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International Trade and Welfare in a Model of Spatial Pricing

by

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Abstract

Traditional theory of international economics deals with trade in the absence of spatial considerations. However, trade occurs between countries which are spread globally, rendering thus economically relevant distances. This article discusses models which follow in their view on trade flows the approach of *August Lösch*, seeking to remedy the shortcomings of spaceless trade theory. After deriving spatial market results with free trade we treat tariff policy and import quota in turn. Subsequently the welfare outcomes of these measures are compared. It turns out that the optimal trade policy choice hinges upon distances between producers' locations and given national borders.

Keywords: international trade, spatial pricing, trade policy

JEL-classifications: D43, F13, R32

1 Introduction

International trade takes place between countries which are spread globally, rendering thus economically relevant trade-distances. Also, in many cases the respective locations of consumption and production within countries is not without economic impact. The same thing holds for the domestic location of an exporting or importing firm. The reasons for the widespread neglect of space as an economic dimension in the theory of international trade can only be suspected. General equilibrium analysis complicates the inclusion of space, since the assumption of perfect competition can hardly be kept in a spatial context, with several problems in suit.

An alternative trade theory, seeking to remedy the shortcomings of spaceless trade models, may recur to *August Lösch*. As much as Lösch regards the theory of comparative costs as suitable to explain the interpersonal division of labour, as unsuitable an instrument it is in his oppinion to determine international specialisation (Lösch [1938], [1939]). To explain the bilateral division of labour the theory of comparative costs assumes spaceless national territories, and thus uniform production conditions across each country. These conditions, however, are not at all identical across different regions of a national economy. "Diese Degradierung der Länder zu Punkten erleichtert die Irrlehre von ihrer wirtschaftlichen Einheit" (Lösch [1944], S. 176). Moreover, transport costs within countries are supposed to be zero and are considered between countries at best. Yet, the location of a production facility within a country may determine greatly its export perspectives. Quite often the total costs of transportation are higher within a country than between countries, whether due to lower charges of naval compared to surface fright-rates, or due to respective proximity to a common border. Finally, the theory of comparative costs proceeds from a uniform national price level, cutting short at the national border. But if this does not apply to the domestic territory, since transportation costs increase the commodity price from the place of production onwards, and consequently there is no uniform domestic price level, this conception cannot apply to international trade either. International trade much rather connects domestic and foreign prices at the border. Price increases do not lift one single domestic price level, they spread across economic space changing the delivered price at every consumer's location, possibly affecting the foreign country likewise.

Now, what does Lösch's proposal, countering the theory of comparative costs, look like? "Staaten sind", according to Lösch (Lösch [1944], S. 178), "... wirtschaftlich gesehen völlig willkürliche Bezugsgebilde. Da bleibt nichts übrig, als die Erzeugung aller Standorte zunächst ohne Rücksicht auf die politischen Grenzen festzustellen, diese Grenzen dann einzuzeichnen und ihre Wirkungen auf die Ausdehnung der Marktgebiete zu berücksichtigen. Dann sind alle Waren, deren Absatzgebiete von den Grenzen durchschnitten werden, Ausfuhrgüter, wenn das Erzeugungszentrum diesseits, und

Einfuhrgüter, wenn es jenseits der Grenze liegt." Apart from the few theoretical contributions combining spatial and international economics mentioned below, this approach has greatly been lying idle, even though it offers novel insight to international trade. Behind it lies a sustained lack of a comprehensive synthesis between these two fields of economic theory.

This essay seeks to combine the existing contributions based on the Löschian ideas in a spatial model of an international oligopoly, i.e. with at least one supplier's market area stretching across a national border. In an early paper Benson and Hartigan [1983] demonstrate, that import tariffs may reduce the (profit-maximising) mill price even of the domestic firm. In further papers these authors also tackle the effects of import quota [1984] and the distributional incidence of tariffs [1987]. An early discussion of welfare effects in the mentioned analytical framework can be found for certain special cases in Porter [1984] as well as, with endogenous revenue and protective tariffs, in Schöler [1990]. Heffley and Hatzipanayotou [1991] investigate the impact of tariffs on population distribution and land rents as well as on consumers' mobility. Furthermore, alternative conjectural variations and heterogenous goods are treated by Heffley, Hatzipanayotou und Mourdoukoutas [1993] in a spatial market model with tariffs. Hass [1996] extends the analysis to alternative models of spatial competition on one hand, and to endogenous welfare maximising tariff rates on the other hand. This kind of endogenous welfare maximising tariff rates, though calculated in a different fashion, are also applied by Schöler [1997]. Finally, Hass and Schöler [1999] reach a differentiated welfare theoretical assessment of export subsidies and Schöler [2001a] discusses the combination of domestic import tariffs and foreign export subsidies. A survey of trade policy with various endogenous instruments is given in Schöler [2001b]. This discussion is extended in the present contribution to domestic and foreign as well as global welfare.

