ENDOGENOUS QUALITY CHOICE AND THE IMPACT OF QUANTITATIVE RESTRICTIONS

Ananish Chaudhuri

In this article a model of vertical product differentiation with two firms (a home firm and a foreign firm) engaged in endogenous quality competition. The firms engage in a two-stage game, where in the first stage they choose qualities in a sequential manner. In the second stage, the firms compete in quantities (a la Cournot) moving sequentially again.

In the second part of this article, the impact of quantitative restrictions (like a VER or quota) on the quality choices and other related variables like prices, firm profitability, consumer surplus, etc.

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I. INTRODUCTION

The immediate motivation of this article is two-fold:

(a) how credible revelation of quality choice and the mode of product market entry affect quality choices and various other related variables such as firm profitability, prices, consumer surplus, etc.

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(b) how a quantitative restriction like a VER or a quota might impact upon those variables.


Motta (1993) modeled the question as a two-stage game. In the first stage firms simultaneously decide on quality. At the end of the first period, the quality choices become common knowledge. Then in the second stage the firms engage in product market competition—either in quantities (a la Cournot) or in prices (a la Bertrand)—deciding simultaneously at this stage also. In section II some of the results from Motta (1993) will be discussed as a point of reference for this article.

Aoki (1994) extends Motta’s work by looking at sequential quality choice in the first stage and simultaneous Bertrand/Cournot competition in the second stage. It turns out that the timing of these choices has a significant impact on the variables mentioned before. In Motta’s case (1993) the firms decide about their own qualities without knowing the quality choice of the other firm, while in Aoki’s article the firm that moves second already knows the quality level chosen by the firm moving first. Aoki and Prusa (1995) extend Aoki’s (1994) theoretical model to the realm of policy-making in analyzing the differences in the U.S. and Japanese patenting systems. Under the Japanese system, it is possible for a firm to apply for a patent knowing the exact specifications of a rival’s patent application. In contrast, in the U.S. the only way a firm learns about a rival’s innovation is upon the granting of the patent. “Under the Japanese patent system the patent application is publicly disclosed or ‘laid open’ 18 months after the filing date, i.e., the Japanese practice of kokai. All key information contained in the patent
application is automatically published in the Patent Gazette. Furthermore, the Patent Office’s examination as to the substance of the application does not begin until after the public disclosure. By contrast, in the U.S., information contained in a patent application is published in the Official Gazette of the United States Patent and Trademark Office only after the patent has been granted.” (Aoki & Prusa, 1995, p. 2). Thus, the U.S. system represents a situation where the qualities are chosen simultaneously (a la Motta), whereas in the Japanese system they are chosen in a sequential fashion (a la Aoki).

One immediate motivation of this article came from the following passage from Aoki and Prusa (1995, p. 4): “First, it is conceivable that due to the differences in the filing dates the firms might receive their patents sequentially and thus reach the product market sequentially. This potential difference in the time the products reach the market will be insignificant as long as the length of the time that both products is patented is relatively large as compared with the time that only one of the products is available, as we assume is the case.” This article asks the question—what if that is not true? In many third world countries, with their bloated bureaucracies, there could quite conceivably be a long lag between the entry of the first firm into the product market and the entry of the second firm after the patents are granted. In this article, a situation is considered where the competition in both stages of the game are sequential. So the model that is set up is a model of Stackelberg competition.

Also considered is the impact of quantitative restrictions on the qualities chosen by the firms. The results in the empirical literature have been on the side of quality increase due to the imposition of the restriction (see, for example, Feenstra (1985, 1988), Boorstein and Feenstra (1991), and Smith and Venables (1991)). Krishna (1990) provides an excellent survey. Das and Donnenfeld (1989) look at the strategic effects of quantity restraints on quality choice in an oligopoly setting where the firms decide simultaneously on output and quality. They show that quantity restraints always improve the quality of the
foreign firm. The quality of the domestic goods increases if the foreign firm produces the higher quality. On the contrary, if the foreign firm produces the lower quality then the domestic firm lowers its quality. In this article it is shown that if the foreign firm produces the higher quality and if firms compete in quantities, then there is a sharp downgrading of quality due to the imposition of restrictions.

