Input Specificity and Location

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Abstract

In a two-region economy, two upstream firms supply an input to two consumer goods firms. For two different location patterns (site specificity and co-location of the suppliers), the firms play a three-stage game: the input suppliers select transport rates; then they choose outputs; finally the buyers select quantities of the consumer good. It is concluded that the site specificity of the input leads to a high transport cost and to its specialized adaptation to the needs of the local user.

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1. Introduction

The issue of input specificity arises when two industries are vertically linked. We assume that a set of upstream firms supplies an input to an equal number of downstream firms. Each downstream firm produces a differentiated consumer good and uses a differentiated intermediate good. Then each input supplier faces the following choice. It can either produce an input that is specially adapted to the requirements of a given buyer, or it can produce a generic or standardized intermediate good that can be used without much penalty by downstream firms other than the intended buyer.

This issue is important for several reasons. Firstly, it entails a technological trade-off. As was acknowledged by RIORDAN and WILLIAMSON (1985), specialization of the input reduces the marginal production cost of the buying firm, although it determines a different cost directly related with the level of input specificity. As McLAREN (2000) remarked, this cost has to do with the difficult adaptation of the specialized input to the needs of downstream firms other than the intended buyer.

Secondly, input specialization can lead to inequalities among downstream firms. If most upstream firms specialize their inputs to a subset of consumer goods firms, the remaining buying firms will have to incur adaptation costs of the input that will lead them to produce a smaller amount of output.

Thirdly, input specificity can lead to vertical integration. This can occur for two different reasons. The specialization of the input creates an incentive for the continuation in time of a relationship between the seller and the buyer of the input. Incomplete contracts and transaction costs lead to a governance of this relation-

ship through common property instead of a market arrangement (RIORDAN and WILLIAMSON, 1985). This can be seen in terms of a bilateral relationship between a seller and a buyer, or in the context of the interdependence of the integration decisions taken by several upstream and downstream firms in vertically-linked industries (McLAREN, 2000; GROSSMAN and HELPMAN, 2002). But vertical integration can also occur for strategic reasons. An upstream firm can decide to adapt the input to the requirements of a given buyer. By doing so, it undertakes not to supply the input to other downstream firms, thus raising their costs. This benefits the downstream firm that buys the specialized input, and this externality can be internalized if the upstream firm merges with the targeted input buyer (CHOI and YI, 2000; CHURCH and GANDAL, 2000).

In this paper, the issue of vertical integration will be left to one side and the focus of our attention will be on the technological aspects of the decision to specialize in terms of input. Just as HOTELLING (1929) and D'ASPREMONT, GABSZWICZ and THISSE (1979) did for the horizontal differentiation of a consumer good, input specificity will be modelled as following from "site specificity". JOSKOW (1987) defined the site specificity of an input through two complementary causes: (1) the upstream and the downstream firms are co-located or (2) the average distances and the unit transport costs among the buyers and the sellers are high.

HELSLEY and STRANGE (2004) related the site specificity of an input to "market thickness". As the number of downstream firms increases, the average distance between each input supplier and each input buyer decreases. The agglomeration of firms decreases input specificity. Site specificity can also be modelled by means of a two- dimensional space, as was done by GROSSMAN and HELPMAN

(2002), where each downstream firm uses a differentiated input with an address within a certain circumference. Each input supplier is defined by a location inside the circle with two coordinates, defined by the radius that joins the location to the center of the circle and to a point on the circumference. This point on the circumference defines the differentiated input in which the upstream firm is relatively specialized. The distance between the location and the center of the circle measures the degree of specialization.

In this paper, we will try to relate location and transport costs as causes of the site specificity of an input. We will follow the approach of the Launhardt model that was presented by DOS SANTOS FERREIRA and THISSE (1996): for different location patterns, the firms first choose transport rates endogenously and then they compete in the product market. Our approach is also closely related with DOS SANTOS FERREIRA and ZUSCOVITCH (1995). Each firm can choose between manufacturing a "light" (flexible) product at a high production cost, or a "heavy" (specialized) product with a low production cost but a high transport cost (adaptation cost), which the firm must incur if it sells the product in a different location (to a different buyer). As ANDERSON and DE PALMA (1996) remarked, this choice amounts to an option for the input supplier between competing locally, i.e. mainly serving a local buyer, and competing globally, where the firm aims to supply clients in different locations.