The paper is organised as follows: In section 2, the assumptions and the basic spatial market model with free trade are illustrated, i.e. in a situation without administrative impediments to trade. Section 3 is committed to tariff policy. Section 4 deals with non-tariff barriers to trade, specifically import quota. Concludingly, in section 5, we compare the welfare effects of different trade policies (free trade, tariffs and import quota).

2 Free Trade

It is appropriate to formulate some of the assumptions common in the literature on spatial price theory in order to keep the model manageable:

$A1$: Domestic and foreign consumers occupy continuosly a homogenous line $\overline{0R}$ at uniform density equal to 1. The locations of firms are exogenously given at the left and right ends of this line, i.e. at 0 for the domestic firm and at R for the foreign competitor. ($A1.1$) The foreign firm exports part of its production to the domestic market, so that it serves the foreign market between its location, R, and the national border, R_G, as well as the domestic market between the national border, R_G, and the market area boundary, R_C. The domestic firm delivers to the remaining part of the domestic market, covering $\overline{0R_C}$.

$$0 - - - - - - - - - R_C - - - - - - - - - R_G - - - - - - - - - R \qquad imports$$

A2: Domestic and foreign household-demand q shall be identical – i.e. there are no country-specific utility and expenditure functions – and are linearly related to the respective delivered price, $p(r)$:

$$q_i = 1 - p_i, \quad p_i = m_i + r, \quad i = I, A, D, \quad r \in [0, \ R], \tag{1}$$

Delivered prices of the domestic firm $p_I(r)$ and the foreign firm $p_A(r)$ or $p_D(r)$ and are composed of the respective mill-price m_I, m_A or m_D and transport costs between the places of production and consumption, r. Transport costs per distance and quantity unit are standardised to zero for both countries, so that r symoblises distance as well as transport cost.

A3: Production technology and costs functions are identical in both countries. The cost functions read thus:

$$K_I = K_A = K_f, \tag{2}$$

with variable costs simplified zero.

A4: Firms aim at maximising their profits under Löschian competition. Consumers aim at maximising their consumers' surplus and purchase the good from the firm which offers the lowest delivered price.

A5: The analysis is confined to the short run, i.e. relocations are neither undertaken nor expected from the competitor.

The existence of a spatial market implies the following conditions: (a) $m_I < m_A + R$ resp. $m_A < m_I + R$: A firm cannot be entirely pushed out of the market via price undercutting by the competitor at the former firm's own location. (b) $\phi(m_I + R_C) > 0$ resp. $\phi(m_A + R - R_C) > 0$: At the competition boundary, R_C, the delivered price is not allowed to be higher than or equal to the prohibitive price $\phi^{-1}(0)$. (c) $R \leq m_I - m_A + 2R_C$: From the fact, that the delivered prices of both firms are identical at the competition boundary, we get the admissible distance, R, between the firms' locations, with R_C being smaller than or at most equal to the monopoly market reach. The market will disintegrate into one or two spatial monopolies, if either one of these three conditions is not fulfilled at least.

Under the given assumptions $A1$ to $A5$ competition in a free trade situation can be modelled in the following manner. The domestic firm's profit function reads:

$$\Pi_I = m_I \int_0^{R_C} (1 - m_I - r)dr - K_f. \tag{3}$$

Maximising profit with respect to m_I we get the domestic firm's mill-price:

$$m^* = 0,5 - 0,25R_C. \tag{4}$$

The foreign firm serves the foreign market between R_G and R as well as part of the domestic market $\overline{R_C R_G}$.

If profit stemming from the foreign part of the market area is denoted Π_D and profit stemming from the domestic country Π_A, total profit amounts to:

$$\Pi_D + \Pi_A = m_D \int_0^{R-R_G} (1 - m_D - r)dr + m_A \int_{R-R_G}^{R-R_C} (1 - m_A - r)dr - K_f. \tag{5}$$

With nondiscriminatory pricing and free trade the foreign firm's mill-prices are identical for both countries, $m_D = m_A$, because the national border does not economically matter. In the presence of tariff or non-tariff barriers to trade, on the other hand, the foreign supplier may either determine a common mill-price or separate prices for the domestic and the foreign country in the sense of spatial price discrimination. Because with trade-barriers it is rational to choose different profit-maximising mill-prices for both parts of the market area, this case shall be considered subsequently. The foreign firm's profit in the foreign country is given by

$$\Pi_D = m_D \int_0^{D} (1 - m_D - r)dr - (1 - s)K_f, \qquad (6),$$

with $s \in [0, \ 1]$ describing that fraction of fixed costs, which can be ascribed to exports, and D being defined as $R - R_G$. The optimal mill-price for the foreign country reads

$$m_D^* = 0,5 - 0,25D. \tag{7}$$

With respect to the profit which the foreign firm yields through its exports, the functional course goes

$$\Pi_A = m_A \int_0^{R_G - R_C} (1 - m_A - D - r)dr - sK_f. \tag{8}$$

The foreign firm's optimal mill-price for its domestic sales can be calculated as

