TARIFFS VERSUS QUOTAS WITH ENDOGENOUS QUALITY

Kala KRISHNA*

Department of Economics, Harvard University, Cambridge, MA 02138, USA
and National Bureau of Economic Research

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This paper analyzes the effects and desirability of tariffs, quotas and quality controls, when the quality of the imported good is endogenous, and the foreign producer is a monopolist. A crucial determinant of the direction of these effects is shown to be the valuation of increments in quality by the marginal consumer, relative to that of all consumers on average. A way of comparing infinitesimal equivalent policies is developed and used to compare import equivalent policies.

1. Introduction

This paper analyzes some aspects of the effects of trade restrictions and their desirability when the quality of the imported good(s) is endogenous, and the foreign producer has market power. Typically, a firm must decide on the number of products produced and their quantities. By introducing many qualities a producer can target products to groups of consumers and make greater profits by doing so. However, there are likely to be significant costs associated with producing many qualities, and to this extent the producer would want to produce one product targeted to all consumers.

This suggests that two aspects of a producer's choice are of interest. The first is how a producer chooses one good which is best suited to diverse consumers and how this aspect of his choice is affected by trade restrictions. The second concerns the pricing of a product line - and the effects of trade restrictions on such pricing policies. I will deal with the first in this paper. The second is dealt with in a companion paper [see Krishna (1984a)].

Existing work in the trade literature on the effects of trade restrictions with endogenous quality focuses mainly on the nature of these effects in a competitive world. The specifications of the models are therefore particularly

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1Advertising costs, for example, are often thought of as being fixed and product specific.

suited to the perfectly competitive paradigm. For example, previous work by Rodríguez (1979) and Santoni and Van Cott (1980) deal with these questions in the context of a specific model [associated with Swan (1970)], where demand is for services of the good only, and higher quality goods are more durable. Unfortunately, this tends to obscure some significant aspects of firm behaviour in an imperfectly competitive world which relate to the role of demand conditions in determining quality.

In this paper, I consider the effects of trade restrictions when the foreign producer is a monopolist, and only one quality is produced - so that the product must be targeted to all consumers. Quality is modeled as a factor that raises the willingness to pay for a unit - as in Spence (1976) and Sheshinski (1976). In contrast to the results obtained using the Swan specification (which is a special case of this specification), quotas do not necessarily raise the level of quality of imports and tariffs do not leave the quality of imports unaffected. Naturally, the welfare comparisons of import equivalent policies are also different. The effects and desirability of various trade restrictions are shown to depend critically on the valuation of quality increments by the marginal consumer as compared to the average valuation of quality increments by all consumers.

These effects are derived in section 2 and used in section 3 to evaluate and compare the effects on welfare of the various restrictions. The effects of trade restrictions and their comparisons are all evaluated at the free trade level throughout the paper. In addition, to simplify the analysis I assume throughout that the derivative of the inverse demand function with respect to quality is a monotonic function of output. The effects of increasing trade restrictions at other than free trade levels are similar to the effects evaluated at free trade levels. Their comparisons become much more complicated away from free trade levels, but the procedure used remains valid.

2. The effects of trade restrictions

The analysis in this paper is confined to a partial equilibrium setting. There is one foreign producer of the product, who acts as a monopolist. The producer is assumed to set a price and quality level (or equivalently, an output and quality level) which the consumer takes as given. Quality is modeled as a uni-dimensional variable, \( q \). In order to focus on the role of demand conditions in this paper, I assume that there is a marginal cost, \( C(q) \), of producing a unit of output of quality \( q \). \( x \) is total demand. The inverse demand function facing the producer is given by \( P(x, q) \). \( P_q(x, q) \) is assumed positive. Quality is thus modeled in a general way as a factor that increases the willingness to pay for any given output level.

