# Endogenous Quality Effects of Trade Policy

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Abstract

We study the optimal trade policy against a foreign oligopoly with endogenous quality. We show that, under the Most Favoured Nation (MFN) clause, a uniform tariff policy is always welfare improving over the free trade equilibrium. However, a nonuniform tariff policy is always desirable on welfare grounds. First best policy typically consists of setting a subsidy on the low-quality product and a tax on high-quality one. Another example of such a nonuniform tariff policy is a Regional Trade Agreement (RTA). We show that, if a welfare improvement is possible through a RTA, it is always with the low-quality producing country that it has to be achieved.

JEL Classification: F12, F13, F15

Keywords: Endogenous Quality, Hedonic Prices, Most Favored Nation (MFN) clause, Optimal Tariff, Regional Trade Agreement (RTA)

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# 1 Introduction

Over the past few years, quality decisions in firm behavior have been extensively examined, to become one of the most active fields of research in industrial organization. Without being comprehensive, the monopolist problem was studied by Mussa and Rosen (1978), Sheshinski (1976) and Spence (1975, 1976). Extensions include Gabszewicz and Thisse (1979) and Shaked and Sutton (1982), who study firms' quality choice in oligopoly. They establish the well-known result that firms have generally an incentive to choose distinct quality levels in an attempt to relax competition in the market. Motta (1993) compares those incentives under Bertrand and Cournot competition and finds that firms differentiate more their goods under price competition. Analysis of regulatory policy in vertically differentiated models is more scarce. Cremer and Thisse (1994) studies the effects of commodity taxation and Ronnen (1991) analyzes the incidence of minimum quality standards, both in a duopoly setting. The international trade literature has focussed on the incidence of various trade policies on the quality of the products and on social welfare under different market structures. Krishna (1987, 1990) and Das and Donnenfeld (1987) study tariffs and quotas under monopoly. In a duopoly consisting of a domestic and a foreign firm Das and Donnenfeld (1989), Ries (1993) and Herguera et al. (1999a) analyze the effects of quantity and quality restrictions, and Reitzes (1992) studies tariffs when buyers have different preferences for brands.

To the best of our knowledge, neither the effects of tariffs nor the choice of the optimal tariff policy against a foreign oligopoly has been considered so far in models of vertical differentiation and international trade. We analyze this problem in a world of three countries. Two firms located in different countries supply a quality-differentiated good to a third (domestic) non-producing country. The activist government is in the domestic country and consumers living there have diverse preferences for the sole product attribute, quality. We assume that the market is not totally served in equilibrium, i.e. the market size is therefore endogenous in our model.[1] The analysis concentrates on ad valorem tariff policies[2] and includes both uniform tariffs such as free

[1] The economy we postulate is empirically relevant in industrialized countries, like the car, computer and electronics markets, and many more in transition and developing countries. See Fershtman et al. (1999) for an empirical analysis of tariff reforms in the automobile market in Israel.

[2] It is more and more common for tariffs and subsidies to be specified in ad valorem terms, i.e. as a percentage of the selling price. The US International Trade Commission has indeed made suggestions to convert most specific, compound and complex rates of duty to their ad valorem equivalents (see http://www.usitc.gov).

trade and the Most Favoured Nation (MFN) clause, and nonuniform tariffs such as a Regional Trade Agreement (RTA). For each form of tariff policy, we investigate a multistage game. The welfare maximizing policy maker of the domestic country first announces subsidy or tariff levels prior to firms' decisions. Subsequently firms select product quality and then prices. Backward induction allows us to solve for a subgame-perfect equilibrium.

Our framework allows us to deal with several important issues. First, it enables us to isolate ways firms take into account international competitive and cost conditions when they select equilibrium product-design strategies. Limited local demand usually forces firms to become global and sell in many nations. These firms develop strategies in which they concentrate on a particular segment of demand worldwide. Some may orient their production toward standardized mass products while others may emphasize quality and exclusivity, choice which is determined by the demand and cost characteristics of the market. Commodity taxation, by distorting competitive competitions, affects product-quality selection in a differentiated oligopoly. Second, rounds of multilateral tariff negotiations under the auspices of WTO are based on a 4 and 6 digit classification of the harmonized system whereas, in practice, individual countries apply a more disaggregated tariff nomenclature, up to a 8-digit level of classification categories. Also, under the Generalized System of Preferences, the President of the United States may give duty-free entry to less than the scope of an existing tariff rate line and therefore subdivides it to accomplish the desired treatment. We believe our model with differentiated quality is valuable in explaining these facts. Finally, as the discriminatory treatment of RTAs changes the relative price among sources of imports, there is the question of how a RTA affects the quality composition of imports (besides prices and quantities). In regard to this, we are interested in determining which of the two possibilities, a RTA with either a low- or a high-quality producing country, is preferable in terms of welfare.

In our model a pure-strategy asymmetric equilibrium arises even if firms have symmetric quality-development costs. A uniform tariff policy alters the costs faced by foreign firms but does not affect the competitive conditions in the market because both firms' costs are distorted in an equal manner. We show that, under the MFN principle, a uniform tariff policy is welfare superior to free trade. This is so because the home country gains by charging a tariff which extracts some of the foreign oligopoly rents (like in Brander and Spencer, 1981, 1984; Helpman and Krugman, 1989). This gain is partially offset by the downgrade in the quality of the imports, which causes a loss in consumer surplus (like in Krishna, 1987; Das and Donnenfeld, 1987).

A key result from our analysis is to show that a nonuniform tariff policy is always desirable on welfare grounds. Such a policy introduces asymmetries in the costs faced by firms. This in turn affects the competitive conditions in the market, and hence the equilibrium quality gap between the products. We show that starting from a MFN clause policy, social welfare can be increased either by raising the tariff of the high-quality product or by decreasing the tariff of the low-quality good. Indeed, the first best policy consists of a subsidy on the low-quality product and a tax on high-quality good. Hence, there exist strong incentives to deviate from the MFN principle which, however, is prohibited by the WTO legislation. We believe that the presence of quality differentiation allows countries to insert a more refined definition of goods in their tariff schedules in order to apply their optimal trade policy while still complying with the MFN principle of the WTO. Another important example of a nonuniform tariff policy (admitted by the WTO) is a RTA. We show that starting from the optimal MFN clause policy, if a welfare improvement is possible through a RTA, it is always with the low-quality producing country that it has to be achieved.

The importance of quality in the volume of international trade is documented in several empirical studies (see e.g. Fontagné et al., 1998; Fershtman et al., 1999). Aw and Roberts (1986), Feenstra (1988), and Boorstein and Feenstra (1991) examine the effects of trade quantity restrictions on the up or down-grading of imports. A common conclusion is that by ignoring quality upgrading, the traditional welfare cost calculation may understate by as much as one-half the actual welfare loss from introducing a trade restriction. Based on numerical simulations of our model we obtain, in equilibrium, welfare gains of 6 to 11 percent when the first best policy is compared to a MFN policy. A trade agreement with a low-quality producing country would provide welfare gains of around 2 percent, whereas losses of 5 to 9 percent would result from a RTA with a high-quality country. We argue that when these results are compared to the usual static or scale effects of economic integration, quality changes are one of the major effects of RTAs.

The remainder of the paper is organized as follows. The next section describes the model. Section 3 derives the firms' optimal decisions. Section 4 studies the effects of uniform and nonuniform tariffs and selects the optimal policy. Section 5 evaluates the incidence of RTAs. Finally, Section 6 includes a discussion of the results and the Appendix contains proofs of some statements to facilitate the reading.

## 2 The model

We consider a world of three countries. Assume that two foreign firms located in different countries, labeled 1 and 2, export a single good to a third country, which is referred to as the domestic country. The activist government is located in the home country, where production of the good in question does not take place. Assume also that the foreign and the domestic markets are segmented, i.e. foreign firms take decisions on exports independently of their home market conditions. Our goal is to uncover the optimal policy of the home government against a foreign (quality-differentiated) oligopoly.

Suppose that a population of measure 1 lives in the domestic country and that preferences of consumer $\theta$ are given by the quasi-linear (indirect) sub-utility function:

$$U = \begin{cases} \theta q - p & \text{if he buys a unit of a good of quality } q \text{ at price } p \\ 0 & \text{otherwise} \end{cases}$$

Consumers buy at most one unit. Suppose that the consumer-specific quality taste parameter $\theta$ is uniformly distributed over $[0; \bar{\theta}]$; $\bar{\theta} > 0$.[3]

We assume that foreign firms producing the good in question must incur the fixed cost of quality development $C_i(q) = c_i q^2/2$; $i = 1; 2$: Suppose without loss of generality that $c_1 \geq c_2$, i.e. we allow for foreign firms to be asymmetric in regard to their setup technologies (here firm 2 is at least as efficient as firm 1).[4] Once the quality of the good is determined, we assume that production takes place at a common marginal cost. We normalize the marginal cost of production to zero. In what follows, development cost asymmetries matter to the extent that they allow for the selection of an equilibrium in qualities. They also allow for more comprehensive numerical results.

We study a three-stage game. In the first stage, the government in the domestic country chooses a tariff policy on imports. We concentrate on ad

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[3] As Tirole (1988, p. 96) argues, $\theta$ can also be interpreted as the reciprocal of the marginal utility of income.