$$m_A^* = 0,5 - 0,25R_G + 0,25R_C - 0,5D \tag{9}$$

and, thus, depends on transport costs between the location of production and the national border, D, as well as between the national and the competition border, $R_G - R_C$. According to assumption $A4$, at this competition border, R_C, mill-prices of both firms are identical:

$$m_I^* + R_C = m_A^* + R_G - R_C + D. \tag{10}$$

Utilising the profit-maximising domestic and foreign mill-prices m_A^*, m_I^*, it is possible to endogenously derive the competition border:

$$R_C^* = \frac{2D + 3R_G}{6}. \tag{11}$$

Applying the endogenous competition border from (11) in price-equations (4) and (9), the mill-prices for the domestic part of the market area read:

$$m_I^* = \frac{12 - 2D - 3R_G}{24} \tag{12}$$

and

$$m_A^* = \frac{12 - 10D - 3R_G}{24}. \tag{13}$$

Both mill-prices contain through equilibrium condition (10) the distances between both, the domestic location as well as the foreign location, and the national border. Consequently, domestic profits are a function of transport costs between the firm's locations and of fixed costs:

$$\Pi_I = (2D + 3R_G)(2D + 3R_G - 12)^2/3456 - K_f \tag{14}$$

and

$$\Pi_A = (3R_G - 2D)(10D + 3R_G - 12)^2/3456 - sK_f. \tag{15}$$

Formulating welfare in the tradition of industrial economics as the sum of producer and consumer surplus, it undoubtedly includes the profit of the domestic firm, Π_I, and domestic consumer surplus, i.e. consumer surplus originated in the domestic firm's market area, Λ_I, as well as in the domestic part of the foreign firm's market area, Λ_A. So relevant welfare is determined by (see Schöler [1997])

$$\Omega_I = \Pi_I + \Lambda_I + \Lambda_A. \tag{16}$$

If profit Π_A, which the foreign firm earns in the domestic country, is not transferred to its home base, but spent in the domestic country, it can also be included in domestic welfare (see Hass [1996], [1997/98]). These two definitions correspond with the formal distinction between resident vs. domestic concept in national income accounting. Henceforth the definition embodied in equation (16) shall apply. In the case of linear demand functions at issue the consumer surplus at a specific location r in the domestic market area equals the surface of a rectangular triangle with $\lambda(r) = (1 - m_I^* - r)^2/2$, so that the entire market area of the domestic producer is given by

$$\Lambda_I = \int_0^{R_C^*} 0,5(1 - m_I^* - r)^2 dr. \tag{17}$$

Analogously, from the consumer surplus at a location r in the domestic market area of the foreign producer, $\lambda(r) = (1 - m_A^* - D - r)^2/2$, the entire consumer surplus in this area can be derived as:

$$\Lambda_A = \int_0^{R_G - R_C^*} 0,5(1 - m_A^* - D - r)^2 dr. \tag{18}$$

Foreign welfare is defined as

$$\Omega_A = \Pi_A + \Pi_D + \Lambda_D. \tag{19}$$

Because the foreign part of the foreign firm's market area signifies $R - R_G = D$, the simple integral $\int_0^D$ can be employed in place of the expression $\int_{R_G}^R$. Furthermore we suppose discriminatory pricing by the foreign firm. In this setting consumer surplus at a location r is given by $\lambda(r) = (1 - m_D^* - r)^2/2$ and the entire consumer surplus in this area reads

$$\Lambda_D = \int_0^D 0,5(1 - m_D^* - r)^2 dr. \tag{20}$$

Taking the endogenous competition border R_C^* as well as prices m_I^*, m_A^*, and m_D^* into account welfare can be expressed in terms of distances. With free trade, domestic welfare is given by

$$\Omega_I = [45R_G^3 + 27R_G^2(3D-8) + 24R_G(4D^2-15D+18) - 4D(11D^2-12D-36)]/1728 - K_f, \tag{21}$$

and foreign welfare by

$$\Omega_A = [27R_G^3 + 54R_G^2(3D-4) + 36R_G(5D^2-16D+12) + 4D(67D^2-204D+252)]/3456 - K_f. \tag{22}$$

Global welfare as a sum of the expressions in (21) and (22) amounts to:

$$\Omega_W = [39R_G^3 + 108R_G^2(D-2) + 4R_G(31D^2-108D+108) + 12D(5D^2-20D+36)]/1152 - 2K_f. \tag{23}$$

Within this basic model it is possible to assess alternative trade barriers, i.e. import taxes and import quota. Needless to say, all results – prices and profits, consumer and producer surplus, as well as optimal tariff rates and optimal import quota below – depend on the assumed conjectural variations (Hass [1996]). For the sake of simplicity in $A4$ we assume Löschian competition, with the conjectural price reactions being exactly 1 and therefore $dR/dm = 0$.

