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Firm Location, Trade and Economic Integration

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Abstract

The aim of this paper is to analyse how a process of economic integration between two adjacent countries with different transport costs (different levels of development) affects firms' decisions on location and prices. Considering the situation where one firm is located in each country and manufactures a product that is imported by the more developed country, we find that when there are barriers to trade one of the firms tends to locate on the common frontier and the other at the far extreme. By contrast, with full economic integration, both firms tend to maximise differentiation, locating themselves at the non-neighbouring extremes, which leads to higher prices and profits. Therefore, the firm located in the more developed country increases its market share.

- **JEL Classifications:** F150, L130, R320
- **Key Words:** Market Integration, Price-Location Competition, Transport Costs

I. Introduction

During recent years we have seen how a number of regions have undergone a very significant process of economic integration, with the most spectacular case being that of the European Union. Here, the then twelve *EU* Member States implemented a single market by way of the Single European Act, which came into force in 1987. This legislation provided for the gradual elimination up to 1992 of many of the barriers that had previously acted as a limitation to trade, even though these countries were already formed into a free trade area. Currently, what are now

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the fifteen *EU* Member States are immersed in the subsequent phase of integration, that is to say, the introduction of Economic and Monetary Union (EMU), which has supposed the creation of the European Central Bank and a single currency -the Euro- with the initial participation of eleven countries. Other important trade agreements which can be cited in this regard are the North-American Free Trade Agreement (NAFTA), which is made-up of the USA, Canada and Mexico; the ASEAN in the Asia-Pacific area; and Mercosur in South-America.

Economic integration processes are normally established between adjacent countries which usually have different levels of development and high levels of trade with each other. It is obvious that a programme of full economic integration, such as that being pursued by the *EU* Member States, leads not only to the elimination of trade barriers, but also to a process of real convergence as regards infrastructures, production technologies, standards of living, etc. between the countries participating in it. This is a phenomenon that can be observed, for example, in Spain, Portugal or Ireland following their respectives entries into the European Union. Against that background, one interesting question to be analysed is the effects of an economic integration process on the location and price decisions taken by firms. Specifically, we concentrate on those firms that make products which are imported by more developed countries. These products give rise to more problems for such countries when economic integration processes are being implemented, by virtue of their fear of losing market share following the elimination of trade barriers. Here, we can cite the example of agricultural products in the European Union.

Whilst the literature on international trade has allowed for the existence of space between countries, it would appear to have ignored that of space within them. Recently, a number of authors have tried to correct this deficiency using spatial models. Their use has demonstrated that the results from non-spatial models can be invalid in the circumstances where transport costs are important. Thus, Benson and Hartigan (1983) showed that a tariff (import duty) could induce the domestic firm to lower its mill price (the Metzler paradox). In a subsequent work (1984), these authors also demonstrated that the same result could be obtained if an import quota was considered in place of a tariff. For their part, Porter (1984) and Schöler (1990) illustrated how in certain situations, tariffs could lead to positive effects on welfare.

All these models consider two adjacent countries represented spatially by a line, with a frontier represented by a point that determines the size of each of them and with the firms located at the extreme ends of that line. They are based on the Löschian approximation with elastic demands and given locations, which has therefore prevented any analysis of the effects of international trade, tariffs and other barriers on the location of the firms within these countries. However, these aspects can be analysed if consideration is given to the approximation of Hotelling (1929)[1]. In this line, Martín-Arroyuelos and Usategui (2000), considering a single firm and linear transport costs, analyse the effects of differences in the quality of infrastructures and in income levels between two adjacent countries, together with a free trade agreement between the two countries, on the location of the firm and its optimum plant size. They determine the circumstances where a free trade agreement may induce a change in the optimum location of the firm from the country with lower transport costs to that with higher transport costs, or vice-versa.

Our study is placed in a similar context, but now considering two firms, one located in each country, which allows us to analyse competition in prices and locations. Our first objective is to analyse the effects of international trade, assuming the existence of trade barriers (import duties, and where the firm can only locate in its own country), on the location of the firms and on the prices in two adjacent countries, considering a product that is imported by the more developed country. Subsequently, we analyse how a process of full economic integration, involving the elimination of all barriers and with real convergence, affects the firms decisions on location and prices.

