating the provision of specialized infrastructure coupled with a redistribution of profits to inactive regions, for example, through joint ownership of industrial zones possibly located on the physical boundary between regions. In Israel, the national government actively encourages adjoining municipal authorities to undertake such cooperative initiatives.

In its theoretical approach, this paper rests on two important strands of the literature: the analysis of Tiebout competition between local jurisdictions and Hotelling's theory of spatial differentiation as revisited by d'Aspremont et al. (1979), both of which principally deal with consumers. The present contribution focuses on Tiebout competition for and differentiation across firms, showing how variety in the needs of firms can be used by regions to blunt the force of fiscal competition between them. In addition, previous analyses of differentiated fiscal competition have largely focused on "vertical" differentiation, i.e., differentiation in quality. Thus Epple and Sieg (1999) analyze inter-jurisdictional competition in the quality of education services and, closer to the present context, King et al. (1993) and Justman et al. (2002) analyze vertical differentiation in industrial infrastructure. Our focus on horizontal differentiation highlights a different, effective strategy for "taking the bite out of fiscal competition": adopting a *niche* approach, which is likely to require of the regions less heavy investment (but possibly more imagination) than competing on infrastructure quality. To this purpose, we adapt the standard Hotelling model to allow regions to offer subsidies to firms, which in the standard Hotelling model is equivalent to allowing sellers to charge negative prices. The benefits that accrue to the region when firms locate there are assumed to derive from the appreciation of land values.

The structure of the paper is as follows. In Section 2 we describe the basic two-region model in which regions initially determine the orientation of their specialized infrastructure, then set subsidies or fees, on which firms base their location decisions. Section 3 characterizes the second-stage equilibrium in which regions determine subsidies or fees after the infrastructure is established. Section 4 analyzes first-stage regional competition in infrastructure development. Section 5 considers the number of active regions in a multi-regional setting, and Section 6 concludes.

2 The model

Consider two regions ($i = A, B$) and a continuum of competitive firms of unit mass selling their output at a given price, which is normalized to one. Region i supplies a technological infrastructure of type $x_i \in [0, 1]$,[5] and we assume without loss of generality that $x_A \leq x_B$. Each firm operates one plant characterized by a type $x \in [0, 1]$ that describes the technological infrastructure that allows it to minimize its investment cost. For simplicity, we assume that the types of firms are uniformly distributed on the interval $[0, 1]$.

Production requires labor and a fixed investment, the value of which depends on the match between the firm's needs and the type of infrastructure available in the chosen region. More specifically, when a firm of type x locates in region i, it must bear a fixed investment $f(x_i, x)$ to adjust the firm's assets to the regional infrastructure. This cost is an increasing and convex function of the distance between the ideal infrastructure x of the firm and the available infrastructure x_i. To fix ideas, we assume here that $f(x_i, x) = \beta(x - x_i)^2$ where β reflects the importance of a good fit between the firm's assets and the region's infrastructure. A firm's choice problem then consists in choosing the region in which to produce and its scale of operation. When it chooses to locate in region i, it receives a subsidy of $s_i(x, x_i)$, where a negative value

[5] We use the term region in a generic sense, to refer to "local" jurisdictions that compete for a common pool of firms through industrial development policies, including both competition between nations for foreign direct investment, and between regional authorities within a country vying to attract domestic investors.

of $s_i(x, x_i)$ indicates a fee which the firm pays the region. The firm produces

$$y(l) = l^\alpha$$

units of output when hiring l units of labor, with $0 < \alpha < 1$.[6] Hence, each firm faces a typical U-shaped average cost function. We assume that labor is homogeneous and perfectly mobile, and relocates so as to equate the wage, w, in both regions

Regional governments choose the infrastructure they supply as well as the subsidy (fee) they offer (charge) to firms locating in their jurisdiction. They set their policies non-cooperatively with the objective of maximizing a fixed fraction, γ, of the wage bill generated by firms locating in the region minus the cost of providing the infrastructure plus fees collected or minus subsidies paid. This formulation is consistent with various approaches. For example, in a standard urban economics setting, assume that the supply of land in each region is fixed and that regions are controlled by landowners seeking to maximize aggregate land rents. Then if each region is populated by workers who maximize a Cobb-Douglas utility function with two commodities, housing services (that are proportional to land) and a composite consumption good, each worker spends a fixed share of his wage on land rents, and aggregate land rents equal a fixed fraction of the wage bill. A similar objective function would also be consistent with regions seeking to maximizing the region's "national output", assuming firms are "foreign" owned; or with regions maximizing the number of jobs.[7]

Competition between the two regions is described by the following three-stage game. In the first stage, each region separately chooses its type of

[6]Observe that the model can be extended to a production function given by $y = g(x_i, x)l^\alpha$ where $g(x_i, x)$ stands for a productivity index specific to the firm of type x investing in region i. This does not change our main conclusions but makes the formal analysis much more involved.

