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On the Equivalence of Tariffs and Quotas under a Revenue Constraint

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Abstract

This paper sets out a duopolistic model to examine the price and welfare equivalence of tariffs and quotas, given the quota rent is equal to the tariff revenue. It shows that the domestic welfare ranking of the two trade policies crucially depends on the relative costs of the domestic and foreign firms; when the domestic firm's relative costs are lower than those of the foreign firm, a quota regime generally leads to a higher welfare level than that of an equivalent tariff regime. This finding contrasts sharply with the conclusions of Dasgupta and Stiglitz (1977), where it was found that a tariff regime always generates higher domestic welfare.

1. Introduction

Although the General Agreement on Tariffs and Trade (GATT), and thereafter the World Trade Organization (WTO), were largely successful in effectively lowering global trade barriers, from both theoretical and practical perspectives, tariffs and quotas have historically represented the two most popular and important tools in trade policies, a situation which remains the case today. When conducting unilateral or multilateral negotiations for increasingly free trade, countries will often encounter the dilemma between the decision to lower tariffs or to loosen up quotas. Research into the equivalence of tariffs and quotas can help these countries to determine the best strategy to be adopted during such trade negotiations, and is therefore clearly worthy of investigation.

Such examination into the equivalence of tariffs and quotas can be traced back to, amongst others, Bhagwati (1965, 1968) and Shibata (1968). Utilizing a general equilibrium model, Bhagwati (1965, 1968) argued that when there is perfect competition in the domestic market, the price equivalence of tariffs and quotas holds, whilst Shibata (1968) further demonstrated that, as long as the domestic producer has no monopoly power, price equivalence would still hold. More recently, Kaempfer, Ross and Rutherford (1997) examined the consequences of the tariffication of a quota when there are distortions present in an economy, including monopoly and wage rigidities.

A number of trade scholars have examined the same issues under the framework of imperfectly competitive markets in the 1980s, and have come up with many interesting findings. For example, Itoh and Ono (1984) and Fung (1989) assumed that the domestic market was oligopolistic with a heterogeneous product, and used either price or quantity as the choice of variables for their analyses. Each of these studies concluded that the domestic price was higher under a quota regime than under a tariff regime, and therefore that price equivalence did not exist in their models. Hwang and

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Table 1. Ratio of Import Duties to Total Tax Revenues

	%	
Country	*Years*	*Ratio*
Chad	1974–76	48
Benin	1977–79	53
Gambia	1976–78	69
Sudan	1980–82	53
Yemen Arab Republic	1981–83	61
Lesotho	1975–77	71
Swaziland	1977–79	58
Botswana	1980–82	52
Jordan	1980–82	58
Bahamas	1977–79	65

Source: Tanzi (1987), Table 8-2.

Mai (1988) employed a conjectural variation duopoly model to further examine the issues, concluding that price equivalence exists only if the domestic and foreign firms play a Cournot game. Levinsohn (1989) proved the equivalence of optimal tariffs and quotas when the markets are oligopolistic and open to direct foreign investment.

The main aim of this paper is to set up a partial equilibrium model as a means of analyzing both the welfare and price equivalence of tariffs and quotas under identical tariff revenues and quota rents. Within the literature on evaluation of the equivalence problem, it is often assumed that import quantities under tariffs and quotas are identical; however, analysis of this particular issue does not necessarily have to follow such a theme. Both in theory and practice, the comparison of quotas and tariffs can be undertaken on the basis of identical revenues, as opposed to identical import quantities. This is especially true for some of the less developed or developing countries in which tariff or quota revenues are an important revenue source for the treasury. As shown in Table 1, the ratio of import duties to total tax revenues could be very high for many less developed and developing countries. For example, the ratio was 0.71 for Lesotho during 1975–77; 0.69 for Gambia during 1976–78; 0.61 for Yemen Arab Republic during 1981–83 and 0.58 for Swaziland during 1977–79. If these countries consider substituting tariffs for quotas, or vice versa, their major concern will clearly be whether tariff revenues can compensate for the loss of quota rents.

There are, however, a few exceptions in the literature that examine the issue of equivalence based on identical revenues from tariff and quota regimes. For example, given the same tariff revenues and quota rents, Dasgupta and Stiglitz (1977) and Young (1980), set up a general equilibrium model with perfectly competitive market structures and uncertain demand as a means of examining the issue of welfare equivalence between tariffs and quotas. Dasgupta and Stiglitz (1977) concluded that the welfare level was higher in tariffs than in quotas, whilst Young (1980) raised some doubts, with the proposal that under certain circumstances the welfare level could be higher under quotas than under tariffs.[1] Their models differ from ours in two respects. First, they assume the market in question to be perfectly competitive, whereas we allow it to be oligopolistic. Second, they take a general equilibrium approach, whilst we adopt a partial equilibrium approach.

The major discernible weakness of the recent literature in this area is that the comparison of tariffs and quotas has been confined to import prices whilst neglecting welfare analysis, an area that is more important in terms of normative analysis. If the markets in question are characterized by perfect competition, such as those in Bhagawati (1965) and Shibata (1968), price equivalence would also imply welfare equivalence, and if this is the case, it will be safe to confine any analysis to price equivalence. If this is not the case, then price equivalence does not lead to welfare equivalence. Since our concern focuses more on welfare equivalence, it would seem more appropriate and of greater use if the ranking of the two trade policies was based on their welfare levels rather than their price levels.

The next section presents the basic model, along with the derivation of the equilibrium price, consumer surplus, profit and welfare levels, under both tariff and quota regimes. The subsequent section provides the conditions under which tariffs and quotas yielding the same revenue are equivalent in terms of either price or welfare. A brief summary is provided in the concluding section.