To that end, we use the spatial approximation of Hotelling with quadratic transport costs. We consider two adjacent countries with different transport costs resulting from their dissimilar geographical characteristics, and with distinct transport infrastructures[2] reflecting their level of economic development. In fact, this is a phenomenon that can be observed with respect to a number of European countries: for example, France and Spain; East and West Germany prior to their

[1]Another approach for analysing the location of the firms in a context of economic integration is offered by Venables (1995). This author uses the model of Dixit and Stiglitz (1977) that considers two locations with a number of firms in each location that allows us to analyse whether or not the firms concentrate. In this model, the locations are given and the firm decides its location in one or the other.

[2]The role of infrastructure on the volume of trade is analysed in Bougheas, Demetriades and Morgenroth (1999). These authors in their model predict a positive relacionship between the level of infrastructure and the volume of trade and offer empirical evidence with data from European countries. The impact of public infrastructure on industrial location can be seen in Martin and Rogers (1995). Other public policies that affect firms' location decisions, considering adjacent countries, are analysed in Holmes (1998)

reunification; and, in general, between the countries of Eastern Europe and those of the European Union, such as Germany and the Czech Republic, Austria and Hungary or Italy and Slovenia. Similarly, it applies to various countries on the American continent, for example the USA and Mexico. At a later stage, when full economic integration is considered, it is assumed that the transport costs are equal in the two countries.

We obtain different results with respect to the location of the firms. In the case of barriers to trade, we find that the firm which exports will tend to locate itself on the frontier of both countries, whilst the other firm differentiates itself from its rival to the maximum extent and locates at the other extreme of the country. The analysis of industrial location in different countries and/or regions with differing transport costs, where these depend on their respective levels of economic development, allows us to identify a number of examples that support this result. These examples appear to confirm that the firms tend to locate in the country with the lower level of development, on the frontier with the more developed country or region. Thus, if we consider the USA and Mexico, we can note how many Mexican firms tend to locate on the frontier with the USA. Similarly, in Spain we can observe a concentration of industrial location in the North-eastern quadrant, on the frontier with France, whilst in the case of Italy we can also note a tendency for firms to locate on its Northern frontier with the rest of the *EU*.

However, when we turn our attention to full economic integration, we find that the location changes. In this case, the firms tend to locate as far away from one another as possible at the non-neighbouring extremes of the countries -in such a way that the principle of maximum differentiation is complied with- in order to avoid competition in prices. Therefore, the firm located in the more developed country increases its market share.

The rest of the paper is organised as follows. The model is presented in Section II. Section III is devoted to an analysis of competition in location and prices under two scenarios, namely with full economic integration and without it. Section IV summarizes the results.

II. THE MODEL

We develop a version of the D'Aspremont, Gabszewicz and Thisse (1979) model, characterized by the following assumptions:

A. Markets

Let us consider a linear market of length 2 which extends over two countries A and *B*.

Country A takes up from 0 to 1 and country B occupies from 1 to 2. Thus, 1 represents the frontier between the two countries and they have equal size.

The goods produced in each of these two countries can be destined either to internal or external consumption. Prior to integration, foreign sales are subject to a specific trade barrier l_i (i= A,B) (for example, an import duty).

B. Firms

There are two firms, which produce the same good and which are differentiated solely by their location.

The firm belonging to country A is situated at a distance “a”, whilst the firm belonging to country *B* is located at a distance “b”, with both distances being measured from the left extreme of the interval [0,2].

Without economic integration, each firm chooses a location in the domestic market alone, in such a way that $a\in [0,1]$ and $b\in [1,2]$. Therefore, the frontier acts as a barrier to location, in the sense that the firms cannot locate in the foreign country.

With economic integration there are no barriers to the location of the firms.

Furthermore, there are no production costs and the location, once chosen, remain fixed. Each firm first decides on location, and subsequently selects a nondiscriminatory (f.o.b.) mill price, p_i, to maximise profits, Π_i (i=a,b).