3 Optimal Tariff

Import tariffs – which we shall address in what follows – arise as goods pass a national border. They can be distinguished in value and quantity added import taxes, both of which can easily be integrated into our basic model. In the case of a quantity added import tax a price markup of t per quantity unit is employed, altering profit equation (8) thus:

$$\Pi_A = m_A \int_0^{R_G - R_C} (1 - m_A - D - t - r)dr - sK_f. \tag{24}$$

In the value added case the price is liftet by a relative tax rate of $(1+t)$, if the value of a quantity unit at the national border, $m_A + D$, serves as the tax base. We shall, however, restrict our further treatment of the problem at hand to quantitative import taxes.

The arguments in favour of tariffs are threefold, with several subordinate motives in each case: (a) By the imposition of an import tariff, domestic industries can be protected from international competitors. The complete protection rate keeps any foreign goods away from the domestic market. The rate of this protective tariff is optimal, if imports are prevented completely. (b) By imposing a tariff, the government obtains a revenue. The importance of this revenue depends on whether other sources of revenue (taxes, public dept) are available. The rate of this tariff is optimal, if the tariff revenue of the government is maximised. (c) An optimal tariff from a national point of view should maximise domestic welfare. Tariffs of course influence welfare in the country which imposes the tariff as well as abroad. A domestic welfare-maximising tariff thereby has an effect on welfare in all countries having a trade relationship with the inland. In a two-country-world, welfare of the home country and the foreign country sum up to *world welfare*, which is influenced by a tariff, too. In the subsequent discussion we shall exclusively consider optimal tariffs with respect to national welfare. Retaliatory measures (e.g. tariffs imposed by the foreign country) shall be ignored because $A5$ assumes a short period.

In a first step the tariff rate, t, ist taken as given. The profit-maximising mill-price of the importing firm in the market area $R_G - R_C$ from equation (23) then reads

$$m_A^* = 0,5 - 0,25R_G + 0,25R_C - 0,5D - 0,5t. \tag{25}$$

From the equilibrium condition, $m_I^* + R_C = m_A^* + R_G - R_C + D + t$, the competition border for the case of import tariffs can be derived as

$$R_C^* = \frac{2D + 3R_G + 2t}{6}, \tag{26}$$

with $\partial R/\partial t = 1/3$. Utilising the endogenous competition border (26) the equilibrium prices are

$$m_I^* = \frac{12 - 2D - 3R_G - 2t}{24}, \tag{27}$$

and

$$m_A^* = \frac{12 - 10D - 3R_G - 10t}{24}, \tag{28}$$

with the partial derivatives $\partial m_I^*/\partial t = -1/12$, and $\partial m_A^*/\partial t = -5/12$. In order to compare the welfare effects of free trade versus the tariff-imposure it is useful to endogenise the tariff rate, t, i.e. to derive the optimal tariff rate under the given goal of domestic welfare-maximisation. The resulting optimal tariff evidently hinges on the definition of the relevant welfare measure. Formulating welfare according to equation (16), and under the assumption that tariff revenues T add to welfare – through tax reduction or public expenditure of the same amount –, we get the welfare effects in the free trade-situation

$$\Omega_I = \Pi_I + \Lambda_I + \Lambda_A + T, \tag{29}$$

with

$$T = \int_0^{R_G - R_C^*} t(1 - m_A^* - D - t - r)dr. \tag{30}$$

The accumulated consumer surplus over the domestic frim's market area is further determined by equation (17) and the profit by equation (26), though the competition border is now given by (26) and the valid mill-price by (27). Consumer surplus in the domestic fraction of the foreign firm's market area reads

$$\lambda(r) = 0,5(1 - m_A - D - t - r)^2 \tag{31}$$

and the entire consumer surplus in this area is

$$\Lambda_A = \int_0^{R_G - R_C} 0,5(1 - m_A - D - t - r)^2 dr. \tag{32}$$

Recognising R_C^*, price equations (27) and (28) as well as the condition of non-negative demand the optimal tariff can be calculated from welfare equation

$$\max_{t_\Omega} \Omega(t_\Omega) = \Lambda_I(t_\Omega) + \Lambda_A(t_\Omega) + \Pi_I(t_\Omega) + T(t_\Omega). \tag{33}$$

The optimal tariff rate amounts to

$$t_\Omega^* = 20/49 + 16R_G/49 - 29D/49 - \sqrt{c_\Omega}/98, \tag{34}$$

with

$$c_\Omega = 1600D^2 - 32D(67R_G + 47) + 1465R_G^2 + 1384R_G - 752.$$

The optimal tariff rate is valid for the range $R_G \in [R_{G_1},\ R_{G_2})$. For $R_G < R_{G_1}$ there there does not exist a real number solution, and for $R_G \geq R_{G_2}$ the condition of non-negativity is violated with respect to demand. The partial derivatives are $\partial t_\Omega^*/\partial D < 0$

and $\partial t^*_\Omega/\partial R_G \lesseqgtr 0$. Employing optimal tariff rates, we yield the following equilibrium prices:

$$m^*_I = 137/294 - 179R_G/1176 - 5D/147 + \sqrt{c}_\Omega/1176 \tag{35}$$

and

$$m^*_A = 97/294 - 307R_G/1176 - 25D/147 + 5\sqrt{c}_\Omega/1176, \tag{36}$$

where

$$R^*_C = 20/147 + 179R_G/294 + 20D/147 - \sqrt{c}_\Omega/294. \tag{37}$$

The welfare effects for the inland under optimal tariff rates read

$$\Omega_I(t_\Omega) = \Omega_I(R_G, D), \tag{38}$$

for the foreign country

$$\Omega_A(t_\Omega) = \Omega_A(R_G, D), \tag{39}$$

and for the world welfare as the sum of (38) and (39)

$$\Omega_w(t_\Omega) = \Omega_w(R_G, D). \tag{40}$$

The exact results for equations (38) to (40) are given in the appendix. Welfare is in each case a function of the distances between the location of the firms and the state frontier. It is dependent on the chosen welfare measure which in turn depends on political and economic circumstances. The endogenous tariff rates are, as equation (34) shows for the optimal tariff rate, only dependent on the transport costs between the location of a firm and the state frontier. Tariffs and transport costs have the same economic impact, the higher they are, the greater is the protection of the domestic economy.

4 Import Quota

Apart from tariffs, non-tariff restrictions to trade, such as import quota and export subsidies, are more and more common interventions in trade. In the former case, the government only allows for a given quantity of imports per unit of time. In a spatial model, this means the limitation of the market area being supplied by the foreign firm (see Hass [1996]). With regard to allocation, an import quota has the same effects as an import tariff or, put differently, for any tariff rate, there exists an import quota having the same spatial and economical effects. There are, however, differences with regard to distribution. More specifically, the government has no revenue if the import quota is not attached to firms by auctions or sales of licences.

Import quota are only a useful mean if autarky is not strived for, and if the quantity of imported goods is positive. The admitted quantity Q can be expressed by the demand

$$Q = \int_0^{R_G - R_C} (1 - m_A - D - r) dr, \tag{41}$$

which yields the foreign mill price

$$m_{A,Q} = \frac{R_c^2 - 2R_C(D + R_G - 1) + 2DR_G + R_G^2 - 2R_G + 2Q}{2(R_C - R_G)}. \tag{42}$$

If the import quota is to be effective, the quantity of the imported good has to be smaller than in the case of free trade, $Q < [(R_C - R_G)(2D + R_G - R_C - 2)]/4$, and consequently the mill price defined by equation (41) has to be higher than with free trade, $m_{A,Q} > m_A^*$. The price which corresponds to an import quota of Q enters, together with the mill price of the domestic firm $m_I^* = 0,5 - 0,25R_C$, into the equilibrium condition $m_{A,Q} + D + R_G - R_C = m_I^* + R_C$, which yields the market border

$$R_C^* = 0,1(-\sqrt{c}_Q + 7R_G + 2) \quad \text{with} \quad c_Q = (3R_G - 2)^2 + 80Q. \tag{43}$$

The mill prices with endogenous market borders now read

$$m_{I,Q}^* = 0,025(18 - 7R_G + \sqrt{c}_Q) \tag{44}$$

and

$$m_{A,Q}^* = 0,025[-7\sqrt{c}_Q + 9R_G - 2(20D - 17)]. \tag{45}$$

In analogy to the case of an optimal tariff, a welfare maximising import quota can be derived, which we subsequently refer to as the optimal quota. From the domestic welfare

$$\Omega_I = \int_0^{R_C^*} (0,5(1 - m_I^* - r)^2 + m_I^*(1 - m_I^* - r))dr - K_f$$
$$+ \int_0^{R_G - R_C} 0,5(1 - m_{A,Q}^* - D - r)^2 dr, \tag{46}$$

an optimal quota

$$Q_\Omega^* = (211R_G^2 - 713R_G + 556 - C)/4356 \tag{47}$$

with

$$C = \sqrt{(553R_G^2 - 1064R_G + 592)} \cdot |7R_G - 13|$$

can be derived. If the optimal quota is considered in the equations for the market border and the mill prices, we get

$$R_C^* = 0,1(-\sqrt{C}_Q + 7R_G + 2) \tag{48}$$

with

$$C_Q = [14021R_G^2 - 27328R_G + 15476 - (20\sqrt{(553R_G^2 - 1064R_G + 592)} \cdot |7R_G - 13|]/1089$$

as well as

$$m^*_{I,Q} = 0,025(18 - 7R_G + \sqrt{C}_Q) \tag{49}$$

and

$$m^*_{A,Q} = 0,025[-7\sqrt{C}_Q + 9R_G - 2(20D - 17)]. \tag{50}$$

The welfare effects with optimal import quota read for the inland

$$\Omega_I(Q_\Omega) = \Omega_I(R_G), \tag{51}$$

for the foreign country

$$\Omega_A(Q_\Omega) = \Omega_A(R_G, D) \tag{52}$$

and for the world welfare as the sum of (51) and (52)

$$\Omega_w(Q_\Omega) = \Omega_w(R_G, D). \tag{53}$$

The exact results for equations (53) to (52) are given in the appendix. Again, the value of the optimal quota and the welfare maximum depend on the composition of the welfare effects.