2. The Basic Model

We consider a duopoly model with a domestic firm and a foreign firm competing in Cournot fashion in the home market. The respective outputs of the home and foreign firms are denoted by q_1 and q_2. In order to simplify our analysis, we assume that the utility function of a representative consumer in the home country can be specified using the following quadratic form:[2]

$$V = I + U(q_1, q_2) = I + a_1q_1 + a_2q_2 - \frac{b_1}{2}q_1^2 - \beta q_1q_2 - \frac{b_2}{2}q_2^2, \tag{1}$$

where V is a quasi-linear utility function; I is a numeraire good; a_i, b_i with $i = 1, 2$ are parameters whose values are all positive, and β measures the substitutability existing between the home and the foreign products with $0 \leq \beta \leq b_i$.

When $\beta = b_1 = b_2$, the result is that q_1 and q_2 become homogeneous products; conversely, if $\beta = 0$, then q_1 and q_2 are independent goods. The market demand functions $p_1 = a_1 - b_1q_1 - \beta q_2$ and $p_2 = a_2 - b_2q_2 - \beta q_1$ are derived from the differentiation of the utility function in equation (1) with respect to q_1 and q_2. The respective profit functions of the home producer and the foreign producer are therefore:

$$\pi_1 = (a_1 - b_1q_1 - \beta q_2 - c_1)q_1, \tag{2}$$

$$\pi_2 = (a_2 - b_2q_2 - \beta q_1 - c_2 - t)q_2, \tag{3}$$

where c_1 and c_2 are the respective constant marginal costs of the home and foreign firms, and t is the specific tariff on the foreign good. In order to avoid mathematical complexity, we further assume that the two demand functions are symmetric, and that their slopes are equal to 1, or formally, $a_1 = a_2 = a$, $b_1 = b_2 = 1$.

The first-order conditions of profit maximization for the two firms are:[3]

$$\frac{\partial \pi_1}{\partial q_1} = a - 2q_1 - \beta q_2 - c_1 = 0, \tag{4}$$

$$\frac{\partial \pi_2}{\partial q_2} = a - 2q_2 - \beta q_1 - c_2 - t = 0. \tag{5}$$

The equilibrium quantities and prices in the home and foreign firms, as well as the profits of the home firm under tariffs, can be obtained from equations (4) and (5) as follows:

$$q_1^t = \frac{2(a-c_1)-\beta(a-c_2-t)}{4-\beta^2}, \tag{6}$$

$$q_2^t = \frac{2(a-c_2-t)-\beta(a-c_1)}{4-\beta^2}, \tag{7}$$

$$p_1^t = \frac{2a-\beta a+\beta c_2+\beta t+2c_1-\beta^2 c_1}{4-\beta^2}, \tag{8}$$

$$p_2^t = \frac{2a-\beta a-\beta^2 c_2-\beta^2 t+\beta c_1+2c_2+2t}{4-\beta^2}, \tag{9}$$

$$\pi_1^t = (q_1^t)^2 = \left[\frac{2(a-c_1)-\beta(a-c_2-t)}{4-\beta^2}\right]^2, \tag{10}$$

where variables with superscripts t indicate that they are derived under a tariff regime.[4]

The welfare function of the home country under a tariff regime can be specified as the sum of consumer surplus, the profits of the home firm, and tariff revenues; that is $w^t = cs^t + \pi_1^t + tq_2^t$, where cs^t represents consumer surplus, defined as $U(q_1, q_2) - p_1q_1 - p_2q_2$, and is equal to $I + (q_1^t + q_2^t)^2/2 - (1 - \beta)q_1^tq_2^t$ by equation (1). Substituting the consumer surplus function (equations (6), (7) and (10)) into the welfare function, we can rewrite the welfare level under a tariff regime as follows:

$$w^t = \left[I + \frac{(Q^t)^2}{2} - (1-\beta)q_1^t q_2^t\right] + (q_1^t)^2 + tq_2^t, \tag{11}$$

where $Q^t = q_1^t + q_2^t$.

We now turn to the alternative case under a quota regime. Given that the equivalence of tariffs and quotas in this paper is based upon identical revenues, tariff revenues tq_2 under a tariff regime are therefore set as equal to quota rents, $\alpha\overline{q}_2$, where $\overline{q}_2$ is the import quota and α the quota price. The profit function of the home firm under a quota regime is therefore:

$$\hat{\pi}_1 = (a - q_1 - \beta\overline{q}_2 - c_1)q_1. \tag{12}$$

In order to differentiate the variables under the two regimes, we let variables under a quota regime wear an upper hat. (The only exception is the foreign import $\overline{q}_2$; by definition, this is exogenously given and is therefore equipped with an upper bar).

Taking $\overline{q}_2$ as given, we can derive the first-order condition for the profit maximization of equation (12) under a quota regime as follows:

$$\frac{d\hat{\pi}_1}{dq_1} = a - 2q_1 - \beta\overline{q}_2 - c_1 = 0. \tag{13}$$

Assuming that the second-order condition for profit maximization is met, we can easily derive from equation (13) the output of the home firm and the prices of the home and foreign outputs as follows:

$$\hat{q}_1 = \frac{a - c_1}{2} - \frac{\beta}{2}\overline{q}_2, \tag{14}$$

$$\hat{p}_1 = \frac{a + c_1}{2} - \frac{\beta}{2}\overline{q}_2, \tag{15}$$

$$\hat{p}_2 = \frac{2a - \beta(a - c_1) + (\beta^2 - 2)\overline{q}_2}{2}. \tag{16}$$

The welfare function of the home country under a quota regime is defined as $\hat{w} = \hat{cs} + \hat{\pi}_1 + \alpha\overline{q}_2 = [U(\hat{q}_1, \overline{q}_2) - \hat{p}_1\hat{q}_1 - \hat{p}_2\overline{q}_2] + \hat{\pi}_1 + R$. The welfare level under a quota regime is similarly derived:

$$\hat{w} = \left[I + \frac{\hat{Q}^2}{2} - (1-\beta)\hat{q}_1\overline{q}_2\right] + (\hat{q}_1)^2 + \alpha\overline{q}_2, \tag{17}$$

where $\hat{Q} = \hat{q}_1 + \overline{q}_2$.

