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Investment in public infrastructure with spillovers and tax competition between contiguous regions

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1. Introduction

The last decades have been marked by a sharp decrease in transportation costs, and more generally trade costs. In addition, market liberalization drastically increased the mobility of capital and of the labour force. As a result, the location of firms’ productive activities is increasingly disconnected from the destination market of their final products. A possibly unhappy consequence of this evolution is that tax competition at national or regional levels is an increasingly important concern for governments. In particular, local authorities face the risk that firms actually bid up one region against the other to obtain tax reliefs or specific infrastructure investments. Observations suggest that the risk is indeed present. For instance, Sorensen (2000) presents evidence of a significant fall in capital nominal tax rate from the 80s to the end of the 90s.

A growing body of the literature deals with tax competition games. Fortunately, this literature shows, more often than not the development of a mitigated tax competition (Wilson and Wildasin, 2004). Accordingly, tax revenues may not decrease that much because of tax competition. At the same time, it is obvious that fiscal motives are by far not the only reason why firms would delocalize production. The specific amenities of regions, be it exogenous or resulting from agglomeration externalities, enter the picture as well and public authorities are not passive in this respect. In particular they tend to attract firms by magnifying their local amenities, and/or stimulating the emergence of strong spatial externalities. Thus, local authorities may affect firms’ location decisions in essentially two ways: by offering an attractive fiscal package, and/or by developing a favorable economic environment (i.e. enhancing the quality of their infrastructure, broadly defined). Head et al. (1999) conducted an empirical analysis revealing the sensitiveness of firms to non-fiscal arguments. The fact that jurisdictions actually combine various tools to enhance their attractiveness has not been explored in detail in the tax competition literature. Noticeable exceptions are Justman et al. (2002, 2005) who formalize this idea in models where firms are heterogeneous and jurisdictions specialize their infrastructure packages in order to relax tax competition.4

3 See also Dembour (2008) for a recent selective survey on theoretical models dealing with competition for business units.
4 Other recent contributions in this area are Zissimos and Wooders (2003, 2006). More generally, local authorities are very likely to transfer tax competition towards less direct fields. See for instance Peralta et al. (2006).
In these papers, local authorities compete one against the other in the level of taxes as well as in the level of infrastructures. Firms have to decide in which of two regions to locate and the infrastructure packages are entirely specific to each region, i.e. their benefits are strictly tied to the location within the jurisdiction. Therefore, regional infrastructures are viewed as substitute amenities from the point of view of the firms. Actually, within such a framework, regional governments face two major risks. The first is to engage in a race-to-the-top whereby regions end up providing infrastructure levels well beyond those required to attract firms. The second risk is that regions engage into a race-to-the-bottom tax competition process. In any case, most of the investment efforts is captured by the incoming firms through increased rents.

Assuming that regional infrastructures are strictly substitutes is clearly reasonable when jurisdictions significantly differ in their geographical locations, i.e. they are located at a significant distance from each other. Suppose however that a well-defined economic activity area is actually divided in two (or several) jurisdictions, each being endowed with fiscal autonomy. In this case firms first contemplate the possibility of locating their activities in the economic area, as a whole. And second, if they choose to move to the area, they would have to address the question of where (i.e. in which jurisdiction) to locate within the area. The choice of a particular jurisdiction will reflect the presence of tax differentials as well as possible differences in the infrastructure supplied by these jurisdictions. However, if jurisdictions are contiguous, it is difficult to argue that the benefits of an infrastructure developed by one of the regional government are entirely confined to its political frontiers. In many cases, a “local” infrastructure will inevitably see its “benefits” spill over across political entities onto the whole economic area. If this is the case, then an infrastructure located in one jurisdiction might be viewed as a complement to the development strategy of the neighbouring entities.

Consider for example an airport terminal located in one jurisdiction. Clearly enough, this infrastructure increases the attractiveness of that particular jurisdiction. However, it is hard to imagine that it would not increase that of the contiguous ones as well. By contrast, the positive nature of the infrastructure determine the level of infrastructure supplied at equilibrium? When political and economic frontiers differ, is regional competition a good or a bad thing? This classical question might be revisited in this particular context where regional spillovers are present.

We develop a stylized model inspired by the canonical location model of Hotelling (1929). This model will allow to formalize regional competition as a two-stage game between two contiguous regions. In the first stage regions choose infrastructure levels non-cooperatively, in the second stage they set taxes non-cooperatively. Then firms decide on location. Our equilibrium concept is Subgame Perfect Nash equilibrium. The importance of regional contiguity is captured by a parameter that measures the extent to which infrastructure benefits spill over across regions. Note that in this set-up a cooperative solution can be viewed as a proxy for the case where political and economic frontiers coincide. Then, by comparing a cooperative solution to the non-cooperative one, one may easily assess the effects of regional competition and the consequences of infrastructure spillovers.

Our main results are the following. First, when the infrastructure has an inter-regional nature, i.e. spillovers across regions are significative, tax competition is mitigated as compared to the case of “intra-regional” infrastructure. More specifically, regional governments manage to control for tax competition intensity through infrastructure decisions. Second, if governments mainly care about tax revenues and/or citizens’ well-being, i.e. the payoff of incoming firms does not enter into the objective function of the regions, we show that the discrepancies between cooperative and non-cooperative outcomes tend to disappear, provided infrastructure spillovers are large enough.

