INTERNATIONAL TRADE AND SPATIAL COMPETITION

LUCA LAMBERTINI

No 199

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and Spatial Competition

Luca Lambertini*

Dipartimento di Scienze Economiche**
Università degli Studi di Bologna
Strada Maggiore 45
40125 Bologna
Italy
tel 39-51-6402600
fax 39-51-6402664
e-mail lamberti@boph01.cineca.it

and

Linacre College
Oxford OX1 3JA
United Kingdom
e-mail econlla@vax.ox.ac.uk

June 1994

JEL classification numbers: F 12, F 13, L 13

Abstract

The consequences of free trade in an international spatial duopoly are investigated, under different market regimes. The optimal setting for both countries appears to be a private duopoly in which both firms operate under the same fiscal regime and a side payment from the larger to the smaller country occurs.

**Acknowledgements*

I wish to thank Paolo Garella, Gianpaolo Rossini and Carlo Scarpa for helpful comments and suggestions. Financial support from a Commission of the EC within the SPES project "Trade Specialization in the EC" is gratefully acknowledged. The usual disclaimer applies.

** Please send correspondence to the Italian address.

1. Introduction

The recent stream of literature on economic geography has outlined the linkages among the location of factors of production, international trade and economic growth (Krugman (1981, 1991); Grossman and Helpman (1990), *inter alia*).

Our purpose is to show that a spatial model *à la* Hotelling (1929) allows to analyse issues such as the choice between alternative market regimes in an international duopoly under horizontal product differentiation and free trade.

The impact of public firms in a horizontally differentiated oligopoly has been studied by Cremer et al. (1991). Their analysis points out that having a public firm maximizing social surplus is not necessarily desirable from a social standpoint, and private firms may benefit from its presence, earning higher profits than in the private oligopoly case. Thus, the optimal policy of the government as well as the social incentive to privatization are very sensitive to market structure, i.e., the number of firms on the market.

We investigate the implications of competition in horizontally differentiated goods between two firms operating in two different countries under different market configurations, i.e., public, mixed or private duopoly. The comparison among the welfare implications of these market settings raises the question whether the opening of trade may influence the incentive to privatization vs nationalization for one country or possibly both. We will show that, under a mixed duopoly regime, if trade opens and the private firm exports to the larger country which is partially served by a domestic public firm, overall transportation costs are minimized. The same result obtains in a private duopoly in which the two governments adopt the same taxation scheme. Though, the incentive to the opening of trade are opposite for the two countries. Thus, provided that side payments between countries are possible, both may benefit from free trade.

The paper is structured as follows: section 2 describes the general model; sections 3 and 4 are devoted to the analysis of the public and the mixed duopoly, respectively; in section 5, the introduction of a tariff or, alternatively, the adoption of a common taxation scheme by both country is discussed. Conclusive comments are proposed in section 6.

2. The model

The two firms sell the same physical good. They produce at constant marginal cost, which can be assumed to be nil. Fixed costs are absent. Consumers of both countries are uniformly distributed along an interval whose total length can be normalized to 1 without loss of generality, and their total density is 1. There is no discontinuity between the two countries, and the border is at $\alpha \in]0, 1[$, so that the number of consumers in country 2 is $1 - \alpha$. Consumers have unit demands, and consumption yields a positive constant surplus s; then, each consumer buys if and only if the net utility derived from consumption is non negative,

$$U = s - td^2 - p_i \geq 0, \quad t > 0, \quad i = 1,2; \qquad (1$$

where td^2 is the transportation cost[1] incurred by a consumer living at distance d from firm i, and p_i is the price of good i. We assume that s is large enough for total demand to be always equal to 1, under both autarky and free trade.

Under autarky, both firms set $p_i = s - td^2$ and locate at the center of their respective countries, i.e., $x_1 = \alpha/2$, $x_2 = (\alpha + 1)/2$, independently of their property structure. These are also the socially optimal locations in autarky,[2] yielding $SC_1^{A*} = \alpha^3 t/12$, and $SC_2^{A*} = (1-\alpha)^3 t/12$. The apex A stands for *autarky*.