3. Price Equivalence and Welfare Equivalence

In the previous section, we derived the equilibria under both tariff and quota regimes, given identical tariff and quota revenues. We devote this section to their price and welfare equivalence.

Price Equivalence under Tariffs and Quotas

Tariff revenues under a tariff regime are set equal to tq_2^t; by definition, such revenue must also be equal to the quota rent, which is defined as $\alpha\overline{q}_2$. If we use α and $\overline{q}_2$ to represent the two axes in Figure 1, the equivalent quota rent curve R should be a rectangular hyperbola which should also pass through A, the point at which tariff revenue is represented by the area $OtAq_2^t$.

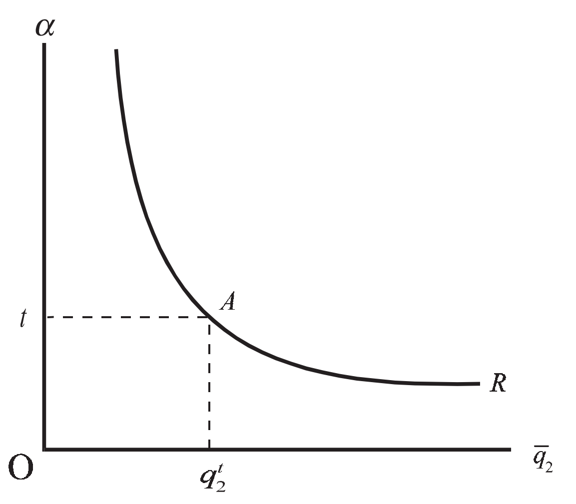

Figure 1. The Revenue Curve

It is further assumed that the quota constraint is effective (or equivalently, that the constraint is binding). This holds true as long as the price under quotas is higher than the marginal costs of the foreign firm; given such a case, the following condition should be satisfied:[5]

$$\bar{q}_2 \leq \frac{2(a-c_2-\alpha)-\beta(a-c_1)}{4-\beta^2}. \tag{18}$$

The right-hand side of the inequality is the import quantity under a quota regime if the import quota is set as equal to α. The shaded areas to the left of line *TB* in Figures 2 and 3 indicate that the inequality of Equation (18) holds. Note that line *TB* must also pass through point *A*; this is because if the quota price α is set at a level equal to the tariff rate t, then imports under a quota regime must be equal to those under a tariff

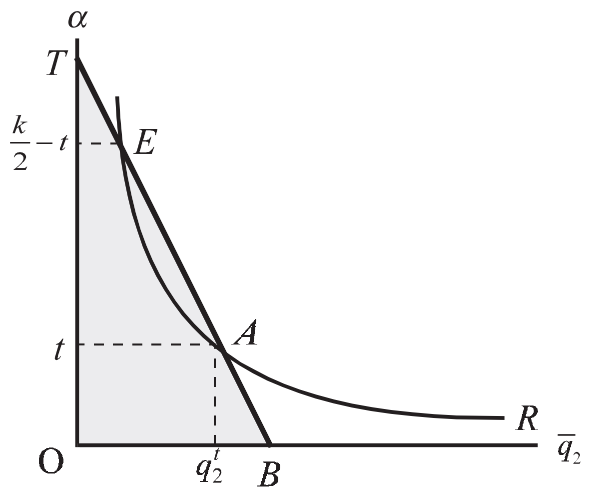

Figure 2. Effective Quota Region when $0 < t < k/4$

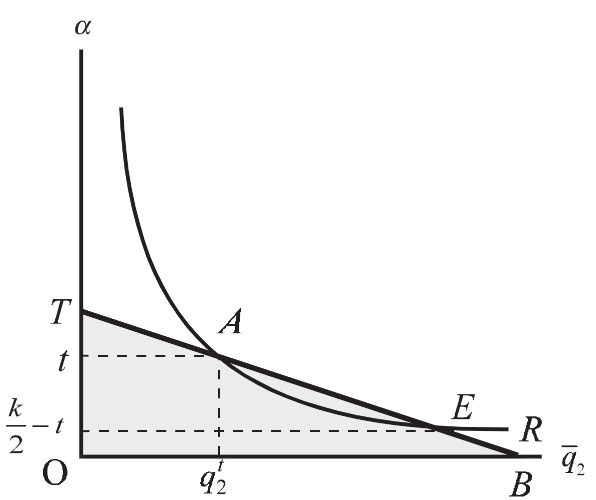

Figure 3. Effective Quota Region when $k/4 < t < k/2$

regime. It is then clear that if $\alpha > (=, <)\ t$, we have $\bar{q}_2 < (=, >)\ q_2^t$. Furthermore, the slope of line TB, which is derivable from equation (18), is constant:

$$\left.\frac{d\alpha}{d\bar{q}_2}\right|_{TB} = -\frac{4-\beta^2}{2} < 0. \tag{19}$$

We have so far determined that line TB is a straight line passing through point A, and that the R curve is a rectangular hyperbola also passing through point A. In order to gain a further understanding of the relative positions of line TB and the R curve, it is necessary to compare the slope of the R curve and line TB at point A. The slope of line TB can be found in equation (19), whilst the slope of the R curve at point A is derivable from $R = tq_2^t$ as follows: $d\alpha/d\bar{q}_2|_R = -\alpha/\bar{q}_2 = -t/q_2^t$. Substituting equation (7) into this yields:

$$\left.\frac{d\alpha}{d\bar{q}_2}\right|_{R} = -\frac{t(4-\beta^2)}{2(a-c_2-t)-\beta(a-c_1)}. \tag{20}$$