The monopolist's choice of \( x \) and \( q \) will be given by the solution to the
profit-maximizing problem:

$$\max_{x,q} \Pi(x, q) = (P(x, q) - C(q))x.$$  \hspace{1cm} (1)

Assume that a unique interior solution exists to this problem. Then, first-order conditions for a maximum require that:

$$\Pi_d(x, q) = P_x(x, q)x + P(x, q) - C(q) = 0$$  \hspace{1cm} (2)

and

$$\Pi_d(q, x) = [P_d(x, q) - C_d(q)]x = 0.$$  \hspace{1cm} (3)

The second-order conditions for a maximum are given by the Hessian $H$ being negative definite at $(x^*, q^*)$, the solutions to (2) and (3), where $H$ at $(x^*, q^*)$ is given by:

$$H = \begin{bmatrix}
2P_x + xP_{xx} & P_{xq}x \\
(P_{xq}x) & (P_{qq} - C_{qq})x
\end{bmatrix} \begin{bmatrix} H_{11} & H_{12} \\
H_{21} & H_{22}
\end{bmatrix}. \hspace{1cm} (4)

The effect of a quantitative restriction on quality may be examined by reformulating the problem set up in (1) as a maximization problem subject to the constraint that $x \leq \bar{x}$. Simple comparative statics on $q$ with respect to $x$, evaluated at $\hat{x} = x^*$, would indicate the effect of a 'slightly restrictive' quota. This procedure gives the result that

$$\frac{dq}{dx} = -\frac{P_{qq}}{P_{qq} - C_{qq}}. \hspace{1cm} (5)

This may be easily interpreted using fig. 1. Eq. (2) gives the level of $x$ that maximizes profits for each given $q$. The locus of such points is traced out by $x(q)$ in fig. 1. Similarly, eq. (3) traces out the level of $q$ that maximizes profits for each given level of $x$. $q(x)$ is the locus of such points. $x^*$ and $q^*$ are given by the intersection of $x(q)$ and $q(x)$ at $E$. Notice that since $H_{11}$ and $H_{22}$, elements of the Hessian $H$, are negative, the signs of the slopes of $x(q)$ and $q(x)$ at $(x^*, q^*)$ are the same as the sign of $P_{xx}$. In addition, since $|H| > 0$, $x(q)$ is steeper than $q(x)$.

The restriction on $x$ essentially suspends eq. (2), replacing it by the vertical line $x = \bar{x}$. Lowering $\bar{x}$ from $x^*$ thus moves the equilibrium in figs. 1(a) and (b) to a point such as $A$. This raises quality if $P_{xx} < 0$, and lowers it if $P_{xx} > 0$. If $P_q$ is monotonic in $x$, then $P_{qq}(x, q) \leq 0$ as

$$\int_0^x P_q(v, q) dv - P_q(x, q)x = 0.$$
Fig. 1

(a) $P_{xq} < 0$

(b) $P_{xq} > 0$
This is because of the usual relation between marginals and averages.

\[ \frac{1}{n} \int_{0}^{x} P_{q}(n, q) \, dn \]

is the average valuation of an increment of quality, while \( P_{q}(x, q) \) is the valuation of an increment in quality by the marginal consumer. The following interpretation of \( P_{xq} \) (as given by Spence) is illuminating in this context. In Spence’s words:

\( P_{xq} \) is the change in \( P_{q} \) as one moves down the spectrum of consumers ordered by their willingness to pay. If \( P_{xq} < 0 \), the marginal value of quality falls as absolute willingness to pay falls. When this is true, the average value attached to quality exceeds the marginal consumer’s valuation.\(^2\)

Lowering output removes the marginal consumer from the market. If the marginal consumer values quality increments less (more) than the average value attached to quality increments, it is in the interest of the monopolist to raise (lower) quality, as shown by eq. (5).\(^3\)

The effects of minimum quality standards may be analyzed in an identical fashion. The comparative statics calculations show that about \((x^*, q^*):\)

\[ \frac{dx}{dq} = \frac{-P_{xq}x}{2P_{xx} + xP_{xx}}. \]  

This expression has the same sign as \( P_{xq} \). If \( P_{xq} < 0 \), \( x \) falls as \( q \) rises. This result may be interpreted as follows. The increase in \( q \) makes serving the marginal consumer less profitable since he does not value increments in \( q \) as highly as all consumers do on average, and so output falls with increases in \( q \). This result can also be seen using fig. 1. The restriction on \( q \) essentially suspends eq. (3), replacing it with the horizontal line, \( q = \bar{q} \), leading to a new equilibrium such as point \( B \). This lowers output for \( P_{xq} < 0 \) and raises it for \( P_{xq} > 0 \).

