Revisiting "On Nations' Size and Transportation Costs"*

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Abstract

In international trade as well in the "New Economic Geography", country size is represented solely by the size of the country's population. A notable exception is the paper by Shachmurove and Spiegel (1995). Applying the Hotelling model to international trade and using the geographical interpretation of the Hotelling line, the authors propose a model where countries differ not only in population size but also in terms of their geographical extent. However, under certain assumptions on the locations of the firms, a pure strategy Nash equilibrium does not exist. In this paper, an alternative way to circumvent this existence problem and to make the analysis possible is presented. The pure strategy Nash equilibrium is restored by changing the assumption on the pricing policies used by the firms. The analysis indicates that while the small country gains from free trade the overall welfare of the larger country is unaffected by the opening of the border. The analysis is also extended to include a discussion of the long run equilibrium locations of firms in the integrated market. The importance of both the population and the geographical size of the countries are shown to be determining in establishing the effect of free trade.

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1 Introduction

There exists an important strand of literature that looks at the size effects in international trade. Both in the neo-classical and the new trade theories, there are papers dealing with country size differences.[1] The common element of all these models is the fact that they view the size of a country solely as measured by its population. However, the importance of geographical size has been known for quite a while; a model where space matters for the strategic interactions between firms is that of Hotelling (1929).

In Shachmurove and Spiegel (1995), the authors apply the spatial competition model of Hotelling (1929) to international trade. More precisely, they use Hotelling's framework to analyze the effect of the nations' size differences on international trade flows and the welfare effect of free trade. In doing so, they use the original specification for the transport costs, which are assumed to be linear in distance. The free trade situation takes the form of a Nash equilibrium in price in a Hotelling duopoly. To analyze the welfare effects of free trade, the authors discuss the properties of the Nash equilibrium. However, since d'Aspremont *et al.* (1979) it is well known that using linear transport costs a Nash equilibrium in prices will only exist if the locations of the two firms respect certain conditions. In the set-up proposed in Shachmurove and Spiegel (1995), the locations of the two firms do not satisfy these conditions, meaning that they discuss the properties of a Nash equilibrium that does not exist. Nevertheless, their approach is interesting and innovative since they consider country size to be reflected not only by population size, but also by its geographical expanse. While country size plays a role in several theoretical models, very little attention has been given to the discussion of the concept of country size. As will become clear from the analysis, the different dimensions of country size such as total demand, geographical size and population density have different and important welfare implications, and taking them into account raises yet another set of interesting questions. From an empirical point of view, this approach is also interesting since transport cost are likely to significantly influence trade flows: Hummels (1999) provides detailed information on international transport costs and shows that they are still high.

[1] For a discussion on how country size affects the welfare impact of free trade in neo-classical trade models, see Takayama (1972). In the case imperfect competition trade models, there is the model of Krugman (1980) with monopolistic competition. Closer to the analysis done here is the duopoly model of Markusen (1981). Other and more recent examples include papers such as Motta (1992) and Cabrales and Motta (2000).

Therefore, I propose to revisit Shachmurove and Spiegel's model and offer a possible correction that makes the analysis possible. This is done by modifying the assumption on the pricing policies that both firms use. When firms use discriminatory pricing, then a Nash equilibrium always exists. There are both theoretical as well as empirical reasons for assuming that firms use discriminatory pricing rather than mill pricing. Thisse and Vives (1988) show in a theoretical model that discriminatory pricing emerges as the equilibrium pricing policy while Phlips (1983) and Greenhut (1981) provide evidence that in a number of industries discriminatory pricing rather than mill pricing is used by firms.

Within this framework, I extend the analysis further. First, I introduce country-specific population densities. Assuming that countries not only have different geographical sizes but also have different population densities allows us to distinguish the impact of geographical size from that of total population size on the welfare effect of free trade. The second issue I consider are the location decisions of the firms after the border has been opened. In the short run, the firms do not move because of the importance of the fixed cost. Since in the long run the firms are likely to relocate, this has to be taken into account the welfare analysis of free trade. The analysis shows the importance of both country size dimensions, population size and geographical size, in determining the long run welfare effects of free trade.

This paper is organized as follows. The following section briefly recalls the setting proposed in Shachmurove and Spiegel (1995). It explains why Shachmurove and Spiegel's model cannot be used and proposes to restore the pure strategy Nash equilibrium by assuming that firms use discriminatory pricing instead of mill pricing. Section 3 looks at the welfare effects of free trade in the short run when the firms do not relocate. Section 4 looks at the equilibrium locations of the firms in the long run. In Section 5, the welfare implications of the firms' relocation are analysed. And finally, Section 6 concludes.

2 A Spatial Model of International Trade

2.1 Shachmurove and Spiegel's model

In Shachmurove and Spiegel (1995), the objective is to analyze the effects of country size differences on the welfare effects of free trade. Their model is a modified Hotelling model with

two linear countries. They assume that the countries differ only in terms of size, size h for the small country and size H for the large country. In terms of all other variables, the two countries are identical : both have only one firm in their market which is located at the centre of the market, both have linear transport costs with the same marginal transportation cost, both countries have the same uniform distribution of consumers over the market space, and all consumers share the same finite reservation price. The two countries are contiguous. This means that the integrated market starts at 0; the common border is at h, the firm of the large country is located at $h + H/2$ and the end of the integrated market is located at $H + h$. Graphically, this gives us the following result.