By comparing equations (19) and (20), we obtain the difference in slopes of line TB and the R curve, at point A, as follows:

$$\left.\frac{d\alpha}{d\bar{q}_2}\right|_{R} - \left.\frac{d\alpha}{d\bar{q}_2}\right|_{TB} = \frac{(4-\beta^2)(k-4t)}{2(k-2t)} > (<)\ 0, \text{ if } t < (>)\ \frac{k}{4}, \tag{21}$$

where $k \equiv 2(a - c_2) - \beta(a - c_1)$ for computational simplification. Inequality in equation (21) shows that the slope of line TB can be either greater or smaller than the slope of the R curve at A. Moreover, imports from the foreign country are reduced to zero if the quota price α (or the tariff rate t) is greater than $k/2$ (see equation (18)). From the above analysis, we can derive the following results:

if $0 < t < k/4$, we have $(d\alpha/d\bar{q}_2)|_R > (d\alpha/d\bar{q}_2)|_{TB}$, as shown in Figure 2;
if $k/4 < t < k/2$, we have $(d\alpha/d\bar{q}_2)|_R < (d\alpha/d\bar{q}_2)|_{TB}$, as shown in Figure 3.

From Figures 2 and 3, we find that the AE section on the R curve satisfies only the following two properties: (i) tariff revenues and quota rents are equal (as on the R curve); and (ii) the quota constraint is effective (since it falls to the left of line TB). In other words, the feasible quota price set α is the AE section of the R curve; therefore, the home government will choose a quota price from this set. Once α is decided, then $\bar{q}_2$ is immediately derivable from the R curve. Note that point A and point E in Figures 2 and 3 can be obtained by solving the equations representing line TB and the R curve. Clearly, at point A, $\alpha = t$ and at point E, $\alpha = k/2 - t$.

The differences in output and price between a quota regime and a tariff regime can be obtained from equations (6) to (9) and equations (14) to (16), as well as the condition $\bar{q}_2 = tq_2^t/\alpha$:

$$\bar{q}_2 - q_2^t = -\frac{(\alpha-t)(k-2t)}{\alpha(4-\beta^2)}, \tag{22}$$

$$\hat{q}_1 - q_1^t = \frac{\beta(\alpha-t)(k-2t)}{2\alpha(4-\beta^2)}, \tag{23}$$

$$\hat{p}_1 - p_1^t = \frac{\beta(\alpha-t)(k-2t)}{2\alpha(4-\beta^2)}, \tag{24}$$

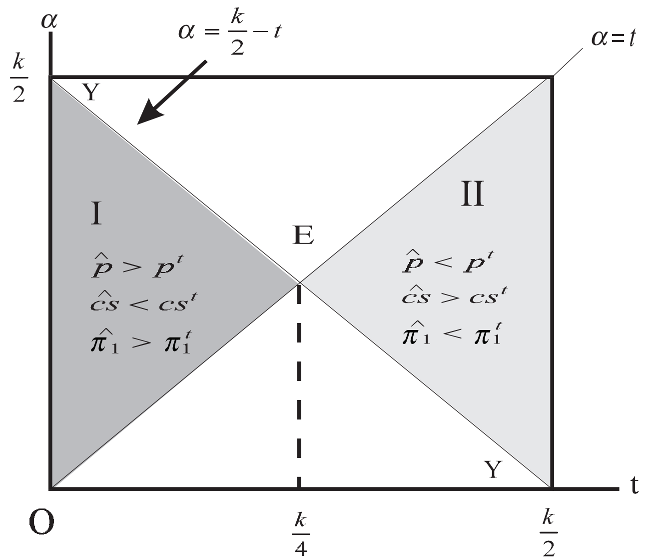

Figure 4. Ranking of Prices, Profit and Consumer Surplus

$$\hat{p}_2 - p_2^t = \frac{\beta(\alpha - t)(k - 2t)(2 - \beta^2)}{2\alpha(4 - \beta^2)}. \tag{25}$$

If the quota price α is set as equal to t (i.e. point A in Figures 2 and 3), then the import quota $\bar{q}_2$ should also be set at the same level as q_2^t under a tariff regime. Consequently, the price of the good in question should also be the same under the two regimes (see equations (24) and (25)), as are the consumer surplus and the profits of the home firm. Given such circumstances, the price and welfare levels under the two regimes are equivalent. This does, however, represent a special case in which tariff revenues are equal to quota rents.

In what follows, we set out to prove that such equivalence does not hold if α is set at a level different to that of t (or if we choose a point other than A on the arc AE).

If $0 < t < k/4$, then as shown in Figure 2, α must be greater than t, but smaller than $k/2 - t$. It can then be seen from equations (22) to (25) that the prices of the two products under a quota regime are higher than those under a tariff regime. Similarly, if $k/4 < t < k/2$, then as shown in Figure 3, α must be less than t, but greater than $k/2 - t$. In this case, the prices of the two products under a quota regime are lower than those under a tariff regime.

The relationship between α and t is depicted in Figure 4. A 45° line is drawn to represent $\alpha = t$ (i.e. point A in Figures 2 and 3), and a line, YY, to represent $\alpha = k/2 - t$ (i.e. point E in Figures 2 and 3). If $0 < t < k/4$, the quota price α must satisfy $t < \alpha < k/2 - t$, which is Region I in Figure 4. Conversely, if $k/4 < t < k/2$, α must satisfy $k/2 - t < \alpha < t$, which is Region II in Figure 4. By the construction of the diagram, only Regions I and II in Figure 4 will satisfy the conditions of equal tariff revenue and quota rent and an effective quota constraint.

From Figure 4 we can establish the following proposition.

Proposition 1. *Assuming that the domestic and foreign firms engage in Cournot competition, and that quota rents are set as equal to tariff revenues, if the tariff rate is lower* *(higher) than k/4, the prices under a quota regime will be higher (lower) than those under a tariff regime. In general, therefore, there is no price equivalence.*

It is a straightforward matter to show that the prices are equivalent under the two policies when $\alpha = t$. Nevertheless, in Region I (II) the costs of the foreign firm under a quota regime are necessarily higher (lower) than those under a tariff regime, yielding $\hat{p}_i > (<)\ p_i^t$. Generally, therefore, prices under the two regimes will not be equivalent unless the quota price is set at a level equal to the tariff rate.