C. Consumers

The consumers are uniformly distributed throughout the length of the interval [0,2] and with density equal to one.

Each consumer buys one unit of the good if the sum of the price and the transport cost is lower than or equal to the reservation price, and zero otherwise.

We consider a reservation price, common for all consumers and sufficiently high for the market to be covered.

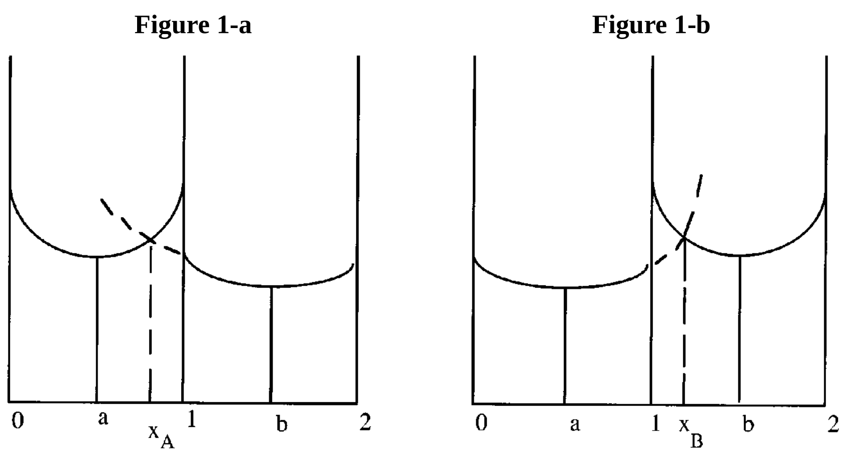
Let t_i, be the per unit of distance cost to transport one unit of the good in country i (i=A,B). We assume quadratic transport costs. Initially, without economic integration, we assume that $t_B > t_A$, in such a way that a consumer X who lives in country A and who buys the product from a firm situated in country *B* and, specifically, located in *Z* and where the frontier is represented by *Y*, incurs the following transport costs: $t_A(X–Y)^2 + t_B(Z–Y)^2$. In this case ,the space is not homogeneous and the transport cost from *X* to *Z* will be given by the total of the transport cost from *X* to the frontier, with this corresponding to country *A*, plus the transport cost from this frontier to *Z*, with this corresponding to country *B*. The following example illustrates what we have just said. *A* consumer living in country *A* takes a taxi from his location to the frontier. This taxi does not have a licence to operate in the other country, and therefore in country *B* the consumer has to take another taxi, which has different fares, from the frontier to the location of the firm in country B. Subsequently, we consider a situation of full economic integration, with the elimination of all barriers and real convergence, in such a way that the countries have equal transport costs *t*, specifically those corresponding to country *A*, $t_A = t$. In this case, the space is homogeneous and, considering the earlier example, the consumer can travel in the same taxi from his location to that of the firm.

III. Analysis

A. Without Economic Integration

Let x_A be the location of the consumer who belongs to country A and who is indifferent as between purchasing the unit of product from firm a or *b* (see Figure 1-a). Formally:

Figure 1. Location of marginal consumers



$$p_a + t_A\,(x_A - a)^2 = p_b + t_A\,(1 - x_A)^2 + t_B\,(b - 1)^2$$

from which we obtain the expression:

$$x_A = \frac{p_b - p_a}{2t_A(1-a)} + \frac{t_B(b-1)^2}{2t_A(1-a)} + \frac{1+a}{2} \tag{1}$$

By analogy, x_B denotes the location of the consumer belonging to country B who is indifferent as between both firms (see Figure 1-b). Formally:

$$x_B = \frac{p_b - p_a}{2t_B(b-1)} - \frac{t_A(1-a)^2}{2t_B(b-1)} + \frac{1+b}{2} \tag{2}$$