The remainder of the paper is as follows. The next section presents the basic model. Section 3 develops the equilibrium analysis of the tax competition stage and the infrastructure stage. To this end we concentrate on the case where infrastructure decisions affect firms symmetrically. Section 4 discusses the normative implications of our analysis as well as some possible extensions. Section 5 concludes.

2. The model

Let us consider a well-defined economic area or country, denoted by C. It is divided in two contiguous “regions” (from now on, “regions” designate local jurisdictions): A and B.

These two regional authorities play a two-stage game. In the first stage, they choose non-cooperatively the level of investment in infrastructure they supply to the firms. In a second stage, they set corporate tax levels non-cooperatively. Then, firms choose their location.

2.1. The regions

The objective of local authorities is to maximize the tax revenue minus the cost of providing infrastructure. Formally, the objective function of region i is given by

\[ W_i = t_i M_i - c(K_i) \]

where \( M_i \) denotes the number of firms locating in the region, \( t_i \) is thus the tax revenue and \( c(K_i) \) is the cost of infrastructure built by region i. This simplified objective function implies that the additional regional welfare accruing from the increase in economic activity is not directly taken into account. Similarly, the surplus obtained by the incoming firms is neglected. This simplified functional form is retained in order to focus on two basic ideas. First, while local

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5 This is typically the case for the Brussels Region in Belgium as for, more generally, economic areas eligible to the Interreg program of the European Commission. More generally, intra-metropolitan competition between jurisdictions may also obey this scenario.

6 Recent papers (DeBoer et al., 2005, 2007) have considered the problem of contiguous regions investments in, and access-pricing to, transport infrastructure under congestion. Regional contiguity is central to the analysis because regional routes are substitutes for transit traffic. However the focus is placed on the trade-off between local and transit traffic, through differentiated pricing.


8 The stage game set-up is meant to capture the idea that infrastructure investments are less easy to alter than tax levels, so that governments may more easily commit to the former.

9 A comparable analysis for type-dependent benefits of infrastructure is developed in the working paper version of the present article, Dembour and Wauthy (2003).
government might value the increase in economic activity attached to the incoming firms, we assume they exhibit a bias towards fiscal revenues: for example, they may want to use such revenues for financing the provision of local public goods benefiting directly to the citizens. Second, we assume that (at least part of) the rents appropriated by the incoming firms fly out of the economic bloc, as would be the case with multinational firms. A more thorough discussion of the limitations resulting from this assumption will be undertaken in Section 4.10.

2.2. The firms

We consider a set of firms which are initially located outside C and contemplate location options in either region A or B.11 Firms are assumed to be heterogeneous: in particular, each firm displays a specific type designating some technological features that will have to be adapted to the specificities of C. A particular type may, for example, consist of a specific know-how that has to be taught to new workers and hence, relates to a particular industry in which the firm is active. When moving to C, the firm will therefore have to bear a fixed, matching, or adaptation cost. Obviously, this cost may depend on the region in which the firm chooses to locate. Indeed, regions themselves display a priori characteristics inherited from their own history. The better a firm’s type fits the host region’s characteristics, the lower its fixed cost. The key point at this step is to assume that regions, as well as firms, are heterogeneous.

Firms choose the location which generates the highest profits. On one hand, if they decide not to move to C, they enjoy a reservation profit. On the other hand, the profits earned in each region depend on the operating profit (i.e. the profit resulting from the production activity), the matching cost and the lump-sum tax chosen by the regions.

There is a continuum of heterogeneous firms identified by a type x. Types are uniformly distributed in the continuous [0,1] interval. The density is normalized to 1 so that the total number of firms is equal to 1. We assume that each region is located at some point denoted xA and xB in the [0,1] interval. For simplicity, let us assume that xA = 0 and xB = 1.12 The matching cost of a firm with type x ∈ [0,1] depends positively on the “distance” from the region’s location. We may therefore define a matching cost function for each region: m x(x) = mx and m x(x) = m(1 − x), with m > 0. This model is formally equivalent to the generic Hotelling model with linear transportation costs and endogenous market coverage. Finally, we denote by tA and tB the lump-sum tax each region levies on firms.

Two basic types of infrastructures can be distinguished. On one hand, we may consider infrastructures whose benefits accrue to a firm as a function of its type. This is especially true for a training program aimed at matching local workers’ qualifications to incoming firms’ needs, or for a development office aimed at helping firms to install their administrative and sales network. These infrastructures essentially affect the matching cost. On the other hand, infrastructures such as the supply of public transport or high speed communication networks have their benefits more uniformly distributed across firms. Moreover, these are recurrent benefits related to the daily activity of incoming firms, i.e. they affect operating profits.13 Obviously, these two infrastructure types may have different implications on the tax competition game. In the following, we concentrate on infrastructures affecting firms’ operating profits and whose benefits apply equally to all firms.14

More importantly, we distinguish infrastructure investments according to the localization of their benefits. To this end we shall rely on a parameter α ∈ [0,1] measuring the extent to which an investment located in one region also benefits to firms locating in the contiguous region. By convention, α = 1 denotes the case where the infrastructure is entirely general, i.e. any firm locating in country C benefits from both regional infrastructures symmetrically. In this case, any infrastructure investment by one region increases the attractiveness of the whole area, without giving any specific advantage to the investing region. Hence, this type of infrastructure does have the feature of an inter-regional public good and a region may be reluctant to invest in such an infrastructure since it has no positive counterpart in terms of relative attractiveness. As a consequence, governments are likely to free ride on each other when α is equal to 1. At the other extreme, α = 0 depicts the case of a purely specific infrastructure.15 In this case, the infrastructure benefits to a firm only if this firm locates in the region where the infrastructure has been installed. Accordingly, no region can benefit from the infrastructure installed by the other one, i.e. it has the nature of an intra-regional public good. In this context, providing more infrastructure in the first stage creates a competitive advantage in the second stage: being more attractive, the high infrastructure region can attract firms even if taxes are significantly higher than in the contiguous region.