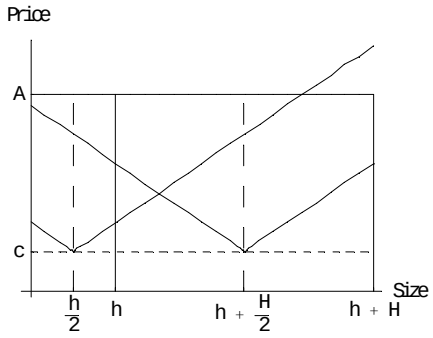

Figure 1: The model

To the best of our knowledge, this is the first time the Hotelling model is applied to analyze international trade to study the impact of countries' geographical size. The shortcomings of the original Hotelling model with its linear transportation costs are well known. One of the major problems, as indicated in the introduction, is that a Nash equilibrium can only exist under certain conditions on the locations which are given in d'Aspremont *et al.* (1979).

The authors summarize the findings of their analysis with the following four propositions. The non-cooperative free-trade Nash (NCFTN) equilibrium price in the small country is higher than the corresponding price in the large country. For the small country, opening the border to free trade may result in an ambiguous price change and welfare effect. The small country producer is not necessarily worse off. The NCFTN equilibrium for foreign consumers who continue to shop in the large country, is higher than the autarky monopoly equilibrium price. International trade causes a decrease in the wedge between prices in the two countries.

2.2 Non-existence of a Nash equilibrium

Hotelling's model was first presented in 1929. At the core of the model was the question of product differentiation in a duopoly: would the two firms prefer to minimize or maximize their differences? To analyze this, Hotelling proposed a two-stage game in which the firms first choose their locations on a line segment and in a second stage compete in prices. His result showed that the firms would rather minimize their differentiation and this result was coined the "Principle of Minimum Differentiation". However, his analysis was flawed: for certain locations close to one another, no Nash equilibrium in prices exists. This was shown in d'Aspremont *et al.* (1979). The explanation and the proof of the non-existence of the Nash equilibrium can be found in the above-mentioned article. The basic intuition is that when the transport costs are linear and locations are close, a firm can find it profitable to undercut the price of its rival and thus obtain the whole market. The authors give conditions on the locations of the two firms for a Nash equilibrium in prices to exist. The conditions can be easily applied to the model of Shachmurove and Spiegel (1995) to show that under their assumptions on the locations, a Nash equilibrium in prices cannot exist. In d'Aspremont *et al.* (1979, p. 1146), the necessary and sufficient conditions for a price equilibrium in a market of length l with firms located at a and $l-b$, are given as:

1. $\left(l+\frac{a-b}{3}\right)^2 \geq \frac{4}{3}l\left(a+2b\right),$
2. $\left(l+\frac{b-a}{3}\right)^2 \geq \frac{4}{3}l\left(b+2a\right)$

In Shachmurove and Spiegel (1995), because $l=h+H$ and the firms are located at $a=h/2$ and $l-b=h+H/2$, the first condition becomes:

$$\left[h+H+\left(\frac{\frac{h}{2}-\frac{H}{2}}{3}\right)\right]^2 \geq \frac{4}{3}\left(h+H\right)\left(H+\frac{h}{2}\right)$$

Rearranging the terms yields the following condition:

$$25h^2-2hH+23H^2 \geq 0$$

It is obvious that this condition is never satisfied for any $h<H$, so that a pure strategy equilibrium does not exist.

2.3 Discriminatory pricing

In their paper, d'Aspremont *et al.* (1979) propose to restore the pure strategy Nash equilibrium in the original Hotelling model by assuming that the transport costs are quadratic rather than linear in distance.[2] Another way to make the analysis possible is to assume that firms use spatial price discrimination rather than mill pricing. Contrary to the approach proposed by d'Aspremont *et al.* (1979), this is not simply a technical change in the model, but pertains to the behaviour of firms. There are several reasons for making this assumption, both theoretical and empirical. From a theoretical point of view, Thisse and Vives (1988) have shown in a non-spatial context that discriminatory pricing rather than mill pricing is the equilibrium pricing policy chosen by firms. Empirically, there is evidence that price discrimination is an important phenomenon in international trade. It has been shown that both the US (Wolf, 1997) and the European (Head and Mayer, 2000) markets are still very much fragmented, giving the possibilities to firms to apply different prices in different markets. The extensive use of anti-dumping measures seems to indicate that international price discrimination is a phenomenon that covers a substantial large of world trade. Comparing different spatial pricing policies that firms use, Greenhut (1981) provides evidence that in countries such as the United States, West Germany and Japan, spatial price discrimination by firms is the rule rather than the exception. And in his book, Phlips (1983) provides evidence that in a number of industries spatial price discrimination is the pricing policy that firms use.

Apart from the difference in pricing policy, another difference with Shachmurove and Spiegel (1995) is that I assume that the population densities in each country are uniform but differ between countries. The population density at location z is given by

$$f(z) = \begin{cases} f_h & \text{if} \quad z \in [0, h] \\ f_H & \text{if} \quad z \in [h, H] \end{cases}$$

This means that the population of the small country is given by hf_h and that of the large country is given by Hf_H.