From (1) and (2) we can obtain the demand functions of the firms:

$$D_a(p) = \begin{cases} 0 & if\ p_a > p_a^{max} \\ \dfrac{P_b - P_a}{2t_A(1-a)} + \dfrac{t_B(b-1)^2}{2t_A(1-a)} + \dfrac{1+a}{2} & if\ p_a^{max} \geq p_a > \tilde{p}_a \\ \dfrac{P_b - P_a}{2t_B(t-1)} - \dfrac{t_A(1-a)^2}{2t_B(b-1)} + \dfrac{1+b}{2} & if\ \tilde{p}_a \geq p_a > p_a^{min} \\ 2 & if\ p_a^{min} \geq p_a \end{cases}$$

where,

$$\tilde{p}_a = p_b + t_B(b-1)^2 - t_A(1-a)^2$$

$$p_a^{max} = p_b + t_B(b-1)^2 + t_A(1+a)(1-a)$$

$$p_a^{min} = p_b - t_B(b-1)(3-b) - t_A(1-a)^2$$

$$D_b(P) = \begin{cases} 0 \quad if\ p_b > p_b^{max} \\ 2 - x_B \quad if\ p_b^{max} \geq p_b > \tilde{p}_b \\ 2 - x_A \quad if\ \tilde{p}_b \geq p_b > p_b^{min} \\ 2 \quad if\ p_b^{min} \geq p_b \end{cases}$$

where,

[3]The profits functions are not quasi-concave in prices, and therefore we cannot guarantee the existence of a perfect equilibrium in sub-games. As a result, we analyse the equilibrium in prices(candidate) and determine the location tendencies. Considering these tendencies, we then determine the Nash equilibrium in prices.

$$\tilde{p}_b = p_a - t_B\,(b-1)^2 + t_A\,(1-a)^2$$

$$p_b^{max} = p_a + t_B\,(3-b)(b-1) + t_A\,(1-a)^2$$

$$p_b^{min} = p_a - t_B\,(b-1)^2 - t_A\,(1+a)(1-a).$$

Consequently, the profit functions[3] will take the following form:

$$\Pi_a(p) = \begin{cases} 0 \; if \; p_a > p_a^{max} \\ p_a\left(\dfrac{p_b - p_a}{2t_A(1-a)} + \dfrac{t_B(b-1)^2}{2t_A(1-a)} + \dfrac{1+a}{2}\right) if \; p_a^{max} \ge p_a > \tilde{p}_a \\ (p_a - 1_B)\left(\dfrac{p_b - p_a}{2t_B(b-1)} - \dfrac{t_A(1-a)^2}{2t_B(b-1)} + \dfrac{1+b}{2}\right) + 1_B \; if \; \tilde{p}_a \ge p_a > p_a^{min} \\ 2p_a - 1_B \;\; if \;\; p_a^{min} \ge p_a \end{cases}$$

$$\Pi_b(p) = \begin{cases} 0 \; if \; p_a > p_a^{max} \\ p_a\left(\dfrac{p_a - p_b}{2t_B(b-1)} + \dfrac{t_A(1-a)^2}{2t_B(b-1)} + \dfrac{3-b}{2}\right) if \; p_b^{max} \ge p_b > \tilde{p}_b \\ (p_b - 1_A)\left(\dfrac{p_a - p_b}{2t_A(1-a)} - \dfrac{t_B(b-1)^2}{2t_A(1-a)} + \dfrac{1+a}{2}\right) + p_b \; if \; \tilde{p}_b \ge p_b > p_b^{min} \\ 2p_a - 1_A \;\; if \;\; p_b^{min} \ge p_b \end{cases}$$

Price Competition

Each duopolist establishes a mill price that maximises its profit, with the price and location of its competitor being considered as fixed.

We shall consider the following price dominion:

$$D_{i0} = \{\tilde{p}_i\}$$

$$D_{i1} = \{p_i / p_i^{max} \ge p_i > \tilde{p}_i\}$$

$$D_{i2} = \{p_i / \tilde{p}_i > p_i \ge p_i^{min}\} \; \forall \; i = a, b$$

In these circumstances, we can state the following lemma.