This finding stands in sharp contrast to others in the literature on the equivalence of tariffs and quotas. Hwang and Mai (1988) and Fung (1989), for example, found that under the same import volume, if the two firms played a Cournot–Nash game, then price equivalence would exist under the two regimes. In contrast, we have found that if equivalence is based on identical tariff revenue and quota rent, and if the two firms engage in Cournot competition, then in general, there is no equivalence in prices under tariff and quota regimes, unless the quota price is set at a level equal to the tariff rate.

Welfare Equivalence under Tariffs and Quotas

The welfare ranking of tariffs and quotas under identical revenues can be derived by comparing equations (11) and (17). The welfare function is defined as the sum of consumer surplus, the profits of the home firm, and tariff revenues or quota rents. Since the model assumes identical tariff revenues and quota rents, the last item in the welfare function can be cancelled out when ranking the welfare levels under the two trade regimes. Although tedious, from the results of the previous section, it is a straightforward matter to derive the rankings of consumer surplus and home profits under a tariff regime and a quota regime.[6] They are summarized in Table 2.

As Table 2 demonstrates, the ranking of consumer surplus is directly opposed to that of the home firm's profit; hence, the welfare ranking of the two trade policies cannot be immediately determined. In order to simplify the analysis, we further assume that the output of the two countries is homogeneous (i.e. $\beta = 1$). Substituting this assumption into equations (11) and (17), the welfare difference of the two policies is reduced to:

$$\hat{w} - w^t = \frac{\phi}{24\alpha^2}(\alpha - t)(k - 2t), \tag{26}$$

where $\phi \equiv (\alpha - t)(k - 2t) + 4\alpha(c_2 + t - c_1)$. Since $k - 2t > 0$, the sign of equation (26) is dependent upon the sign of $\alpha - t$ and also upon the sign of ϕ. Equation (26) can be

Table 2. Comparison of Tariff and Quota Regimes

	$0 < t < k/4$	$k/4 < t < k/2$
Quota price α	$k/2 - t > \alpha > t$	$k/2 - t < \alpha < t$
Home product price p_1	$\hat{p}_1 > p_1^t$	$\hat{p}_1 < p_1^t$
Foreign product price p_2	$\hat{p}_2 > p_2^t$	$\hat{p}_2 < p_2^t$
Home product quantity q_1	$\hat{q}_1 > q_1^t$	$\hat{q}_1 < q_1^t$
Foreign product quantity q_2	$\bar{q}_2 < q_2^t$	$\bar{q}_2 > q_2^t$
Home consumer surplus cs	$\hat{cs} < cs^t$	$\hat{cs} > cs^t$
Home firm profit π_1	$\hat{\pi}_1 > \pi_1^t$	$\hat{\pi}_1 < \pi_1^t$

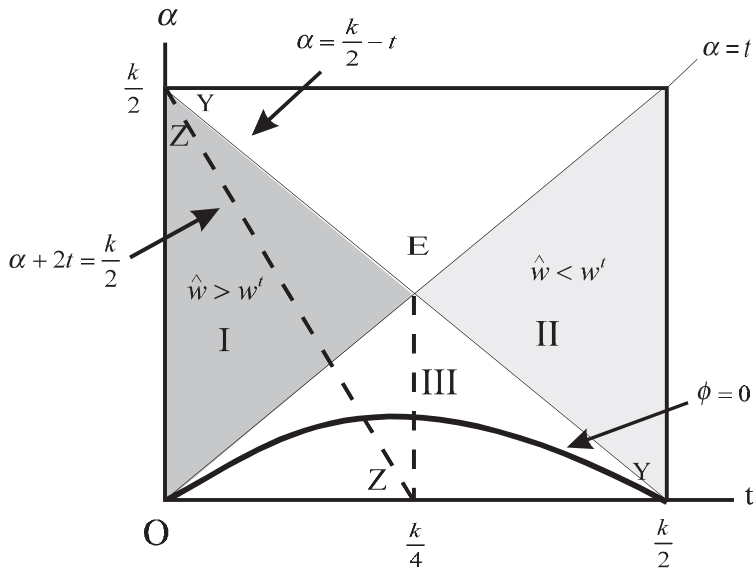

Figure 5. The Case of $c_1 - c_2 < 0$

solved by a diagrammatical approach. In order to do this, we first of all add a curve representing $\phi = 0$ to Figure 4; the shape of this curve depends on the relative production costs of the two firms c_1 and c_2 (see the appendix for details). Three cases are presented in Figure 5, according to the magnitudes of c_1 and c_2.

Figure 5 shows the case of $c_1 < c_2$. In this case, the curve $\phi = 0$ locates entirely within Region III, with $\phi > 0$ for the area above the curve, and $\phi < 0$ for the area below the curve. Therefore, for any (α, t) combination falling within Regions I and II, the value of ϕ must be positive. Given this, the sign of equation (26) is dependent only upon the sign of $\alpha - t$. We can therefore establish $\hat{w} > (<)\ w^t$, if $\alpha > (<)\ t$.