Unlike a quota and quality control, which in effect suspend one equation, an ad-valorem tariff affects the position of both \( x(q) \) and \( q(x) \). The problem

\(^2\)Spence (1976).

\(^3\)As an example, one might consider the following. There is a continuum of consumers, indexed by \( \theta \), with reservation price \( u(\theta, q) \). All consumers purchase one unit of the commodity, or none. Consumers are distributed by \( f(\theta) \), \( \int f(\theta) \, d\theta = \theta(d(q) \) where \( \theta^{*} \) indexes the marginal consumer. \( P(x, q) \) represents the corresponding inverse demand function. Messy calculations show that if high \( \theta \) consumers value increments in quality more than low \( \theta \) ones, so that \( u_{x} < 0 \) as expected. Das and Donnenfeld (1984) have an example of this where \( u(\theta, q) = \theta d(q) \).
facing the producer is:

$$\max_{x,q} (P(x,q)(1-t) - C(q))x.$$  \hspace{1cm} (7)

Simple comparative statics yield:

$$\frac{dx}{dt} = \frac{(P_{x}x + P)(P_{qq} - C_{qq})x - P_{qq}xP_{q}x}{|H|}$$ \hspace{1cm} (8)

and

$$\frac{dq}{dt} = \frac{(2P_{x} + P_{xx}x)P_{q} - (P_{x}x + P)xP_{qq}}{|H|}.$$ \hspace{1cm} (9)

Second-order conditions ensure that if $P_{qq} > 0$, $dq/dt < 0$ and $dx/dt < 0$, so that a positive tariff is needed to lower imports. If $P_{qq} < 0$, the signs of $dx/dt$ and $dq/dt$ are indeterminate and a negative tariff may be needed to reduce imports. Figs. 1(a) and (b) illustrate the effect of a tariff which reduces imports. $E$ is the free trade equilibrium, $C$ is the equilibrium when a positive tariff reduces imports, and $D$ is the equilibrium when a negative tariff reduces imports.

The effects of a specific tariff are qualitatively the same as those of a quota. The specific tariff, $s$, has producers maximizing profits given by:

$$\Pi(x,q,s) = (P(x,q) - C(q) - s)x.$$ \hspace{1cm} (10)

Doing the required comparative statics yields:

$$\frac{dx}{ds} = \frac{(P_{qq} - C_{qq})x}{|H|} < 0$$ \hspace{1cm} (11)

and

$$\frac{dq}{ds} = -xP_{qq}.$$ \hspace{1cm} (12)

A specific tariff always lowers output. It raises quality if $P_{qq} < 0$, while lowering it if $P_{qq} > 0$. A specific tariff shifts only the $x(q)$ function so that a lower output is produced for every $q$. Hence, the equilibrium is along the $q(x)$ function at a point such as $A$ in fig. 1. These results are summarized in table 1.

Having derived the effects of different kinds of restrictions on the quality and output choices of a monopolist, it is appropriate to relate the results in this section to previous work in the area.
In discussing the effect of trade restrictions on quality, trade theorists have focused their attention on models of perfect competition, and on the demand characterization associated with Swan (1970). As a result of this focus, the two aspects of a producer's choice mentioned in the introduction did not attract attention. In the Swan model, it is desirable to produce only one quality, so that questions concerning the product line do not arise. Moreover, this choice of quality can be interpreted as a cost-side phenomenon.