Lemma 1:

With the exception of autarky, the price equilibrium $(p_a^*; p_b^*)$, if it exists, can only belong to the dominion, $p_a^* \in D_{a1}$ and $p_b^* \in D_{b2}$ or $p_a^* \in D_{b2}$ and $p_b^* \in D_{b1}$

Proof:.

Once we exclude the autarky equilibrium, i.e. $(\tilde{p}_a, \tilde{p}_b)$ there are four possible combinations:
(i) $p_a^* \in D_{a1}$ and $p_b^* \in D_{b1}$
(ii) $p_a^* \in D_{a2}$ and $p_b^* \in D_{b2}$
(iii) $p_a^* \in D_{a2}$ and $p_b^* \in D_{b1}$
(iv) $p_a^* \in D_{a1}$ and $p_a^* \in D_{b2}$

It can easily be confirmed that cases (i) and (ii) imply a contradiction.

Hence, we are left with cases (iii) and (iv). These correspond to situations where one country imports, while the other exports.

Given that we are interested in the products that are imported by more developed countries, let us consider the case where firm b exports to country A. In this situation the following proposition is established:

Proposition 1:

If firm b exports to country A and firm a supplies only one part of its domestic demand, the candidate Nash price equilibrium is given by:

$$p_a^* = \frac{t_B(b-1)^2 + t_A(1-a)(5+a) + l_A}{3};\; p_b^* = \frac{t_A(1-a)(7-a) - t_B(b-1)^2 + 2l_A}{3}$$

if the condition: $t_B\,(b–1)^2 – t_A\,(1–a)^2 + l_A < 0$ holds.

Proof:

The relevant sections of the profits functions are:

$$\Pi_a = p_a\left(\frac{p_b - p_a}{2t_A(1-a)} + \frac{t_B(b-1)^2}{2t_A(1-a)} + \frac{1+a}{2}\right)$$

$$\Pi_b = (p_b - l_A)\left(\frac{p_a - p_b}{2t_A(1-a)} - \frac{t_B(b-1)^2}{2t_A(1-a)} + \frac{1-a}{2}\right) + P_b$$

The first order maximization conditions define the corresponding system of equations formed by the reaction functions, whose resolution defines the price levels:

$$p_a^* = \frac{t_B(b-1)^2 + t_A(1-a)(5+a) + l_A}{3};\; p_b^* = \frac{t_A(1-a)(7-a) - t_B(b-1)^2 + 2l_A}{3}$$

The said equilibrium will constitute an interior solution always provided that

$$p_a^{max} \geq p_a^* > \tilde{p}_a y \tilde{p}_b > p_b \geq p_b^{min},$$

which results in the satisfaction of the inequality: $t_B(b-1)^2 - t_A(1-a)^2 + l_A < 0$ (3)

Location Tendencies

Substituting the prices equilibrium in the corresponding expressions of the profits functions, we obtain these functions in terms of the locations and the import duties fixed by the government of the importing country.

The profits of the firm will be given by:

$$\Pi_a = \frac{[(1-a)(5+a)t_A + (b-1)^2 t_B + l_A]^2}{18(1-a)t_A};$$

$$\Pi_b = \frac{[(1-a)(7+a)t_A + (b-1)^2 t_B + l_A]^2}{18(1-a)t_A} + l_A$$

Differentiating the profits function of each firm with respect to its location, and always provided that the necessary condition for the existence of equilibrium in prices, expressed in (3), is satisfied, we obtain:

$$\frac{\partial \Pi_a}{\partial a} = \frac{[(1-a)(5+a)t_A + (b-1)^2 t_B + 1_A] \times [(b-1)^2 t_B + 1_A - 3(1+a)(1+a)t_A]}{18(1-a)^2 t_A} < 0,$$

$\frac{\partial \Pi_b}{\partial b} = \frac{-2(b-1)t_B[(1-a)(7-a)t_A - (b-1)^2 t_B - l_A]}{9(1-a)t_A} \leq 0$. Note that this derivative will be equal to zero only if b=1.