[4] Many studies of product introductions abroad associate successful entry to an accurate understanding of buyer needs abroad. The cost $c_i$ reflects therefore the cost of quality development needed to meet specific foreign preferences like the American desire for convenience, the German love for ecology (and Autobahn), the Japanese taste for compactness and the Scandinavian concern for safety (Porter, 1990). Elements like factor costs and sophistication of demand in the manufacturing countries are also other important determinants of relative cost differences (Motta et al., 1997).

valorem tariffs and denote $t_q$ as the tariff levied on imports of goods of quality $q$.[5] In the second stage of the game, foreign firms choose their qualities to produce, and incur the fixed costs. Finally, in the third stage, firms indulge in price competition and demand is satisfied. The appropriate solution concept is subgame perfectness.

There are three observations in line here. First, our setting implicitly assumes that the activist government can credibly commit to its policy choice before the firms make their decisions. According to Brander (1995) most international trade observers agree in that governments often possess credible commitment devices. For example, when tariff rates are set by multilateral negotiations they usually remain fixed until the next round of negotiations. Of course we are aware of the recent literature dealing with time-consistent strategic trade policy. The main contribution of this literature is to show how the optimal trade policy is sensitive to the timing of policy moves (see e.g. Goldberg, 1995; Leahy and Neary 1994, 1996, 1999; Herguera et al., 1999b). The second remark is related to the assumption that the only activist government is located in the home country. Of course, this is a simplifying assumption since foreign countries can engage into retaliatory trade policies (see e.g. Collie, 1991). Finally, our market structure ignores the possibility of entry in the domestic market which can be ensured by appropriately choosing entry costs (see e.g. Donnenfeld and Weber (1992) for a model of sequential entry).

# 3 Foreign firms' decisions

The presence of heterogeneity in consumer tastes for quality implies that it is optimal for foreign firms to differentiate their export goods by choosing different quality levels. Thus, a pure-strategy asymmetric equilibrium emerges when qualities are endogenously determined by the firms.[6] The intuition behind this is encountered in the fact that firms can relax price competition through quality differentiation.

Let us denote high-quality by $q_h$ and low-quality by $q_l$, $q_h \geq q_l$. Since a firm will produce a higher quality than the other, for the domestic government it suffices to announce a couple of tax rates $(t_l; t_h)$; one for the low-quality good and the other for the high-quality one. Suppose also, for the moment,

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[5] Note that a tariff $t = 0$ implies free trade while $t < 0$ indicates subsidization.

[6] This fact, which is true even if firms are symmetric ($c_1 = c_2$); is a standard result in the literature on vertical product differentiation (see e.g. Motta, 1993; Tirole, 1988; Shaked and Sutton, 1982).

that $p_h \geq p_l$, that is the firm producing a higher quality charges a higher price.[7]

We now derive the domestic demand functions for the two qualities. There is a consumer indifferent between purchasing the two varieties. This buyer is characterized by the parameter $\tilde{\theta}$ satisfying $\tilde{\theta}q_h - p_h = \tilde{\theta}q_l - p_l$. Then, $\tilde{\theta} = (p_h - p_l)/(q_h - q_l)$. Any consumer such that $\theta > \tilde{\theta}$ will purchase from the firm producing high-quality, provided that $\theta q_h - p_h \geq 0$. On the other hand, any consumer such that $\theta < \tilde{\theta}$ will buy from the firm offering low-quality, provided that $\theta q_l - p_l \geq 0$. Assume that the hedonic price (price-quality ratio) of the low-quality good is lower than that of the high-quality good, i.e. $p_l/q_l < p_h/q_h$. This guarantees that a consumer who does not buy the low-quality product does not buy the high-quality one either.[8] Define $\hat{\theta}$ as the consumer indifferent between acquiring the low-quality good and nothing at all, i.e. $\hat{\theta} = p_l/q_l$.

Armed with these critical parameters, we are now ready to compute demands. High-quality good will be demanded by those consumers such that $\tilde{\theta} < \theta < \bar{\theta}$ whereas the low-quality commodity will be demanded by those buyers such that $\hat{\theta} < \theta < \tilde{\theta}$. Using the fact that $\theta$ is uniformly distributed on $[0; \bar{\theta}]$, we derive demands for the high-quality and the low-quality goods in the domestic country:

$$D_l(\cdot) = \frac{p_h - p_l}{\bar{\theta}(q_h - q_l)} - \frac{p_l}{\bar{\theta}q_l}; \quad D_h(\cdot) = 1 - \frac{p_h - p_l}{\bar{\theta}(q_h - q_l)}. \tag{1}$$

## 3.1 The pricing subgame.

Let us look first at the third stage of the game, i.e. price competition. Taking the pair of demands in (1), tariff rates $(t_l; t_h)$, and quality choices $(q_h; q_l)$ as given, the problem of any firm $i = 1; 2$ which chooses to produce a lower quality good consists of finding $p_l$ so as to maximize:

$$\pi_i = (1 - t_l)p_l \left( \frac{p_h - p_l}{\bar{\theta}(q_h - q_l)} - \frac{p_l}{\bar{\theta}q_l} \right) - \frac{cq_l^2}{2};$$

where $i = 1$ or $2$ depending on whether the low-quality good is manufactured by firm 1 or 2.

[7] We check below that this is actually satisfied in the equilibrium of the subgame.

[8] This assumption, which we later check in equilibrium, makes the problem interesting. Otherwise only high-quality goods would be sold.

On the other hand, the rival firm chooses $p_h$ to maximize its profits:

$$\pi_j = (1 - t_h) p_h \left( 1 - \frac{p_h - p_l}{\bar{\theta}(q_h - q_l)} \right) - \frac{c_j q_h^2}{2}; \quad j = 1,2; \quad j \neq i.$$

The system of first order conditions is:

$$\begin{aligned} 2 q_h p_l - q_l p_h &= 0 \\ 2 p_h - p_l - \bar{\theta}(q_h - q_l) &= 0 \end{aligned}$$

Solving this pair of reaction functions in prices, we obtain the subgame equilibrium (domestic) prices for the two varieties of the good:

$$p_h = \frac{2\bar{\theta} q_h (q_h - q_l)}{4q_h - q_l}; \quad p_l = \frac{\bar{\theta} q_l (q_h - q_l)}{4q_h - q_l} \tag{2}$$

A number of observations are in line here. First, notice now that equation (2) shows that $p_h/q_h \geq p_l/q_l$. Therefore, if there is an equilibrium, the high-quality good is priced higher than the low-quality one. Second, observe that equilibrium prices do not directly depend on tariff rates. They do not directly depend on cost asymmetries either. However, as we shall see, equilibrium prices depend on firms' set-up costs and tariff rates indirectly, i.e. through the firms' quality selection $q_h$ and $q_l$.

## 3.2 The quality subgame

Consider now the firms' quality selection. In this second stage of the game, firms take domestic government tariff policy $(t_l; t_h)$ as given and, anticipating the equilibrium prices of the continuation game obtained in (2), choose their qualities to maximize profits. In particular, firm $i$ choosing to produce a lower quality selects $q_l$ to maximize:[9]

$$\pi_i = (1 - t_l) \frac{\bar{\theta} q_l q_h (q_h - q_l)}{(4q_h - q_l)^2} - \frac{c q_l^2}{2};$$

[9] This expression is the reduced-form profit equation of a low-quality firm. It is obtained by substituting the equilibrium prices of the goods (equation (2)) into the profits expression.

where $i = 1$ or $2$ depending on whether the lower quality good is produced in country 1 or 2. The first order condition is:

$$(1-t_l)\frac{\bar{\theta}q_h^2(4q_h-7q_l)}{(4q_h-q_l)^3} - c_i q_l = 0; \quad i = 1 \text{ or } 2: \tag{3}$$

Likewise, a foreign firm choosing to produce a higher quality good selects $q_h$ to maximize:

$$\pi_j = (1-t_h)\frac{4\bar{\theta}q_h(q_h-q_l)}{(4q_h-q_l)^2} - \frac{c_j q_h^2}{2}; \quad j = 1 \text{ or } 2; \quad j \neq i: \tag{4}$$

The first order condition is:

$$(1-t_h)\frac{4\bar{\theta}q_h(4q_h^2-3q_hq_l+2q_l^2)}{(4q_h-q_l)^3} - c_j q_h = 0: \tag{5}$$

Since $q_h \geq q_l$; we can define $\mu = q_h/q_l$; $\mu \geq 1$: Variable $\mu$; referred to in what follows as the quality gap, measures the degree of product differentiation.

By taking the ratio of first order conditions and using the definition of $\mu$ we obtain:

$$\frac{c_i(1-t_h)}{c_j(1-t_l)} = \frac{\mu^2(4\mu-7)}{4(4\mu^2-3\mu+2)}; \quad i; j = 1; 2; \quad j \neq i: \tag{6}$$

Equation (6) describes the equilibrium product differentiation as an implicit function of firms' cost asymmetries and ad valorem tariffs. The RHS of (6) is a third degree polynomial whose valid real root solution can be conveniently written as:

$$\mu = F\left(\frac{c_i(1-t_h)}{c_j(1-t_l)}\right) \tag{7}$$

The next lemma shows that $F' > 0$:

**Lemma 1** *Quality gap $\mu$ increases (lowers) as the tariff rate on the low (high)-quality variant increases (decreases).*

**Proof.** Consider the functions $g_1(t_h; t_l; c_i; c_j) = c_i(1-t_h)/c_j(1-t_l)$ and $g_2(\mu) = \mu^2(4\mu-7)/(4(4\mu^2-3\mu+2))$: Note that $dg_1/dt_l = c_i(1-t_h)/c_j(1-t_l)^2 > 0$; $dg_1/dt_h = -c_i/(1-t_l)c_j < 0$ and $dg_2/d\mu = \mu(16\mu^3-24\mu^2+45\mu-28)/4(4\mu^2-3\mu+2)^2 > 0$: Therefore, as (6) must be satisfied in equilibrium, holding $t_h$ constant, $\mu$ increases as $t_l$ increases. Holding $t_l$ constant, $\mu$ decreases as $t_h$ increases. Hence, $F' > 0$ in (7). ■

Figure 1 depicts the unique real solution to equation (6). Observe that $\mu$ is always larger than 1.75 for any parameters $c_i; c_j; t_h; t_l$. This fact will be useful in what follows.