[7]Setting maximization of land values as the objective function avoids the difficulty of formulating government objectives for mobile populations, on which Mansoorian and Myers (1997) expand.

infrastructure. In the second stage each region separately sets the subsidy (fee) it pays (charges) firms that choose to locate in the region given the choice of infrastructure of the two regions in the first stage. Finally, in the third stage, each firm decides in which region to locate and how much output to produce so as to maximize its profits. As usual, we solve the game by backward induction.

In the third stage of the game the regional infrastructures have been chosen and the fees or subsidies set. A firm of type x located in region i earns a profit of

$$\pi_i(x) = \max_l \{y(l) - wl - f(x_i, x) + s_i(x, x_i)\}.$$

Profit maximization yields the following demand for labor, which is the same for all firms:

$$l^* = \alpha y/w$$

so that the profit-maximizing output of a firm is given by

$$y^* = \left(\frac{\alpha}{w}\right)^{\frac{\alpha}{1-\alpha}}$$

which is independent of the firm's type. This yields the following profit for a firm of type x locating in region i:

$$\begin{aligned} \pi_i(x) &= (1-\alpha)y^* - f(x_i, x) + s_i(x, x_i) \\ &= (1-\alpha)\left(\frac{\alpha}{w}\right)^{\frac{\alpha}{1-\alpha}} - \beta(x_i - x)^2 + s_i(x, x_i). \end{aligned} \tag{1}$$

As expected, the firm's profit is a decreasing function of the distance between its most preferred infrastructure and the one supplied by the region in which it is established. The firm locates in the region in which its profits are greater, provided it can earn non-negative profits.[8] Thus a firm of type x locates in region A if and only if

[8] We assume throughout this paper that firms make positive profits. This condition is fulfilled when y^* is large in relation to β.

$$\pi_A(x) \geq \pi_B(x)$$

which is equivalent to

$$-f(x_A, x) + s_A(x, x_A) \geq -f(x_B, x) + s_B(x, x_B)\} \qquad (2)$$

3 Fiscal competition in subsidies

We now turn to the second stage of the game in which the infrastructure supplied by each region is given, and the distribution of firms between the regions depends on the subsidies (fees) they offer (charge). As we noted in the introduction, the nature of fiscal competition between the regions will depend on their ability to distinguish between different types of firms. We consider two polar cases. In the first, regions have full knowledge of each firm's type and are able to set a different fee or subsidy for each firm contingent on the matching cost they observe. As there are no variable costs associated with the supply of infrastructure, competition for each firm is strategically independent in this case. In the second case, regions only know the statistical distribution of firm types but cannot identify firms' individual types prior to location and are, therefore, constrained to set a single tax or subsidy for all firms.[9] In either case, regions simultaneously choose their fees or subsidies and firms then observe these offers and choose to locate in the region that yields the higher net profit.

3.1 Fiscal competition under complete information

In this scenario, each firm can credibly play the second nearest region against the nearest one in order to secure the highest subsidy or the lowest fee, net of the matching cost. We model this as an auction under complete information

[9]Since a firm's matching cost is independent of the operating scale, there is no adverse selection problem.

between the regions in which region i's bid for a firm of type x is given by the subsidy $s_i(x, x_i)$. As each firm seeks the most profitable region in which to locate, (2) implies that it chooses the region in which the *effective bid*, defined as the subsidy less the adjustment cost, $s(x, x_i) - f(x, x_i)$, is the highest (or least negative). The region chosen by the firm will be the one with the highest possible effective bid, and it will set its subsidy so that its effective bid is equal to (or just exceeds) its rival's.