The assumption in the Swan model is that demand is essentially for services produced by the goods, and higher quality goods have greater durability and hence produce more services, but cost more to produce. The profit-maximizing quality choice under monopoly or competition can be shown to be that which minimizes cost per unit of services, and to be independent of the level of services produced. This allows the choice of quality to be interpreted as a pure cost side decision. In the Swan model, an ad-valorem tariff does not effect this choice of quality, but a quota or specific tariff does. The intuition is that the quota can be thought of as having a shadow price per unit of output associated with it, which is why its effects are like those of a specific tariff. The effect of raising $q$ on cost per unit of a service is, to the first order, equal to zero, since cost per unit of a service is minimized. However, an increase in $q$ lowers the shadow price of the quota, since it makes the constraint less binding. Thus, on the margin, raising $q$ in response to a quota is profitable. Similarly, a specific tariff leads to an increase in $q$ because this makes the specific tariff less restrictive. Ad-valorem tariffs do not raise quality since the cost minimization problem is unaffected by such a tariff.4

The more general analysis here has two advantages over the specific characterization mentioned above. First, it shows that the monopolist, with two characteristics to set so as to maximize profits, will use both to extract

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**Table 1**
The effects of trade restrictions.

<table>
<thead>
<tr>
<th>Sign of $P_{*t}$</th>
<th>Tariff ($t$)</th>
<th>Quota ($c$)</th>
<th>Quality control ($q$)</th>
<th>Specific tariff ($s$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{*t} &lt; 0$</td>
<td>$dx \leq 0$, $dq \leq 0$</td>
<td>$dx \leq 0$, $dq \leq 0$</td>
<td>$dx &lt; 0$, $dq &lt; 0$</td>
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<td>$dx &gt; 0$, $dq &gt; 0$</td>
</tr>
</tbody>
</table>

4See Rodriguez (1979) and Santoni and Van Cott (1980) for details.
as much surplus from consumers as possible. Any restriction changes the
optimal mix between the use of the two, and how this mix changes can be
interpreted in terms of demand characteristics, as shown earlier. The second
advantage of the approach is its generality. The approach of Rodriguez
(1979) and Santoni and Van Cott (1980) emerges as a special case. Though
they only consider the case of competition, it is easy to extend some of their
results to the monopoly case.5

The analysis of the effects of trade restrictions on the product line have
also been focused on the cost side. Falvey (1979) considered the effect of
trade restrictions on the product line under monopoly and competition. He
argues that specific tariffs and quotas raise the quality composition of
imports, while ad-valorem tariffs do not. The essence of his argument is that
prices are closely related to costs. Specific tariffs, or quotas implemented by
the sale of licenses, raise all prices by the same amount. Thus, the relative
price of higher quality goods falls. If relative demand depends inversely on
relative price, the relative demand for higher quality products rises, and this
raises the quality composition of imports. Ad-valorem tariffs do not change
relative prices and so have no effect on the composition of imports.

While this argument is relatively plausible in the context of a competitive
market structure, it is less so when the producer has market power. In such
cases, the prices of goods of different qualities must be set together to allow
the producer to discriminate between consumers. It is therefore essential to
study the pricing of an entire product line, as is done in Krishna (1984a),
rather than assume that relative prices reflect relative costs, as is done by
Falvey.

3. Import equivalent restrictions

3.1. Preliminary remarks

This section compares ad-valorem tariffs, quotas, and quality controls that
achieve a given slight reduction of imports. A few preliminary remarks are in
order before we start the analysis.

I will assume that any desired quality level can be achieved. It is assumed
that the administrative machinery can set both minimum and maximum
quality standards. In the same spirit, tariffs are not confined to being positive.
It is possible for a tariff to raise imports, and decreases in physical imports
may require subsidies.

3.2. The sale of licenses

In order to compare tariffs and quotas, it is necessary to specify how
import licenses are distributed, who appropriates the rents, and what these

5For their specification, P_{m}<0.
rents are. This is easy in the case of competition, where the difference between domestic price (as determined by market supply with the quota and market demand), and the foreign price, determines the level of rents. This difference is the price of a license auctioned to competitive suppliers.

In the case of foreign monopoly, no foreign supply curve exists, with or without any restrictions present. It is not obvious how much would be paid for a license, and what ensures that a license is used. The problem is that of specifying how the sale of a license affects the profit-maximization problem perceived by the monopolist. One interpretation of my specification is that the government sets a price for a license which is sold to foreign producers who take this price as given and beyond their control. The license allows the foreign producer to export one unit of a good of any quality it desires. Thus, a license acts exactly like a specific tariff. If a government wishes to set a quota at the level \( R \), it would implement it by setting the license price \( p' \) such that the foreign monopolist chooses to sell only \( R \).