Under free trade, firms locate respectively at x_1 and x_2, $x_1 \leq x_2$. Demands are defined as follows:

1. Convex transportation costs are necessary to ensure the existence of a duopolistic price equilibrium in pure strategies. Cfr. D'Aspremont et al. (1979) and Economides (1986).

2. Since the demand functions are linear in prices, the private and the public monopolist choose the same location (Spence, 1975, p.421). See also Bonanno (1987).

$$y_1 = x_1 + \frac{(x_2 - x_1)}{2} + \frac{(p_2 - p_1)}{2t(x_2 - x_1)} \qquad (2$$

$$iff \quad 0 < x_1 + \frac{(x_2 - x_1)}{2} + \frac{(p_2 - p_1)}{2t(x_2 - x_1)} < 1,$$

$$y_1 = 0 \quad iff \quad x_1 + \frac{(x_2 - x_1)}{2} + \frac{(p_2 - p_1)}{2t(x_2 - x_1)} \le 0, \qquad (2'$$

$$y_1 = 1 \quad iff \quad x_1 + \frac{(x_2 - x_1)}{2} + \frac{(p_2 - p_1)}{2t(x_2 - x_1)} \ge 1. \qquad (2''$$

$$y_2 = 1 - \frac{(x_1 + x_2)}{2} + \frac{(p_1 - p_2)}{2t(x_2 - x_1)} \qquad (3$$

$$iff \quad 0 < 1 - \frac{(x_1 - x_2)}{2} + \frac{(p_1 - p_2)}{2t(x_2 - x_1)} < 1,$$

$$y_2 = 0 \quad iff \quad 1 - \frac{(x_1 + x_2)}{2} + \frac{(p_1 - p_2)}{2t(x_2 - x_1)} \le 0, \qquad (3'$$

$$y_2 = 1 \quad iff \quad 1 - \frac{(x_1 + x_2)}{2} + \frac{(p_1 - p_2)}{2t(x_2 - x_1)} \ge 1. \qquad (3''$$

The definition of each firm's objective function depends on whether it is private or public. If both firms are private (respectively, public), they maximize profit (respectively, minimize each country's total transportation costs). If instead one is private while the other is public, the first will maximize profit while the other will minimize the total transportation costs of the inhabitants of its country.

3. A public duopoly under free trade

Let us now concentrate on the case in which both firms are public, and, without loss of generality, assume $\alpha > 1/2$. Their respective objectives are then:

$$\min_{x_1, p_1} \quad SC_1^D = t\left[\int_0^{y_1} (m - x_1)^2 dm + \int_{y_1}^{\alpha} (m - x_2)^2 dm\right], \tag{4}$$

$$\min_{x_2, p_2} \quad SC_2^D = t\int_{\alpha}^{1} (m - x_2)^2 dm, \tag{5}$$

where apex D stands for *duopoly*. From the first order conditions relative to the price stage, it can be easily verified that $p_1^* = p_2^*$, while at the location stage

$$x_1^* = \frac{\alpha + 1}{6}, \quad x_2^* = \frac{\alpha + 1}{2} \tag{6}$$

which yields $SC_1^{D*} = (5\alpha^3 - 12\alpha^2 + 15\alpha - 4)t/108$ and $SC_2^{D*} = (1 - \alpha)^3 t/12$, so that the opening of trade drives the firm operating in the larger market to the left of the position chosen in autarky,[3] while leaving unaffected both the location of the firm operating in the smaller market and the total transportation costs relative to the latter. Furthermore, $y_1^* = (\alpha + 1)/3$, so that part of the consumers of country 1 are now being served by firm 2; this is sufficient to imply $SC_1^{D*} < SC_1^{A*}$. As a consequence, we can conclude that the opening of trade leads to a Pareto-improvement for the larger country.