Summing up, each firm chooses among three locations. First, it can stay outside country C (strategy ∅) and therefore realizes a “status quo” profit πC which is normalized to zero without loss of generality.16 Second, a firm can locate in region A or in B. The attractiveness of a particular region depends on its matching with the type of firm but also on the level of infrastructure made available in C. The payoff secured by a firm with type x if it locates in A is defined by:

\[\pi_A(x) = K_A + \alpha K_B - mx - t_A.\] (1)

Conversely, if a firm decides to settle in region B its profits are:

\[\pi_B(x) = K_B + \alpha K_A - (1 - x) - t_B.\] (2)

where K denotes the level of infrastructure made available by government of region i.

Firms choose their location (∅, A or B) in order to maximize profits, the optimal location is therefore defined as

\[\text{Argmax}_{\emptyset, A, B} \{\pi(x), \pi_A(x), \pi_B(x)\} \]

This model is inspired by Justman et al. (2005) who also tackle tax competition and regional infrastructure issues within a Hotelling framework. But our approach differs from theirs in three fundamental respects. First, they model infrastructure decisions as location decisions in the space of firms’ types (exactly like in the Hotelling model). As a consequence, infrastructure decisions affect the relative attractiveness of the regions and firms may differ in the way they value a particular decision. By contrast, in our model, infrastructure

10 Note that such a specification nevertheless assumes a positive cost of public funds. Implicitly, public funds devoted to attracting new firms are not available anymore for the provision of other regional public goods benefiting more directly to the region’s inhabitants.
11 An alternative interpretation of this model consists of considering a set of entrepreneurs who wish to launch their own activity within the country C.
12 Since we are not interested in the location of the regions within the [0,1] interval, we stick to the easiest parametric locations. Considering interior locations would not alter our qualitative results as long as regions are not too close. Should regions be located within the second and third quartiles, no tax equilibrium would exist anymore.
13 Think for instance of an investment increasing labour productivity.
14 The case of infrastructures affecting matching is briefly discussed in the last section of the paper; a more detailed analysis is available in the working paper version of the present note, Dembour and Wauthy (2003).
15 The specific vs general typology is inherited from Labour Economics, where human capital is said to be “general” if transferable from one firm to another.
16 A very interesting extension of the present model would consist in considering that the third location is also a region, located “at a different place” but playing strategically with the two neighbors. Focusing on taxes, Haufer and Wooton (2006) show that regional coordination will lead to welfare gains.
levels affect the absolute attractiveness of a region by increasing potential benefits for all firms. Second, and most importantly, their model does not allow for inter-regional spillovers, whereas these spillovers form the core of our model. Their model is therefore not suited to capture the implications of regional contiguity. However, their model allows for an endogenous degree of regional differentiation whereas ours assumes a given degree of differentiation. Third, in Justman et al. (2005), firms are somewhat “forced” to locate in either A or B, i.e. there is no outside option for the firms. This assumption is fairly innocuous in their model because strategic decisions only affect the relative attractiveness of the regions. By contrast, it is essential in our model to allow for an outside option since the absolute attractiveness of each region and of the economic area are directly affected by infrastructure decisions. Actually, the presence of this outside option turns out to be crucial in disciplining tax competition. Finally, the (complete information) tax competition game considered in Justman et al. (2005) can be viewed as a special case of our model where \( \alpha = 0 \) and all the firms settle in the economic area. However the first stage of the games and the ensuing structure of the subgames are entirely different.

3. Equilibrium analysis

3.1. Tax competition

We start by characterizing firms’ optimal behaviour given \( K_A, K_B, t_A \) and \( t_B \). In order to choose location, each firm compares \( \pi^c(\tilde{x}) \) and \( \pi^f(x) \). Given \( K_A \) and \( K_B \), two types of configurations must be distinguished depending on \( t_A \) and \( t_B \):

- \((t_A, t_B)\) are such that some firms are better off choosing their outside option. We shall denote such configurations as non-covered ones. In this case, regional governments do not directly compete against each other. They behave like local monopolists “competing” with an exogenous outside option, i.e. there is no strategic interaction between the regions in a non-covered situation.

Characterizing the type of the firm that is indifferent between locating in region 1 and the status quo, i.e. \( x^\alpha \) is such that \( \pi^c(x^\alpha) = 0 \), we obtain

\[
x^\alpha(t_A, K_A, K_B) = \frac{K_A + \alpha K_B - t_A}{m}
\]  

\[
x^\alpha(t_B, K_A, K_B) = 1 - \frac{K_B + \alpha K_A - t_B}{m}.
\]

Any firm with type \( x < x^\alpha \) locates in region A; firms with type \( x > x^\alpha \) locate in region B, whereas firms with type \( x \in [x^\alpha, x^\beta] \) prefer to stay outside country C.