II. MODEL

The case of 2 countries is considered—a home country and a foreign country. There are two firms, one in each country producing a vertically differentiated good. Competition occurs in the home country. The marginal cost of production is zero for both firms and does not depend on the choice of quality \((s)\). High quality is denoted by \(s_H\) and the low quality by \(s_L\), such that \(s_H > s_L\) always.

For this article, it will be explicitly assumed that the foreign firm produces the higher quality \(s_H\) and the home firm produces the lower quality \(s_L\).

There is a continuum of consumers in the domestic market, each identified by her taste parameter \(\Theta\) distributed uniformly over the interval \([0,1]\) with density one. Each consumer has unit demand for the good and the utility function,

\[
U = \Theta s - p \text{ if she buys one unit of the good with quality } s \\
= 0 \text{ otherwise.}
\]

However, providing quality has a cost involved and the marginal cost of providing an additional unit of quality is increasing in \(s\) and is given by \(s^2/2\).

The game proceeds in two stages. In the first stage the firms decide on their qualities. In Motta (1993) this decision is simultaneous. In Aoki (1994) and in this article, this decision is sequential. It is explicitly assumed, however, that the foreign firm moves first and produces the
higher quality.\footnote{This is actually an innocuous assumption since Aoki and Prusa (1997) demonstrate that in the set-up described here, the first mover will always choose a higher quality firm. The model is solved using the standard concept of backward induction.} So the foreign firm files for a patent ahead of the domestic firm and the contents of the patent application are thrown open. The domestic firm then commits to its quality after having been informed of the quality choice of the foreign firm. In this stage, where qualities are chosen, the firms incur a unit cost of $s^2/2$ for providing quality. In the second stage, the firms compete in quantities where there is zero cost of production. In both Motta and Aoki, this competition is simultaneous a la Cournot, whereas in this article the competition is sequential under the assumption that the foreign firm that files for and obtains a patent first also enters the product market ahead of the domestic.

First, the demand for the high and the low quality good is derived. Let the price of the high quality good be $p_H$ and the price of the low quality good $p_L$. Then the consumer buys the high quality if $\Theta_H s_H - p_H > \Theta_L s_L - p_L > 0$, which implies that the consumer who is exactly indifferent between the high and low quality has a taste parameter $\Theta_H = (p_H - p_L)/(s_H - s_L)$. On the other hand, if $\Theta_H s_H - p_H < \Theta_L s_L - p_L > 0$, then the consumer who is indifferent between buying the lower quality and not buying at all has the taste parameter $\Theta_L = p_L/s_L$. So a consumer buys the high quality if her taste parameter $\Theta$ is such that $1 \geq \Theta \geq \Theta_H$, while a consumer buys the low quality if her taste parameter $\Theta$ is such that $\Theta_H \geq \Theta \geq \Theta_L$. The consumer for whom $\Theta \leq \Theta_L$ does not buy the good.

Then the demand for the high and low quality goods are given by

\begin{align*}
(1) \quad x_H(p_H, p_L) &= 1 - \frac{p_H - p_L}{s_H - s_L} \\
(2) \quad X_L &= \frac{p_H - p_L}{s_H - s_L} = \frac{p_L}{s_L}
\end{align*}

Solving for the inverse demand function, one gets
In this section one looks at Motta’s analysis of simultaneous quantity competition in the second stage. Keeping with the notion of backward induction the second stage is solved first. For any given pair of qualities $S_H$ and $S_L$, firm $i$ maximizes its profits $\pi_i(x_i, x_j) = p_i^*x_i$ over the choice of quantities $x_i$, given the quantity of its rival $x_j$. The cost of production of this quantity as mentioned before is zero. This gives one the best response functions.

\[
x_H = \frac{1}{2} - \frac{s_L}{2 s_H} x_L; x_L = \frac{1-x_H}{2}.
\]

Solving for $x_H^*$ and $x_L^*$ one gets

\[
x_H^* = \frac{2 s_H - s_L}{4 s_H - s_L};
\]

\[
x_L^* = \frac{s_H}{4 s_L - s_H}.
\]