Up to now, the discussion is based on a division of the markets such that imports of the domestic country arise and thus, because intraindustrial trade is excluded from the analysis by assumption $A4$ in combination with $A1$, no exports occur simultaneously. This always signifies that the domestic market is larger than the market area of the domestic firm, and that the remaining area is provided by the foreign firm, $R_G > R_C$. In the opposite case – the domestic firm provides not only the entire domestic market, but also a fraction of the foreign market area by exporting the good, $R_G < R_C$ – the use of export subsidies can be discussed (see Hass/ Schöler [1999]). Since the welfare effects in this scenario cannot be compared to the cases considered above, a discussion of export subsidies is renounced.

5 Comparison of results

In the present contribution, it is shown that, in the context of a spatial price theory model with given locations of domestic and foreign firms, the optimal choice of the trade policy measures tariffs and quota can be traced back to transport costs to the state border, and, therefore, be derived endogenously. Yet, it must be taken into account that the derived solutions are partial in that they are respectively related to one market, whereas traditional trade theory provides, apart from partial, general equilibrium results also. However, under the given assumptions (onedimensional space, two firms, Lösch-competition, no intraindustial trade), the analysis allows to draw conclusions from the welfare equations.

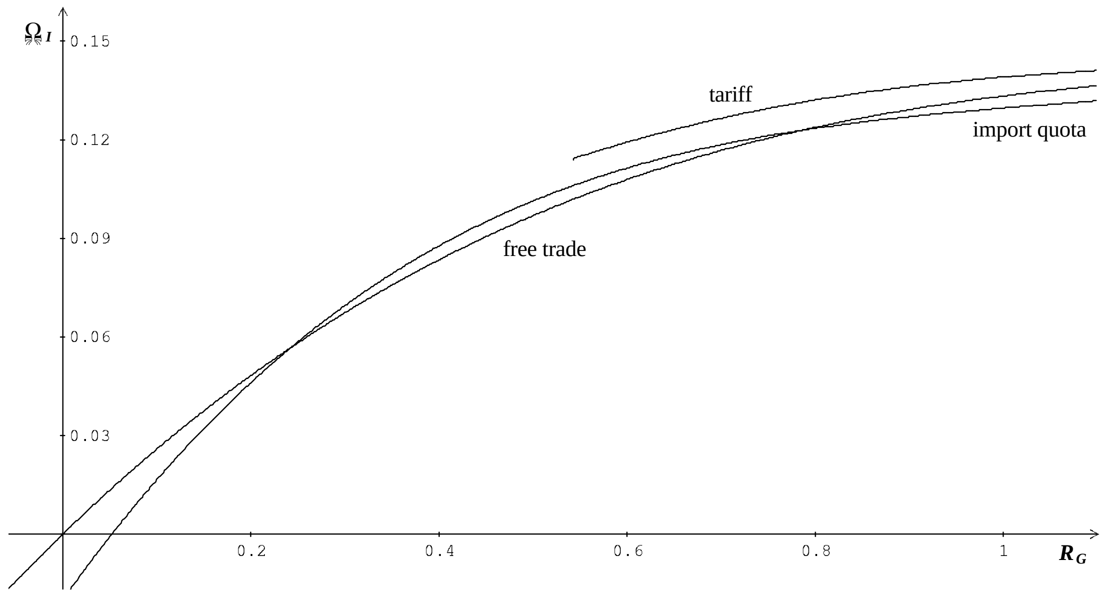

Figure 1: Domestic Welfare

A comparison of the welfare effects for alternative trade policy options (free trade, optimal tariff, and optimal import quota) is easily possible if the exogenous variables in the model equations - the transport costs to the state border from the location of the domestic firm, R_G, and from the location of the foreign firm, $D = R - R_G$, - are replaced by numerical values. Additionally, it shall be assumed for figures 1 to 3 that $3D = R_G$ to avoid a three-dimensional representation of the problem.