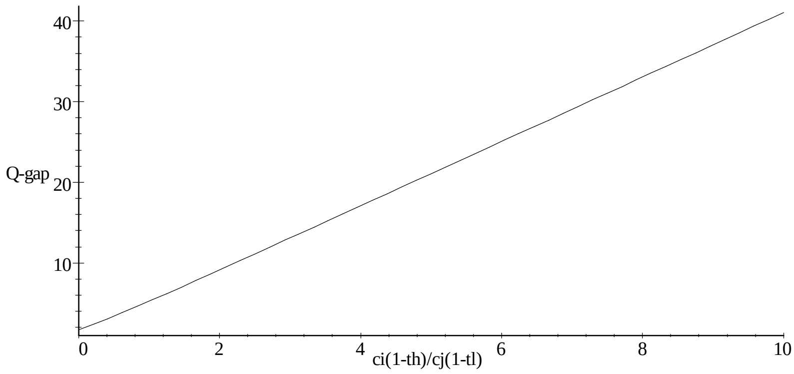


Figure 1: Quality gap related to relative costs and tariffs.

It is now convenient to solve for equilibrium qualities from (3) and (5), and rewrite equations (1) and (2):

$$D_l = \frac{\mu}{4\mu - 1}; \quad D_h = \frac{2\mu}{4\mu - 1} \tag{8}$$

$$p_l = \frac{\bar{\theta}(\mu - 1)q_l}{(4\mu - 1)}; \quad p_h = \frac{2\bar{\theta}(\mu - 1)q_h}{(4\mu - 1)} \tag{9}$$

$$q_l = (1 - t_l)\frac{\bar{\theta}\mu^2(4\mu - 7)}{c_i(4\mu - 1)^3}; \quad i = 1; 2 \tag{10}$$

$$q_h = (1 - t_h)\frac{4\bar{\theta}\mu(4\mu^2 - 3\mu + 2)}{c_j(4\mu - 1)^3}; \quad j = 1, 2; \quad j \neq i. \tag{11}$$

From (9) we obtain a relation between domestic prices: $p_h/p_l = 2\mu$. Hence, the variable $\mu$ is also a measure of price competition among the two firms in the domestic country, the latter increasing with a narrowing quality gap (smaller $\mu$). From these expressions we derive hedonic prices $p_h/q_h$ and $p_l/q_l$; both increasing in $\mu$. From (8) we obtain that demand for the high-quality product is twice that of the low-quality. We also observe a negative relationship between $\mu$ and the quantities sold. This is essentially due to the fact that as the quality gap widens price competition relaxes and transaction prices increase, which consequently reduces demands. Also, the position of the marginal consumer $\hat{\theta} = p_l/q_l = \bar{\theta}(\mu - 1)/(4\mu - 1)$ increases with $\mu$. This implies that the number of consumers not served in the market $(1 - D_h - D_l)$ increases as well. These observations will be useful later in the paper.

## 3.3 Existence and uniqueness of (subgame) equilibrium

We are now ready to characterize and select firms' equilibrium quality decisions. There may be two equilibrium quality spectra. In the first one, the high-quality good is produced by the most efficient firm, i.e. firm 2. Let us refer to this situation as Assignment 1. In this case, the equilibrium product differentiation is given by the solution to the equation (6) properly rewritten:

$$\frac{c_1(1-t_h)}{c_2(1-t_l)} = \frac{\mu^2(4\mu-7)}{4(4\mu^2-3\mu+2)}.$$

Let us denote the solution to this equation as $\mu_1$. The equilibrium under Assignment 1 is then characterized as follows:

ASSIGNMENT 1: Firm in country 1 (the least efficient) produces the lower quality good $q_l = (1-t_l)\frac{\bar{\theta}\mu_1^2(4\mu_1-7)}{c_1(4\mu_1-1)^3}$ and sells it at price $p_l = \frac{\bar{\theta}(\mu_1-1)q_l}{(4\mu_1-1)}$. Firm in country 2 (the most efficient) produces high-quality $q_h = (1-t_h)\frac{4\bar{\theta}\mu_1(4\mu_1^2-3\mu_1+2)}{c_2(4\mu_1-1)^3}$ and charges price $p_h = \frac{2\bar{\theta}(\mu_1-1)q_h}{(4\mu_1-1)}$.

There is, however, an alternative quality spectrum where the high-quality good is produced by firm 1, i.e. the least efficient firm. Let us refer to this second situation as Assignment 2. In this case, the equilibrium product differentiation is given by the solution to:

$$\frac{c_2(1-t_h)}{c_1(1-t_l)} = \frac{\mu^2(4\mu-7)}{4(4\mu^2-3\mu+2)}.$$

Denote such a solution as $\mu_2$. Then, under Assignment 2, the equilibrium candidate is as follows:

ASSIGNMENT 2: Firm in country 1 (the most inefficient) produces the higher-quality good $q_h = (1 - t_h)\frac{4\bar{\theta}\rho_2(4\rho_2^2 - 3\rho_2 + 2)}{c_1(4\rho_2 - 1)^3}$ and sells it at price $p_h = \frac{2\bar{\theta}(\rho_2 - 1)q_h}{(4\rho_2 - 1)}$. Firm in country 2 manufactures a low-quality good $q_l = (1 - t_l)\frac{\bar{\theta}\rho_2^2(4\rho_2 - 7)}{c_2(4\rho_2 - 1)^3}$ and sells it at price $p_l = \frac{\bar{\theta}(\rho_2 - 1)q_l}{(4\rho_2 - 1)}$.

These two proposed equilibrium configurations are not feasible for all parameter constellations. The next result studies existence of (subgame) equilibrium and uniqueness. For this purpose it is convenient to define the following expressions:

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\begin{aligned}
f(x) &= \frac{4x^2 - 3x + 2}{(4x - 1)^3} \\
g(x) &= \frac{x^3 - (4x - 7)}{4(4x - 1)^3} \\
h(x) &= \frac{x^3(4x - 7)(4x^2 - 3x + 2)}{(4x - 1)^6}
\end{aligned}
$$

Denote by $\lambda_1$ the solution to equation $f(\lambda) = \frac{1 - t_l}{1 - t_h} g(\rho_1)$ and by $\lambda_2$ the solution to $f(\lambda) = \frac{1 - t_h}{1 - t_l} g(\rho_2)$, where $\rho_1$ and $\rho_2$ have already been defined above.

**Lemma 2** (i) Assignment 1 constitutes an equilibrium of the continuation game if and only if primitive parameters $(c_1; c_2; t_l; t_h)$ are such that condition $16h(\lambda_1)(1 - t_h)^2 \le h(\rho_1)(1 - t_l)^2$ is satisfied. The set of these parameters is not empty.

(ii) Assignment 2 is an equilibrium of the continuation game if and only if $(c_1; c_2; t_l; t_h)$ are such that condition $16h(\lambda_2)(1 - t_h)^2 > h(\rho_2)(1 - t_l)^2$ is fulfilled. The set of these parameters is not empty.

(iii) For those parameters such that the condition in (i) is verified while the condition in (ii) is not fulfilled, Assignment 1 is the unique equilibrium of the subgame. Otherwise, Assignment 2 is the only equilibrium.

The proof is in the Appendix. For any assignment to be an equilibrium of the continuation game, we need to check that no firm benefits by deviating from it. The conditions in Lemma 2 simply state that the profits attained in equilibrium by the low-quality firm are higher than the profits it would obtain by deviating from it and leapfrogging "upward" its rival's choice.

To better understand the conditions in Lemma 2 consider Figure 2, which illustrates these conditions when tariff rates equal zero ($t_h = t_l = 0$). A similar graph can be obtained for $t_h = t_l \neq 0$.[10] On the vertical axis we have represented the difference between the equilibrium profits of the low-quality firm and the deviating profits it would attain by leapfrogging the rival and producing an even higher quality good. The curve "difference1" refers to the Assignment 1 while "difference2" applies to Assignment 2. On the horizontal axis we have the relative development unit costs $c = c_i/c_j$. Notice that $c \geq 1$ since $c_i \geq c_j$. Observe that both curves intersect when $c = 1$ because when cost conditions are equal, both assignments coincide, except for the labels of the producers. In such a case, the qualities produced in equilibrium are identical under both assignments. The figure shows that when cost asymmetries are not very significant, i.e. for low values of $c$, both assignments constitute equilibria of the subgame. Indeed, both curves are above zero, which means that the low-quality producer has no economic interest in leapfrogging upward its rival's choice. However, when the cost difference exceeds a threshold, in this case $c_i = 1.59c_j$, the curve "difference2" takes negative values. Under Assignment 2, the low-quality firm (which is the most efficient in such a case) finds it profitable to leapfrog its rival's choice and produce a higher quality. Hence, only Assignment 1 is an equilibrium.