Therefore, the firm located in country A will try to differentiate itself to the maximum from its rival, reaching the lower extreme of the market, $a^* = 0$. By contrast, firm b will try to capture the maximum market share, locating itself as close as possible to its competitor. This implies that its optimum location is found on the frontier between both countries, $b^* = 1$. The exporting firm tends to locate itself on the frontier, whilst the other firm tends to locate as far away as possible from its rival.

Furthermore, introducing these locations in condition (3), we determine the upper limit of the import duty, with $l_A < t_A$.

Proposition 2:

When the firm belonging to the importing country is located at the lower extreme of its market and the firm located in the other country fixes its location on the frontier, we have that:

(i) if $\frac{3l_B - 2l_A}{4} \geq t_A > l_A$, or

(ii) if $t_A > \frac{3l_B - 2l_B}{4}$ and where the inequality $(5t_A + l_A)^2 \geq 6t_A(8t_A + 4l_A - 3l_B)$ is satisfied, there is a Nash prices equilibrium defined by $[P_a^*, P_b^*] = \left[\frac{5t_A + l_A}{3}; \frac{7t_A + 2l_A}{3}\right]$:

Proof:

See the Appendix.

Note that the equilibrium price fixed by the exporting firm is higher than the price fixed by the other firm.

B. With Economic Integration

We now consider a situation of full economic integration, with the elimination of all barriers and real convergence, in such a way that the two countries have equal transport costs (t), specifically, those corresponding to country A, $t_A = t$.

Proposition 3:

With full economic integration the firms locate at the non-neighbouring extremes, differentiating themselves to the maximum from their rival ($a^{**} = 0$, $b^{**} = 2$) and the Nash equilibrium in prices is given by $p_a^{*} = p_b^{**} = 4t$.

Proof:

See D'Aspremont, Gabscewicz and Thisse (1979), considering that the length of the line is 2.

In this case, the demand and the profits functions are concave and there is a perfect equilibrium in sub-games given for the locations $a^{**} = 0$, $b^{**} = 2$ and for the prices, $p = 4t$, $p = 4t$. The demand of each firm is equal to 1 and the profit is equal to the price. Furthermore, the firm located in the importing country does not lose market share, but rather increases it. By contrast, the other firm does lose market share but, we will see in the following proposition, its profit increase.

Note that the convergence process implies equal prices in the two countries.

Proposition 4:

With full economic integration the prices and profits of the firms are higher than without economic integration.

Proof:

From the comparison of prices and profits, considering the condition $1_A < t_A$, we can easily show that $p_i^* < p_i^{**}$ and $\Pi_i^* < \Pi_i^{**}$ for $i = a, b$.

With full economic integration, and due to the greater differentiation, competition in prices is lower and implies higher prices and profits than in the case where there is no integration.

IV. Conclusions

In this paper we have analysed competition in both location and prices between two firms situated in two adjacent countries and which make a product that is imported by the more developed country. We have first assumed that there is no economic integration, in the sense that there are import duties, a frontier that supposes a barrier to the location of the firms and different transport costs (different levels of development) in each country. Subsequently, we have assumed a process of full economic integration between the countries that leads to the elimination of the import duties and of the barriers to location, as well as to convergence in transport costs.

The results make clear that the location of the firms is affected by the process of economic integration. Thus, when there are barriers to trade, the firm that exports tends to locate itself on the frontier between both countries, whilst the other firm locates at the far extreme of its country. By contrast, in the case of full economic integration, the firms tend to locate as far away from one another as possible at the non-neighbouring extremes, under the principle of maximum differentiation, in order to avoid competition in prices. As a consequence, the prices with economic integration are higher than without it, whilst such a process results in the firms' profits increasing, as compared to the situation where there are barriers to trade. Furthermore, for the firm located in the more developed country, the process of economic integration leads to an increase in its market share.