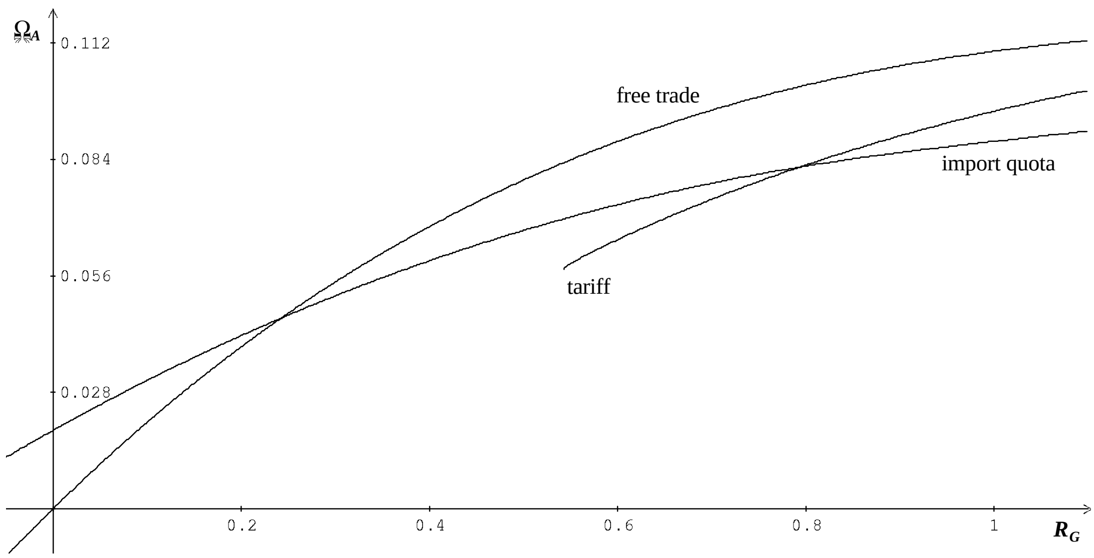

Figure 2: Foreign Welfare

The variable R_G runs from zero to unity, where the permitted values for the composition of the distances between both firms are given by the relation $R = R_G + D \leq 4/3$. Two further restrictions apply. First, the optimal choice of the tariff rate can only be given for the range $R_{G_1} > 0,5442$ because of mathematical reasons. Secondly, in the case of optimal import quota $m^*_{A,Q} > m^*_A$ must be fulfilled since only then the mill price of the foreign firm is higher than with free trade and, consequently, the traded quantity is lower. In figure 1 the domestic welfare effects with free trade Ω_I, with optimal tariff $\Omega_I(t_\Omega)$, and with optimal import quota $\Omega_I(Q_\Omega)$ are depicted.

These variables are plotted in figure 2 for the foreign country and in figure 3 for the world welfare. Figure 1 shows the orders $\Omega_I > \Omega_I(Q_\Omega)$ for $0,7865 < R_G \leq 1$, and $\Omega_I(Q_\Omega) > \Omega_I$ for the range $0,2425 < R_G < 0,7865$. The policy of an optimal tariff is, as in the following figures, only defined for $0,5442 \leq R_G \leq 1$ and yields the highest welfare over the entire permitted range. For every given distance, the foreign country attains the highest welfare with free trade: $\Omega_A > \Omega_A(Q_\Omega)$. Regardless of the value of R_G, import tariffs lead to smaller welfare effects as free trade. In the case $0,5442 \leq R_G < 0,7937$, the order $\Omega_A > \Omega_A(Q_\Omega) > \Omega_A(t_\Omega)$ yields, if $0,7937 < R_G \leq 1$, one gets $\Omega_A > \Omega_A(t_\Omega) > \Omega_A(Q_\Omega)$. Figure 3 which depicts world welfare, shows very impressively the advantages of free trade policy. Between $R_G = 0,6117$ and $R_G = 1$ it is true that $\Omega_w > \Omega_w(t_\Omega) > \Omega_w(Q_\Omega)$, and between $R_G = 0,5442$ and $R_G = 0,6117$ it turns out that $\Omega_w > \Omega_w(Q_\Omega) > \Omega_w(t_\Omega)$.