Three main findings follow from our analysis. The first is that the location and transport cost factors of site specificity are closely related. Firms will be more likely to produce "heavy" inputs if they are co-located with their buyers than otherwise. In each case, transport costs will be higher when the returns to specialization in terms of production cost reduction are higher. The second is that

for moderate returns to specialization there will be multiple equilibria in transport rates, while there will be a single equilibrium for extreme values. The third is that the intermediate equilibria will be symmetric in the event of the co-location of input suppliers and buyers and asymmetric if the upstream firms cluster in one location. This result is reminiscent of DOS SANTOS FERREIRA and THISSE (1996).

In section 2. the model is presented. In subsection 2.1. the assumptions are defined and the game structure is described. In subsection 2.2. the case is presented where each upstream firm locates separately with each downstream firm. In subsection 2.3. the other polar case is presented where the input suppliers co-locate. The conclusions are drawn in section 3..

2. The model

2.1. Assumptions and game structure

The model describes a spatial economy that obeys the following assumptions:

1. The economy is composed of two regions, A and B, each with the same number n of consumers. Through normalization, we have $n = 1$. The distance between the regions, δ, is also normalized to $\delta = 1$.

2. Each consumer has an inverse linear demand function $p = a - bx$. For the sake of simplicity, it will be assumed that $a = b = 1$.

3. Two downstream firms, D_1 in region A, and D_2 in region B, produce a homogenous consumer good under local monopoly. The consumer good is supposed to be non-tradable: the transport cost of the final good is so high

that, for each downstream firm, it is more profitable to charge the monopoly price than to undercut the competitor.

4. Each downstream firm uses one unit of an input in order to produce one unit of the final good. The input price is the only marginal production cost of the downstream firm, which does not incur any fixed costs.

5. Two upstream firms, U_1 and U_2, produce and deliver a homogeneous intermediate good to the final producers, D_1 and D_2. The upstream firms compete in quantities sold to each downstream firm.

6. Each upstream firm U_i $(i = 1, 2)$ chooses its transport rate t_i in the distance between the regions. The marginal production cost of the input is a decreasing function of the transport rate, so that the production of a "lighter" input entails a higher marginal production cost. The input supplier trades off the spatial flexibility of the intermediate good against productive efficiency. The relationship is linear, so that the marginal production cost of the input produced by firm U_i is given by

$$c_i = \alpha - \beta t_i$$

where

$$
\begin{aligned}
t_i &\in \left[0, \frac{\alpha}{\beta}\right] \\
\alpha &\in (0, 1) \\
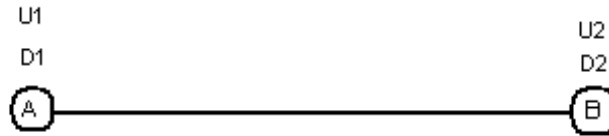\beta &\in (0, 1)
\end{aligned}
$$

Figure 1: The case of site specificity

$t_i \in \left[0, \frac{\alpha}{\beta}\right]$ means that the transport cost and the production cost can take zero values, which is not realistic, but is admitted for the sake of simplicity. $\alpha \in (0,1)$ ensures that the production cost does not exceed each consumer's reservation price (equal to 1, according to assumption 2). $\beta \in (0,1)$ ensures that the total marginal cost (production plus transport) of each upstream firm in the distant market increases with the transport rate.

With these assumptions, a noncooperative game with three stages is modelled. This game is inspired by the case of vertically-linked industries in a successive Cournot oligopoly, where firms first select the kind of product differentiation for given values of the adaptation costs of the inputs, as presented in BELLE-FLAMME and TOULEMONDE (2003). However, in our game, the locations of the firms are assumed to be given and the transport rates are endogenous. Two different patterns of locations of the upstream firms are considered and compared: "site specificity", where each upstream firm locates alongside a different input buyer (see Figure 1); and "co-location", where both upstream firms cluster close to the same downstream firm (see Figure 2).
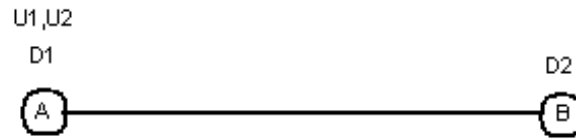
The game has the following stages:

U1,U2
D1

A ———————————————————————— B

D2

Figure 2: Co-location of input suppliers

First Stage : Firms U_1 and U_2 select the transport rates t_1 and t_2.