V. Appendix

Proof of Proposition 2:

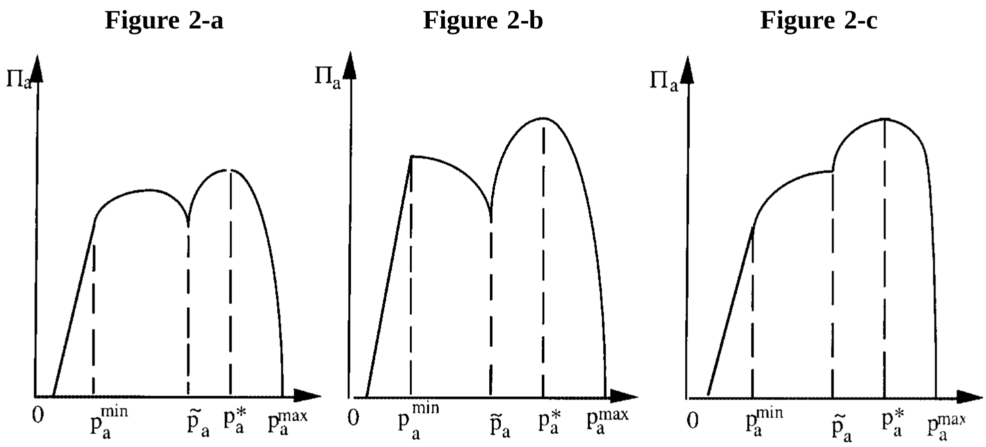
The existence of the Nash equilibrium in prices will be assured when neither of the firms has any incentive to unilaterally deviate from the non-cooperative solution, given the level of prices fixed by its rival. In other words, we must establish the set of conditions for which the chosen price strategy constitutes a global maximum in the profits function of each firm.

Let us begin the analysis from the point of view of firm a. Maintaining the duopolist price b at level p_b^*, if that duopolist locates itself in the section of demand corresponding to the situation in which it exports, it should maximise the profits function:

$$\hat{\Pi}_a(\hat{p}_a, p_b^*) = (\hat{p}_a - l_B)\left(\frac{p_b^* - \hat{p}_a}{2t_B(b-1)} - \frac{t_A(1-a)^2}{2t_B(b-1)} + \frac{1+b}{2}\right) + l_B$$

The first order condition $\frac{\partial\hat{\Pi}_a}{\partial\hat{p}_a} = 0$, defines the price fixed by the firm located in country A, where:

Figure 2. Profits of Firm a



$$\hat{p}_a = \frac{p_b^* + l_B - t_A(1-a)^2 + t_B(b-1)(1-b)}{2}$$

In order for that price to represent an interior solution, the condition $\tilde{p}_a \geq \hat{p}_a > p_a^{min}$ must be verified. Substituting p_b^* for its value, we obtain the expression:

$$2t_A(1-a)(2+a)-2t_B(b-1)(10-b) \leq 3l_B - 2l_A < 2t_A(1-a)(2+a)-2t_B(b-1)(4-b) \quad (4)$$

Under the compliance of (4), the existence of a global maximum for firm a in the prices interval in which only one part of the national market is captured (see Figure 2-a), is given by:

$$\frac{[(1-a)(5+a)t_A + (b-1)^2 t_B + l_A]^2}{18(1-a)t_A} \geq$$

$$\frac{[2t_A(1-a)(2+a) + 2t_B(b-1)(2+b) + 2l_A - 3l_B]^2}{72t_b(b-1)} + l_B \quad (5)$$

Assuming that (4) is not satisfied, and as can be appreciated in Figures 2-b and 2-c, respectively, the sufficient condition of existence will be given by:

$\Pi_a(p_a^*;p_b^*) \geq \Pi_a(p_a^{min}, p_b^*),\ if\ \hat{p}_a < p_a^{min}$, which correspond to the expressions:

$$\frac{[(1-a)(5+a)t_A-(b-1)^2t_B+l_A]^2}{18(1-a)t_A} \geq$$
$$\frac{2[t_A(1-a)(2+a)-2t_B(b-1)(4+b)]+4l_A-3l_B}{3} \qquad (6)$$

and $3l_B$-$2l_A < 2t_A(1–a)(2+a)–2t_B(\mathrm{b}–1)(10–b)$ (7)

whilst if $\hat{p}_a \geq \tilde{p}_a$ the condition of existence of a global maximum is assured and corresponds to the expression:

$$3l_B–2l_A \geq 2t_A(1–a)(2+a)–2t_B(b–1)(4–b) \qquad (8)$$

We shall apply a similar reasoning from the point of view of firm b. Maintaining the price of firm a at the equilibrium level p_a^*, if the firm located in country *B* decides to supply one part of its national market, it would try to maximise the section of its profit function:

$$\hat{\Pi}_b(p_a^*,\hat{p}_b) = \hat{p}_b\left(\frac{p_a^*-\hat{p}_b}{2t_B(b-1)}+\frac{t_A,(1-a)^2}{2t_B(b-1)}+\frac{3-b}{2}\right)$$