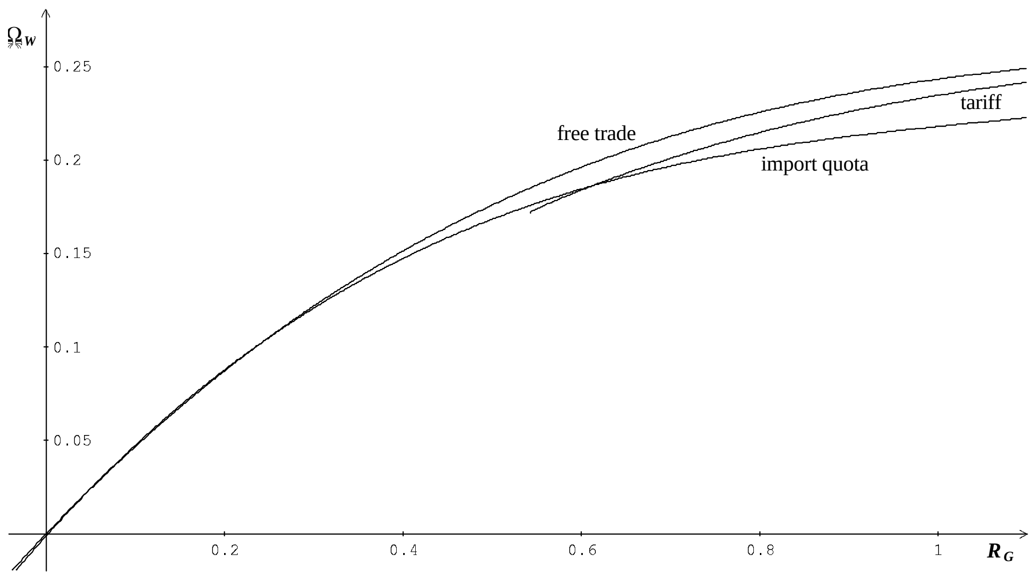

Figure 3: World Welfare

The results correspond to the outcome of traditional trade theory. They provide support for the idea that tariffs enhance welfare of the country which levies the tariff, but that welfare abroad and worldwide are always lowered. Though, it must be taken into account that the order of welfare effects may be dependent (1) on the composition of distances between the location of the firms and the state border, (2) on the employed definition of welfare, and (3) on the assumed conjectural reactions (see Hass [1996], pp.

129). Other contributions show that trade policy measures may as well increase world welfare compared to free trade (Hass/Schöler [1999]). In this context, there arise three questions which deserve further research: (1) How robust are the welfare results, especially concerning import quota, compared to other conjectural reactions of firms? (2) Do the results hold if a two-dimensional space with more than two firms is considered? (3) Which welfare effects come to light if the foreign country equally levies tariffs on its import markets, to be calculated following the same criteria? Notwithstanding these unsolved problems, the described approach can answer the question August Lösch asked over sixty years ago. It can show how prices vary over space and how they are transformed at national borders. Moreover, it can be illustrated in what manner this transformation itself is a consequence of the spatial dimension of the economy.

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Appendix

In the case of optimal tariffs, the expressions for domestic welfare read

$$\Omega_I(t_\Omega) = [c_\omega^{3/2} - 64000D^3 + 1920D^2(67R_G + 47) + 240D(1399R_G^2 - 3191R_G + 964)$$
$$+54109R_G^3 - 611508R_G^2 + 1067088R_G + 77120]/4148928 - K_f, \qquad (A38)$$

for foreign welfare we get

$$\Omega_A(t_\Omega) = [2\sqrt{c_\omega}(20000D^2 - 250D(19R_G + 134) - 27772R_G^2 + 45671R_G - 2932)$$
$$+12164933D^3 + 12D^2(121000R_G - 2890523) + 12D(132815R_G^2 - 484670R_G + 3137163)$$
$$+10(263824R_G^3 - 680433R_G^2 + 774360R_G - 204688)]/101648736 - K_f \qquad (A39)$$

and for world welfare

$$\Omega_w(t_\Omega) = [\sqrt{c_\omega}(52800D^2 + 8D(5169R_G + 8654) - 13101R_G^2 + 83500R_G - 16192)$$

$$+7064622D^3 + 8D^2(383640R_G - 2706283) + 8D(818325R_G^2 - 2048260R_G + 3609523)$$
$$+2642607R_G^3 - 14524184R_G^2 + 22591504R_G - 104960)]/67765824 - 2K_f \qquad (A40),$$

with

$$c_\omega = 1600D^2 - 32D(67R_G + 47) + 1465R_G^2 + 1384R_G - 752.$$

The expressions for welfare in the case of an optimal import quota are for the inland

$$\Omega_I(Q_\Omega) = -[(10C + 13433R_G^2 - 25144R_G + 13448)\sqrt{(} - 20C + 14021R_G^2 - 27328R_G$$
$$+15476)]/26136000 + [(13 - 7R_G)C]/435600 + [696371R_G^3 - 2014692R_G^2$$
$$+2192928R_G + 273616]/8712000 - K_f, \qquad (A51)$$

for the foreign country

$$\Omega_A(Q_\Omega) = [7(C - 211R_G^2 + 713R_G - 556))\sqrt{(} - 20C + 14021R_G^2 - 27328R_G$$
$$+15476)]/5749920 + [C(40D - 9R_G - 34)]/174240$$
$$+[23595D^3 - 65340D^2 - 20D(422R_G^2 - 1426R_G - 2155)$$
$$+1899R_G^3 + 757R_G^2 - 19238R_G + 18904]/1742400 - K_f \qquad (A52)$$

and for world welfare

$$\Omega_w(Q_\Omega) = [(350(C - 211R_G^2 + 713R_G - 556) - 110C - 11(13433R_G^2 - 25144R_G + 13448))$$
$$\sqrt{(} - 20C + 14021R_G^2 - 27328R_G + 15476)]/287496000 + [C(200D - 59R_G - 144)]/871200$$
$$+[1179750D^3 - 3267000D^2 - 1000D(422R_G^2 - 1426R_G - 2155)$$
$$+791321R_G^3 - 1976842R_G^2 + 1231028R_G + 1218816]/8712000 - 2K_f \qquad (A53),$$

with

$$C = \sqrt{((553R_G^2 - 1064R_G + 592) \cdot |7R_G - 13|)}.$$

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