Second Stage : Firm U_1 chooses the quantities q1a and q1b and Firm U_2 chooses the quantities q2a and q2b of the intermediate good to be sold to the downstream firms in regions A and B.

Third Stage : Downstream firms D_1 and D_2 choose quantities of the consumer good x_1 and x_2 to be sold in regions A and B respectively.

2.2.   The case of the site specificity of the input

In this case, it is assumed that each upstream firm locates in a different region alongside a consumer good producer (see Figure 1) This corresponds to the Williamsonian concept of the "site specificity" of an asset. It will be shown that this kind of site specificity implies a specialized adaptation of the input to the needs of the local buyer, in the sense that the upstream firm will find it profitable to produce a "heavy" input at a low production cost and sell it to the local buying firm.

We seek to solve the three-stage game by backward induction in order to find a subgame perfect equilibrium.   The profit functions of firms D_1 and D_2 in the

third stage are:

$$\pi_1^D (x_1, \text{wa}) = [(1 - x_1) - \text{wa}] \, x_1 \tag{1}$$

$$\pi_2^D (x_2, \text{wb}) = [(1 - x_2) - \text{wb}] \, x_2 \tag{2}$$

where wa and wb are the delivered prices of the input in regions A and B. If these profit functions are maximized in relation to x_1 and x_2, we obtain

$$x_1^* = \frac{1}{2} (1 - \text{wa}) \tag{3}$$

$$x_2^* = \frac{1}{2} (1 - \text{wb}) \tag{4}$$

In the second stage, let q1a, q1b, q2a, q2b be the quantities of the input sold by the upstream firms U_1 and U_2 to the downstream firms in regions A and B. Then the derived demand of the input in each region is given by the equalities

$$\text{q1a} + \text{q2a} = x_1^* = \frac{1}{2} (1 - \text{wa}) \tag{5}$$

$$\text{q1b} + \text{q2b} = x_2^* = \frac{1}{2} (1 - \text{wb}) \tag{6}$$

If these equalities are solved in relation to wa and wb, we obtain inverse demands for the input in each region:

$$\text{wa} = 1 - 2 \, (\text{q1a} + \text{q2a}) \tag{7}$$

$$\text{wb} = 1 - 2 \, (\text{q1b} + \text{q2b}) \tag{8}$$

The profit functions firm U_1 and firm U_2 are:

$$\pi_1^U\left(q1a, q1b, q2a, q2b, t_1\right) \;=\; [wa - (\alpha - \beta t_1)]\, q1a + [wb - t_1 - (\alpha - \beta t_1)]\, q1b$$

(9)

$$\pi_2^U\left(q1a, q1b, q2a, q2b, t_2\right) \;=\; [wa - t_2 - (\alpha - \beta t_2)]\, q2a + [wb - (\alpha - \beta t_2)]\, q2b$$

(10)

where wa and wb are defined by 7 and 8. The Cournot equilibrium outputs in the second stage of the game follow easily:

$$
\begin{aligned}
\overset{*}{q1a}(t_1, t_2) &= \frac{1}{6}t_2 - \frac{1}{6}\alpha + \frac{1}{3}\beta t_1 - \frac{1}{6}\beta t_2 + \frac{1}{6} \\
\overset{*}{q1b}(t_1, t_2) &= \frac{1}{3}\beta t_1 - \frac{1}{3}t_1 - \frac{1}{6}\alpha - \frac{1}{6}\beta t_2 + \frac{1}{6} \\
\overset{*}{q2a}(t_1, t_2) &= \frac{1}{3}\beta t_2 - \frac{1}{3}t_2 - \frac{1}{6}\beta t_1 - \frac{1}{6}\alpha + \frac{1}{6} \\
\overset{*}{q2b}(t_1, t_2) &= \frac{1}{6}t_1 - \frac{1}{6}\alpha - \frac{1}{6}\beta t_1 + \frac{1}{3}\beta t_2 + \frac{1}{6}
\end{aligned}
$$

(11)

We will assume henceforth that these outputs are positive for any values of the transport rates. It is shown in the Appendix that a sufficient condition for this to be satisfied is that

$$\alpha \leq \frac{\beta}{2}$$

(12)

This condition means that the marginal production cost of each upstream firm should be sensitive enough to the variation of its transport rate.