This is portrayed in figs. 2(a) and (b). Fig. 2(a) shows the optimal choice of \( x \) for a given \( q \) and fig. 2(b) depicts the optimal choice of \( q \) for a given \( x \). The former is characterized by the familiar marginal cost equals marginal revenue condition. The latter is characterized by the inverse demand function being tangent to the unit cost function. These are implications of the first order conditions for a maximum. \( MR(x, q^l) \) is the marginal revenue function corresponding to the inverse demand function, \( P(x, q^l) \). \( x^f \) and \( q^f \) are the profit-maximizing output and quality choices for the monopolist under free trade.

When imports are restricted to be \( R \), \( q^R \) is the profit maximizing quality choice for the monopolist as shown in fig. 2(b). If \( q^R \) is the quality choice, \( P(x, q^R) \) is the inverse demand function facing the monopolist in fig. 2(a), and \( MR(x, q^R) \) is the corresponding marginal revenue curve. If a license price of \( P^L \) is set, the monopolist would wish to produce \( R \). Thus, the quota at level \( R \) can be implemented by setting a license price of \( P^L \), since \( R \) and \( q^R \) are the profit-maximizing choices of output and quality on the part of the monopolist, given a license price of \( P^L \) and his beliefs about how he can affect the price \( P^L \). The effects of a quota are therefore identical to those of the specific tariff which implements it.

This assumption on the beliefs of the foreign monopolist is not the only possible assumption that could be made. The foreign firm might believe that it can influence the price of a license. In this case, the relative strengths of the monopolist and the government would determine what part of the rents were appropriated by the monopolist. If the monopolist refused to purchase any licenses and the government wished to have the quota level actually imported, the only price it could charge for a license would be zero. All rents would accrue to the foreign firm under this assumption. There are two reasons why I do not choose to make this assumption. First, the relative strength of a government as compared to a firm makes this assumption implausible. In addition, it is often argued that in practice, tariffs generate revenues but quotas do not, as licenses are rarely sold. I compare tariffs and quotas when the best case for quotas is made. I show that even on these terms, the revenue effects of a tariff tend to dominate those of a quota. The assumption that quotas generate no revenues would needlessly bias the welfare comparisons in favor of tariffs.
3.3. The welfare function

In order to compare different kinds of restrictions, it is necessary to specify the national welfare function. I will assume that the demand side can be represented by a utility-maximizing aggregate consumer who consumes the imported good and a domestically produced, competitively supplied numeraire good. He also has rights on all tariff revenues and profits generated by domestic sources. The profits generated by production of the imported good accrue to foreign nationals. The weight given to revenue in the welfare function, \( \alpha \), varies with the importance of revenue in welfare. It is less than one if there are considerable administrative costs to collecting the revenue, or if the government essentially wastes part of revenue raised. Similarly, if the government cannot undertake policies in the national interest due to revenue considerations, this weight will exceed one. Under these assumptions, national welfare, \( W \), is given by the sum of consumer surplus and the weighted revenues generated by the trade restriction. For example, under a specific tariff \( s \), the national welfare function is defined by:

\[
W(x, q, s) = [U(x, q) - P(x, q)x] + \alpha sx.
\]  

Notice that \( P(x, q) \) is the price paid by the consumer for purchasing a unit of the good of quality \( q \). Both \( x \) and \( q \), of course, depend on \( s \) as well. The analogues of (13) for ad-valorem tariffs and quality controls are similarly defined. Thus, any tariff will affect national welfare both directly through the level of the tariff and indirectly through the induced effects on \( x \) and \( q \). These are called the revenue, output and quality effects of a tariff on welfare, and the total effect of the tariff is their combined effect.