With spatial price discrimination, firms compete for consumers at each location in space. Since both firms sell the same homogenous good and they compete in prices, the firm quoting

[2] Tharakan and Thisse (2001) use this approach to restore the pure strategy Nash equilibrium in the model of Shachmurove and Spiegel (1995).

the lowest price obtains the whole demand at that location. As it is the case in a Bertrand game, the firm which obtains the whole demand is the firm with the lowest cost. Since by assumption both firms have the same cost of production, the firm with the lowest cost is the firm with the lowest transport cost. At each point demand is inelastic: each consumer buys one unit of the good if the equilibrium price for this good is lower than the reservation price A. The resulting demand for firm i at location z with population density $f(z)$ is given by

$$\begin{aligned} \upsilon_i(z) &= f(z) \text{ if } t|z_i - z| < Min\{t|z_j - z|, A\},\ i = h, H,\ i \neq j \\ &= 0 \text{ otherwise} \end{aligned}$$

When the pricing policy is discriminatory pricing, the profit is obtained by deducting from the sales revenues both the production cost and the cost of transport. The profit of firm i is written as

$$\pi_i = \int_z [p_i(z) - c - t|z_i - z|]\, \upsilon_i(z)\, dz$$

where $p_i(z)$ is the equilibrium price in location z, c is the constant marginal cost of production and t is the unit cost of transport. For simplicity, and without loss of generality, I normalise the geographical size of the small country h as well as the population density of the large country f_H and the marginal cost of transport t is normalised to 1.

3 Trade effects in the short run under discriminatory pricing

To be able to analyze the welfare effects of free trade, I start by looking at the equilibrium in autarky, when both firms are unable to sell to consumers of the other country. This is then compared to the free trade equilibrium in order to derive the welfare effects of opening the border.

3.1 Equilibrium in autarky

In autarky, both firms are monopolists and they can determine for each location a price without having to fear competition. In other words, each firm is able to perfectly price discriminate

among locations and extract the complete consumer surplus. This, of course, means that the consumer surplus is zero. The price equilibrium in autarky is easily characterized. Given that the firm is located at the centre of the market, the equilibrium price schedule is given by:

$$p_l^a(z) = Max\left\{\left|\frac{l}{2} - z + c\right|, A\right\},\ \forall z \in l,\ l = h, H \tag{1}$$

Two possibilities may arise: either all consumers buy the differentiated good or some of them (those located the furthest from the firm) do not consume. To have a base of comparison, the assumption will be that all consumers buy the differentiated good. This means that there are two conditions on the parameters: one for each country. The condition is given by comparing the full price paid by the consumers located the furthest of the domestic firm with the reservation price. For the small country, this condition is

$$\frac{1}{2} + c \leq A$$

and for the large country, it is given by

$$\frac{H}{2} + c \leq A$$

The parameter condition of the large country being more restrictive, this condition shall be adopted as the *full market condition*.

Denote $TC(z_l = z)$ as the total transport cost in autarky when the firm is located at z. The profit for the small country is given by:

$$\begin{aligned} \pi_h^a &= f_h\left(A - TC\left(z_h = 1/2\right) - c\right) \\ &= f_h\left(A - \frac{1}{4} - c\right) \end{aligned}$$

For the large country, this is given by:

$$\begin{aligned} \pi_H^a &= AH - TC\left(z_H = 1 + H/2\right) - cH \\ &= H\left(A - \frac{H}{4} - c\right) \end{aligned}$$

The total surplus is given by the sum of profits made in the country and the consumer surplus. Because the consumer surplus is zero, the total welfare in autarky for both countries is given by the firm's profit:

$$W_h^a = \pi_h^a \quad \text{and} \quad W_H^a = \pi_H^a$$

3.2 Free trade equilibrium

In free trade, the border is opened and both firms compete in prices in the integrated market. Because both firms use delivered pricing, there is no existence problem.[3] As it was the case in autarky, the firm determines a delivered price for each location. Now however, in setting the price the firm has to take into account the rival firm. Two types of market areas can be identified: the competitive zones and the non-competitive zones. In the latter, the home firm enjoys a status of effective monopolist and is able to set the monopoly price A since in that region the rival firm has a (transport) cost disadvantage. In the competitive zones, both firms are able to supply the consumers because their delivery cost are sufficiently low. In these competitive zones, the firms compete in each point for consumers and they play a Bertrand game in price. The winner of this game is the firm with the low transportation cost in that region and the equilibrium price is equal to the transport cost of the other firm.

For the small country firm, the equilibrium price schedule is given by:

$$p_h^*(z) = \begin{cases} A & \text{if} \quad A < 1 + \frac{H}{2} - z + c \\ 1 + \frac{H}{2} - z + c & \text{if} \quad 1 + \frac{H}{2} - z + c < A \end{cases} , \quad z \in [0, x] \tag{2}$$

Similarly, we have for the large country:

$$p_H^*(z) = \begin{cases} A & \text{if} \quad A < z - \frac{1}{2} + c \\ z - \frac{1}{2} + c & \text{if} \quad z - \frac{1}{2} + c < A \end{cases} , \quad z \in [x, 1 + H] \tag{3}$$

In Figure 2, the equilibrium price schedule is given by the solid line.