The highest possible subsidy that region i will offer a firm of type x is the benefit it derives from its location in the region, which we assume is equal to a fraction γ of the firm's wage bill, $\gamma w l^*$, in which case the profit of the firm equals

$$\pi_i(x) = (1-\alpha)y^* - f(x_i, x) + \gamma w l^* = (1 - \alpha + \gamma\alpha)y^* - f(x_i, x).$$

as $wl^* = \alpha y^*$. Say A's infrastructure is closest to the needs of a firm of type x and it sets a subsidy that is just higher than the other region's maximal subsidy. Then its equilibrium bid $s_A^*(x, x_A)$ is such that

$$(1-\alpha)y^* - f(x_A, x) + s_A^*(x, x_A) = (1 - \alpha + \gamma\alpha)y^* - f(x_B, x)$$

where the LHS stands for the net profit earned by firm x in region A and the RHS by its profit in region B when the highest possible bid there is offered. Given the form of f, region A attracts all firms of type $x < (x_A + x_B)/2$ and offers the following subsidy, which is contingent on the type of firm:

$$\begin{aligned} s_A^*(x, x_A) &= \gamma\alpha y^* - [f(x_B, x) - f(x_A, x)] \\ &= \gamma\alpha y^* - \beta[(x_B - x)^2 - (x_A - x)^2] \end{aligned} \quad (3)$$

Similarly, region B attracts all firms whose type $x > (x_A + x_B)/2$ and offers a subsidy given by

$$s_B^*(x, x_B) = \gamma\alpha y^* - \beta[(x_A - x)^2 - (x_B - x)^2] \quad (4)$$

Note that $(x_B - x)^2 - (x_A - x)^2$ for a firm of type x that chooses A , as well as $(x_A - x)^2 - (x_B - x)^2$ for a firm of type x that chooses B, is always positive.

Hence the equilibrium subsidy at x may be positive or negative depending on the degree of differentiation in infrastructure between the two regions, $x_B - x_A$, the salience coefficient β, and the degree in which a firm of type x favors one infrastructure over the other. When regional differentiation is sufficiently low so that $x_B - x_A$ is small, all firms may receive subsidies. In any case, firms in the vicinity of the indifferent firm (of type $(x_A+x_B)/2$), for which the two regions are close substitutes, always receive a positive subsidy as they are able to extract much of the local surplus. However, firms closer to x_A or x_B may pay a fee. Thus regions have an interest in differentiating their infrastructures as this reduces the subsidies they pay out or increases the fees they are able to charge.

Hence, we have shown:[10]

Proposition 1 *For given $x_A \leq x_B$, when regions have complete information on individual firm types:*

(a) Fiscal competition has a unique Nash equilibrium given by (3) *and* (4).

(b) The market for firms is always segmented at $(x_A + x_B)/2$, and the allocation of firms between the two regions is efficient.

3.2 Fiscal competition under incomplete information

When regions cannot observe individual firm types and are not able to discriminate among firms, all firms locating in a region are offered the same subsidy or charged the same fee.

For any pair of subsidies (s_A, s_B) denote by $\hat{x}(s_A, s_B)$ the firm that is indifferent between locating in either region. The value of $\hat{x}(s_A, s_B)$ is obtained as the solution of the equation:

$$\pi_A(\hat{x}) = \pi_B(\hat{x}). \tag{5}$$

[10] Clearly, (3) and (4) are still the equilibrium schedule when there is no differentiation ($x_A = x_B$).

After substitution this gives:

$$s_A - \beta(x_A - \hat{x})^2 = s_B - \beta(x_B - \hat{x})^2 \tag{6}$$

the solution of which is

$$\hat{x}(m_A, m_B) = \frac{x_A + x_B}{2} + \frac{s_A - s_B}{2\beta(x_B - x_A)}. \tag{7}$$

Since the profit function is a decreasing function of the distance between x and x_i, all firms with a type satisfying $x < \hat{x}(s_A, s_B)$ locate in region A while those with type $x > \hat{x}(s_A, s_B)$ locate in region B.

Expression (7) describes the marginal firm when (6) has an interior solution ($0 < \hat{x} < 1$), namely when

$$-\beta(x_B^2 - x_A^2) < s_A - s_B < -\beta(x_B^2 - x_A^2) + 2\beta(x_B - x_A).$$

Corner solutions are obtained when either

$$s_A - s_B \geq -\beta(x_B^2 - x_A^2) + 2\beta(x_B - x_A)$$

in which case all firms locate in region A ($\hat{x} = 1$); or when

$$s_A - s_B \leq -\beta(x_B^2 - x_A^2)$$

in which case all firms locate in region B ($\hat{x} = 0$).