The number of firms locating in the regions is thus

\[
M_A^c = \frac{K_A + \alpha K_B - t_A}{m}
\]

\[
M_B^c = \frac{K_B + \alpha K_A - t_B}{m}.
\]

\((t_A, t_B)\) are such that all firms are attracted in country C. These configurations will be referred to as covered configurations. In this case, firms react to tax differentials while taking their matching cost into account. In other words, regional authorities compete against each other in order to “steal” some firms from their neighbouring region.

We denote the type of the firm which is indifferent between locating in region A and B by \( \tilde{x} \), i.e. \( \tilde{x} \) is such that \( \pi_A(\tilde{x}) = \pi_B(\tilde{x}) \), and we obtain

\[
\tilde{x}(t_A, t_B, K_A, K_B) = \frac{m + (1-\alpha)(K_A - K_B) - (t_A - t_B)}{2m}
\]  

Any firm with type \( x < \tilde{x} \) locates in region A whereas firms with types \( x > \tilde{x} \) locate in region B. We have

\[
M_A^\tilde{x} = \frac{m + (1-\alpha)(K_A - K_B) - (t_A - t_B)}{2m}
\]

\[
M_B^\tilde{x} = 1 - \frac{m + (1-\alpha)(K_A - K_B) - (t_A - t_B)}{2m}.
\]

These expressions reveal that the levels of regional infrastructures matter in the covered configurations only when these levels differ. This property captures an important feature of the model: in the class of tax subgames where covered configurations prevail, absolute levels of investment do not matter at all. Competition between regions is based on relative attractiveness.

Having identified optimal locations for firms as a function of governments’ actions, it is now possible to check that the boundary conditions, i.e. the conditions ensuring that the number of firms located in each region is non-negative, are satisfied. Using Eq. (5) we obtain:

\[
0 < \tilde{x} < 1 \iff (1-\alpha)(K_A - K_B) - m - t_A - t_B < (1-\alpha)(K_A - K_B) + m.
\]

Direct computations using expressions (3a), (3b), (4a) and (4b) indicate that \( M_A^c + M_B^c \geq 1 \) (or \( x^\alpha > x^\beta \)) whenever \( (1+\alpha)(K_A - K_B) - m - t_A + t_B \), i.e. tax levels deter some firms to enter country C. When \( (1+\alpha)(K_A - K_B) - m - t_A + t_B \), no firm prefers the status quo to locating in at least one region, i.e. we have a covered configuration.

Fig. 1 partitions the \((t_A, t_B)\) space according to the firms’ optimal location choices.

In order to characterize a tax equilibrium, we may restrict attention to the sub-domain where \( t_A \leq K_1 + \alpha K_2 \). Indeed, \( t_A - t_B \) clearly dominates as region \( i \) would not attract any firm (\( \pi_i(x) < 0, \forall x \)). Therefore 4 areas of interest remain. In Area I, each region benefits from a local monopoly; they are not in competition among themselves but each region is separately “competing” with the status quo option. In Area II, they share the firms’ pool and are truly competing with each other. In Areas III, with \( i = AB \), tax differentials are so large that region \( i \) alone attracts all firms. Note that the domain of taxes such that all firms are attracted in area C enlarges whenever \( \alpha \) gets bigger. Intuitively, given some levels of infrastructure, an increase in \( \alpha \) increases the absolute attractiveness of the whole region so that higher tax levels remain compatible with a covered situation. Obviously, different infrastructure levels induce an asymmetry between regions that will result in asymmetrical market coverage. This is materialized by the fact that the frontiers separating areas IA and IB from IIC may not be positioned symmetrically with respect to the 45° line. Similarly, whenever \( t_A = t_B \), regions’ market shares differ if \( K_A \neq K_B \). However the impact of differing infrastructure levels on the competitive advantage of a particular region becomes smaller when \( \alpha \) increases.

These outcomes can now be used to solve the second stage of the game where regions compete in taxes. Fig. 1 provides a useful benchmark to understand the nature of tax competition in this game. In Area I, a region’s payoff does not depend on the other region’s action at the tax stage. We characterize a region’s optimal behavior by maximizing \( t_A M_A^\tilde{x} \) over \( t_A \). We obtain

\[
t_A^c = \frac{K_1 + \alpha K_2}{2}.
\]

The superscript \( c \) denotes covered configurations.