The first order maximisation condition determines the price fixed by the firm,

$$\hat{p}_b = \frac{p_a^*+t_A(1-a)^2+t_B(b-1)(3-b)}{2}$$

This price will constitute an interior solution always provided that the relation: $p_b^{max} \geq \hat{p}_b > \tilde{p}_b$ is verified. Introducing the expression of the price p_a^*, we deter-

Figure 3. Profits of Firm b

Figure 3-a

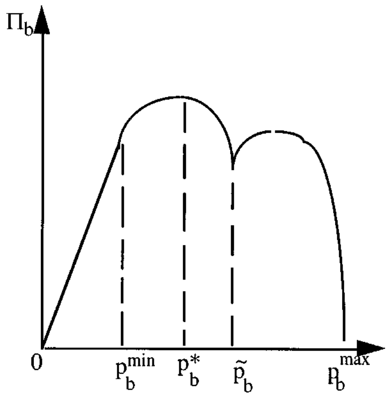
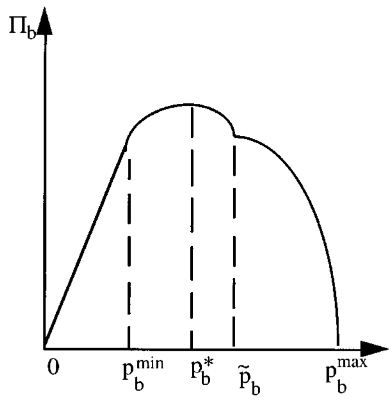


Figure 3-b



mine the inequality:

$$l_A - 2t_B(b-1)(2+b) + 2t_A(1-a)(4-a) < 0 \tag{9}$$

If this inequality holds, as we can see in Figure 3-a, then the existence of a global maximum in p_b^* will be given by the condition:

$$\frac{[(1-a)(7-a)t_A - (b-1)^2 t_B - l_A]^2}{18(1-a)t_A} + l_A \geq \frac{[2t_B(b-1)(4-b) + 2t_A(1-a)(4-a) + l_A]^2}{72t_B(b-1)} \tag{10}$$

If (9) is not satisfied, in such a way that $\hat{p}_b$ is not an interior solution (see Figure 3-b), then, given the continuity of the profits function, the existence of a global maximum in p_b^* is assured.

Substituting the locations in the conditions for the existence of equilibrium in prices relative to firm a, we can easily note that condition (4) is not complied with, from which we can deduce that the existence of a global maximum will be given by the inequalities (7) and (8).

Concentrating on the first of these, we have that if $t_A > \frac{3l_B - 2l_A}{4}$, the condition of a global maximum of the profits function in the section corresponding to the situation where that firm only supplies one part of its market will be determined by compliance with inequality (6):

$$(5t_A + l_A)^2 \geq 6t_A(8t_A + 4l_A - 3l_B)$$

By analogy, in accordance with conditions (3) and (8), if $l_A < t_A \leq \frac{3l_B - 2l_A}{4}$, the necessary and sufficient conditions for the existence of equilibrium in prices is perfectly assured.

Applying a similar reasoning to firm *b*, we have that for such locations inequality (9) is not satisfied, from where we can deduce the existence of a global maximum of the profits function in the interval corresponding to the situation where the firm exports to country *A*.

Finally, introducing the locations in the equilibrium prices we have:

$$p_a^* = \frac{5t_A + l_A}{3}, \quad p_b^* = \frac{7t_A + 2l_A}{3}$$

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