The case of $0 < c_1 - c_2 < k/4$ is illustrated in Figure 6, which shows the curve $\phi = 0$ dividing Region I into two parts, with the part above $\phi = 0$ representing $\hat{w} > w^t$, and the part below representing $\hat{w} < w^t$. With the increase of $c_1 - c_2$, the curve $\phi = 0$ moves upwards, narrowing down the scope of $\hat{w} > w^t$. As the figure shows, the welfare ranking is ambiguous, i.e. $\hat{w} > w^t$ for Region II and the heavily shaded area in Region I, otherwise $\hat{w} < w^t$. The intuition for this result, from an economics perspective, is as follows: $0 < c_1 - c_2 < k/4$ implies that the home firm's production costs are higher than those of the foreign firm, but the cost difference is not too great. When $\alpha > t$, the profit under quotas exceeds the profit under tariffs (i.e. $\hat{\pi}_1 > \pi_1^t$), but the profit advantage given by a quota regime may not be sufficiently high to outweigh its disadvantage, in terms of consumer surplus. As a result, the welfare ranking is ambiguous under the two regimes.

Figure 7 represents the case of $c_1 - c_2 > k/4$. The curve representing $\phi = 0$ is no longer a parabola passing through $(0, 0)$ and $(k/2, 0)$ as in the case of Figure 5 or Figure 6, but rather, it becomes a convex curve passing through $(k/2, 0)$ and then approaches the vertical axis. Since its slope is less than -1, the curve $\phi = 0$ must locate above line YY. Moreover, the curve $\phi = 0$ divides Region II into two parts, with each part having a different welfare ranking. The part above the curve yields $\hat{w} < w^t$, whilst the part below the curve requires $\hat{w} > w^t$.

The ranking in Region I is unambiguous with $\hat{w} < w^t$, because $\alpha > t$ and $\phi < 0$. The intuition, from an economics perspective, is similar to the preceding two cases and is

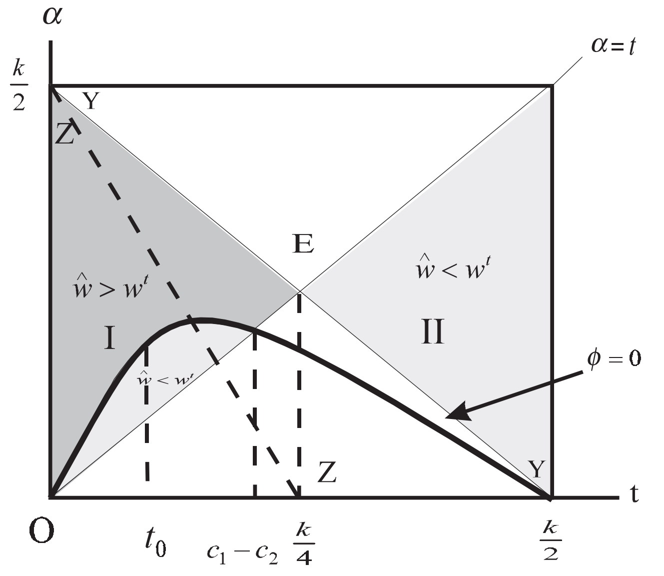

Figure 6. The Case of $0 < c_1 - c_2 < k/4$

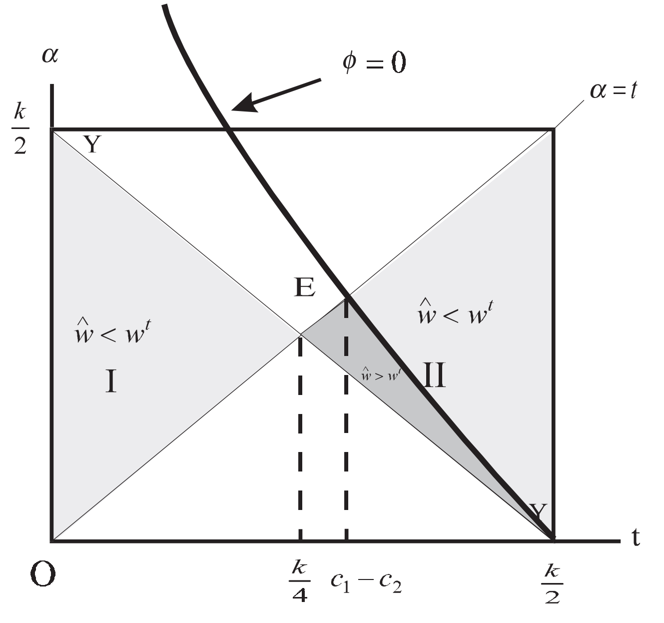

Figure 7. The Case of $c_1 - c_2 > k/4$

not therefore repeated here. When the production costs of the home firm are higher than those of the foreign firm, so that $c_1 - c_2 > k/4$, then even if $\alpha > t$, the gain in profits under a quota regime cannot compensate for the loss in consumer surplus, resulting in $\hat{w} < w^t$. In contrast, if $\alpha < t$, we have $\hat{cs} > cs^t$, and $\hat{\pi}_1 < \pi_1^t$. Nevertheless, as long as the value of α is not too great, the price under a quota regime will be lower, such that the gain in consumer surplus is sufficiently high to compensate adequately for the loss in profits under a quota regime. If this is the case, we have $\hat{w} > w^t$.

Based on the three inferences, it is found that under a tariff regime, when the cost disadvantage of the home firm becomes greater, there is an increase in welfare, leading to the following proposition:

Proposition 2. *Welfare equivalence, under both tariff and quota regimes, is dependent on the cost difference between the two firms. If the marginal costs of the home firm are lower than those of the foreign firm ($c_1 < c_2$) and the unit quota price is higher (lower) than the tariff rate, the welfare level will be lower (higher) under a tariff regime than under a quota regime. Conversely, if the marginal costs of the home firm are higher, the welfare level under a tariff regime is more likely to exceed that of a quota regime with an increase in the cost difference.*

By assumption, tariff revenue is set at a level equivalent to quota rent; therefore, the welfare ranking of the two policies is determined by the difference in the consumer surplus and the profits of the home firm:

$$cs^t - \hat{cs} = \frac{1}{2}(Q^t)^2 - \frac{1}{2}\hat{Q}^2 = \frac{1}{2}(Q^t + \hat{Q})(Q^t - \hat{Q}), \tag{27}$$

$$\pi_1^t - \hat{\pi}_1 = (q_1^t)^2 - \hat{q}_1^2 = (q_1^t + \hat{q}_1)(q_1^t - \hat{q}_1). \tag{28}$$