Plugging the outputs 11 into the profit functions 9 and 10, we obtain the profit

functions of the input suppliers in the first-stage game.

$$
\begin{aligned}
\pi_1^U(t_1, t_2) &= \frac{1}{9}t_2 - \frac{2}{9}t_1 - \frac{2}{9}\alpha + \frac{2}{9}\alpha t_1 - \frac{1}{9}\alpha t_2 + \frac{4}{9}\beta t_1 - \frac{2}{9}\beta t_2 - \\
&\quad - \frac{4}{9}\alpha\beta t_1 + \frac{2}{9}\alpha\beta t_2 + \frac{4}{9}\beta t_1 t_2 + \frac{1}{9}\alpha^2 + \frac{2}{9}t_1^2 \\
&\quad + \frac{1}{18}t_2^2 - \frac{4}{9}\beta t_1^2 - \frac{1}{9}\beta t_2^2 + \frac{4}{9}\beta^2 t_1^2 + \frac{1}{9}\beta^2 t_2^2 + \frac{1}{9} - \frac{4}{9}\beta^2 t_1 t_2
\end{aligned}
\tag{13}
$$

$$
\begin{aligned}
\pi_2^U(t_1, t_2) &= \frac{1}{9}t_1 - \frac{2}{9}\alpha - \frac{2}{9}t_2 - \frac{1}{9}\alpha t_1 + \frac{2}{9}\alpha t_2 - \frac{2}{9}\beta t_1 + \frac{4}{9}\beta t_2 + \frac{2}{9}\alpha\beta t_1 - \\
&\quad - \frac{4}{9}\alpha\beta t_2 + \frac{4}{9}\beta t_1 t_2 + \frac{1}{9}\alpha^2 + \frac{1}{18}t_1^2 + \frac{2}{9}t_2^2 - \frac{1}{9}\beta t_1^2 - \frac{4}{9}\beta t_2^2 - \\
&\quad - \frac{4}{9}\beta^2 t_1 t_2 + \frac{1}{9}\beta^2 t_1^2 + \frac{4}{9}\beta^2 t_2^2 + \frac{1}{9}
\end{aligned}
\tag{14}
$$

The second partial derivative of the profit function of each upstream firm in relation to its own transport rate is given by

$$
\frac{\partial^2 \pi_i^U(t_1, t_2)}{\partial t_i^2} = \frac{4}{9} - \frac{8}{9}\beta(1-\beta)
\tag{15}
$$

for $i = 1, 2$. It can be easily seen that the second partial derivative 15 is positive for $\beta \in (0, 1)$, thus ensuring that the profit function of each upstream firm is strictly convex in its transport rate. Hence the profit function of each input supplier reaches its maximum value at a boundary point of the domain $\left[0, \frac{\alpha}{\beta}\right]$, so that there are four candidates for a subgame perfect equilibrium in transport rates: two symmetric equilibria $(0,0)$, $\left(\frac{\alpha}{\beta}, \frac{\alpha}{\beta}\right)$; and two asymmetric equilibria $\left(0, \frac{\alpha}{\beta}\right)$, $\left(\frac{\alpha}{\beta}, 0\right)$. Since the game is symmetric, it is sufficient to explicitly consider only one of these asymmetric equilibria, $\left(0, \frac{\alpha}{\beta}\right)$ w.l.g.