Infrastructural expenses made in stage 1 are irrelevant at this stage since they are already sunk.
The corresponding partition of the firms is given by $M_A = \frac{K_A + \alpha K_B}{2m}$ and $M_B = \frac{K_A + \alpha K_B}{2m}$, which is feasible only if the tax equilibrium is indeed located in Area I. Solving $(1 + \alpha)(K_A + K_B) - m \leq c_B + t_B$ we obtain the necessary and sufficient condition

$$(1 + \alpha)(K_A + K_B) \leq 2m. \quad (C1)$$

Turning to Area II, we observe that an equilibrium cannot lie in Area IIA or IIB. Indeed, in these areas, one region enjoys a zero payoff since its relatively high tax level deters all firms from locating in that region. As a consequence, it will always quote a lower tax, leading to Area IIC where its payoff is positive. Accordingly, we may concentrate on the payoffs in Area IIC. Since by the definition of $x(t, t_B, K_A, K_B)$ these payoffs are interdependent, maximizing $tM_I$ over $t_B$ gives the following specification for the regions' best reply functions:

$$\varphi_i(t_B) = \frac{t_B + m}{2} + \frac{(1 - \alpha)(K_i - K_J)}{2}. \quad (9)$$

Straightforward computations lead to the following characterization of Nash equilibrium tax levels:

$$t^*_i = m + \frac{(1 - \alpha)(K_i - K_J)}{3}. \quad (10)$$

Those firms positioned to the left of type $x = \frac{1}{2} + \frac{(1 - \alpha)(K_i - K_J)}{3m}$ locate in region $A$ whereas the complement locate in region $B$. Hence, whenever infrastructures are not strictly inter-regional ($\alpha \neq 1$), investing more than the other region has a strategic value in the tax competition game. It then remains to verify that this solution is indeed defined in Area IIC. And since we need $(1 + \alpha)(K_A + K_B) - m \geq c_A + t_A$ for the solution to belong to area IIC, we obtain the necessary and sufficient condition

$$(1 + \alpha)(K_A + K_B) \geq 3m. \quad (C2)$$

Combining (C1), the feasibility condition for the non-covered interior equilibrium, with that of the interior covered equilibrium (C2), we observe that none of them is satisfied in the sub-domain $(1 + \alpha)(K_A + K_B) \in [2m, 3m]$. In such cases, a continuum of corner solutions exists. They are defined by:

$$t_{iB}^* = \max \left\{ \frac{K_A + \alpha K_B}{2}, \frac{K_A(3 + \alpha) + K_A(1 + 3 \alpha)}{3} - m \right\} (1 + \alpha)(K_A + K_B) - m - t_i^*$$

with $t_i^* = \max \left\{ \frac{K_A + \alpha K_B}{2}, \frac{K_A(3 + \alpha) + K_A(1 + 3 \alpha)}{3} - m \right\}$ and $t_{iB}^* + t_i^* = (1 + \alpha)(K_A + K_B) - m$.

We do not develop the characterization of these corner solutions further. A key feature of these equilibria is that regions’ payoffs are located along the monopoly payoff function, though along its decreasing part. Accordingly, the largest payoff a region can secure is obtained when this region sets the lowest tax level within the set of tax equilibria. Fig. 2 depicts a tax subgame exhibiting a set of corner equilibria.

For intermediate values of $(1 + \alpha)(K_A + K_B)$ relative to $m$, each region’s best reply consists of three segments. The first, increasing, segment is defined by $\phi_i$ in the interior of the shared region (IIIC). The second, decreasing, segment starts at the intersection between $\phi_i$ and the coverage frontier (between Areas I and II). The third segment is defined by $t_i^*$, i.e. the monopoly tax level. As a consequence, depending on the parameters of the tax subgame, we may observe configurations where the intersection between regions’ best replies occurs along the second branch, i.e. the coverage frontier. In this case, we obtain a continuum of equilibria, as illustrated on Fig. 2.

We summarize the characterization of equilibrium tax levels as a function of $K_A$ and $K_B$ in the following proposition.

**Proposition 1.** Nash equilibrium tax levels in stage 2 are given by:

- $t_i^* = m + \frac{(1 - \alpha)(K_i - K_J)}{3m}$ whenever $K_A + K_B \geq 2m - \frac{2m}{1 + \alpha}$
- $(t^*_i, t^*_B)$ whenever $K_A + K_B \in \left[ \frac{2m}{1 + \alpha}, \frac{3m}{1 + \alpha} \right]$
- $t_i^* = \frac{K_A + \alpha K_B}{2}$ whenever $K_A + K_B \leq \frac{2m}{1 + \alpha}$

An interesting property of the equilibrium outcomes associated with the equilibria identified above is that whenever a covered equilibrium prevails, all firms are able to appropriate a strictly positive part of the surplus generated by their localization in the region. Taxes are therefore too low in a well-defined sense: a coordinated tax increase by the two governments would not affect firms’ decisions even though it would strictly increase governments’ joint revenues. By contrast, in corner equilibria, there is no scope for such a coordinated tax increase because the marginal firm is indifferent between locating in the economic area or

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*One could think here of a variant of the model where the payoffs in these areas might be positive, and increasing in the number of firms located in the other region. This could be the case with a spillover effect. Typically, attracting firms might require a tax decrease which may not compensate for the gain.*
staying "abroad". Accordingly, any tax increase would induce fewer firms to come in. Obviously, in non-covered configurations, the same property holds.

We shall refer later on to overinvestment by the regional authorities whenever the joint level of infrastructures $K_A + K_B$ is such that the ensuing equilibrium taxes are low enough to secure a covered configuration. Overinvestment therefore refers to a situation where, ex post, regions could have enjoyed higher revenues, either by raising their taxes or decreasing the level of infrastructure without seeing any firm leaving the region. Formally, overinvestment prevails whenever $K_A + K_B \geq \frac{3m}{1-\alpha}$.