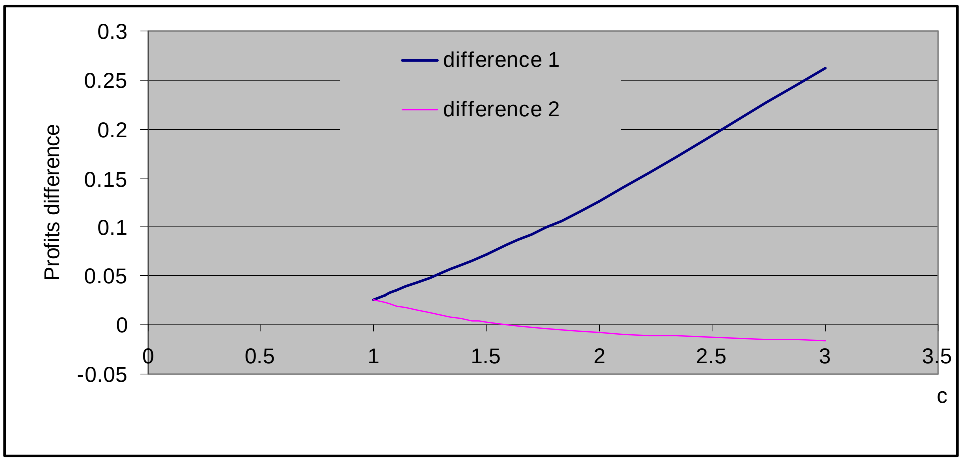


Figure 2: Equilibrium existence under Assignments 1 and 2 ($t_h = t_l = 0$).

When cost asymmetries are low, the existence of multiple equilibria in our model raises the problem of equilibrium selection. There are two arguments that help us in selecting Assignment 1 as the prevailing equilibrium.

[10] When tariff rates are different ($t_h \neq t_l$) the graph may also include values of $c = c_i(1 - t_h)/c_j(1 - t_l)$ lower than 1. When $c$ is very low, only Assignment 2 is subgame perfect equilibrium because the condition in part (i) of Lemma 2 is not verified (see the Appendix for details).

The first one employs the Risk Dominance Criterion of equilibrium selection of Harsanyi and Selten (1988) to select away Assignment 2. The intuition behind the argument is as follows. In Assignment 2 the higher quality good is produced by the most inefficient firm. Of course production of higher qualities needs greater quality investments. But the relative inefficiency of firm 1 implies that such a firm has to make a greater quality investment to produce a higher quality as compared to the efficient firm. The larger this investment the greater the risk it would take in the case that firm 1 forecasts the strategy of firm 2 incorrectly.[11]

The second argument rests on the fact that social welfare is always higher under Assignment 1 as compared to Assignment 2, for similar positive tariff rates. A formal proof of this statement is given in Lemma 6 below. This result says that social welfare increases with increasing quality gap when the tariff rates are positive. Upon observation of equation (6), since $c_1 \geq c_2$ it is clear that the quality gap under Assignment 1 is greater than that under Assignment 2 for similar tariff rates.

Our analysis, in the remainder of the paper, will employ Assignment 1 as the prevailing equilibrium in the international market. Therefore the equilibrium quality gap will be $\mu_1$ as defined above. For a more concise notation, we will drop the subscript. At this point it is necessary to mention, however, that most of the qualitative results we present below also hold for Assignment 2.

# 4 The tariff policy

Finally, in the first stage of the game, the domestic government chooses the optimal tariff policy that maximizes domestic social welfare. We assume that the proceeds obtained from import taxation are uniformly distributed among the consumers. Therefore social welfare equals domestic consumer surplus plus the (unweighted) revenues generated by the tariffs:

$$W = CS + t_l p_l D_l(\cdot) + t_h p_h D_h(\cdot)$$

[11] This problem of equilibrium selection in this class of vertically differentiated models appears when firms differ in some characteristic. In a related paper Motta et al. (1997) tackle a similar problem when countries differ in size. The Appendix uses the Risk Dominance Criterion and proves that Assignment 2 is refined away.

Consumers surplus is given by:

$$CS = \int_{\frac{p_h - p_l}{q_h - q_l}}^{\bar{\theta}} (x q_h - p_h) dx + \int_{\frac{p_l}{q_l}}^{\frac{p_h - p_l}{q_h - q_l}} (x q_l - p_l) dx$$

Employing (10), (11) and (2) and undertaking some algebraic computations, consumers surplus can be written more conveniently as:

$$CS = \frac{\bar{\theta}\mu^2 (4\mu + 5) q_l}{2(4\mu - 1)^2} \tag{12}$$

where $\mu$ is the solution to equation (6) and $q_l$ is given by (10). On the other hand, tariffs revenues obtained from imports are given by:

$$TR_k = t_k p_k D_k(.), \quad k = h, l$$

and sum up to

$$TR_l = \frac{t_l \bar{\theta}\mu(\mu - 1) q_l}{(4\mu - 1)^2}, \quad TR_h = \frac{t_h 4\bar{\theta}\mu^2(\mu - 1) q_l}{(4\mu - 1)^2} \tag{13}$$

Using the previous expressions we can write the social welfare function of the domestic country as:

$$W = A(\mu(t_l, t_h, c_1, c_2), t_l, t_h) \cdot q_l(\mu(t_l, t_h, c_1, c_2), t_l, c_1) \tag{14}$$

where $A(.) = \bar{\theta}[\mu^2(4\mu + 5)/2 + t_l\mu(\mu - 1) + 4t_h\mu^2(\mu - 1)]/(4\mu - 1)^2$ and $q_l = (1 - t_l)\bar{\theta}\mu^2(4\mu - 7)/c_1(4\mu - 1)^3$.

## 4.1 Effects of uniform and nonuniform tariffs

We are now ready to study the effects of tariffs on our equilibrium. We consider the cases of uniform taxation and nonuniform taxation separately. Consider uniform taxation first, i.e. $t_l = t_h = t$. It is clear from the equilibrium equation (6) that the quality gap remains unaltered after the policy. This enables us to state that

**Proposition 3** *Starting from the free trade situation, a small uniform tariff on both products results in (i) a downgrade in the quality of the imports, (ii) a decrease in the domestic price of the goods, (iii) a decrease in consumer surplus, and (iv) an increase in social welfare. Free trade is not an optimal policy.*

Proof. Statements (i) and (ii) follow from mere observation of equations (9)-(11). Upon observation of equation (12) one sees that the uniform tariff policy reduces consumer surplus, which proves (iii). As a result, a uniform tariff can only be desirable on welfare grounds if it allows government to extract enough foreign rents. We check this next. When the tariff policy is uniform social welfare can be written as:

$$W = \frac{\bar{\theta}\mu^2(4\mu+5)}{2(4\mu-1)^2}q_l + \frac{4\bar{\theta}\mu^2(\mu-1)}{(4\mu-1)^2}tq_l \tag{15}$$

where the first term represents consumer surplus and the second term aggregate tariff revenues. We need to calculate the sign of $dW/dt$. For this it is useful to know that $dq_l/dt = -q_l/(1-t)$. Employing this we have:

$$\frac{dW}{dt} = \frac{\bar{\theta}\mu q_l}{(1-t)(4\mu-1)^2}\left[-\frac{\mu(4\mu+5)}{2} + (1-2t)(\mu-1)(4\mu+1)\right] \tag{16}$$

Evaluating this derivative in a neighborhood of the free trade equilibrium ($t=0$) we clearly obtain that $dW/dt|_{t=0} = -0.5\mu(4\mu+5)+(\mu-1)(4\mu+1)$. Or $dW/dt|_{t=0} = 0.5(4\mu^2-11\mu-2)$; which is positive whenever $\mu \geq 2.921164$. Observe that since $c_1 \geq c_2$ and tariff rates are equal, the solution to equation (6) satisfies $\mu \geq 5.25123$. Therefore we conclude that $dW/dt|_{t=0} > 0$. ■

Proposition 3 indicates that the policy prescription known in the literature[12] that a small uniform tariff against a foreign oligopoly of homogeneous goods is welfare enhancing also applies to a vertically differentiated oligopoly. As in that literature, a tariff is attractive because income is taken from foreign firms, which compensates for the reduction in consumer surplus that the policy generates.

It is also possible to compare our results with those obtained when demand is satisfied by a foreign monopolist with endogenous quality (Krishna, 1987; Das and Donnenfeld, 1987). We also obtain that the imposition of a tariff results in a downgrade of the quality of the imports,[13] which of course has a negative impact on social welfare. Unlike these two papers where the effect of the tariff on the quantity of imports is ambiguous, it is zero here because the policy does not affect the terms of competition between the two foreign firms. In our setting the policy brings about a substantial increase in tariff revenues which more than offsets the decrease in social welfare caused

[12] See Brander and Spencer (1984) and Helpman and Krugman (1989, ch. 4).

[13] In order to be able to compare with Krishna (1987) notice that, given our preference structure, demand for a monopolist would be $x = 1 - p/q\bar{\theta}$. Therefore $P_{xq} < 0$.

by the quality downgrading. In contrast, in the monopoly settings mentioned a tariff on the imports may increase welfare even if tariff revenues are disregarded. This happens when the typical quantity distortion introduced by a monopolist is substantially reduced.

Let us now consider the effects of a nonuniform tariff policy on our equilibrium. As Lemma 1 shows, an asymmetric trade policy alters the equilibrium quality gap because the imposition of distinct tariffs on the imports alters the international competitive conditions and causes asymmetric effects on the quality of imports from the two distinct countries. To study the incidence of nonuniform tariffs, one must consider two effects: On the one hand, the direct effects of the policy, which are basically due to cost increases, have been already presented in Proposition 3. On the other hand, there are indirect effects due to the strategic decisions firms take in response to the alteration of competitive conditions.