The two regions thus enter into a game whose strategies are $s_A \in R$ and $s_B \in R$ after their choice of infrastructure, x_A and x_B, has been made. Let c be the cost of building an infrastructure in either region. The payoff function for region A is then:

$$U_A(s_A, s_B; x_A, x_B) = \begin{cases} \gamma w l^* - s_A - c & \text{if } s_A \geq \overline{s}_A \\ (\gamma w l^* - s_A)\hat{x}(s_A, s_B) - c & \text{if } \underline{s}_A \leq s_A \leq \overline{s}_A \\ -c & \text{if } s_A \leq \underline{s}_A \end{cases} \tag{8}$$

where $\underline{s}_A = s_B - \beta(x_B^2 - x_A^2)$ and $\overline{s}_A = s_B - \beta(x_B^2 - x_A^2) + 2\beta(x_B - x_A)$; and the payoff function of region B is

$$U_B(s_A, s_B; x_A, x_B) = \begin{cases} \gamma w l^* - s_B - c & \text{if } s_B \geq \overline{s}_B \\ (\gamma w l^* - s_B)[1 - \hat{x}(s_A, s_B)] - c & \text{if } \underline{s}_B \leq s_B \leq \overline{s}_B \\ -c & \text{if } s_B \leq \underline{s}_B \end{cases} \tag{9}$$

where $\underline{s}_B = s_A + \beta(x_B^2 - x_A^2) - 2\beta(x_B - x_A)$ and $\overline{s}_B = s_A - \beta(x_B^2 - x_A^2)$. We solve this game as a Nash equilibrium in s_A and s_B.

If there exists an interior equilibrium in which both regions attract some firms it must satisfy the following first order conditions:

$$\frac{dU_A}{ds_A} = -\hat{x} + \frac{d\hat{x}}{ds_A}(\gamma w l^* - s_A) = 0$$

and

$$\frac{dU_B}{ds_B} = -(1 - \hat{x}) - \frac{d\hat{x}}{ds_B}(\gamma w l^* - s_B) = 0.$$

From equation (7)

$$\frac{d\hat{x}}{ds_A} = \frac{1}{2\beta(x_B - x_A)} = -\frac{d\hat{x}}{ds_B}$$

and so the candidate equilibrium strategies are defined by

$$s_A^* = \gamma w l^* - \frac{2}{3}\beta(x_B - x_A) - \frac{1}{3}\beta(x_B^2 - x_A^2) \tag{10}$$

and

$$s_B^* = \gamma w l^* - \frac{4}{3}\beta(x_B - x_A) + \frac{1}{3}\beta(x_B^2 - x_A^2). \tag{11}$$

Substituting (10) and (11) in (7) yields

$$0 < \hat{x}^* = \frac{2 + x_A + x_B}{6} < 1 \tag{12}$$

which is strictly positive and less than one,[11] confirming that (s_A^*, s_B^*) is an interior solution. Note that when x_A and x_B are symmetrically placed around the center, so that $x_A + x_B = 1$, we have

$$s_A^* = s_B^* = \gamma w l^* - \beta(x_B - x_A) < 0.$$

As the benefit functions U_i are concave in s_i, (s_A^*, s_B^*) is a Nash equilibrium, and as the first order conditions are linear it is the only interior equilibrium. Finally, it is readily verified that a situation in which a region attracts all the firms is never an equilibrium. Hence, we have shown:

Proposition 2 *When regions have set $x_A \leq x_B$ and cannot identify the type of an individual firm, the fiscal competition game has a unique interior Nash equilibrium given by (10) and (11).*

The impact of fiscal competition on regional budgets varies with the degree of differentiation between their infrastructures. When regions supply very similar infrastructures, firms are able to play one region against the other. Specifically, firms extract subsidies from the regional governments that are almost equal to γ times their wage bill, thus capturing most of the surplus they generate for the region. When the infrastructures are more differentiated (that is, when $x_B - x_A$ increases), competition between the regional governments is less pronounced. Indeed, each region has some market power over a particular segment of firms for which the infrastructure it supplies is much better than the other region's.[12] If they are sufficiently differentiated they may be able to collect positive fees for their infrastructure services. If infrastructures are not symmetrically located, (10) and (11) imply that the region with an infrastructure closer to 1/2, i.e., the region with the larger natural pool of firms, always pays a lower subsidy or collects a larger fee than the rival region. In other words, *the region whose infrastructure better fits firms' average needs is less hurt by fiscal competition.*

[11] When $x_A = x_B$, we must have $s_A^* = s_B^*$ otherwise one region captures the entire market, which cannot be an equilibrium. But then, $\hat{x}^*$ is undetermined.