$(t_1^*, t_2^*) = (0, 0)$ is a Nash equilibrium of the first-stage game if and only if:

$$\pi_1^U(0, 0) \geq \pi_1^U\left(\frac{\alpha}{\beta}, 0\right)$$
$$\pi_2^U(0, 0) \geq \pi_2^U\left(0, \frac{\alpha}{\beta}\right)$$

Following 13 and 14, these conditions are both equivalent to

$$\alpha \leq \frac{\beta(1 - 2\beta)}{1 - \beta} \tag{16}$$

On the other hand, $(t_1^*, t_2^*) = \left(\frac{\alpha}{\beta}, \frac{\alpha}{\beta}\right)$ is a Nash equilibrium of the first-stage game if and only if

$$\pi_1^U\left(\frac{\alpha}{\beta}, \frac{\alpha}{\beta}\right) \geq \pi_1^U\left(0, \frac{\alpha}{\beta}\right)$$
$$\pi_2^U\left(\frac{\alpha}{\beta}, \frac{\alpha}{\beta}\right) \geq \pi_2^U\left(\frac{\alpha}{\beta}, 0\right)$$

These conditions are equivalent to

$$\alpha \geq \frac{\beta(2\beta - 1)}{2\beta^2 - \beta - 1} \tag{17}$$

Finally, the asymmetric equilibrium $(t_1^*, t_2^*) = \left(0, \frac{\alpha}{\beta}\right)$ holds if and only if

$$\pi_1^U\left(0, \frac{\alpha}{\beta}\right) \geq \pi_1^U\left(\frac{\alpha}{\beta}, \frac{\alpha}{\beta}\right) \Leftrightarrow \alpha \leq \frac{\beta(2\beta - 1)}{2\beta^2 - \beta - 1}$$
$$\pi_2^U\left(0, \frac{\alpha}{\beta}\right) \geq \pi_2^U(0, 0) \Leftrightarrow \alpha \geq \frac{\beta(1 - 2\beta)}{1 - \beta} \tag{18}$$

By plotting 12, 16 and 17 together in the (α, β) space, it is possible to define the regions where each type of equilibrium holds in Figure 3. It is clear that
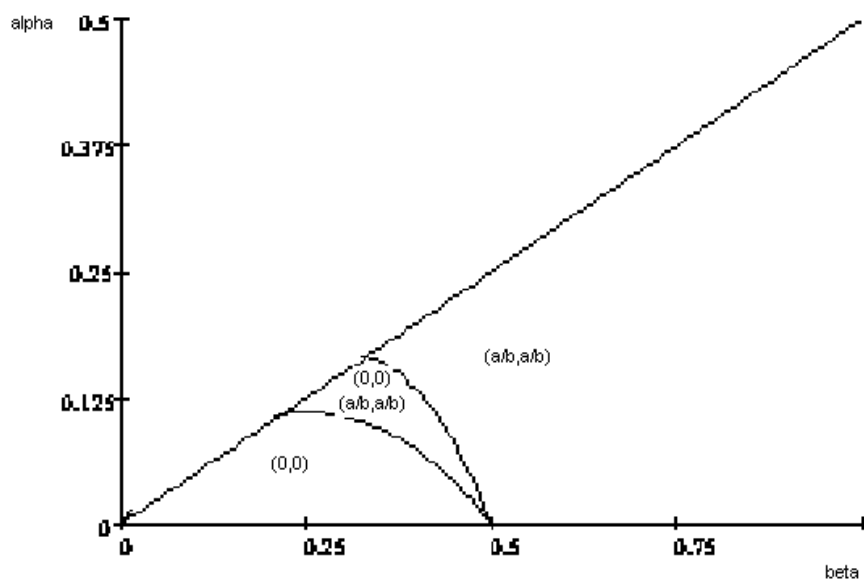
Figure 3: Equilibria in transport rates in the site specificity case

conditions 18 are incompatible, so that asymmetric equilibria do not exist.

Figure 3 shows that equilibrium transport rates are minimal when the parameters α and β are small and that they are maximal otherwise. For intermediate values of the parameters, both symmetric equilibria coexist. Basically, the equilibrium with high transport rates occurs if the returns to specialization of the input (as measured by β) are high.

2.3. The case of co-location of the input suppliers

Let us assume now that the input suppliers are clustered in region A, so that the spatial pattern of the economy is as described by Figure 2. In this case, the inputs are not specific to the location of the downstream firms.

Solving the game by backward induction, it is clear that the third-stage game is identical to the one that was described in subsection 2.2., so that the profit functions of the downstream firms are given by 1 and by 2 and the equilibrium outputs of the consumer good are expressed by 3 and 4.