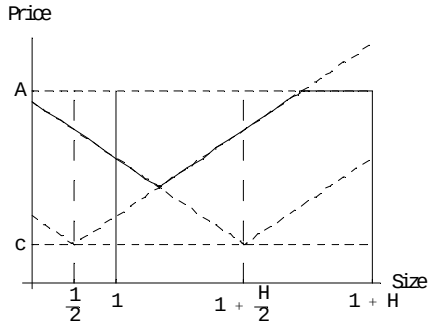

Figure 2: Free trade equilibrium

[3]For a Hotelling model with discriminatory pricing, see Hurter and Lederer (1985).

The marginal consumer x is given by the intersection of the two transport cost lines:

$$x = \frac{H+3}{4} \tag{4}$$

Because $H > 1$, we have that $x > 1$. In other words, *trade flows from the small to the large country*. Here it is the country size which determines the direction of trade. The second element to note is that since this result is independent of the population densities, the direction of trade is independent of the total population size.

3.3 Welfare changes under free trade

The characterisation of the free trade equilibrium enables us to look at the welfare consequences of opening the border to international trade in both countries. For each country, the changes in profits, consumer surpluses and total welfare are discussed.

3.3.1 Small country

The opening of the border to trade leads to two different effects. The first effect is to increase the competitive pressure on the price of the small country firm: in order not to lose some of its consumers to the rival firm, it has to decrease its price for these consumers. The second effect is to allow the small country firm to supply some consumers of the large country because of its (transport) cost advantage. The first effect is measured by the reduction in sales for the small country firm and depends on the cost conditions:

$$\Delta\pi_h^1 = \begin{cases} \frac{f_h}{2}\left(A - \frac{H}{2} - c\right)^2 & \text{if} \quad \frac{H}{2} + c < A < \frac{H}{2} + 1 + c \\ f_h\left(A - \frac{H+1+2c}{2}\right) & \text{if} \quad A > \frac{H}{2} + 1 + c \end{cases}$$

The second effect is given by the profit of the sales in the foreign market:

$$\Delta\pi_h^2 = \frac{(H-1)^2}{16}$$

The total change in profit is positive if:

$$\Delta\pi_h^2 > \Delta\pi_h^1$$

which is equivalent to

$$A < \begin{cases} \frac{\left(\sqrt{2f_h}+2\right)H - \sqrt{2f_h} + 4cf_h}{4f_h} & \text{if} \quad \frac{H}{2} + c < A < \frac{H}{2} + 1 + c \\ \frac{(H-1)^2}{16f_h} + \frac{H+1+2c}{2} & \text{if} \quad A > \frac{H}{2} + 1 + c \end{cases} \tag{5}$$

The reason is that for high values of A the large country firm is able to put more competitive pressure on the small country firm since the importance of transport costs decreases with A. The result can be summarised in the following proposition.

Proposition 1 *Assuming that the full market condition holds, under free trade, the profit change for the small country firm is positive if the reservation price A is not too high.*

The consumer surplus change is positive provided that in free trade some consumers are able to purchase the good at a lower price than the autarky price. From the price equilibrium given in (2), we know that the consumers located at the border pay a delivered price which is given by:

$$p_h^*(1) = \frac{H}{2} + c$$

The consumer surplus change is positive if and only if:

$$p_h^*(1) = \frac{H}{2} + c \leq A$$

which is guaranteed by the full market condition. This leads us to the following proposition.

Proposition 2 *Assuming that the full market condition holds, under free trade, the consumer surplus change for the small country is always positive.*

This, again, is an illustration of the fact that free trade increases the competitive pressure on the equilibrium prices and benefits the consumers.

Finally, for the overall welfare of the small country, we have:

Proposition 3 *The overall welfare change in the small country is positive.*

As shown before, the change in profit can be separated into two effects: a decrease in profit on the sales to domestic consumers because of the greater competitive pressure and a increase in the profit due to sales to the consumers located in the large country. The first effect is simply a transfer between the firm and consumers, and so cancels out for the overall welfare change. What is left over is the increase in profit due to sales to foreign consumers. This means that the positive overall welfare change after free trade is due to the market expansion of the small country firm. This condition is reminiscent of the *production expansion condition* described in Markusen (1981).

3.3.2 Large country

The welfare changes for the large country are slightly different. As in the case of the small country, a change in the equilibrium price due to free trade has two effects: it influences the profitability of home sales and it changes the market share of the country's firm.

First, free trade leads to a decrease in the equilibrium price. This is the pro-competitive effect of free trade. Second, free trade lowers the market share of the large country firm. This can be easily deduced from the position of the marginal consumer. Compared to the autarky situation, the large country firm sells at a lower average price and from (4) we know that the large country firm sells on a smaller scale. This means that:

Proposition 4 *Under free trade, the profit of the large country firm decreases.*

As it is often the case, free trade leads to a decrease in prices. But, contrary to the small country firm, the large country firm is unable to benefit from the opening of borders because it has a transport cost disadvantage and is unable to expand its market share.

The change in the equilibrium price influences the change in the consumer surplus. The consumers which gain from trade can be split into two categories. The first category no longer buys from the home firm but from the small country firm at a lower price. The second category of consumers still buy from their home firm but at a lower delivered price because of the increased competition induced through the opening up of the border.

Proposition 5 *The change in the consumer surplus for the large country is positive.*

As was the case for the small country, the consumers of the large country gain from the pro-competitive effect of international trade.