**Proposition 4** *(i) Starting from free trade a small tariff on the low-quality variant leads to: (a) a downgrade in the quality of both variants, (b) an increase in the price of the high-quality product, (c) a reduction in the price of the low-quality good, (d) a reduction in the quantities sold and in the number of consumers being served (and so market size), (e) a reduction in consumer surplus and (f) a decrease in social welfare.*

*(ii) Starting from free trade a small tariff on the high-quality variant leads to (a') a downgrade in the quality and price of both variants and (b') an increase in the quantities sold and in the number of consumers being served, (c') a decrease in consumer surplus and (d') an increase in social welfare.*

The proof is in the Appendix. This result illustrates that the effects of asymmetric tariff policies are sensitive to whether it is the low-quality or the high-quality firm which is conferred a technological advantage. Essentially, both policies downgrade qualities, which reduces consumer surplus. However, a tariff on the low-quality producing country has two additional pervasive effects: the rise of the price of the high-quality good and the fall in the number of active consumers. This together with the fact that the proceeds obtained from the tariff policy are small imply that a tariff on the low-quality good is undesirable on welfare grounds. In contrast, a tariff on the high-quality firm raises welfare. This measure fosters competition which reduces equilibrium prices and increases market size. Though the overall effect is a fall in consumer surplus, tariff revenues more than offset this reduction.

## 4.2 The MFN principle

We are now in a position to study the optimal tariff policy under the MFN principle. This principle is a central pillar of international trade whose description is given by Article I of the General Agreement on Tariffs and Trade (GATT):

> "With respect to customs duties and charges of any kind imposed on or in connection with importation or exportation..., any advantage, favour, privilege or immunity granted by any contracting party to any product originating in or destined for any other country shall be accorded immediately and unconditionally to the like product originating in or destined for the territories of all other contracting parties." (GATT, 1994, p. 486)

The MFN obligation has the effect of treating activities of a particular foreign country at least as favorably as activities of other countries. Applying the MFN principle to our framework is equivalent to set optimal tariffs in a manner such that $t_h = t_l = t$. Policymaker of the domestic country thus chooses the MFN tariff $t$ to maximize domestic social welfare. As noticed above, an important observation is that equilibrium product differentiation is independent of the MFN clause since tariff rates are similar in this case (see equation (6)). Hence, the social planner chooses $t$ to maximize (15). The first order condition is (16). Solving for $t$ we obtain the MFN clause tariff.

**Proposition 5** *Under the MFN principle, firms are taxed at the positive rate*

$$t^{MFN} = \frac{1}{2}\left[1 - \frac{\mu(4\mu + 5)}{2(\mu - 1)(4\mu + 1)}\right] \tag{17}$$

*where $\mu$ is the solution to equation (6).*

*Proof.* It only remains to prove that the optimal MFN clause tariff is positive. Note that $t > 0$ if and only if $2(\mu - 1)(4\mu + 1) > \mu(4\mu + 5)$. That is whenever $4\mu^2 - 11\mu - 2 > 0$. Solving this inequality we obtain that $t > 0$ if and only if $\mu > 2.921164$, which is always satisfied since $c_1 \geq c_2$ (see equation (6)). ■

The following observations are worth mentioning. The MFN clause tariff rate increases as the quality gap increases, i.e. $dt^{MFN}/d\mu > 0$. This implies that the $MFN$ tariff is larger, the greater the asymmetries between the firms. It is however never larger than 25 percent ($\lim_{\mu \to 1} t(\mu)^{MFN} = 0.25$). Table 1 reports the values of the $MFN$ clause tariff for some parameter constellations. In addition, we report the social welfare gains obtained by applying the $MFN$ principle as compared to a free trade ($FT$) policy. As it can be seen, when firms are symmetric welfare gains of 2.5 percent can be achieved by imposing a $MFN$ tariff of 13.51 percent. These welfare gains are larger when firms differ substantially. It is also worth mentioning that, since the $MFN$ policy does not affect the quality gap, hedonic prices are not modified (i.e. prices and qualities fall in the same proportion; see (9), (10) and (11)).

| $c_l/c_h$ | 1 | 1.1 | 1.5 | 2 | 3 |
|---|---|---|---|---|---|
| $t^{MFN}$ (%) | 13.51 | 14.44 | 17.05 | 18.94 | 20.91 |
| $W^{FT}$ | 0.04322 | 0.04229 | 0.03965 | 0.03770 | 0.03565 |
| $W^{MFN}$ | 0.04430 | 0.04353 | 0.04140 | 0.03988 | 0.03832 |
| % gains over FT | 2.50 | 2.93 | 4.41 | 5.77 | 7.51 |

Table 1: The Most-Favored-Nation tariff policy ($\bar{\theta} = 1$)

The optimum found above is a constrained optimum since tariffs are restricted to be identical by the $MFN$ principle. Basic optimization theory suggests that a constrained optimum generates values of the objective function that are lower than those in a free optimum. Hence, a higher welfare level can be attained by setting differentiated tariff rates. In what follows we study the domestic government's incentives to deviate from the $MFN$ clause described in Proposition 5.

Differentiating (14) with respect to $t_l$ and $t_h$ and rearranging terms we obtain:

$$\frac{dW}{dt_l} = \frac{W}{(1-t_l)} \left[ \frac{\mu \bar{\theta}(1-t_l)(\mu-1)}{A(\cdot)(4\mu-1)^2} - 1 + \alpha\beta \right] \tag{18}$$

$$\frac{dW}{dt_h} = \frac{W}{(1-t_h)} \left[ \frac{4\mu^2 \bar{\theta}(1-t_h)(\mu-1)}{A(\cdot)(4\mu-1)^2} - \alpha\beta \right] \tag{19}$$

where $\alpha = \frac{\partial \mu}{\partial c}\frac{c}{\mu}$ with $c = \frac{c_h(1-t_h)}{c_l(1-t_l)}$; and $\beta = \frac{\partial W}{\partial \mu}\frac{\mu}{W}$. The explicit values of $\alpha$ and $\beta$ are given in the Appendix. Here $\alpha$ represents the elasticity of the quality gap $\mu$ with respect to the relative unit costs in (6), which by Lemma 1 is positive. The other parameter $\beta$ represents the elasticity of welfare $W$ with respect to the quality gap $\mu$. The next Lemma shows that this last elasticity is also positive when tariff rates are positive (as those under the MFN principle).

**Lemma 6** *For any given positive tariff policy $(t_l, t_h)$, social welfare is increasing with the quality gap $\mu$ (i.e. $\beta > 0$).*

*Proof.* For a given pair of tariffs $(t_l, t_h)$ we can compute $dW/d\mu = (dq_l/d\mu)A + q_l(dA/d\mu)$. It is easily checked that

$$\frac{dq_l}{d\mu} = \frac{(1-t_l)2\bar{\theta}\mu(8\mu+7)}{c_l(4\mu-1)^4} > 0$$

and that

$$\frac{dA}{d\mu} = \frac{\bar{\theta}[(8\mu^2-6\mu-5)\mu + t_l(2\mu+1) + 2\mu t_h(8\mu^2-6\mu+4)]}{(4\mu-1)^3}.$$

Since $\mu$ is always larger than 1.75 in any equilibrium, this latter derivative has a positive sign when $t_h, t_l > 0$. Therefore $dW/d\mu > 0$ when $t_h, t_l > 0$. ■

Expressions (18) and (19) imply that an increase in a tariff affects welfare in several different ways. First, it increases tariff revenues. Second, it lowers the quality of the variant considered (this effect has been substituted away in (19) for convenience). Third, it affects price competition between the two firms. This last effect is positive for $t_l$ and negative for $t_h$, as they affect the LHS of (6) in a different manner. This, together with Lemma 6, demonstrates that a MFN tariff policy is not optimal.

**Proposition 7** *Starting from a MFN policy, social welfare can be increased by (1) slightly lowering the tariff rate on the low-quality good and (2) slightly raising the tariff on the high-quality good, iff $\alpha\beta < 4\mu/(1+4\mu)$.*

*Proof.* The idea behind the proof is to evaluate (18) and (19) at $t_h = t_l = t^{MFN}$ and study their signs at that point. Consider first (19). Notice that $dW/dt_h|_{t_h=t_l=t^{MFN}} > 0$ if and only if

$$4\bar{\theta}\mu^2(\mu-1)(1-t^{MFN}) > \alpha\beta(4\mu-1)^2 A(\cdot)$$

Since Lemma 6 shows that $\beta > 0$, this condition rewrites as (substituting the expression for $A(\cdot)$):

$$\alpha\beta < \frac{4\mu(\mu-1)(1-t^{MFN})}{0.5\mu(4\mu+5) + t^{MFN}(\mu-1)(1+4\mu)}$$

Using (17), this condition reduces to:

$$\alpha\beta < \frac{4\mu}{4\mu+1} \tag{20}$$

Consider now (18). Then we have that $dW/dt_l < 0 \,|_{t_h = t_l = t^{MFN}}$ if and only if:

$$(\mu - 1)\mu\beta\theta(1 - t^{MFN}) < (1 - \alpha\beta)(4\mu - 1)^2 A(\cdot).$$

Substituting $A(\cdot)$ and $t^{MFN}$ into this inequality, we obtain (20) too. ■

The condition in Proposition 7 turns out not to be restrictive at all. Table 2 reports simulated values of $\alpha$ and $\beta$ as well as the condition $\alpha\beta < 4\mu/(4\mu+1)$ at the point $t_h = t_l = t^{MFN}$, for different values of $c = c_1/c_2$. It is clear that this condition is generally fulfilled in our model.

| $c_1/c_2$ | $\alpha$ | $\beta$ | $\alpha\beta$ | $4\mu/(4\mu+1)$ |
|---|---|---|---|---|
| 1 | 0.725645 | 1.11727 | 0.810742 | 0.954556 |
| 1.1 | 0.749793 | 1.09673 | 0.821223 | 0.957509 |
| 1.5 | 0.814169 | 1.05040 | 0.855206 | 0.96636 |
| 2 | 0.861392 | 1.02647 | 0.884193 | 0.97338 |
| 3 | 0.909234 | 1.00973 | 0.918077 | 0.98127 |

Table 2: Condition in Proposition 7.