3.2. Infrastructure equilibrium

Using the above proposition, we now analyze the first stage of the game where regions choose infrastructure levels. In order to study equilibrium choices, we assume that

$$c(K_i) = \frac{K_i^2}{F} \quad \text{(A2)}$$

with $F>0$.

Fig. 3 partitions the strategy space according to the nature of tax equilibrium that will follow the corresponding choices of infrastructure levels.

As shown in Fig. 3, there are three areas of interest in the $(K_A,K_B)$ space. Either both infrastructure levels are low and the non-covered configuration prevails (area c), or we have a domain of intermediate values where the ensuing tax game exhibits corner equilibria (area b). Last, for high levels of $K_a$, covered configurations displaying an interior equilibrium prevail in the ensuing tax game (area a). The frontiers between the three areas are derived from Proposition 1. Note that a larger $\alpha$ goes along with a downward shift of the two frontiers i.e. covered market configurations apply for a wider domain, and in particular for lower levels of infrastructure.

Since we are particularly interested in studying the impact of regional spillovers on strategic investments and tax competition, we shall focus on the cases where the incentives to commit to large investment levels for strategic purposes are the largest. This is the case when $F$ is large enough, i.e. the cost of infrastructure is small or even negligible. Given our previous analysis of the tax subgames, we know that whenever investments are large, the market is covered in the tax game. We therefore concentrate on this case.

In covered configurations (area a), each region’s payoffs are dependent on both $K_A$ and $K_B$. More precisely, a region’s equilibrium gross welfare, i.e. neglecting investment costs, is given by:

$$W_i^e(K_i, K_j) = \frac{(3m + (1-\alpha)(K_i-K_j))^2}{18m}$$

(15)

This expression is convex in $K_i$ and reaches a minimum for $K_i = -3m + \frac{1}{\alpha}$. Accordingly, as far as tax revenues are concerned, regions are always willing to increase $K_i$ in the covered configuration domain. The upper bound to investments levels should therefore result from the cost side. Using Eq. (15), we express a region’s net welfare as:

$$W_i^e(K_i, K_j) = \frac{(3m + (1-\alpha)(K_i-K_j))^2}{18m} - \frac{K_i^2}{F}$$

(16)

This expression is globally concave whenever $F<\frac{18m}{1-\alpha}$. In this domain, region $i$’s best reply in the first stage is given by:

$$K_i^a(K_j) = \frac{3m - (1-\alpha)K_j}{1-\alpha}$$

(17)

Straightforward algebra yields the subgame perfect equilibrium candidate:

$$K_A^* = K_B^* = \frac{F}{6}(1-\alpha).$$

(18)

Interiority conditions are defined as $K_A^* + K_B^* \geq \frac{3m}{1-\alpha}$. They are satisfied whenever $F \geq \frac{9m}{1-\alpha}$.

The following proposition summarizes the analysis:

**Proposition 2.** Whenever $F \in \left[\frac{9m}{1-\alpha}, \frac{18m}{1-\alpha}\right]$, there exists a unique subgame perfect equilibrium where regions overinvest in infrastructure up to $K_A^* = K_B^* = \frac{F}{6}(1-\alpha)$; equilibrium taxes are $t_A^m = t_B^m = m$; each region hosts half of the firms and all firms enjoy a strictly positive surplus at this equilibrium.

Let us then discuss the implications of Proposition 2. We start with the case where $\alpha = 0$, i.e. infrastructure benefits are purely specific to a region. A sufficient condition for overinvestment to prevail at equilibrium is $F > 9m$. When this is the case, both regions invest in $K_i$ up to levels which are unnecessarily high, given the ensuing tax competition. Beyond a given threshold, investment benefits are simply captured by the firms as pure rents. Whenever $F \leq 9m$, best replies are not defined anymore in the interior of the covered region.

In this case, the best replies correspond to the frontier of area a where all firms prefer country C to the outside option. It follows that any possible subgame perfect equilibrium exhibits no overinvestment whenever $F \leq 9m$.21 As a corollary, $F \leq 9m$ is also a sufficient condition for a mitigated tax competition to prevail. Recall indeed that in a corner tax equilibrium, tax levels are such that the marginal firm is precisely indifferent between locating in any of the two regions or taking its outside option. To state it differently, the marginal firm is left with no rent. In conclusion, when $\alpha=0$, there exists a wide domain of the parameters’ value for which infrastructure costs do not provide sufficient incentives to regions for avoiding overinvestment, which in turn intensifies tax competition.

Our analysis then shows that the presence of inter-regional spillovers, i.e. $\alpha>0$, allows to control for this destructive competition. The presence of more intense spillovers indeed shrinks the domain for which overinvestment is an issue. Summing up, we have:

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21 Note however that there exist multiple equilibria located along the frontier.
Proposition 3. Suppose investment costs are such that overinvestment occurs at equilibrium when there are no spillovers, then there always exists a threshold level for inter-regional spillovers above which regions do not overinvest anymore and minimize the rents they leave to the incoming firms.

Intuitively, as α rises, the relative benefits of the investment made by one region decrease since they mostly spill over onto the other region. Fig. 4 illustrates this dampening of infrastructure competition as α rises. Two effects are at work. Recall first that when α rises, the frontiers partitioning the \((K_A,K_B)\) space shifts (see Fig. 3) so that the domain over which a corner solution prevails becomes larger. Second, the shape of the infrastructure best replies is affected (see Eq. (17)): best replies shift down and their slope decreases. In other words, infrastructure levels become less and less strategic substitutes as α increases (see the case of \(α_1\) and \(α_2\) on Fig. 4).