In the second stage, the inverse demand functions of the input in the two regions are still given by 7 and 8. But the profit functions of the upstream firms now become

$$\pi_1^U \left(\text{q1a}, \text{q1b}, \text{q2a}, \text{q2b}, t_1 \right) \quad = \quad \left[\text{wa} - \left(\alpha - \beta t_1 \right) \right] \text{q1a} + \left[\text{wb} - t_1 - \left(\alpha - \beta t_1 \right) \right] \text{q1b}$$

$$(19)$$

$$\pi_2^U \left(\text{q1a}, \text{q1b}, \text{q2a}, \text{q2b}, t_2 \right) \quad = \quad \left[\text{wa} - \left(\alpha - \beta t_2 \right) \right] \text{q2a} + \left[\text{wb} - t_2 - \left(\alpha - \beta t_2 \right) \right] \text{q2b}$$

$$(20)$$

The equilibrium outputs of the upstream firms in the second-stage game become

$$
\begin{array}{rcl}
\overset{*}{\text{q1a}} \left(t_1, t_2 \right) & = & \dfrac{1}{3}\beta t_1 - \dfrac{1}{6}\alpha - \dfrac{1}{6}\beta t_2 + \dfrac{1}{6} \qquad\qquad\qquad (21) \\[2mm]
\overset{*}{\text{q1b}} \left(t_1, t_2 \right) & = & \dfrac{1}{6}t_2 - \dfrac{1}{3}t_1 - \dfrac{1}{6}\alpha + \dfrac{1}{3}\beta t_1 - \dfrac{1}{6}\beta t_2 + \dfrac{1}{6} \\[2mm]
\overset{*}{\text{q2a}} \left(t_1, t_2 \right) & = & \dfrac{1}{3}\beta t_2 - \dfrac{1}{6}\beta t_1 - \dfrac{1}{6}\alpha + \dfrac{1}{6} \\[2mm]
\overset{*}{\text{q2b}} \left(t_1, t_2 \right) & = & \dfrac{1}{6}t_1 - \dfrac{1}{6}\alpha - \dfrac{1}{3}t_2 - \dfrac{1}{6}\beta t_1 + \dfrac{1}{3}\beta t_2 + \dfrac{1}{6}
\end{array}
$$

If we plug the outputs 21 into the profit functions 19 and 20, we obtain the

profit functions in the first-stage game.

$$\pi_1^U (t_1, t_2) = \frac{1}{9}t_2 - \frac{2}{9}t_1 - \frac{2}{9}\alpha + \frac{2}{9}\alpha t_1 - \frac{1}{9}\alpha t_2 + \frac{4}{9}\beta t_1 - \frac{2}{9}\beta t_2 -$$
$$- \frac{2}{9}t_1 t_2 - \frac{4}{9}\alpha\beta t_1 + \frac{2}{9}\alpha\beta t_2 + \frac{4}{9}\beta t_1 t_2 + \frac{1}{9}\alpha^2 + \frac{2}{9}t_1^2 + \frac{1}{18}t_2^2 -$$
$$- \frac{4}{9}\beta t_1^2 - \frac{1}{9}\beta t_2^2 - \frac{4}{9}\beta^2 t_1 t_2 + \frac{4}{9}\beta^2 t_1^2 + \frac{1}{9}\beta^2 t_2^2 + \frac{1}{9}$$

(22)

$$\pi_2^U (t_1, t_2) = \frac{1}{9}t_1 - \frac{2}{9}\alpha - \frac{2}{9}t_2 - \frac{1}{9}\alpha t_1 + \frac{2}{9}\alpha t_2 - \frac{2}{9}\beta t_1 + \frac{4}{9}\beta t_2 -$$
$$- \frac{2}{9}t_1 t_2 + \frac{2}{9}\alpha\beta t_1 - \frac{4}{9}\alpha\beta t_2 + \frac{4}{9}\beta t_1 t_2 + \frac{1}{9}\alpha^2 + \frac{1}{18}t_1^2 +$$
$$+ \frac{2}{9}t_2^2 - \frac{1}{9}\beta t_1^2 - \frac{4}{9}\beta t_2^2 - \frac{4}{9}\beta^2 t_1 t_2 + \frac{1}{9}\beta^2 t_1^2 + \frac{4}{9}\beta^2 t_2^2 + \frac{1}{9}$$

(23)

If we compute the second partial derivatives of the profit functions of the input suppliers in relation to their own transport cost rates, we conclude that they are still given by 15, so that each profit function is convex in its own transport rate. Hence the equilibrium transport rate of each firm will necessarily be a boundary point of $\left[0, \frac{\alpha}{\beta}\right]$. In what follows, we check the possible Nash equilibria in transport rates.