3.4. Equivalent policies

In order to compare the welfare effects of a quantitative restriction to an ad-valorem tariff or a quality control which leads to the same level of imports, we first need to evaluate the welfare effects of the individual policies. Consider the welfare effects of a quota which reduces imports by one unit and which is implemented by selling licenses as outlined in section 2.2. As shown, this is identical to a specific tariff, \( \Delta s \), which reduces imports by one unit. The level of \( \Delta s \) can be found using (11). The effect of this tariff on welfare can then be estimated using (13), (11), (12), and the fact that the change in welfare due to such a quota, denoted by \( \Delta W_q \), equals:

\[
\Delta W_q = \frac{\partial W}{\partial x} \frac{\partial x}{\partial s} \Delta s + \frac{\partial W}{\partial q} \frac{\partial q}{\partial s} \Delta s + \frac{\partial W}{\partial x} \Delta x.
\]
Also notice that \( P(x, q) = U_q(x, q) \) as a result of consumer utility maximization. Then,

\[
\Delta W_q = -(P - C) \left( U_q - P_q x \right) \frac{(x P_{xq})}{(P_{qq} - C_{qq})x} - \frac{\partial H}{\partial x}, \tag{14}
\]

This expression shows that there is always an adverse effect on welfare via output of a quota of \(- (P - C)\). This is expected, since a monopolist produces too little output for any given quality level, and a quota aggravates this distortion.

Less expected is the fact that as \( P_q \) is assumed to be monotonic in output, there is always a beneficial effect on welfare via quality and revenue. Notice that:

\[
U_q(x, q) - P_q(x, q) = \left[ x \int_0^x \left( U_{xq}(v, q) \right) dv + P_q(x, q) \right]
\]

\[
= x \left[ \int_0^x \left( P_q(v, q) \right) dv + P_q(x, q) \right].
\]

Hence, the sign of the above expression is the opposite of the sign of \( P_{xq} \).

Since \( P_{qq} - C_{qq} < 0 \) by second-order conditions, the second term in (14) is always positive. When \( P_{qq} < 0 \), the monopolist is producing too low a quality level (as \( \partial W/\partial q > 0 \)), and a quota raises quality, thus raising welfare. If \( P_{xx} > 0 \), too high a quality level is being produced (\( \partial W/\partial q < 0 \)), and a quota lowers quality, which again raises welfare. The effect on welfare, via revenue, is always beneficial, since the sale of licenses transfers some of the monopolist's profits to the national government.

Similarly, the ad-valorem tariff, \( \Delta t \), which reduces imports by one unit can be calculated from (8). Then (8), (9), and (13) can be used to evaluate the total effect of such a tariff. This shows that the change in welfare of such a tariff, \( \Delta W_T \), is:

\[
\Delta W_T = -(P - C) \left( \frac{U_q - P_q x}{(P_{xx} + P)(P_{qq} - C_{qq})} \right) P_q x + P_q \left( \frac{[2P_x + xP_{xx}]P_q - (P_x + P)P_{xq}]}{[(P_{xx} + P)(P_{qq} - C_{qq}) - P_{xx}xP_q]} \right) \frac{\alpha(P_x)H}{[(P_{xx} + P)(P_{qq} - C_{qq})x - P_{xx}xP_q^2]}.
\]

(15)

The three terms give the output, quality, and revenue effects of such a tariff. The effect on welfare via output of an import equivalent tariff and quota are identical. The effect of the tariff on welfare via quality is beneficial.
if $P_{xq} > 0$, since then the tariff lowers quality and since quality is at too high a level, this is beneficial. If $P_{xq} < 0$, quality is set at too low a level, but the tariff may lower it further, and the effect of a tariff on welfare via quality may be harmful. The effect via revenue raises welfare if a positive tariff is required to lower imports, while it lowers welfare if a subsidy is required.

Finally, using (6) to get $\Delta q$, the change in the quality of imports required to lower imports by one unit, gives the effect on welfare of an import equivalent quality control policy to be:

$$\Delta W_q = -(P - C) + (U_q - P_{eq}) \left( \frac{2P_x + xP_{xx}}{P_{xq}x} \right).$$

(16)

Notice that there are no revenue effects of quality controls, and that quality controls always raise welfare via their effects on quality, but as usual lower welfare via their output effects.

Eqs. (14), (15), and (16) allows a comparison of the three equivalent policies, or of their quality or revenue effects alone. Of course, they all have identical output effects. This procedure yields some formidable equations and the following results. These can be verified algebraically by comparing the relevant components of (14), (15) and (16).