3. It can be checked that $(\alpha + 1)/6 < \alpha/2$ for all $\alpha \in]1/2, 1[$.

4. Mixed duopoly

Let us now turn to the case of a mixed duopoly, in which firm 1 is public while firm 2 is private. The public firm only cares about the welfare of the population of its country. If $y_1 \geq \alpha$, its objective is:

$$\min_{x_1} \quad SC_1^D = t\int_0^{\alpha}(m-x_1)^2 dm. \qquad (7$$

Since the upper bound of the integral is not function of prices, the public firm can be assumed to price at marginal cost. The objective of the private firm is:

$$\max_{x_2,p_2} \quad \pi_2 = p_2 y_2. \qquad (8$$

Given $p_1^* = 0$, the first order condition (FOC) of firm 2 in the price stage is the following:

$$\frac{\delta\pi_2}{\delta p_2} = 1 - \frac{(x_1+x_2)}{2} - \frac{p_2}{t(x_2-x_1)} = 0, \qquad (9$$

yielding

$$p_2^* = \frac{t}{2}(x_1-x_2)(x_1+x_2-2), \qquad (10$$

so that the private firm's profit function at the location stage is

$$\pi_2 = \frac{t}{8}(x_2-x_1)(x_1+x_2-2)^2. \qquad (11$$

The FOCS at this stage are the following:

$$\frac{\delta SC_1}{\delta x_1} = t(x_1^2 - (\alpha - x_1)^2) = 0; \tag{12}$$

$$\frac{\delta \pi_2}{\delta x_2} = \frac{t}{8}(3x_2 - x_1 - 2)(x_1 + x_2 - 2) = 0. \tag{13}$$

The solution of the system (12-13) is ($x_1 = \alpha/2; x_2 = (4+\alpha)/6$).[4] The total transportation costs for country 1 amount to $SC_1^{D*} = \frac{t}{12}\alpha^3$, the same value assumed under autarky, while firm 2's profit is $\pi_2^* = \frac{t}{54}(2-\alpha)^3$. Thus, since $SC_2^{D*} > (1-a)^3 t/12$ for all $\alpha \neq 1/2$, in this setting the opening of trade damages countri 2 while leaving unaffected country 1, so that if the public firm exports, this raises the transportation costs incurred by country 2. Equilibrium demands are $y_1^* = (\alpha+4)/6, \quad y_1^* \in]2/3, 5/6[$; and $y_2^* = (2-\alpha)/6, \quad y_2^* \in]1/6, 1/3[$. It appears that (7) is a valid specification of firm 1 objective if $\alpha \leq 4/5$. Furthermore, since $y_1^* = x_2^*$, the private firm serves only the market segment to its right.

If $\alpha > 4/5$, the objective of the public firm is

$$\min_{x_1} \quad SC_{y_1}^D = t\int_0^{y_1} (m - x_1)^2 dm, \tag{14}$$

while the private firm's objective is (8). Conditions (9-11) still hold. The FOCs relative to the location stage are:

$$\frac{\delta SC_{y_1}^D}{\delta x_1} = \frac{t}{64}(37x_1^2 + 36x_1 - 12x_2 + 18x_1x_2 - 3x_2^2 - 12) = 0 \tag{15}$$

and

4. A second critical point does not meet the second order conditions.

$$\frac{\delta\pi_2}{\delta x_2} = \frac{2t}{49}(2x_2 - 3)(5x_2 - 4) = 0. \qquad (16$$

The equilibrium locations are ($x_1^* = 0.366025$; $x_2^* = 0.788675$). Demands are $y_1^* = 0.788675$ and $y_2^* = 0.211325$, the private firm's profit is $\pi_2^* = 0.03775t$, while $SC_{y_1}^{D*} = 0.041512t$. It appears that firm 2 locates now in country 1, serving again the market segment to its right.

We can now deal with the case in which the private firm exports to country 1 ($\alpha > y_1$) and the public firm minimize the total transportation costs incurred by the population of its country. The objective of firm 1 is thus

$$\min_{x_1, p_1} \quad SC_1 = t\left[\int_0^{y_1}(m - x_1)^2 dm + \int_{y_1}^{\alpha}(m - x_2)^2 dm\right]. \qquad (17$$