Note that since infrastructure best replies both shift and see their slope diminishing as α grows larger, the symmetric equilibrium exists for smaller values of \(K_A\), until we reach spillover levels for which the best replies exhibit a kink when they hit the frontier before the 45° line. This is the case with \(α_2\). In such cases, multiple equilibria prevail along the coverage frontier.

More precisely, for any combination of parameters \((F,m)\) such that the subgame perfect equilibrium of the game without spillovers lies in the interior of covered region, there exists a value \(α > 0\) beyond which no overinvestment prevails at equilibrium and firms’ rents are kept to the minimum. Fig. 5 summarizes Proposition 3.

Consider then the limiting case where the benefits of an infrastructure supplied by region \(i\) spill over onto the whole country, i.e. access to the infrastructure cannot be denied to a firm on the basis of its location anymore. Formally, this amounts to assume that \(α = 1\). In this context, investing in infrastructure increases the global attractiveness of country \(C\) irrespective of the particular region that initiates the investment. Because they are no longer the exclusive attributes of each region, infrastructure levels now only affect the absolute attractiveness of a region (i.e. in comparison to the status quo without modifying its relative attractiveness (i.e. in comparison with the contiguous region)). In the tax competition game, we immediately observe from Eq. (9) that tax best replies are symmetric irrespective of the investment levels decided in the first stage. This is so because when infrastructures are strictly inter-regional, providing more infrastructure than the other region has no strategic value in the tax competition game. Consequently, tax revenues do not depend on investment levels whenever covered configurations apply. Accordingly, when we turn to the first stage of the game, it is obvious that no \((K_A,K_B)\) pair such that \(K_A + K_B > \frac{m}{2}\) can be part of a subgame perfect equilibrium. For any such pair indeed each region unilaterally benefits from a downward deviation to the frontier of the covered area. By lowering its investment, the region saves on investment costs without losing tax revenues. As a consequence, in the case where \(α = 1\), there is simply no incentive to overinvest at all. We have a continuum of equilibria which all satisfies \(K_A + K_B = \frac{m}{2}\).

4. Normative discussion and extensions

In this paper, we proposed a model of regional competition where governments compete in infrastructure before they compete in tax levels. When regions are contiguous, we expect that the benefits of local infrastructures spill over from one region to the other. We have shown that the mere presence of these spillovers directly affects the intensity of competition between regional governments. More precisely, there always exists a degree of inter-regional spillovers above which governments are able to obtain the cooperative outcome in a subgame perfect Nash equilibrium.

4.1. Normative implications

From a normative point of view, we may evaluate the social "cost" of tax competition for the economic area by comparing cooperative and non-cooperative outcomes. In this respect, whenever overinvestment prevails in a Nash equilibrium, this equilibrium is inefficient for the economic area in a well-defined sense: given infrastructure levels, regions could increase taxes without seeing any firm leave the area and conversely, given tax levels, decreasing infrastructure levels would save on costs without inducing any firm to leave. This is so because all incoming firms enjoy strictly positive rents at equilibrium. As soon as these rents fly away from the economic bloc, the rents reduction increases social welfare of the economic area, as summarized by the regions’ objective functions. In a cooperative solution, firms’ rents are minimized, subject to the fact that all firms are willing to come in one of the two regions. The social cost of non-cooperation between the regions within the economic area is therefore related to the rents regional authorities leave to firms at the subgame perfect equilibrium. This cost turns out to be directly related to the strength of the spillovers: larger spillovers tend to decrease the amount of overinvestment, and, therefore, inefficiencies.

Regions are to some extent in a co-operation context (see Brandenburger and Nalebuff, 1996 for a non formal treatment of co-operation...
theory). Because of their contiguity, the spatial externalities are magnified when the country as a whole becomes larger. Thus, as far as the total number of firms to attract is concerned, regions share a common interest: it is best for both to attract as many firms as possible. Still, they might compete for the associated fiscal revenues. Intuition suggests that regions should at least cooperate as far as infrastructures are concerned, even if they do not manage to refrain from competing in taxes. In the present model we have considered a purely non-cooperative context. This allows us now to clearly identify the scope for cooperation. More precisely, it turns out that the interest of cooperation, and the difficulties it involves, differ according to the type of infrastructure.

Essentially, when considering the limiting cases where $\alpha = 0$ or $\alpha = 1$ we observe the following. When the infrastructure is inter-regional, avoiding overinvestment and maximizing joint tax revenues may be obtained as an equilibrium outcome. By contrast, the case of an intra-regional infrastructure calls for a very different form of cooperation. Indeed, when $\alpha = 0$, unless infrastructure costs are very high, regions will overinvest in infrastructure in any SPE. They are caught in a prisoner’s dilemma where they both end up investing in a totally unproductive manner, given their objective. A cooperative solution in this case should improve regions’ welfare since it prevents overinvestment. However, it is not self-enforcing. If regions wish to implement this solution, they must be able to make credible commitments on the cooperative actions. This requires additional cooperation in the design of institutional rules governing regional investment decisions. The lack of a central authority, which could enforce cooperation, is particularly damaging here. A key insight of our analysis however is that the presence of significant spillovers across regions is a very powerful instrument that can be viewed as a substitute to explicit cooperation between regions. Formally, our analysis indeed suggests that if regions can coordinate on the type of infrastructure they develop, by concentrating their investments on infrastructures displaying large enough spillovers, they may completely avoid upfront tax competition. Strictly speaking, they may obtain the maximal joint payoff at a non-cooperative equilibrium.