Now going back to the first stage, net profit for a given pair of qualities is

\[
\Pi_i(s_H, s_L) = p_i x_i^*(s_H, s_L) - (1/2) s_i^2.
\]

It can be checked that $\frac{\partial^2 \pi}{\partial s_H \partial s_L} > 0$, which implies that the low quality is a strategic complement to the high quality, while the high quality is a strategic substitute to the low quality. If the home firm, which produces the lower quality, raises its quality, then the foreign firm’s marginal profit goes up. This gives the foreign firm an incentive
to increase its quality and go for the maximum possible differentiation in quality. On the other hand, since the high quality is a strategic substitute for the low quality so as the foreign firm’s quality increases, then the home firm’s marginal benefit from increasing its quality decreases.

In this first stage, the firms choose their qualities \( s_i \) to maximize their profits as given in (8) given the quality of its rival \( s_j \). The first-order conditions then are as follows:

\[
\begin{align*}
  s_H &= \frac{(2s_H - s_L)(8s^2_H - 2s_Hs_L + s_L^2)}{(4s_H - s_L)^3} \\
  s_L &= \frac{s_H^2 (4s_H + s_L)}{(4s_H - s_L)^3}
\end{align*}
\]

Solving for the equilibrium quality levels one gets \( s_H^* = 0.2519 \) and \( s_L^* = 0.0902 \). The equilibrium quantities are \( x_H^* = 0.4508 \) and \( x_L^* = 0.2746 \). The equilibrium prices are \( p_H^* = 0.1135 \) and \( p_L^* = 0.0248 \). Looking at firm profits one sees that the foreign firm has \( \pi_H^* = 0.01947 \) and the home firm gets profit \( \pi_L^* = 0.00273 \). 72.5% of the market is covered, where market coverage is defined as the sum of \( x_H + x_L \). And finally, if one looks at consumer surplus then one gets a value of 0.04016. One point needs to be mentioned before leaving this section. Once the second stage problem for the two firms is solved, the quantity is expressed as a function of the qualities \( x^i = x(s_{Hi}, s_{Li}), i = 1, 2 \). Now, in the first stage, profit for a firm is a function of the qualities \( \pi^i = \pi(s_{Hi}, s_{Li}), i = 1, 2 \). Given the assumption that the foreign firm (home firm) moves first (second) and produces the higher (lower) quality, if the profit for each firm is plotted against its quality keeping the other firm’s quality fixed, then one gets a smooth inverted U-shaped curve with a unique maxima.

\[\text{To compute consumer surplus the formula found in Motta (1993) is used:}\]

\[
CS = \int_{\theta_L}^{\theta_H} (\theta s_L - p_L) d\theta + \int_{\theta_H}^{\theta_L} (\theta s_H - p_H) d\theta.
\]
Aoki (1994)

Aoki (1994) considers simultaneous competition in quantities as well as prices in the second stage, but allows for both simultaneous and sequential moves in the first stage where qualities are decided. For those purposes, concentration will be on the situation where the firms move sequentially in the first stage and then compete in quantities a la Cournot in the second stage. Aoki allows for either the home firm or the foreign firm to go first. She establishes bounds for the various qualities chosen by the rival and characterizes the best response functions within those bounds. The main insight for this part of the article is summed up in Proposition 8. When there is Cournot competition in the sales stage and firms choose qualities sequentially, the first mover will choose a quality higher than that of the rival. The first mover's quality will be higher than the higher quality chosen under simultaneous choice, but the choice of the second mover will be lower than the lower quality chosen under simultaneous choice. As far as firm profits are concerned, they are almost equal to that derived in the Motta case. Consumer surplus is higher. The higher price is slightly higher, while the lower price is slightly lower than those found in the Motta Section. “When there is Cournot competition the qualities are strategic substitutes for the lower quality firm. Thus, the first mover reduces rival quality by increasing its quality. This benefits the first mover in two ways. Increasing its own quality directly increases its revenue in addition to the positive effect of reducing rival quality. There is an overwhelming benefit to the first mover with higher quality when there is Cournot competition.” (Aoki, 1994, p. 27). The values of the different variables that are obtained in this scenario are: $s_H = .2726$; $s_L = .0862$; $\pi_H = .0198$; $\pi_L = .00263$; $x_H = .457$; $x_L = .2714$; $CS = 0.042$; $p_H = .1256$; $p_L = .0234$. Market coverage is almost the same as that in Motta’s case, roughly 72.8% of the market is covered by the two firms.
Sequential Entry into the Product Market