The objective of firm 2 is described by (8). The FOCs pertaining to the price stage are

$$\frac{\delta SC_1^D}{\delta p_1} = \frac{p_2 - p_1}{2t(x_1 - x_2)} = 0; \qquad (18$$

$$\frac{\delta\pi_2}{\delta p_2} = \frac{2p_2 - p_1 - 2t(x_2 - x_1) + t(x_2^2 - x_1^2)}{2t(x_1 - x_2)} = 0, \qquad (19$$

yielding

$$p_1^* = p_2^* = t(x_1 - x_2)(x_1 + x_2 - 2) \qquad (20$$

as the equilibrium prices (cfr. Cremer et al., 1991). The objective functions at the location stage look as follows:

$$SC_1^D = \frac{t}{12}(4\alpha^3 + 3x_1^3 - 12\alpha^2 x_2 + 3x_1^2 x_2 + 12\alpha x_2^2 - 3x_1 x_2^2 - 3x_2^3), \quad (21$$

$$\pi_2 = \frac{t}{12}(x_1 + x_2)(x_1 + x_2 - 2)^2. \quad (22$$

The FOCs relative to the location stage are:

$$\frac{\delta SC_1}{\delta x_1} = \frac{t}{4}(x_1 + x_2)(3x_1 - x_2) = 0, \quad (23$$

$$\frac{\delta \pi_2}{\delta x_2} = \frac{t}{2}(3x_2 - x_1 - 2)(x_1 + x_2 - 2) = 0. \quad (24$$

By checking the second order conditions, it appears that the equilibrium is given by ($x_1^* = 1/4$; $x_2^* = 3/4$), while demands are $y_1^* = y_2^* = 1/2$. Finally, equilibrium profits are $\pi_1^* = \pi_2^* = t/4$, and the total transportation costs incurred by consumers of country 1 is $SC_1^{D*} = t\left(\frac{1}{64} + \frac{(\alpha - 3/4)^3}{3}\right)$, while those incurred by country 2 are $SC_2^{D*} = t\left(\frac{1}{192} - \frac{(\alpha - 3/4)^3}{3}\right)$, so that while tho opening of trade is advantageous for country 1, it is not for country 2. Nevertheless, global transportation costs are being minimized, corresponding to $t/48$, and it is easily verified that $SC_1^{D*} + SC_2^{D*} < SC_1^{A*} + SC_2^{A*}$, so that market integration coupled with side payments between the two countries would lead to a substantial Pareto-improvement. Notice that these results coincide with those obtained by Cremer et al. (1991, p.49) for a mixed spatial duopoly in a single country, in which the public firm minimizes total transportation costs. This means that the presence of a public firm minimizing the transportation costs incurred by a small number of consumers actually being served by the other firm is sufficient to reach the globally efficient locational configuration.[5]

5. Notice that this perspective requires $\alpha > 1/2$. If $\alpha < 1/2$, the objective function of the public firm becomes the integral of transportation costs for country 1 as in expression (7) above.

5. Tariff vs taxation in a private duopoly

Let us now turn to the private duopoly setting. The behavior of private duopolists under free trade is well known:[6] both locate outside the global market, in x_1=-1/4 and x_2=5/4, respectively. This implies that if both firms are private, the opening of trade lowers welfare, i.e., increases total transportation costs in both countries. As we have seen in the previous section, the global social transportation costs incurred by the two countries can be minimized under free trade if the private firm exports to the larger country, which is partially being served by a public firm. We may now ask ourselves if and under which conditions this result may be achieved under a private duopoly regime. If country 1 is larger ($\alpha > 1/2$), firm 2 exports to country 1 and the government of the latter may be induced to introduce a tariff aiming both at protecting the domestic (private) firm and at reducing the social cost to the level attainable if the firm were publicly held. In such a case, the price set by firm 2 in country 1 is now $p_2(1+\tau)$, where $\tau > 0$ is the tariff. Solving the game, we obtain that the equilibrium level of social transportation cost is

$$SC_1^{D*}(\tau) = \frac{t(16\alpha^3 - 60\alpha^2 + 75\alpha - 18 + 21\alpha\tau + 30\alpha^2\tau - 12\alpha^3\tau + 36\alpha^2\tau^2 + 3\alpha^3\tau^2 + 13\alpha^3\tau^3)}{48(1+\tau)^3} \quad (25$$

The relevant comparison is between (25) and (17), that is

$$\Delta SC_1^{D*} = t\left(\frac{1}{64} + \frac{(\alpha - 3/4)^3}{3}\right) -$$

$$\frac{t(16\alpha^3 - 60\alpha^2 + 75\alpha - 18 + 21\alpha\tau + 30\alpha^2\tau - 12\alpha^3\tau + 36\alpha^2\tau^2 + 3\alpha^3\tau^2 + 13\alpha^3\tau^3)}{48(1+\tau)^3} \quad (26$$

Numerical computation shows that[7]

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6. See Lambertini (1993a) and Tabuchi and Thisse (1993).