Combining the changes in the profit and the consumer surplus, we see that consumers gain exactly what the firm loses. In this case, the loss of the firm matches exactly the gains of the consumers, which means that

Proposition 6 *Free trade has no effect on the overall welfare of the large country.*

This result is reminiscent of a result in the neo-classical theory of international trade. There a country either gains or is indifferent to international trade. When the difference in country

size is sufficiently important, the equilibrium terms of trade are identical to the autarky price ratio of the large country, and this implies that the large country is indifferent between autarky and free trade. In our case, this result holds whenever the country is greater in terms of its *geographical* size.

3.3.3 Global welfare change

Now remains the question of the link between free trade and production allocation efficiency. The locations of the firms, determined when the countries were in autarky and efficient locations for the domestic markets, are not the efficient locations in the integrated market. However, free trade is an intermediate step towards efficiency in this case.

Proposition 7 *The overall joint welfare change is positive.*

This can easily be shown. In free trade, two types of consumers who gain can be identified: those who continue to buy from their home firm and those who change and buy from the other firm. When the consumer continues to buy from the same firm at a lower price, this is simply a transfer between economic agents. When the consumer switches to another supplier, they switch to a lower cost supplier.

The fact that the overall joint welfare change is positive allows for the possibility that both countries gain from a move towards free trade. Indeed, the model makes the (simplifying) assumption that the production costs of both firms are constant and identical. This is done to focus on the spatial impact of the welfare changes. However, if decreasing marginal costs are taken into account, the large country firm has a production cost advantage over the small country firm. This means that a split of the efficiency gains associated with free trade is possible between the firms.[4]

A final remark here is that it is the geographical size of the countries that plays a role in the welfare effects of free trade *at given firms' locations*. The total population of the countries or their population densities do not play a role except in determining the condition on the reservation price A for which the change in profit for the small country firm is positive. But, although the size of the population does not determine the direction of the welfare change, the importance of the welfare gain is affected by the population densities.

[4]Note that in this case the small country might no longer be able to export to the large country.

4 Long-run equilibrium

Allowing for the population densities to differ, two main issues are considered. The first issue pertains to the firms' locations. When borders are opened, the locations of firms reflect the autarky conditions and, because of the importance of the fixed costs, firms will not relocate immediately after the border is opened. While this is true in the short run, it is not in the long run. When the firms are in an integrated market, the nationality of the consumers no longer matters. Therefore, firms will want to relocate. The second issue pertains to the welfare results of free trade: are these welfare results modified when we allow population densities to differ? In this section, we look at the long run equilibrium locations and in the following section, we look at the welfare effects of this relocation.

One can show that if the firms are allowed to relocate, the equilibrium locations are given by

$$z_h^* = \begin{cases} \frac{1}{4}\left(1 + \frac{H}{f_h}\right) & \text{if} \quad f_h > \frac{H}{3} \\ \frac{H - 3f_h}{4} + 1 & \text{if} \quad f_h < \frac{H}{3} \end{cases} \tag{6}$$

and

$$z_H^* = \begin{cases} \frac{3}{4}\left(1 + \frac{H}{f_h}\right) & \text{if} \quad f_h > 3H \\ \frac{3H - f_h}{4} + 1 & \text{if} \quad f_h < 3H \end{cases} \tag{7}$$

Proof. To proof this, I make use of Proposition 2 in MacLeod *et al.* (1988, p. 440) which states that locations that minimise the total transport costs are equilibrium locations. In other words, the quartiles of the population distribution represent equilibrium locations. The locations given in (6) and (7) are the quartiles of the distribution. ■

The equilibrium locations depend on the geographical size as well as on the total population size. Note that these locations are also the socially optimal locations since they minimize the total transport costs incurred within the integrated market. If the population densities are the same, then the equilibrium locations are as follows:

$$z_h^* = \frac{H+1}{4} \quad \text{and} \quad z_H^* = \frac{3\,(H+1)}{4}$$

Graphically, the equilibrium locations can be represented as follows.

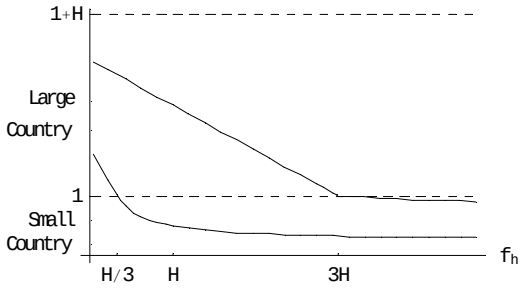

Figure 3: Equilibrium locations

If $f_h > 3H$, that is if the small country has a population which is at least three times the population of the large country, both firms locate in the small country. On the contrary, if $f_h < H/3$, which means that the small country has a population which is smaller than one third of the population of the large country, then both firms locate in the large country. If the two countries differ in their geographical size but have the same total population, that is if $f_h = H$, then both firms stay in their own countries but the small country firm exports to the large country. If both countries have the same population densities, then the relative equilibrium locations of the two firms depends on the geographical country size H: (i) if $H < 3$, then both firms remain in their own country; (ii) if $H > 3$, then both firms are in the large country.