Clearly, there will be a Nash equilibrium $(0,0)$ if and only if

$$\pi_1^U (0,0) \geq \pi_1^U \left(\frac{\alpha}{\beta}, 0\right)$$
$$\pi_2^U (0,0) \geq \pi_2^U \left(0, \frac{\alpha}{\beta}\right)$$

These conditions are equivalent to

$$\alpha \leq \frac{\beta (1 - 2\beta)}{1 - \beta} \tag{24}$$

which is the same as 16.

On the other hand, $\left(\frac{\alpha}{\beta}, \frac{\alpha}{\beta}\right)$ will be a Nash equilibrium in the first-stage game if and only if

$$
\begin{aligned}
\pi_1^U \left(\frac{\alpha}{\beta}, \frac{\alpha}{\beta}\right) &\geq \pi_1^U \left(0, \frac{\alpha}{\beta}\right) \\
\pi_2^U \left(\frac{\alpha}{\beta}, \frac{\alpha}{\beta}\right) &\geq \pi_2^U \left(\frac{\alpha}{\beta}, 0\right)
\end{aligned}
$$

These conditions are equivalent to

$$
\beta \geq \frac{1}{2} \tag{25}
$$

Finally, an asymmetric equilibrium $\left(\frac{\alpha}{\beta}, 0\right)$ exists if and only if

$$
\begin{aligned}
\pi_1^U \left(\frac{\alpha}{\beta}, 0\right) &\geq \pi_1^U (0,0) \\
\pi_2^U \left(\frac{\alpha}{\beta}, 0\right) &\geq \pi_2^U \left(\frac{\alpha}{\beta}, \frac{\alpha}{\beta}\right)
\end{aligned}
$$

which are equivalent to

$$
\left\{
\begin{array}{c}
\alpha \geq \dfrac{\beta (1 - 2\beta)}{1 - \beta} \\
\beta \leq \frac{1}{2}
\end{array}
\right. \tag{26}
$$

Conditions 24, 25 and 26 are plotted in Figure 4.

Comparing Figure 4 with Figure 3, it is clear that, as in the case of site specificity, in the case of co-location of the suppliers, the equilibrium transport rates will be maximal if the returns to specialization (as measured by β) are high and they will be minimal if these returns are low. However, there are differences between the two cases. Firstly, the region where transport rates are maximal is much
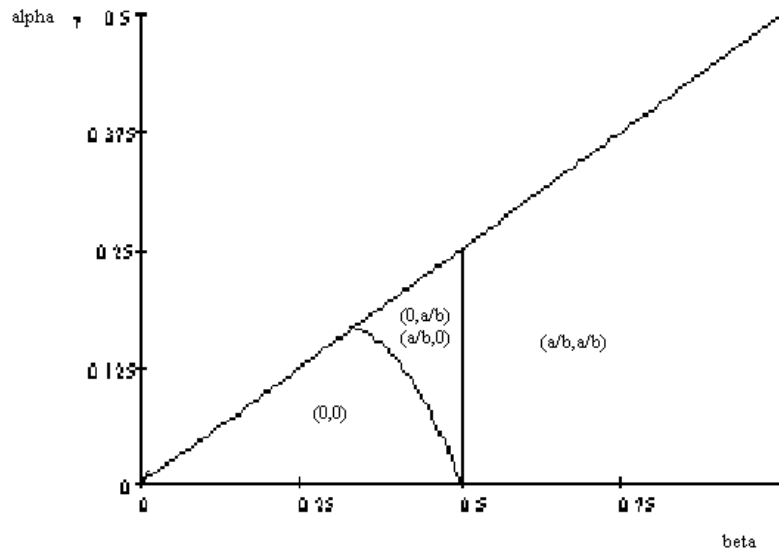
Figure 4: Equilibrium transport rates in the case of co-location of input suppliers

smaller in the case of co-location of suppliers when compared with the case of site specificity. Secondly, for intermediate values of β, we now have multiple asymmetric equilibria instead of multiple symmetric equilibria. In this case, one of the upstream firms chooses to basically supply the local buyer, while the other one selects a low transport rate in order to serve downstream firms in both regions.