7. Resorting to the same technique, it can also be verified that $SC_1^{A*} - SC_1^{D*}(\tau) < 0$

$$\Delta SC_1^{D*} < 0 \quad \forall \alpha \in]1/2, 1[, \quad r \in [0, \infty[; \qquad (27$$

Since the introduction of a tariff cannot mimic the performance of a public firm, some alternative device may be adopted. Lambertini (1993b) shows that appropriate taxation may induce private firms to locate at the (globally) socially efficient positions, minimizing the sum of the transportation costs incurred by the two countries. The tax burden is increasing in the distance between the locations noncooperatively chosen by firms and the generic starting point set by the authorities, j_i, so that the profit functions look as follows:

$$\pi_i = p_i y_i - k(j_i - x_i)^2, \quad i = 1, 2, \quad j \in [0, 1/2]. \qquad (28$$

The governemnts' problem consists in defining the appropriate valus of k and j_i in order to induce firms to locate in 1/4 and 3/4, respectively. Solving the first stage of the game, we obtain:

$$x_1^* = j_1 - \left(j_1 - \frac{1}{4}\right)\left(\frac{t}{3k + t}\right); \quad x_2^* = 1 - x_1^2, \quad j_2 = 1 - j_1, \qquad (29$$

so that

$$x_1^* = \frac{1}{4}; \quad x_2^* = \frac{3}{4} \quad iff \quad \frac{k}{t} = \frac{2}{3(4j_1 - 1)}. \qquad (30$$

Notice that the ratio k/t exhibits a hyperbolic behavior and is everywhere decreasing in j_1; this implies that if $j_1 \in [0, 1/4[$ firms receive a subsidy, while they are being taxed if $j_1 \in]1/4, 1/2]$. The choice between tax and subsidy by the governments of the two countries clearly depends on factors external to the model. Given the optimal choice of k, we have

$$SC_1^{D*} = t\left(\frac{1}{64} + \frac{(\alpha - 3/4)^3}{3}\right); \quad SC_2^{D*} = t\left(\frac{1}{192} - \frac{(\alpha - 3/4)^3}{3}\right), \tag{31}$$

which coincide with the transportation costs respectively incurred by the two countries under the mixed duopoly regime in which the public firm operates in the larger country (cfr. above, eqs. 17-24). Notice, furthermore, that this result holds independently of the relative size of the two countries as well as the direction of the trade flow. Given the size of each country's transportation costs, country 1 is incentived to adopt a free trade regime, while country 2 is not; nevertheless, since the gain accruing to country 1 is larger than the loss suffered by country two,

$$\Delta SC_1^{D-A} + \Delta SC_2^{D-A} = \frac{(2\alpha - 1)^2 t}{16} > 0 \quad \forall \alpha \neq 1/2, \tag{32}$$

a side payment from country 1 to country 2, coupled with the harmonization of the fiscal regime, is sufficient to ensure that both countries benefit from trade.

6. Conclusions

The consequences of free trade on welfare in a spatial market in which two firms operates in two different countries have been analysed. The implications of the property structure have also been stressed. Generally, the incentives to the opening of trade are opposite for the two countries, unless both firms are publicly held, a case in which the larger country benefits from free trade, while the smaller one is indifferent between the two regimes.

The analysis carried out in section 5 points to the adoption of a regulated private duopoly regime. The introduction of a tariff is uneffective, being unable to restore the welfare levels associated with both autarky and the mixed duopoly regimes, while the adoption of a taxation/subsidy scheme under which both firms are induced to choose the globally optimal locations appears optimal, provided that both governments set the same tax rate and side payments between the two countries are possible.

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