As is clear from the expressions for the equilibrium locations, these locations depend crucially on the relative population densities. Using the expressions for the equilibrium locations, if the population density changes (while the geographical size of the market remains unchanged), then it follows immediately from (6) and (7) that

$$\frac{\partial z_h^*}{\partial f_h} < 0 \quad \text{and} \quad \frac{\partial z_H^*}{\partial f_h} < 0$$

This implies that the higher the population density of the small country is compared to that of the larger country, the more the equilibrium locations are located close to the market of the small country.

Another question is to consider what happens to the equilibrium locations when the geographical size of the countries changes but the population remains identical in both countries.

More precisely, we have $f_h = H$ and $f_H = 1$, which means that the total population in each country is equal to H. In this case, the equilibrium locations are given by:

$$z_h^* = \frac{1}{2} \quad \text{and} \quad z_H^* = \frac{(H+2)}{2} \tag{8}$$

These are the autarky equilibrium locations. In this case, a change in the geographical size of the large country which keeps the total population constant has no impact on the location of the firm in the small country, while

$$\frac{\partial z_H^*}{\partial H} > 0$$

that is, an increase in the size of the large country leads to its domestic firm to locate further away from the common border.

5 Welfare effects of free trade in the long run

Given the equilibrium locations obtained in the previous section, we are able to determine the welfare effects in the long run and compare this to the welfare in autarky. As before, the welfare effects are analysed in terms of changes in the profits, the consumer surpluses and the overall welfare which is the sum of the two. Since the equilibrium locations depend on the population densities, the welfare effects will depend crucially on the population densities. In this section, I focus on three polar cases. The first one considers countries which differ only in terms of their geographical size. The second case considers a case where the small country has also the smallest population. Finally, the last case considers a situation where the small country has the largest population.

5.1 Both countries have the same total population size

In this case, I assume that $f_h = H$ which means that both countries have a total population which is equal to H. From (8), we know that the long run equilibrium locations are the same as the autarky equilibrium locations of the firms. This implies that the long run welfare impact of free trade is exactly the same as in the short run: while the small country gains from free trade, the large country is indifferent between autarky and free trade.

5.2 The small country has the smaller population

Assume that $H/3 > f_h$. This implies that the small country has a population which is less than one third of the population of the large country. In that case, it is easy to show that both firms locate in the larger market. Clearly, the marginal consumer x is located in the large country.

We know that the consumer surplus change is positive for both countries. The reason is that once the border is opened, the domestic firm no longer has a monopoly power over its whole market and is no longer able to extract the complete consumer surplus.

The change in the profit of the small country firm can be written as:

$$\begin{aligned}\Delta\pi_h &= \pi_h^{ft} - \pi_h^a \\ &= \left(z_H^* - z_h^*\right) f_h + \left(z_H^* - z_h^*\right)\left(z_h^* - 1\right) + \frac{\left(z_H^* - z_h^*\right)^2}{4} - f_h\left(A - \frac{1}{4} - c\right)\end{aligned}$$

The first term of the free trade profit is the profit on the domestic market and the last two are the profits on the foreign market. Since there is a negative relationship between the profit difference and A, there is always a critical value of A for which the difference is negative. I assume that $A \geq H + 1 + c$. This means that a firm is able to supply any point of the integrated market whatever its location. Under this assumption, at the lowest possible value for the reservation price A, the change in profit can be written as

$$\Delta\pi_h|_{A=H+1+c} = \frac{1}{16}\left[3f_h^2 + 3H^2 - 2f_h\left(6 + 5H\right)\right]$$

This change in profit is positive if the population density is not too high, i.e. $0 < f_h < f_h'$ where

$$f_h' = \frac{1}{3}\left(6 + 5H - 2\sqrt{9 + 15H + 4H^2}\right)$$

If the density is higher ($f_h' < f_h < H/3$), then the change is negative.

The change in the profit of the large country firm can be written as

$$\begin{aligned}\Delta\pi_H &= \pi_H^{ft} - \pi_H^a \\ &= \frac{1}{4}\left(z_H^* - z_h^*\right)^2 + \left(z_H^* - z_h^*\right)\left(H + 1 - z_H^*\right) - H\left(A - \frac{H}{4} - c\right) \qquad (9)\end{aligned}$$

which means that

$$\frac{\partial\Delta\pi_H}{\partial A} < 0$$

Setting $A = H + 1 + c$, we can rewrite the profit change as follows

$$\Delta\pi_H|_{A=H+1+c} = \frac{1}{16}\left(3f_h^2 + 6f_hH - H\left(16 + 9H\right)\right)$$

We have that

$$\frac{\partial\Delta\pi_H}{\partial f_h} > 0$$

When $A = H+1+c$ and $f_h = H/3$ (which leads to the highest possible profit level) the change in profit can be written as

$$\Delta\pi_H = -\frac{1}{12}\left(12 + 5H\right)H$$

This means that the change is always negative.

Since the gains from free trade obtained by the consumers results from a reduction in the revenues of the domestic firm, the change in the total welfare is measured by the change in the total transport cost in the home market to which the net profit of foreign sales is added. The expression for the change in welfare for the small country is given by

$$\Delta W_h = \frac{7f_h^2 + 3H^2 - 2f_h\left(2 + 3H\right)}{16}$$

Since

$$\frac{\partial\Delta W_h}{\partial f_h} = \frac{14f_h - 2\left(2 + 3H\right)}{16} > 0$$

for any $f_h < H/3$, and since

$$\Delta W_h|_{f_h=0} = \frac{3H^2}{16} > 0$$

we know that the change in welfare for the small country is always positive.