[12] The second term in the RHS of (10) and (11) increases.

Does fiscal competition lead to an efficient allocation of firms between the two regions, given the location of infrastructure? Clearly, efficiency requires that firms with $x < (x_A + x_B)/2$ locate in region A and those with $x > (x_A + x_B)/2$ locate in region B. However, the locational choice of firms is based on a profit comparison that takes into consideration not only production efficiency (how well the region's infrastructure matches the firm's needs) but also the fee or subsidy which the regions have set. It follows from (10), (11) and (12) that only when the two regions offer infrastructure types that are symmetric around 1/2 will firms locate optimally. Otherwise, an equilibrium in subsidies emerges in which some firms will locate in the region that is less productive for them in terms of infrastructure, in order to take advantage of the better fiscal terms it offers.

4 Regional competition in infrastructure

We now turn to the first stage of the game in which regions strategically choose the infrastructure they provide, anticipating the outcome of fiscal competition and firms' choices in subsequent stages described above. The regions' strategies are thus the infrastructure types they supply, x_A and x_B. It is readily verified that the efficient supply of infrastructure types is given by 1/4 and 3/4, i.e. the locations that minimize total matching costs.

As in the foregoing, we consider the two polar cases of complete and incomplete information. In the first case, the regions' payoffs are given by[13]

$$U_A(x_A, x_B) = \beta(x_B - x_A)(x_A + x_B)^2/2 - c$$

$$U_B(x_A, x_B) = \beta(x_B - x_A)(2 - x_A - x_B)^2/2 - c.$$

The best-reply functions, obtained from the first-order conditions, are:

$$x_A = \frac{x_B}{3}$$

[13] This derives from $U_A(x_A, x_B) = \int_0^{(x_A+x_B)/2}[wl^* - s_A^*(x, x_A)]dx - c$ and $U_B(x_A, x_B) = \int_{(x_A+x_B)/2}^1 [wl^* - s_B^*(x, x_B)]dx - c$

$$x_B = \frac{2 + x_A}{3}$$

and the unique equilibrium is $x_A^* = 1/4$ and $x_B^* = 3/4$.

Proposition 3 *When regions are able to identify individual firms types there exists a unique equilibrium in the infrastructure game in which the regions' infrastructures are located at $x_A^* = 1/4$ and $x_B^* = 3/4$. The subsidies (fees) they offer (charge) to a firm of type x are*

$$s_A^*(x) = \gamma w l^* - \beta \frac{1 - 2x}{2} \quad \text{and} \quad s_B^*(x) = \gamma w l^* - \beta \frac{2x - 1}{2}.$$

Firms with $x \in [0, 1/2]$ locate in region A while those with $x \in [1/2, 1]$ locate in region B.

Thus, when regions are able to identify individual firm types the equilibrium that results is efficient in minimizing firms' adjustment costs with respect to both the choice of infrastructure by the regions and the choice of region by firms.

If regions only have information about the distribution of firm types the payoff functions, as functions of the strategies $x_i \in [0, 1], i = A, B$, are:

$$U_A(x_A, x_B) = (\gamma w l^* - s_A^*)\hat{x}^* - c = \left[\frac{2}{3}\beta(x_B - x_A) + \frac{1}{3}\beta(x_B^2 - x_A^2)\right] \frac{2 + x_A + x_B}{6} - c \tag{13}$$

$$\begin{aligned} U_B(x_A, x_B) &= (\gamma w l^* - s_B^*)(1 - \hat{x}^*) - c \\ &= \left[\frac{4}{3}\beta(x_B - x_A) - \frac{1}{3}\beta(x_B^2 - x_A^2)\right] \left[1 - \frac{2 + x_A + x_B}{6}\right] - c \end{aligned} \tag{14}$$

where s_A^*, s_B^* and $\hat{x}^*$ are as defined above. Inspecting (13) and (14) reveals that U_A is a decreasing function of x_A while U_B increases with x_B. Consequently, we have:

Proposition 4 *When regions are unable to identify individual firm types it is in each firm's interest to differentiate itself unilaterally from the other region* *as much as possible. Hence there exists a unique equilibrium in the infrastructure game in which both regions choose to maximize their differentiation, setting* $x_A^* = 0$ *and* $x_B^* = 1$, *offer subsidies equal to* $s_A^* = s_B^* = \gamma wl^* - \beta$, *and extract a surplus of* $U_A = U_B = \beta/2 - c$.