## 4.3 First best policy

The preceding result has clearly indicated the incentives for the activist government to deviate from the MFN principle and apply a nonuniform tariff policy. In the remainder of the paper we will consider several nonuniform tariff policy options the government can choose from.

The activist government can implement a nonuniform tariff policy by redefining its tariff nomenclature. Proposition 7 indeed suggests that it is optimal for the government to include two distinct entries for the good in question, one which specifies the characteristics of the low-quality variant, the other for the high-quality one. By doing so, the MFN principle is no longer operative since we now face two "different" goods originating from two different countries. In addition, the first best policy can be applied while still complying with the WTO legislation. Our next results sheds light on the optimal policy.

**Proposition 8** *The optimal trade policy involves a tariff on the high-quality good and a subsidy on the low-quality good.*

*Proof.* The optimal policy is a triple $(t_l; t_h; \mu)$ such that (18), (19) and (6) hold. From (18) we have:

$$\alpha\beta = 1 - \frac{\bar{\theta}(1 - t_l)\mu(\mu - 1)}{A(\cdot)(4\mu - 1)^2}$$

This expression together with (19) gives the relation

$$A(\cdot)(4\mu - 1)^2 - \bar{\theta}(1 - t_l)\mu(\mu - 1) = 4\bar{\theta}(1 - t_h)\mu^2(\mu - 1)$$

Using the expression for $A(\cdot)$, this equation reduces to:

$$16 t_h \mu(\mu - 1) + 4 t_l(\mu - 1) = 4\mu^2 - 11\mu - 2.$$

We can isolate $t_l$ to obtain:

$$t_l = \frac{4\mu^2 - 11\mu - 2}{4(\mu - 1)} - 4\mu t_h \tag{21}$$

This equation gives the relationship between $t_l$ and $t_h$. Notice that the first term of the RHS of expression (21) is positive. As a result, $t_l < 0$ necessarily implies that $t_h > 0$. Hence, it suffices to show that the optimal policy is such that $t_l < 0$. To that end, we isolate $t_h$ in (21) and substitute it into (18) to study the sign of $dW(t_l; t_h^*(t_l))$ for several values of $t_l$. It is easily shown that

$$\left.\frac{dW}{dt_l}\right|_{t_l = t^{MFN}} < 0; \text{ and } \left.\frac{dW}{dt_l}\right|_{t_l = 0} < 0.$$

Therefore there exists a negative $t_l^*$ in the interval $(-\infty; 0)$ for which social welfare function reaches a maximum. Hence, the optimal policy will include a subsidy on the low-quality good. ∎

Table 3 reports social welfare $W^*$ attained under the optimal tariff policy. Percentage changes in welfare and in hedonic prices with respect to free trade (FT) and the optimal MFN policy are also reported. Compared to the MFN clause, social welfare gains of about 6 to 11 can be achieved via a hedonic price reduction of about 10 to 16 percent. It can also be observed that the policy is shaped to reduce the high-quality and increase the low-quality. Indeed $q_h^{FT} > q_h^* > q_h^{MFN}$ and $q_l^* > q_l^{FT} > q_l^{MFN}$.

| $c_1 = c_2$ | 1 | 1.1 | 1.5 | 2 | 3 |
|---|---|---|---|---|---|
| $W^*$ | 0.04925 | 0.04830 | 0.04545 | 0.04317 | 0.04061 |
| % Change over MFN : | | | | | |
| Welfare | 11.17 | 10.97 | 9.79 | 8.26 | 5.97 |
| Hedonic Prices | -16.40 | -16.25 | -15.11 | -13.32 | -10.17 |
| % Change over FT : | | | | | |
| Welfare | 13.95 | 14.22 | 14.64 | 14.51 | 13.93 |

Table 3: The optimal policy ($\bar{\mu} = 1$)

# 5 Regional Trade Agreements

A typical example of a nonuniform tariff policy which complies with the WTO legislation is a RTA. A common feature of these agreements is the discriminatory treatment which favors members relative to non-members. Goods imported from member countries face a zero tariff while similar goods imported from non-member countries face a positive tariff. Consider the case where domestic authorities desire to form a RTA with one of the two foreign countries.[14] An interesting question arises here: Is it preferable to form a RTA with the country where the low-quality firm is located or with the country hosting the high-quality firm? We study this issue starting from the MFN clause policy.

**Proposition 9** *A Regional Trade Agreement with the low-quality producing country is always welfare superior to one with the high-quality producing country.*

**Proof.** The reasoning behind the proof is to show that (18) when evaluated at $t_h = t^{MFN}$ is in absolute value larger than (19) when evaluated at $t_l = t^{MFN}$: If this is true for any $(t_l; t_h)$ in the interval $(0; t^{MFN})$; then the result follows. Figure 3 illustrates this reasoning.

From Proposition 7 we know that (i) keeping $t_h = t^{MFN}$ fixed, social welfare $W(t_l; t_h = t^{MFN})$ is downward sloping in a neighborhood of $t_l = t^{MFN}$; and that (ii) keeping $t_l = t^{MFN}$ fixed, $W(t_l = t^{MFN}; t_h)$ is upward sloping in a neighborhood of $t_h = t^{MFN}$. Therefore starting from the MFN policy (point M in Figure 3) a RTA with the low-quality country would lead

[14] Notice that a RTA with both countries is nothing else than FT. Proposition 3 has already shown that the planner at the domestic country does not desire such a policy.

to a welfare level determined by point A in the Figure whenever $W$ is a well-behaved function. In contrast, a RTA with the high-quality country would lead to the welfare level B. Analytically, this is the case if and only if:

$$\frac{(-1+\alpha\beta)}{(1-t_l)}+\frac{(1+\alpha\beta)}{(1-t_h)}+\frac{\beta\theta\mu(\mu-1)}{(4\mu-1)^2}\left[\frac{1}{A(t_l;t^{MFN};\mu)}-\frac{4\mu}{A(t_h;t^{MFN};\mu)}\right]<0$$

where $A(\cdot)$ and $t^{MFN}$ are given above. The term within square brackets is strongly negative and more than offsets any positive sum of the two first terms of the condition above. Starting from the MFN principle, this condition is generally satisfied. ■

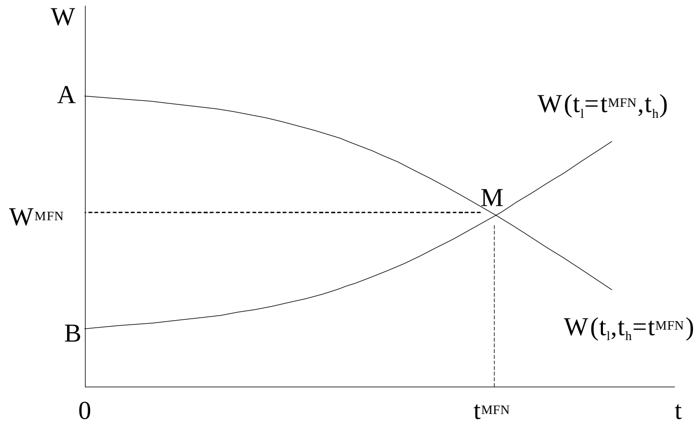


Figure 3: Regional Trade Agreements

The next table reports the welfare levels attained by establishing RTAs with the high and the low-quality producing countries. It also gives the percentage changes in social welfare as well as in hedonic prices with respect to the MFN clause. We can see that the ranking of welfare levels corresponds to that of Figure 3. A RTA with the country which exports the low-quality good is always welfare increasing. In contrast, a RTA with the other country is always welfare reducing, the welfare loss increasing with the cost asymmetry. The reason is that even though both hedonic prices are affected in the same proportion (see (9)), they change in opposite directions: they decrease under a RTA with the low-quality country while increase under a RTA with the high-quality one. Intuitively, the RTA with the low-quality country is preferable because it comes closest to the first best policy.[15]

[15] A further remark is that it should be noted that in the RTAs we have presented, the firm which does not take part in the agreement continues in general facing the optimal

| $c_1/c_2$ | 1.1 | 1.5 | 2 | 3 |
|---|---|---|---|---|
| 1. W ($RTA_{low}$) | 0.04396 | 0.04227 | 0.04035 | 0.03891 |
| % Change over MFN: | | | | |
| -Welfare | 0.99 | 2.11 | 1.19 | 1.53 |
| -Hedonic prices | -1.24 | -2.03 | -1.85 | -1.49 |
| 2. W ($RTA_{high}$) | 0.04120 | 0.03863 | 0.03680 | 0.03495 |
| % Change over MFN: | | | | |
| -Welfare | -5.31 | -6.68 | -7.71 | -8.80 |
| -Hedonic prices | 1.90 | 1.80 | 1.58 | 1.22 |

Table 4: Welfare and RTAs ($\bar{\mu} = 1$)

Based on the numerical simulations of the model reported in Tables 3 and 4, it is possible to establish a ranking of tariff policies based on social welfare levels. Second in the ranking after the first best policy is a RTA with the country where the low-quality firm is located. Indeed, such a RTA is closest to the optimal policy. These welfare levels exceed those of the MFN principle and free trade. In contrast, a RTA with the country where the high-quality firm is established is the worst option.