Here again, the increase in the consumer surplus is due to a reduction of the revenues of the domestic firm. Since there are no foreign sales, the change in the total welfare for the large country is obtained by looking at the difference in total transport cost. The change for the large country is given by

$$\begin{aligned}
\Delta W_H &= W_H^{ft} - W_H^a \\
&= AH - cH - TC_H^{ft} - \left(AH - cH - TC_H^a\right) \\
&= TC_H^a - TC_H^{ft} \\
&= -\frac{\left(f_h - H\right)^2}{16}
\end{aligned}$$

which is always negative given the assumption on f_h.

When the geographical size of the country is correlated with the size of the country's population, it is clear that the small country gains from trade in the long run, while the large country loses. The reason for this is that the market of the small country is so small both in terms of geographical size as well as in terms of population, that both firms locate in the large country. While this allows the small country firm to expand its market share, it reduces the market share of the large country firm. In the large country, the gains of the consumers are not sufficient to compensate for the loss of the firm which leads to a decrease of the welfare of the large country. In summary, the host country loses from trade while the country of origin gains. This result can seem at first counterintuitive since one would think that in the event of a delocalisation of a firm to a foreign country, this would benefit the host country at the cost of the country of origin. The reason for obtaining such a result is that this is a partial equilibrium model and it does not deal with issues such as production and wages. This means that a change of country by one of the firms does not lead to a change in the wage level. The second reason for obtaining this result here is that under the current assumption the host country does not obtain the profits the foreign firm makes. As a result, the only effect that remains is the increased competition effect.

5.3 The small country has the larger population

Assume now that $f_h > 3H$ which means that although country h is smaller in terms of geographical size, it is much larger in terms of total population, and vice versa for country H.

In this case, both firms locate in the small country which means that the marginal consumer is located there as well. As in the previous case, the consumer surplus change is positive.

The change in profit of the small country firm can be written as

$$\begin{aligned}
\Delta\pi_h &= \pi_h^{ft} - \pi_h^a \\
&= f_h\left(z_H^* - z_h^*\right) z_h^* + f_h \frac{\left(z_H^* - z_h^*\right)^2}{4} - f_h\left(A - \frac{1}{4} - c\right) \\
&= \frac{6Lf_h + 3H^2 + f_h\left(7 - 16A + 16c\right)}{16f_h}
\end{aligned}$$

There is a negative relationship between the reservation price A and the difference in profits.

This expression evaluated at the lowest possible value for A $(=H+1+c)$ gives us

$$\Delta\pi_h|_{A=H+1+c} = \frac{6f_hH + 3H^2 - 4f_h^2(9+16H)}{16f_h}$$

From this expression, it is clear that there is a negative relationship between $\Delta\pi_h$ and f_h. This means that

$$\Delta\pi_h|_{f_h=3H} = -\frac{1}{4}H(5+12H) < 0$$

For population densities which are higher than $3H$, the change is always negative. The change in the large country is given by

$$\begin{aligned}
\Delta\pi_H &= \pi_H^{ft} - \pi_H^a \\
&= \frac{f_h}{4}(z_H^* - z_h^*)^2 + f_h(z_H^* - z_h^*)(1 - z_H^*) + (z_H^* - z_h^*)H - H\left(A - \frac{H}{4} - c\right) \\
&= \frac{3f_h^2 + 3H^2 + 2f_hH(3 - 8A + 8c + 2H)}{16f_h}
\end{aligned}$$

Here also the difference in profits is clearly negatively related to the reservation price. The difference in profit evaluated at the lowest possible reservation price gives us

$$\Delta\pi_H|_{A=H+1+c} = \frac{3f_h^2 + 3H^2 - 2f_h(5+6H)}{16f_h}$$

If the population density is not too important, i.e. $3H < f_h < f_h'$ where

$$f_h' = \frac{1}{3}\left(6H^2 + 5H + 2H\sqrt{9H^2 + 15H + 4}\right)$$

then the change is negative. Otherwise the change is positive.

If both firms are in the small country, then the welfare change for the small country can be written as:

$$\begin{aligned}
\Delta W_h &= TC_h^a - TC_h^{ft} \\
&= -\frac{(f_h - H)^2}{16f_h}
\end{aligned}$$

from which it follows that the change for the small country is always negative.

The change in total welfare is the difference in total transport cost to which the net profit on foreign sales is added. The total welfare change for the large country can be written:

$$\Delta W_H = \frac{3f_h^2 + 7H^2 + 2Hf_h(2H+3)}{16f_h}$$

This expression is positive if and only if

$$f_h > \frac{1}{3}\left(3H + 2H^2 + 2H\sqrt{-3 + 3H + H^2}\right) = f_h'$$

As in the previous subsection, the conclusion here is that the small country gains and the large country loses from trade. But contrary to the previous section, *here it is the population size and not the geographical size that plays a central role*. Here again, we obtain the somewhat surprising result that the host country loses and the country of origin gains from free trade. The reasons for obtaining this result are exactly the same as before. Regarding the population size, another interesting analogy can be made. As was the case in the previous section, when the population sizes are sufficiently different, the country with the larger population attracts both firms. This is at a more micro level the equivalent of the "home market effect": the larger market has the greater variety.