Adding equations (27) and (28) together and making use of $Q^t - \hat{Q} = -(q_1^t - \hat{q}_1) = (\alpha - t)(\alpha + c_1 - 2c_2 - 2t)/6\alpha$, the welfare difference under the two policies can then be shown as:

$$w^t - \hat{w} = -(q_1^t - \hat{q}_1)\left[\tfrac{1}{2}(Q^t + \hat{Q}) - (q_1^t + \hat{q}_1)\right]. \tag{29}$$

Hence, the welfare difference depends on the relative magnitude of $(Q^t + \hat{Q})/2$ and $(q_1^t + \hat{q}_1)$. We can express these two respective terms as follows:

$$\frac{1}{2}(Q^t + \hat{Q}) = \frac{1}{12b\alpha}\{(7\alpha + t)(a - c_1) + 2(\alpha + t)[c_1 - (c_2 + t)]\}, \tag{30}$$

$$q_1^t + \hat{q}_1 = \frac{1}{6b\alpha}\{(5\alpha - t)(a - c_1) - 2(\alpha + t)[c_1 - (c_2 + t)]\}. \tag{31}$$

It is clear from equations (30) and (31) that if the competitiveness of the home firm diminishes (i.e. an increase in $c_1 - c_2$), then there will be an increase in the difference in consumer surplus between the two regimes, whereas there will be diminution of the difference in the profits of the home. Eventually, the former will outweigh the latter, causing the welfare ranking under the two regimes to be led by the consumer surplus ranking. Conversely, if there is only a small disadvantage (or even an advantage) for the home firm over the foreign firm, the welfare comparison under the two regimes will be led by the difference in the profits of the home firm.

As indicated in Region I of Figures 5 to 7, if $t < k/4$, and if the home government implements a quota regime based on identical revenues from both tariffs and quotas, the quota price α must then be set at a level higher than t. A higher quota price will create higher profits for the home firm under a quota regime; however, with the consequent lower cost advantage for the home firm, the advantage to the home firm from a quota regime is also reduced. In contrast, if the production costs of the home firm are very high, the advantage from the consumer surplus will be less than the disadvantage. In sum, with an increase in the production costs of the home firm, the welfare level under a quota regime is less likely to exceed that of an equivalent tariff regime.

This finding contrasts sharply to other findings within the literature. Setting up their general equilibrium model, Dasgupta and Stiglitz (1977) found that the welfare level under a tariff regime must be higher than that under an equivalent quota regime, whilst in their discussion of the equivalence of tariffs and quotas in a partial equilibrium framework under imperfect competition, Hwang and Mai (1988) and Fung (1989) both found that the two regimes were price equivalent only if the domestic and foreign firms played in Cournot fashion.

As noted earlier, price equivalence does not imply welfare equivalence, particularly in models with an imperfect market. In this paper, we have examined welfare equivalence in a model with a duopolistic market, concluding that welfare levels under tariffs can be higher or lower than those under quotas, depending mainly on the cost difference between the domestic and foreign firms. If the output is sold only in a third country, with no domestic consumption of the commodity (as in the model of Brander and Spencer, 1985), the welfare of the home country is defined as the profit of the home firm. Under such circumstances, welfare equivalence implies price equivalence. However, if the home country consumes some of the output, as in the present model, consumer surplus must be taken into account when measuring home welfare. As a result, price equivalence does not lead to welfare equivalence.

As shown in Figure 5, both the price and welfare levels are equivalent under the two trade regimes only when $\alpha = t$. Nevertheless, for the cases specified in Figures 6 and 7, price equivalence holds when $\alpha = t$, whereas welfare equivalence requires not only $\alpha = t$, but also $\phi = 0$. It is therefore clear that price equivalence does not lead to welfare equivalence. At point F in Figure 6, for example, price equivalence holds whilst welfare equivalence does not. The above discussion leads to the following proposition.

PROPOSITION 3. *The existence of price equivalence is only a sufficient condition for the existence of welfare equivalence.*

4. Conclusions

Most research works on the equivalence of tariffs and quotas are based on identical import volumes; however, for many of the less-developed or developing countries, tariff revenues and quota rents are often an important source of government revenues. When making policy choices between tariff and quota regimes, or when switching from one to the other, the governments of these countries are likely to take into consideration the revenues that may be accrued from the two trade policies. For these countries, analysis of tariff and quota equivalence will be much more meaningful if equivalence is based upon identical tariff revenues and quota rents. The literature in this area has nevertheless, by large, focused on price equivalence, whilst neglecting welfare ranking. Despite this focus, we regard the latter to be of greater importance than the former, particularly with regard to the provision of more appropriate regime implications. In order to fill the current gap, this paper has set up a duopolistic model to discuss the price and welfare equivalence between tariffs and quotas, given identical tariff revenues and quota rents. Our results differ significantly from the existing literature on the equivalence of tariffs and quotas based on equal import volumes.

The main findings of our study are as follows. First, price equivalence depends on the magnitude of the tariff rate and the quota price, and indeed, there is general inequality in the domestic prices of the two trade regimes. If the tariff rate is higher than (equal to, less than) the quota price, then the domestic price under a tariff regime will be higher than (equal to, less than) that under a quota regime.

Second, when the quota price is higher (lower) than the tariff rate, the consumer surplus will decrease (increase) under a quota regime as compared to a tariff regime, whereas the profits of the home firm will increase (decrease). Furthermore, domestic welfare is crucially dependent upon the relative costs of the domestic and foreign firms. Generally speaking, if the costs of the home firm are higher than those of a foreign firm, then the greater this cost difference, the more likely that the welfare level under a tariff regime will be greater than that under a quota regime. Finally, given the condition of equal tariff revenues and quota rents, if the price levels under the two policies are equivalent, then so are their welfare levels, but the reverse is not necessarily the case.