3.   Concluding remarks

The analysis has enabled us to draw several conclusions. The first, unsurprising finding is that specialization occurs if its returns in terms of production cost reduction are high. This is more likely to occur if each upstream firm is close to a buyer than if they cluster in one single location. The second conclusion is that there will be one single equilibrium in transport rates if the returns to specialization are extreme (either too low or too high), but there will be multiple equilibria if these returns are intermediate. In this case, the multiple equilibria will be symmetric in the case of site specificity, but asymmetric in the case of co-location of input suppliers. Finally, while the output of the consumer good will be the same in both regions in the case of site specificity, it will be different in the case of co-location of input suppliers. In this latter case, the output of the consumer good is higher in the region where the input suppliers are located, if at least one of the upstream firms specializes its intermediate good. These conclusions are reminiscent of (although not entirely coincident) DOS SANTOS FERREIRA and THISSE (1996). The conclusions can be summarized by saying that the site specificity of the input, following from the joint location of an upstream and a downstream firm, leads to its specialization as a result of the choice of high transport rates by the suppliers.

This paper has a rather specific flavor. Two extensions can be contemplated.

The first one is the endogenisation of the location choice made by the firms, which determines the degree of input specificity. If this is done, it becomes necessary to explain why the upstream firms may co-locate, by means of some kind of agglomeration economy. The second extension would be to consider different values for the distance between the regions, δ, instead of a single value. Following ANDERSON and DE PALMA (1996), it is expected that a high value of δ will by itself lead to a higher degree of localization of competition in the input market and to a higher input specificity.

Appendix: Derivation of condition $\alpha \leq \dfrac{\beta}{2}$.

We deal first with the case of site specificity presented in subsection 2.2.. From 11, it is clear that $q1b\,(t_1, t_2) \geq 0$ and $q2a\,(t_1, t_2) \geq 0$ are equivalent respectively to

$$
\begin{aligned}
t_1 &\leq \frac{\alpha + \beta t_2 - 1}{2\beta - 2} \\
t_2 &\leq \frac{\alpha + \beta t_1 - 1}{2\beta - 2}
\end{aligned}
\tag{A.1}
$$

If the relations A.1 are taken as equalities, they define two decreasing functions in the space (t_1, t_2), which intersect at

$$
t_1^* = t_2^* = \frac{1 - \alpha}{2 - \beta}
\tag{A.2}
$$

Clearly, a sufficient condition for each upstream firm to be active in its distant market, for any transport rate that may be selected by the competing upstream

firm, is that its transport rate does not exceed A.2, i.e.

$$\frac{\alpha}{\beta} \leq \frac{1-\alpha}{2-\beta}$$

which is equivalent to $\alpha \leq \dfrac{\beta}{2}$.

Then the case of co-location of the input suppliers, which is dealt with in subsection 2.3., is examined. From 21, it is clear that q1b $(t_1, t_2) \geq 0$ and q2b $(t_1, t_2) \geq 0$ mean respectively that

$$
\begin{aligned}
t_1 &\leq \frac{\alpha - t_2 + \beta t_2 - 1}{2\beta - 2} \\
t_2 &\leq \frac{\alpha - t_1 + \beta t_1 - 1}{2\beta - 2}
\end{aligned}
\tag{A.3}
$$

If relations A.3 are met as equalities, they define two increasing functions. The intercept of each function in its axis is given by

$$t_1^* = t_2^* = \frac{1-\alpha}{2(1-\beta)} \tag{A.4}$$

Clearly, a sufficient condition for each upstream firm to be active in the distant market B, for any transport rate that may be selected by the competitor, is that its transport rate does not exceed A.4, or

$$\frac{\alpha}{\beta} \leq \frac{1-\alpha}{2(1-\beta)}$$

which is equivalent to

$$\alpha \leq \frac{\beta}{2-\beta} \tag{A.5}$$

A.5 is less binding than $\alpha \leq \frac{\beta}{2}$, which is therefore a sufficient condition for

each upstream firm to be active in its distant market for any transport rate that may be selected by the competitor.

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