Finally, there is the issue of the ownership of profits and the location of the owners. When the firm has a specific location in space and when firms make pure profits, there is the question of where the owners of the firms are located. In the last two subsections, the assumption was that the total population size of the two countries were very different. In those cases, we saw that the firm of the country with the small population delocated to the other country. In assessing the total welfare impact of free trade, the assumption was made that the profits go back to the country of origin where the owners of the firms are assumed to be.[5] It is however important to note that this assumption has important implications. This issue has not been looked at in detail and there are no clear-cut results. Economic geography models typically do no consider this issue since in equilibrium firms make zero profits. While the initial assumption on the ownership of profits is perfectly plausible, consider the other (extreme) possibility that the profits go to the host country. When $f_h < H/3$, both firms locate in the large country. Under the assumption that the ownership of the firm is with the country it is located in, the welfare of the small country no longer includes the profits of the small country firm. The change in welfare is given by

$$\Delta W_h = A - z_H^* + \frac{1}{4}$$

[5]Note, however, that even in the case where both firms remain in their respective markets, one can also raise the question of the ownership of profits since domestic consumers could have shares of the foreign firm.

The assumption that $A \geq H + 1 + c$ guarantees that this difference is always positive. The welfare of the large country in the integrated market includes this time the profits of the small country firm

$$\Delta W_H = \frac{H^2 - 3f_h^2}{8}$$

This change is welfare is positive if $f_h \leq H/\sqrt{3}$ which is guaranteed in this case. This means that a change in the assumption about ownership leads to the result that both countries gain from trade. The second case of interest is the situation where $f_h > 3H$. This leads both firms to locate in the geographically smaller country. In this case, the welfare of the small country is modified to include the profits made by the large country firm. The change in welfare of the small country can be written as

$$\Delta W_h = \frac{f_h - 3H^2}{8f_h}$$

This difference is positive when $f_h > \sqrt{3}H$, a condition which is satisfied in this case. The welfare change for the large country no longer includes the profits of the large country firm and becomes

$$\Delta W_H = -H\left((1 - z_h^*) + \frac{H}{4}\right)$$

This expression clearly shows that the change in welfare for the large country is negative. Here also, a change in the assumption of ownership reverses the results: now the country with the smallest geographical area gains while the geographically larger country loses from free trade.

6 Conclusions

In recent years, international trade literature has started to give importance to the effect of locations, transport costs and country size. However, most theoretical models consider country size solely to be measured by the size of the country's population. From a geographical or spatial point of view, countries are considered as dimensionless points which are separated in space by a fixed distance. Schachmurove and Spiegel (1995) innovate in that they propose to look at countries as having a geographical size. They analyze this by applying the Hotelling model to analyze trade between two countries which differ in terms of their geographical size.

However, they have overlooked a well known result in the spatial competition literature: in a spatial duopoly with linear transport costs, for certain intermediate locations of the two firms, no pure Nash equilibrium in prices exists. Nevertheless, taking into account the spatial dimension of countries into account remains an important issue since it has important welfare conclusions. In this paper, I show why their analysis cannot be used. I propose to restore the pure strategy Nash equilibrium by assuming that firms use discriminatory rather than mill pricing. This assumption is justified by empirical observations of the behaviour of firms.

The results show that, as it is the case in Tharakan and Thisse (2001), *the smaller country gains more from free trade than the larger country.* In the case of quadratic transportation costs, the result is even stronger given that the larger country is a net loser from free trade. Both approaches show that the small country is able to gain from trade because of its competitiveness in delivering to certain consumers of the large country and thus able to expand its market share.

The initial framework of analysis of Schachmurove and Spiegel (1995) was extended to take into account not only the geographical country size difference but also the differences in countries' population size. The analysis shows that at given locations' for the firms, differences in population densities do not affect the direction of the welfare changes but affect the size of the effects. The main result is that geographical country size determines the welfare gains of the country: the geographically smaller country gains from trade while the larger country is indifferent

A second extension of the model is the analysis of the long run equilibrium locations in the integrated market. In this case, both the geographical size as well as the population size determine the equilibrium locations of the firms. The relative importance of these two elements in determining the locations of the firms depends itself on the size of the demand.

The welfare effects of free trade in the long run depend also on both the population density as well as on the geographical size of countries. The analysis shows that country size, as in the short run, is crucial in determining whether the country gains from trade. The analysis shows that while the small country gains from trade, the large country actually loses from trade integration. However, if population differences are so important such that the population of the small country is several times larger than that of the large country, then the conclusions are reversed: the geographically smaller country loses from trade. This means that if the differences in demand are important, then it is the size of demand and no longer the geographical size

that determines the gains from trade. The analysis has also shown the importance of another question that has rarely been addressed in economic geography models, namely the ownership of profits. Although there is no clear answer to this question, this assumption has been shown to be important in terms of welfare conclusions. It is evident that there are several other factors that influence the welfare impact of free trade. The main objective of this paper is to illustrate, with the help of a simple model, the importance of taking into account space and strategic spatial interaction. When this is done, the two country size dimensions, geographical size as well as total population size are shown to be important elements.

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