Now attention is turned to the case where there is sequential entry in both stages of the game. More specifically, the foreign firm, which produces the higher quality, moves first in both the quality setting and the quantity setting stage, while the home firm acts as a follower in both stages. Keeping with the notion of backward induction one looks at the second stage first. In the second stage, the home firm moves second and takes the quantity chosen by the foreign firm as given. The first-order conditions for profit maximization yield the best response function for the home firm. The foreign firm then arrives at its quantity decision by plugging in the home firm’s reaction function into its profit function.

**Proposition 1.**

The best response functions (in terms of quantities) of both the foreign and the home firm in the second stage are independent of the quality levels chosen in the first stage.

Profit for the home firm is given by $\pi = p_L^*x_L = (s_L - s_L^*x_H - s_L^*x_L)x_L$.

Maximizing $\pi_L$ with respect to $x_L$, one gets the best response function for the home firm as $x_L^* = (1-x_H)/2$.

Looking at the profit function of the foreign firm and substituting in the home firm’s best response function (in keeping with the notion of backward induction), one gets $\pi_H = (s_H - s_H^*x_H - s_L^*(1 - x_H/2)^*x_H)$. Maximizing $\pi_H$, with respect to $x_H$, and solving for $x_H$ one gets $x_H = 0.5$. And if the foreign firm produces an output of 0.5, then the home firm’s output is 0.25.

Thus, the quantities produced by the two firms in the second stage are independent of the quality levels chosen in the first stage.

Having solved for the quantities in the second stage, one can now go back to the first stage and express the profits of the two firms as functions of their qualities, that is, $\pi_H = \pi_H(s_H^*, s_L)$ and $\pi_L = \pi_L(s_H^*, s_L)$. 
Proposition 2.

(a) In the first stage the profit of each firm is a function of its own quality and does not depend on the quality of its rival, that is, qualities are neither strategic complements nor strategic substitutes to each other;

(b) Both the higher quality and the lower quality are lower than those found under Motta and Aoki.

In the first stage, the profit of the home firm can be written as $\pi_l = p_l^*x_l - s^2_l/2 = (s_l - s_l^*x_l - s_l^*x_l)*x_l - s^2_l/2$. After substituting the value of $x_H^*$ and $x_L$ obtained from the second stage, one gets $\pi_l = s_l^1/16 - s^2_l/2$. Maximizing $\pi_l$ with respect to $s_l$, one obtains the value of $s_l = .0625$. Similarly, maximizing the profit of the foreign firm, with respect to the high quality $s_{H}$, one gets the value of $s_H = .25$. Once again, solving for the values of other key variables one gets $\pi_H$ (profit of the foreign firm) = .0234; $\pi_k$ (profit of the home firm) = .00195; consumer surplus = .0410; $p_H = .1094$; $p_l = .0156$.

The results mentioned in the two previous propositions are somewhat striking and require an intuitive explanation. To understand the intuition behind these results, one has to understand that the Stackelberg scenario represents a situation of perfect information. Obviously, the second firm knows the first firm’s quality choice in the first stage and the first firm’s quantity choice in the second stage before it makes its decision. But the foreign firm knows the best response functions of the home firm in both stages as well. Thus, the foreign firm basically knows how the home firm is going to react and also knows that in equilibrium, there is no incentive for the home firm to deviate because that would lead to lower profits. The result of this perfect information is a clear segmentation of the market where noncooperatively the two firms implicitly divide the market into two parts—a higher end to be serviced by the foreign firm and a lower end to be catered to by the home firm. Moreover, given complete segmentation, each firm now has the luxury of behaving in a monopolistic fashion in its own segment knowing that the other firm will not deviate from its own strategy and will not at-
tempt to capture market share by producing a higher quantity or by shading price since that would unambiguously lower that firm’s profit. Consider, then, the competition in the second stage. Each firm has chosen a certain level of quality in the first stage and they both know those choices. Now the foreign firm gets to move first in the second stage and knows that the home firm will observe its quantity choice and respond with \( x_L = (1-x_H)/2 \). So right now, the foreign firm is basically in the situation of a monopolist facing unit demand \((\theta \in [0,1])\) with an inverse demand of the form \( p = 1-Q \). So all it has to do is decide on a profit maximizing quantity and the corresponding price—that is, in reality this firm now has the luxury of deciding its exact market share, that is, how many consumers it wishes to cater to and at what price given unit demand. This firm will then decide to produce its *monopoly output* which is 0.5. The home firm moves next after having seen the foreign firm’s price–quantity decision. The home firm then faces the residual demand equal to 1/2, that is, it behaves as if it faces an inverse demand function of the form \( p = 1/2-Q \) and this firm in turn produces its profit maximizing monopoly output which is 0.25. This is the key point to understanding the strange result. The Stackelberg scenario leads to complete market segmentation, where in the second stage each firm can act as a monopolist.