Throughout the paper, we have assumed that regions were maximizing tax revenues net of the infrastructure cost. As is well-known, the particular form of the objective function influences the optimal behavior of the regional governments. Incorporating the firms’ welfare into the objective function of the regions would obviously make the questions of firms’ rents irrelevant to the issue of efficiency. However, this would also reinforce tax competition, inducing regions to subsidize firms. In that set-up, we will be left with the redistribution issues pertaining to the weight regional governments place on their inhabitants’ well-being and incoming firms’ profits.

When assuming that a regional government maximizes net tax revenues, we implicitly assume that public funds are costly since expenses or lost taxes negatively affect a region’s welfare. However, in reality, local public authorities may truly face binding budget constraints, for instance because their Constitution does not allow them to decrease expenses or lost taxes negatively affect a region’s welfare. However, when regions are faced with binding budget constraints, the Constitution imposes strict budget balance. Thus, any investment aimed at attracting firms must be financed by the tax levied on the incoming firms. This obviously affects the outcomes of the game since any investment committed to in period 1 places a lower bound on the minimum tax revenue a region must secure in stage 2. Moreover, tax revenues of a region depend on the tax pair $(t_A, t_B)$, and not only on this region’s actions. This implies that the analysis of tax competition is much more involved because of the additional constraints. We plan to pursue the analysis of such situations in future research.

4.2. Reducing firms’ matching costs

Up to now we have considered the case where regional infrastructure was increasing operating profits uniformly across firms. However, it seems equally reasonable to assume that, depending on their specific type, firms value regional policies differently. For example, this may be the case of training programs aimed at matching workers’ qualifications to the firms’ requirements. The actual value of such a program is typically dependent on the firms’ types. To what extent do the implications of such policies differ from those emphasized in the case of $K_t$ infrastructure?

In our model, these policies can be captured by assuming that they decrease the matching costs (captured through the function $m_i(x)$). A region is more likely to host a firm if it commits to bear part of its matching cost. Formally, and focusing on the extreme values for $\alpha$, we alter our basic model as follows:

- First we define matching costs as $m_A(x) = \frac{x}{\lambda_A}$ and $m_B(x) = \frac{1-\lambda_A}{\lambda_B}$.
- In the inter-regional case, we assume that $q_A = q_B = q_i$ whereas for the intra-regional case, each region is characterized by its specific $q_i$.
- Then we solve the model using the methodology developed in the previous section.

The analytical developments are available in Dembour and Wauthy (2003). The analysis reveals that, contrarily to the case where investments affect operating profits $K_t$, the fact that infrastructures are intra-regional goods is not sufficient to remove the multiplicity of subgame perfect equilibria. Actually, when investments are aimed at decreasing $m_i(x)$ regions always end up on the frontier that separates non-covered configurations from covered ones. The intuition for this result is to be found in the strategic value of the infrastructure investment. As long as we consider non-covered configurations, the strategic values of $K_t$ and $q_i$ are strictly positive, irrespective of the inter-regional or intra-regional nature of the infrastructure. However, for covered configurations, this is no longer true. We indeed observe that $K_t$ positively alters the level of $t_i$ as well as the number of firms actually attracted in region $i$ at equilibrium. In other words, the strategic value of $K_t$ is positive. By contrast, we observe that a larger $q_i$ decreases equilibrium taxes since it is equivalent to increasing firms’ mobility, thereby reinforcing tax competition. Therefore, in the inter-regional case, investing beyond the level that ensures coverage is clearly wasteful. In the intra-regional case, increasing $q_i$ decreases $t_i$ but increases the number of firms attracted in region $i$ since it becomes more attractive relative to the other region. However, at equilibrium, the negative tax effect dominates, which means that investing beyond the coverage threshold is not profitable.

Both types of infrastructure make regions more attractive to firms. However, they have very different implications for the tax competition game in a covered configuration. Improving matching can be viewed as making firms more mobile from one region to the other. This has the unhappy consequence of reinforcing tax competition, so that at equilibrium, tax levels are lower.

5. Final remarks

A key feature of the regional competition we envision in this paper is that competition takes place between contiguous regions. Within our model this is first illustrated by the fact that regions face firms with the
same status quo option. This assumption was meant to capture the idea that firms put the two regions “on a par”, except for taxes and infrastructures (when they differ). More importantly, regions’ contiguity translates into the possible inter-regional nature of infrastructure made available to the firms. Indeed, if regions are truly contiguous, physical location in region A rather than B does not actually matter as far as spatial externalities are concerned. This is exactly what happens when infrastructure is inter-regional. We have shown that, in this particular context, the extent to which the non-cooperative behaviour of local authorities (i.e. tax and infrastructure competition) results at equilibrium outcomes that depart from the cooperative ones is directly, and inversely, related to the importance of the spillovers attached to the infrastructure.

References