# 6 Discussion

This paper has considered optimal tariff policy in a context where products contain different quality attributes and where local demand is met by imports from two firms located in two different countries. It has been shown that a pure-strategy asymmetric equilibrium arises whenever consumers have heterogenous tastes on quality. While prior research has indicated how social welfare can be improved by altering quality through taxation in monopoly settings, our analysis has refined the discussion by determining the optimal tariff policy in the set of alternatives under oligopoly. The existence of asymmetric qualities gives rise to a first best policy consisting of setting a nonuniform tariff policy.

This result gives rise to a dilemma-like situation. On the one hand, there are clear incentives for the activist government to deviate from the MFN

MFN tariff. As expected, when the government reduces the tariff on one of the countries to zero, it does better by recalculating the tariff for the other country. As mentioned above, the domestic government wishes to form a RTA with the low-quality producing country. For this case, re-optimization would give a new tariff for the high-quality producing country which is higher than that under the MFN clause.

principle. On the other hand, because of possible sanctions, the authority wishes to comply with the WTO legislation. The government is therefore tempted to use quality as an argument for entering different variants of a good in its tariff nomenclature and thus pursue its optimal tariff policy. Our numerical simulations reveal gains of about 14 percent of a first best policy over free trade, which are likely to be larger than the administrative costs of implementing such a policy.

Alternatively, the government may consider the formation of a regional agreement. In this regard, our theory makes predictions concerning potential members of a RTA: welfare improvement is only possible if a RTA is achieved with a low-quality producing country. However, according to the same argument, the latter may have no incentive to join unless liberalization in other areas is granted as well. Though our model is too partial equilibrium to answer questions of reciprocity, it is interesting to observe that regional trade agreements seldom address only trade barriers.[16]

[16]For example, Ethier (1998) argues that regional trade agreements give newcomers a marginal advantage compared to non-participating countries in attracting foreign direct investments, which then give access to a larger market.

# 7 Appendix

## 7.1 Proof of Lemma 2

Recall the following definitions and notation:

$f(x) = \frac{4x^2 - 3x + 2}{(4x-1)^3}$

$g(x) = \frac{x^3(4x-7)}{4(4x-1)^3}$

$h(x) = \frac{x^3(4x-7)(4x^2-3x+2)}{(4x-1)^6}$

It can be easily checked that $f'(x) < 0$; $f''(x) > 0$; $g'(x) > 0$; $g''(x) < 0$ and $h'(x) > 0$ for all $x \geq 7/4$.

We denote $\mu_1$ as the solution to equation:

$$k_1 = \frac{\mu^2(4\mu - 7)}{4(4\mu^2 - 3\mu + 2)} \tag{22}$$

with $k_1 = \frac{c_1(1-t_h)}{c_2(1-t_l)} > 0$; and $\mu_2$ as the solution to:

$$k_2 = \frac{\mu^2(4\mu - 7)}{4(4\mu^2 - 3\mu + 2)} \tag{23}$$

with $k_2 = \frac{c_2(1-t_l)}{c_1(1-t_h)}$. In addition, we denote $\lambda_1$ as the solution to equation $f(\lambda) = \frac{1-t_l}{1-t_h} g(\mu_1)$ and $\lambda_2$ as the solution to $f(\lambda) = \frac{1-t_h}{1-t_l} g(\mu_2)$.

(i) First we study the conditions under which Assignment 1 is an equilibrium. To do so, we first prove that both firms' profits at the proposed equilibrium are non-negative. Then, we check that no firm has an incentive to deviate from it, i.e. no firm has an incentive to leapfrog its rival's choice. Notice first that equilibrium profits under Assignment 1 can be written as:

$$\pi_{1,l} = \frac{\bar{\theta}^2(1-t_l)^2 \mu_1^3(4\mu_1 - 7)(4\mu_1^2 - 3\mu_1 + 2)}{2c_1(4\mu_1 - 1)^6} \tag{24}$$

and

$$\pi_{2,h} = \frac{16c_1(1-t_h)^2}{c_2(1-t_l)^2}\pi_{1,l}. \tag{25}$$

It is easy to check that $\mu_1'(k_1) > 0$. Then, in equilibrium, for any parametrical constellation, it must be the case that $\mu_1 \geq 7/4 = 1.75$. This actually implies that $q_l$ and $q_h$ are positive and that both firms' equilibrium benefits are non-negative (see (24) and (25)).

Now, let us see that no firm has an incentive to deviate by leapfrogging the rival's choice. The case of "downward" leapfrogging only makes sense if the low-quality good generates higher profits as compared to the high-quality good. Corrected for cost and tariff differences, selling a higher quality good pays 16 times more than manufacturing a lower quality good (see (25)). Therefore, for reasonable tariff rates downward leapfrogging can be ruled out. The same reasoning, however, suggests potential for "upward" leapfrogging. Suppose firm at country 1 deviates by leapfrogging its rival. In such a case, firm at country 1 would select $q \geq q_h$ to maximize deviating profits:

$$\tilde{\pi}_{1,h} = (1 - t_h)\frac{4\bar{\theta}q^2(q - q_h)}{(4q - q_h)^2} - \frac{c_1 q^2}{2}$$

The first order condition is:

$$(1 - t_h)\frac{4\bar{\theta}q(4q^2 - 3qq_h + 2q_h^2)}{(4q - q_h)^3} - c_1 q = 0$$

Define $\lambda \geq 1$ such that $q = \lambda q_h = \lambda \mu_1 q_l$. Then, we can write:

$$q = (1 - t_h)\frac{4\bar{\theta}\lambda(4\lambda^2 - 3\lambda + 2)}{c_1(4\lambda - 1)^3} = \lambda q_h = \lambda(1 - t_h)\frac{4\bar{\theta}\mu_1(4\mu_1^2 - 3\mu_1 + 2)}{c_2(4\mu_1 - 1)^3}$$

From this equality, we obtain that $\lambda$ must satisfy:

$$\frac{c_1}{c_2} = \frac{(4\lambda^2 - 3\lambda + 2)(4\mu_1 - 1)^3}{(4\lambda - 1)^3\mu_1(4\mu_1^2 - 3\mu_1 + 2)}$$

Using the definitions given above and equation (22), we can write:

$$f(\lambda) = \frac{(4\lambda^2 - 3\lambda + 2)}{(4\lambda - 1)^3} = \frac{1 - t_l}{1 - t_h}\frac{\mu_1^3(4\mu_1 - 7)}{4(4\mu_1 - 1)^3} = g(\mu_1; t_l; t_h) \qquad (26)$$

The solution to this equation is $\lambda_1$ as defined above. Equation (26) gives the optimal deviating product differentiation ($\lambda_1$) as a function of the proposed equilibrium product differentiation $\mu_1$. Taking into account this relationship, we can compare deviating profits $\tilde{\pi}_{1,h}$ with those at the proposed equilibrium $\pi_{1,l}$. Low-quality firm at country 1 does not deviate whenever $\tilde{\pi}_{1,h} \leq \pi_{1,l}$: Deviating profits can be written as:

$$\tilde{\pi}_{1,h} = (1 - t_h)^2\frac{8\bar{\theta}^2 h(\lambda_1)}{c_1}$$

while equilibrium profits are:

$$\pi_{1,h} = (1-t_l)^2 \frac{\bar{\theta}^2 h(\mu_1)}{2c_1}$$

Dividing these two expressions we get:

$$\frac{\tilde{\pi}_{1,h}}{\pi_{1,l}} = \frac{(1-t_h)^2}{(1-t_l)^2}\frac{16h(\lambda_1)}{h(\mu_1)}$$

Therefore, firm 1 does not deviate if and only if $16h(\lambda_1)(1-t_h)^2 \le h(\mu_1)(1-t_l)^2$, which is the condition given in Lemma 2. Thus, for primitive parameters $(c_1, c_2, t_l, t_h)$ such that this inequality is satisfied, Assignment 1 is an equilibrium. To complete the proof we need to show that the parametrical space for which the equations above have real well-defined solutions and the above inequality is fulfilled is not empty. We do this by means of one example. First, note that equation (6) is a cubic equation in $\mu$. Notice also that its RHS is increasing in $\mu$. Therefore, since any valid set of parameters $(c_1, c_2, t_1, t_2)$ satisfies $\frac{c_i(1-t_j)}{c_j(1-t_i)} > 0$, $i, j = 1, 2$, $i \neq j$, there is always a real solution to (6) satisfying $\mu \ge 1.75$. Now, given this, notice that there also exists a solution to equation $f(\lambda) - kg(\mu) = 0$. Indeed, this is also a cubic equation in $\lambda$ that writes $(4\lambda^2 - 3\lambda + 2)/kg(\mu) = (4\lambda - 1)^3$. Since the LHS is ever positive, the solution satisfies $\lambda \ge 1$, as required. It can be shown that primitive parameters exist for which Assignment 1 is an equilibrium of the continuation game. Suppose $c_1 = 1.1$ and $c_2 = 1$ and a MFN clause tariff policy i.e. $t_1 = t_2$. Then, $\mu_1 = 5.6335$, $\lambda_1 = 1.2578$ and therefore $16h(\lambda_1)(1-t_h)^2 = -4.1582 \times 10^{-3} < 0 < h(\mu_1)(1-t_l)^2 = 3.1208 \times 10^{-3}$. Thus, Assignment 1 is an equilibrium of the continuation game. This completes the proof of part (i).