Proposition 1 compares the three policies on the basis of their quality or revenue effects alone. Propositions 2 and 3 concern some special cases.

**Proposition 1.** First consider the case where revenue considerations are unimportant ($\alpha = 0$). If $P_{xq} < 0$, and a positive ad-valorem tariff is needed to reduce imports ($dx/dt < 0$), then a quality control dominates a quota (or specific tariff) which dominates an ad-valorem tariff. If an ad-valorem subsidy is required to reduce imports ($dx/dt > 0$), then a tariff dominates a quality control which dominates a quota. If $P_{xq} > 0$, then a quality control dominates a tariff which dominates a quota.

Next, consider the case where only revenue considerations are important ($\alpha = -\infty$). If $P_{xq} > 0$, then a tariff or quota dominates a quality control, although they cannot be unambiguously ranked vis-à-vis each other. If $P_{xq} < 0$ and a subsidy is required to reduce output, ($dx/dt > 0$), then a quota dominates a quality control which dominates a tariff. If $P_{xq} < 0$, and a tax reduces output, ($dx/dt < 0$), then a tariff dominates a quota which dominates a quality control.

These results are summarized in table 2.

The intuition behind these results may be understood by noticing that if $\alpha = 0$, only quality effects matter, and these can be compared by using fig. 1. If

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Propositions 1-3 are presented in greater detail in Krishna (1984b).

Of course, by continuity arguments, the same results go through for $\alpha$ small enough, or large enough.
Table 2
The ranking of trade restrictions which reduce imports by a unit.

<table>
<thead>
<tr>
<th>Sign of $P_{xq}$ and $\frac{dx}{dt}$</th>
<th>$P_{xq} &gt; 0$</th>
<th>$P_{xq} &lt; 0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{dx}{dt}$</td>
<td>$\frac{dx}{dt} &gt; 0$</td>
<td>$\frac{dx}{dt} &lt; 0$</td>
</tr>
<tr>
<td>$q &gt; t &gt; \hat{q}$</td>
<td>$t &gt; \hat{q} &gt; \hat{q}$</td>
<td>$\hat{q} &gt; \hat{q} &gt; t$</td>
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<tr>
<td>$x &gt; \hat{d}$</td>
<td>$\hat{q} &gt; t$</td>
<td>$t &gt; \hat{q} &gt; \hat{q}$</td>
</tr>
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<td>$\frac{dx}{dt}$</td>
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$P_{xq} < 0$, welfare increases with $q$ and $x$, as mentioned above. Similarly, if $P_{xq} > 0$, welfare rises as $q$ falls and $x$ rises. A quota leading to a decrease in output of a unit leads to equilibrium at a point like $A$ in figs. 1(a) and (b). A quality control that lowers output by as much leads to equilibrium at point $B$ in fig. 1(a) and $B'$ in fig. 1(b). For $\frac{dx}{dt} < 0$, a positive tariff shifts both $x(q)$ and $q(x)$, as shown in figs. 1(a) and (b), and leads to equilibrium at a point such as $C$. Finally, for $P_{xq} < 0$ and $\frac{dx}{dt} > 0$, a subsidy is required to lower output, and the new equilibrium would be at a point such as $D$. If $P_{xq} < 0$ and $\frac{dx}{dt} > 0$, a tariff dominates a quality control, which dominates a quota. This is because increases in quality are desirable and the tariff has the greatest positive effect on quality as $D$ lies directly above $B$, which lies directly above $A$ in fig. 1(a). For $\frac{dx}{dt} < 0$ and $P_{xq} < 0$, however, a quality control dominates a quota which dominates a tariff, as $B$ lies above $A$ which lies above $C$ in fig. 1(a). If $P_{xq} > 0$, $\frac{dx}{dt}$ must be negative, and a decrease in quality raises welfare. As $B'$ lies below $C$, which lies below $A$ in fig. 1(b), a quality control dominates a tariff which dominates a quota.

Now to consider the ranking of policies when only revenue considerations matter, i.e. $\alpha \rightarrow \infty$.