These findings have shown that when quota rents are set at the same level as tariff revenues, the welfare levels of the two regimes are closely related to the costs of the home firm *vis-à-vis* those of the foreign firm. Our findings lead us to the following policy implication.

When negotiating with foreign trading partners, a home government often has to choose between lowering tariff levels and loosening up quotas. If a government is confined to achieving identical tariff and quota revenues, the efficacy of the two policies will be heavily dependent upon the marginal costs of home firms in relation to those of foreign firms. In more specific terms, if the home firms are to be given cost advantages (disadvantages), then quotas (tariffs) will tend to be the better policy choice.

Appendix

In order to draw $\phi = (\alpha - t)(k - 2t) + 4\alpha(c_2 + t - c_1)$ in Figure 1, we must first derive the slope of $\phi = 0$, and then the intersection of $\phi = 0$ and $\alpha = t$. The slope of $\phi = 0$ is derivable as follows:

$$\frac{d\alpha}{dt} = \frac{k + 2\alpha - 4t}{k + 2t + 4(c_2 - c_1)}. \tag{A1}$$

The curve $\phi = 0$ intersects the horizontal axis twice, at $t = 0$ and again at $t = k/2$. The respective slopes of $\phi = 0$ at the two intersection points of (0, 0) and (k/2, 0) can be derived from equation (A1) as follows:

$$\left.\frac{d\alpha}{dt}\right|_{\substack{t=0\\ \alpha=0}} = \frac{k}{k + 4(c_2 - c_1)} \begin{cases} \in (0,1) & c_1 - c_2 < 0 \\ >1 & \text{if } 0 < c_1 - c_2 < k/4 \\ <0 & c_1 - c_2 < k/4 \end{cases} \tag{A2}$$

$$\left.\frac{d\alpha}{dt}\right|_{\substack{t=k/2\\ \alpha=0}} = \frac{-k}{2(a - c_1)} < 0 \quad \begin{cases} < -1 \\ \in (-1,0) \end{cases} \text{if } \begin{matrix} c_1 - c_2 > k/4 \\ c_1 - c_2 < k/4 \end{matrix}. \tag{A3}$$

Equation (A2) shows that:

(i) the slope of $\phi = 0$ at (0, 0) takes a value between 0 and 1 if $c_1 - c_2 < 0$; i.e. the curve $\phi = 0$ must locate below the 45° line (which is also the line $\alpha = t$);

(ii) if $0 < c_1 - c_2 < k/4$, then $d\alpha/dt > 1$; that is, $\phi = 0$ locates above the $\alpha = t$ line; and,
(iii) if $c_1 - c_2 > k/4$, then the slope of $\phi = 0$ becomes negative.

Conversely, equation (A3) shows that the slope of $\phi = 0$ at $(k/2, 0)$ is less than -1 (steeper than the 45° line) when $c_1 - c_2 > k/4$, with the slope falling between 0 and -1 when $c_1 - c_2 < k/4$.

Furthermore, we can set $d\alpha/dt = 0$ and infer from this that the maximum value should pass the line representing $\alpha + 2t = k/2$ (that is line ZZ in Figure 1). Additional information which can be useful in locating the $\phi = 0$ curve, is its intersection with the line $\alpha = t$.

The intersection point can be derived by substituting $\alpha = t$ into $\phi = 0$ which yields either $t = 0$ or $t = c_1 - c_2$. More specifically, if $0 < c_1 - c_2 < k/4$, the intersection of $\phi = 0$ and $\alpha = t$ locates to the left of point E; if $c_1 - c_2 > k/4$, the intersection locates to the right of point E.

Based on the above discussions, we can draw $\phi = 0$ in the following three cases: $c_1 - c_2 < 0$, $0 < c_1 - c_2 < k/4$, and $c_1 - c_2 > k/4$.

For the case of $c_1 - c_2 < 0$, $\phi = 0$ has a positive slope at $(0, 0)$; it then passes through line $\alpha + 2t = k/2$ when its slope becomes negative and intersects the horizontal axis at point $(k/2, 0)$. The $\phi = 0$ curve and the $\alpha = t$ line meet only at the origin. We can similarly draw the $\phi = 0$ curve for the other two cases which are respectively shown in Figures 6 and 7.

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Notes

1. In addition to the literature on tariffs and quotas under the same quota and tariff revenues, there are a few papers discussing trade issues under a revenue constraint. For example, Kubota (2000) studied how the interaction of government revenue requirement and administrative capabilities explained the shift from reliance on easy-to-collect taxes to tax-base broadening. Moutos (2001) employed a model of trade in vertically differentiated products to determine the preferences of the households among different ways of raising government revenue. Keen and Ligthart (2002) analyzed the welfare effect of a simultaneous change in tariffs and commodity taxes under a revenue constraint.
2. This utility function is the most frequently used functional form in the analysis of heterogeneous products; see Harris (1985) for detail.
3. Satisfaction of the second-order and stability conditions is easily verifiable.
4. We further assume that $2(a - c_1) - \beta(a - c_2 - t) > 0$, and $2(a - c_2 - t) - \beta(a - c_1) > 0$, in order to ensure that the quantities in equations (6) and (7) are positive.
5. Equation (18) can be derived from equation (7). Under a tariff regime, the marginal cost of the foreign firm is $c_2 + t$; while under a quota regime, it becomes $c_2 + \alpha$. Therefore, at quota price α the export of the foreign firm will not exceed that indicated in equation (18).
6. The consumer surplus is derived from the prices in equations (8), (9), (15), and (16), and the demand functions, while the profit is derived from: $\pi_1^t - \hat{\pi} = (q_1^t)^2 - \hat{q}_1^2 = (q_1^t + \hat{q}_1)(q_1^t - \hat{q}_1)$.