In this case, regions differentiate their infrastructures as much as possible, and this choice is a dominant strategy for each region. The loss of firms to the region as a result of its moving away from the center is more than offset by the increase in fees it can charge as a result of relaxed fiscal competition. In this equilibrium, firms are efficiently allocated between the regions but the supply of infrastructure is not efficient.[14]

When regions are unable to distinguish between individual firm types and, hence, must each offer a single uniform subsidy, regional competition yields a higher surplus than when they have complete information on individual firm types. Comparing the two information regimes, we find that the uniform subsidy offered by each region under incomplete information, $\gamma wl^* - \beta$, is lower than the subsidy either region offers under complete information, $\gamma wl^* - \beta/2$. There are two reasons for this. First, *competition with uniform subsidies is less fierce than competition with firm-specific subsidies*, as it requires a region to increase the subsidy it charges to all firms located in the region if it wishes to attract new firms. As a result, this reduces its incentive to increase its subsidy. Second, *competition under uniform subsidies yields more differentiation between regional infrastructures*, which further relaxes subsidy competition between regions.

Finally, we ask what is the impact of regions agreeing to coordinate the subsidies they offer and compete only on infrastructure? If regions agree on the fee they charge before choosing their infrastructure, then clearly by choosing a fee that is sufficiently high they can increase the surplus they extract from firms. However, their choice of infrastructure will not be efficient as both regions will select the same infrastructure, $x_A = x_B = 1/2$. In this

[14] As we saw above, this would require $x_A = 1/4$ and $x_B = 3/4$.

context, fiscal coordination does not increase efficiency though it can increase the share of the surplus that the regions are able to capture.

5 Two regions or one?

So far we have assumed that there are two regions actively competing for firms' location. We ask now, under what conditions is such competition efficient, considering separately the cases of full information and of incomplete information.

In the case of full information, for the two regions to be viable each must generate a positive surplus. Using Proposition 1, this holds when

$$\gamma w l^* - \beta/4 - c > 0$$

Adjustment costs in this case are given by

$$\beta \int_0^{1/2} (x - 1/4)^2 dx + \beta \int_{1/2}^{1} (x - 3/4)^2 dx = \beta/48$$

with only a single active infrastructure, located at the midpoint 1/2, adjustment costs are

$$\beta \int_0^{1} (x - 1/2)^2 dx = \beta/4$$

Two active regions are more efficient than one when the advantage of a choice of infrastructure outweighs the additional fixed cost, i.e., when

$$c > 11\beta/48.$$

Thus, we may have two active regions when one would be more efficient, if both the wage bill and the fixed cost of the infrastructure are large enough; or the opposite, one active region when two would be more efficient, when the opposite holds. For intermediate values, the number of active regions is efficient.

When regions have imperfect information and are not able to differentiate among firms, each region extracts a positive surplus if $\gamma w l^* - \beta/2 - c > 0$. Adjustment costs in this case are

$$\beta \int_0^{1/2} (x-0)^2 dx + \beta \int_{1/2}^1 (1-x)^2 dx = \beta/4$$

and thus are equal to adjustment costs in the case of a single infrastructure. Thus when regions are unable to discriminate among firms, it is inefficient to have two active regions as the added fixed cost of a second infrastructure is not offset by a reduction in adjustment costs. This results because the two regions are excessively differentiated. A more general result for the case of n firms can be derived through straightforward extension of the model and shows that in the general case of incomplete information, too, the number of regions able to extract a positive surplus is inefficiently large.

6 Concluding remarks

We have seen that regions can gain from by specializing in a unique infrastructure niche and thus differentiating the infrastructure services they offer from those of other regions. This dampens the head-to-head competing that results when regions offer identical infrastructures and are forced to compete on subsidies. Through such differentiation a region can reduce its fiscal outlays for attracting outside investment and capture a greater share of the regional surplus that is generated. Moreover, *differentiation is reciprocally beneficial*: specialization by one region will not lead other regions to imitate its orientation but rather to seek other niches which further increases differentiation between them and dampens competition. We have also seen that the number of active regions may be inefficiently large, in which case regions supply infrastructure that are likely to be too similar. Although this works to the benefit of firms, the loss to regions more than outweighs their gains. This suggests that there is scope for coordination or regulation of competition among regions for external investment.

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