The comparative revenue effect alone can be expressed as

$$ (\Delta W_Q - \Delta W_T)_{R} = -\left[\frac{dx}{dt}\right]^{-1} x \left[\frac{P_{xq}(P_{eq} - C_{eq}) - P_{xq}P_{eq}x}{(P_{eq} - C_{eq})}\right]. $$

If $P_{xq} < 0$ and $\frac{dx}{dt} < 0$, which is called the 'normal' case, then both tariffs and quotas which reduce imports by one unit generate positive revenues. Thus, both are better than a quality control which generates no revenues.
Moreover, the preceding equation shows that a tariff is better than a quota in this case. If $P_{xq} < 0$ and $dx/dt > 0$, then a subsidy is required to reduce output. Thus, a quota raises revenue and a tariff eats into existing revenues. Hence, a quota is better than a quality control which is better than a tariff in this case. If $P_{xq} > 0$, then $dx/dt$ must be negative so that both a tariff and a quota raise revenue and so are better than the quality control. However, it is not possible to rank them vis-à-vis each other as can be verified from the preceding equation.

Propositions 2 and 3 are results for some special models which have been considered in the literature.

**Proposition 2.** If the valuation of an increment in quality, $P_q$, is independent of output, so $P_{xq} = 0$, then a tariff always dominates an import equivalent quota which dominates a quality control.

The proof follows from the assumptions and eqs. (14) and (15) adapted for the special case, which show that:

$$\Delta W_Q - \Delta W_t = - \frac{(P_x)^2 x^2 (2P_x + xP_{xq})}{P_x (P_x x + P)},$$

which is less than zero. Another way of understanding this result is to notice that the ranking of the tariff and quota is independent of $\alpha$ because there is no effect on welfare of a change in quality because $P_{xq} = 0$. Thus, their comparison is really only based on their relative revenue effects. Moreover, because $dx/dt$ must be negative if $P_{xq} = 0$, both tariffs and quotas raise revenues. Therefore, this is like the case where $P_{xq} < 0$, $dx/dt < 0$, and $\alpha \to \infty$, where a tariff dominates a quota in its revenue effects which are the only relevant ones. Since a quality control has no revenue effect, both tariffs and quotas dominate it.

**Proposition 3.** If demand for the good is derived from services produced by the good and higher quality goods produce more services, then if $\alpha = 0$, so that revenue considerations are unimportant, a quota is preferable to an import equivalent tariff. If $\alpha$ is large, and revenue considerations are of primary importance, a tariff is preferable to an import equivalent quota. If both are equally important, $\alpha = 1$, and demand for services is linear, a tariff is preferable to the import equivalent quota.

The proof follows from the method of analysis developed in earlier propositions, and though tedious, is straightforward and so omitted. It is
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easier to understand part of these results indirectly. Note that for this specification of preferences, $P_{xq} < 0$ and $dx/dt < 0$. The results of Proposition 1 when $P_{xq} < 0$ and $dx/dt < 0$ now apply. Notice that this also allows us to rank tariff and quotas and quality controls unambiguously when $\alpha$ is close to zero or when $\alpha$ is very large.

4. Conclusions

Although the effects of trade restrictions with endogenous quality have been studied previously, the specification of the structures to be analyzed have been particularly suited to the paradigm of perfect competition. Quotas are widely used in order to restrict trade. However, the common feeling is that tariffs are a superior way of restricting trade. If the quality aspect is suppressed in the above framework, so that only revenue considerations are important, it is easy to verify that tariffs dominate import equivalent quotas. However, when quality aspects are introduced, a tendency emerges for quotas to dominate tariffs on the basis of their quality effects in the 'normal' case, and their ranking depends on the importance of such effects, relative to other effects. In other words, quotas become more desirable instruments, compared to tariffs, when their effects on quality are taken into account. Similar comparisons of policies which are equivalent in terms of revenue or foreign exchange use can be made with similar results.

In an imperfectly competitive world, a large number of questions arise which do not have corresponding analogues in a competitive world. In order to study such questions, it is important to develop simple models to capture the factors which might be important in answering such questions. This paper is to be viewed as an attempt at doing just this.

References

Krishna, K., 1984b, Tariffs vs. quotas with endogenous quality, Working NBER paper no. 1535.