The proof of part (ii) is analogous. To economize on space we do not present it here. It is easily seen that Assignment 2 is also an equilibrium for the parameters given above. Indeed $\mu_2 = 4.906$; $\lambda_2 = 1.4038$ and $16h(\lambda_2)(1-t_l)^2 = -0.035971 < 0 < h(\mu_2)(1-t_h)^2 = 0.0029849$.

Part (iii) follows from (i) and (ii). We simply need to show that the parameters for which only one equilibrium exists is not empty. Consider for instance $c_1 = 3$ and $c_2 = 1$ with a MFN clause tariff policy. ■

## 7.2 The Harsanyi-Selten criterion

Here we apply the Risk Dominance criterion to the case where tariff rates are zero. We follow Motta et al. (1997) who provide an excellent guide to apply this refinement in the class of games we are considering. Represent firms choices between both assignments $A_k$; $k = 1; 2$ as a $2 \times 2$ game as follows:

| | $A_1$ | $A_2$ |
|---|---|---|
| $A_1$ | $(x_{11}; y_{11})$ | $(x_{12}; y_{12})$ |
| $A_2$ | $(x_{21}; y_{21})$ | $(x_{22}; y_{22})$ |

Here $x$ represents payoffs for firm 1 and $y$ payoffs for firm 2. Clearly, $[A_1; A_1]$ and $[A_2; A_2]$ are both equilibria of the game with corresponding payoffs $(x_{11}; y_{11})$ and $(x_{22}; y_{22})$ respectively. Let $G_{11} = x_{11} - x_{21}$ be the gain to firm 1 by predicting correctly that firm 2 will select Assignment 1 (and best responding to the prediction). Likewise, $G_{12} = x_{22} - x_{12}$ is the gain to firm 1 by forecasting correctly that firm 2 will select Assignment 2. For firm 2 we have $G_{21} = y_{11} - y_{12}$ and $G_{22} = y_{22} - y_{21}$: It is said that Assignment 1 risk dominates Assignment 2 whenever $G_{11}G_{21} > G_{12}G_{22}$:

Figure 4 represents $G_{11}; G_{12}; G_{21}$ and $G_{22}$ for the case where tariff rates are zero in the region of relative costs $c$ for which both equilibria exist, i.e. $c_1 \leq 1.59\, c_2$. It can be seen that the inequality above is satisfied and therefore the unique equilibrium remaining is Assignment 1. It is important to note that for any policy such that the MFN principle applies, i.e. $t_h = t_l$ the graph below only changes quantitatively, not qualitatively. Therefore, under the MFN principle, only Assignment 1 is an equilibrium.[17]

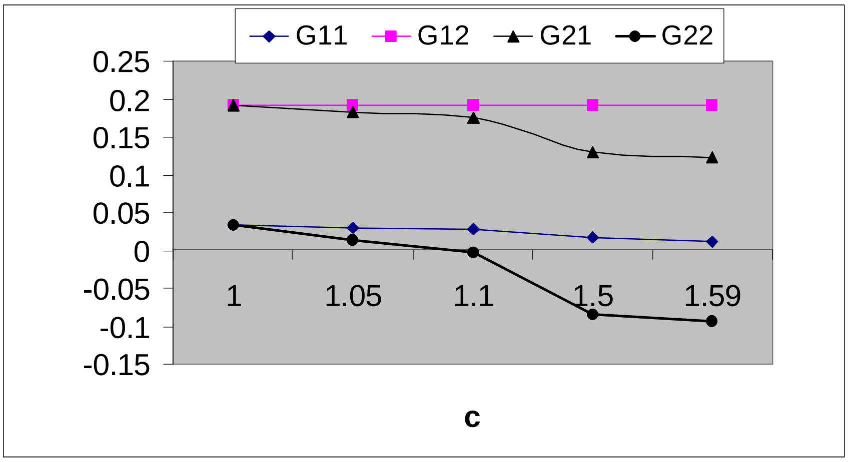


Figure 4: Risk Dominance Criterion

[17] The calculations and figures showing that Assignment 1 is the unique refined-equilibrium for other tariff schedules are similar and therefore omitted.

## 7.3 Proof of Proposition 4

(i) First, notice that by Lemma 1 $\frac{\partial \mu}{\partial t_l} > 0.$ (a) We need to compute the sign of $\frac{dq_h}{dt_l} = \frac{\partial q_h}{\partial \mu}\frac{\partial \mu}{\partial t_l}.$ From 11 we have $\frac{\partial q_h}{\partial \mu} = -\frac{(1-t_h)8\bar{\theta}(5\mu+1)}{c_2(4\mu-1)^4} < 0.$ Therefore $\frac{dq_h}{dt_l} < 0.$ We also need the sign of $\frac{dq_l}{dt_l}.$ Write $q_l = \frac{q_h}{\mu}.$ Since $q_h$ falls and $\mu$ increases with $t_l$, then $\frac{dq_l}{dt_l} < 0.$ (b) Use (11) and (9) to rewrite $p_h = \frac{(1-t_h)8\bar{\theta}^2\mu(\mu-1)(4\mu^2-3\mu+2)}{c_2(4\mu-1)^4}$. We need the sign of $\frac{dp_h}{dt_l} = \frac{\partial p_h}{\partial \mu}\frac{\partial \mu}{\partial t_l}.$ Since $\frac{\partial p_h}{\partial \mu} = \frac{(1-t_h)8\bar{\theta}^2(12\mu^3-19\mu^2+14\mu+2)}{c_2(4\mu-1)^5} > 0$, we conclude that $\frac{dp_h}{dt_l} > 0$, i.e. the domestic price of the high-quality good increases. (c) From (9) we have $p_l = p_h/2\mu.$ Then, $p_l = \frac{\bar{\theta}(\mu-1)}{\mu(4\mu-1)}q_h.$ Observe that $\frac{\bar{\theta}(\mu-1)}{\mu(4\mu-1)}$ decreases with $\mu \geq 5.25123$, and so with $t_l.$ Also that $q_h$ falls with $t_l.$ Then we conclude that $\frac{dp_l}{dt_l} < 0.$ (d) The result follows from the fact that $dD_i/d\mu < 0$, $i = 1, 2$ (see (8)). (e) Consumer surplus can be written as $CS = \frac{\bar{\theta}\mu(4\mu+5)}{2(4\mu-1)^2}q_h.$ It can be seen that both factors $\frac{\bar{\theta}\mu(4\mu+5)}{2(4\mu-1)^2}$ and $q_h$ fall with $\mu.$ Therefore $\frac{dCS}{dt_l} < 0.$ (f) Using (12), (13) and (10), the relevant expression of social welfare is $W = \frac{\bar{\theta}^2\mu^3(4\mu-7)(1-t_l)(\mu(4\mu+5)+2t_l(\mu-1))}{2c_1(4\mu-1)^2}.$ We need the sign of $\left.\frac{dW}{dt_l}\right|_{t_l=0} = \left.\frac{\partial W}{\partial t_l}\right|_{t_l=0} + \left.\frac{\partial W}{\partial \mu}\frac{\partial \mu}{\partial t_l}\right|_{t_l=0}.$ We can compute $\left.\frac{\partial W}{\partial t_l}\right|_{t_l=0} = -\frac{\bar{\theta}^2\mu^3(4\mu-7)(4\mu^2+3\mu+2)}{2c_1(4\mu-1)^5} < 0.$ Also $\left.\frac{\partial W}{\partial \mu}\right|_{t_l=0} = \frac{\bar{\theta}^2\mu^3(16\mu^3-24\mu^2+45\mu+35)}{c_1(4\mu-1)^6} > 0.$ From equation (6) we have that $\left.\frac{\partial \mu}{\partial t_l}\right|_{t_l=0} = \frac{c_2\mu^3(4\mu-7)^2}{4c_1(16\mu^3-24\mu^2+45\mu-28)} > 0.$ Using again (6) to substitute $c_2 = c_1$, we can write $\left.\frac{\partial \mu}{\partial t_l}\right|_{t_l=0} = \frac{\mu(4\mu-7)(4\mu^2-3\mu+2)}{16\mu^3-24\mu^2+45\mu-28} > 0.$ Now we are ready to compute the total derivative
$\left.\frac{dW}{dt_l}\right|_{t_l=0} = -\frac{\bar{\theta}^2\mu^3(4\mu-7)(128\mu^6+32\mu^5+40\mu^4-154\mu^3+79\mu^2-370\mu+56)}{c_1(4\mu-1)^5(128\mu^4-224\mu^3+408\mu^2-314\mu+56)} < 0.$ This completes the proof of (i).

The proof of (ii) is analogous and therefore omitted. ■

## 7.4 Elasticities $\alpha$ and $\beta$ in (18) and (19)

$\alpha = \frac{4k(4\mu^2-3\mu+2)^2}{\mu^2(16\mu^3-24\mu^2+45\mu-28)}$ with $k = \frac{c_i(1-t_h)}{c_j(1-t_l)}.$

$\beta = y_1/y_2$ where

$$
\begin{aligned}
y_1 = \; & 24t_l^2(\mu-1.21825)(\mu+0.718246) + t_l[21+\mu(82-112t_h) + \\
& \mu^2(66+108t_h) - \mu^3(48+96t_h) + \mu^4(32+64t_h)] - \\
& 32\mu(\mu+0.553809)(\mu^2-2.05381\mu+3.94992) - \\
& 64\mu t_h(\mu-1.26179)(\mu^2-0.238215\mu+1.38692)
\end{aligned}
$$

and

$$y_2 = (-1 + t_l)(4\mu - 7)(4\mu - 1)(t_l(\mu - 1) + \mu(2.5 + 4 t_h(\mu - 1) + 2\mu)).$$

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