Now one goes back to the first stage. As was already noted in a previous section, once the quantities have been selected and the profit function is expressed as a function of the qualities alone, then each firm has a well-defined profit maximizing quality (given the constraint that the home firm’s quality choice will always be less than that of the foreign firm), which turns out to be 0.25 for the foreign firm and 0.0625 for the home firm.

At this juncture, the reader is justified in raising the following question: Why then, when one has Cournot competition in the second stage, do the firms not produce the standard Cournot output of 1/3 each, given the inverse demand function \( p = 1-Q \)? The answer to that question is that Cournot competition in the second stage represents a situa-
tion involving *simultaneous* choices. No firm knows the other firm’s output decision when it makes its own. Thus, choosing 1/3 is clearly not a best response because if firm A knows that firm B will choose a quantity of 1/3 *no matter what*, then there is always an incentive for firm A to deviate from its own quantity of 1/3 in the absence of binding commitments. So each firm knows that the quantities and, therefore, prices chosen in the second stage must be chosen in a strategic manner because that will determine the market share of each firm, therefore, how much profit they are going to make. Thus, the resolution of the second stage problem in the Cournot case is not as simple as the second stage problem in the Stackelberg scenario.

Now one is in a position to compare the three models—Motta, Aoki, and this article. As can be seen clearly from Table I, in this case, both firms produce qualities that are lower than the qualities produced either under Motta or in Aoki. Market coverage, that is, the sum of the quantities produced by the two firms ($x_H + x_L$) is, however, higher under sequential entry. In Motta’s case, the foreign firm serves 45% of the market while the low quality firm serves 27.5% of the market, that is, 72.5% of the market is covered. The coverage is about the same in Aoki. In this case, the coverage is a little higher—75%; consumer sur-

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plus is lower than that in Motta but higher than that in Aoki. However, in this case, firm profits are higher for the foreign firm—0.0234 for the foreign firm (as opposed to 0.01947 for Motta and 0.0198 for Aoki). However, the profit of the home firm producing the lower quantity is actually lower—0.00195 (versus .00273 in Motta and .00263 in Aoki). However, the prices charged are substantially lower in this case for both firms. Now, recall the discussion on how the Stackelberg scenario leads to a complete segmentation of the market where each firm acts as a monopolist in its own segment. It is noted that in this case even though it is a monopolist, still the home firm is actually left with lower valuation consumers and is, therefore, compelled to charge a lower price resulting in lower profit. Since the prices charged are lower, the consumer surplus does not decline too much despite the fact that firms engage in monopolistic pricing policies.

III. QUANTITATIVE RESTRICTION IN A COURNOT SETTING

In this section, the impact of quantitative restrictions on the foreign firm will be looked at in a situation where the firms compete simultaneously in qualities in the first stage and then in the second stage the firms engage in simultaneous competition in quantities.

Suppose the foreign firm is now faced with a restriction on the amount of output it can produce in the second stage. It will be assumed that the restriction is imposed at the free trade level of output, that is, the maximum amount that the foreign firm can produce is $x_R = 0.4508$. The foreign firm then chooses $x_H = \min\{x_R, \frac{1}{2} - (s_L/2s_H)X_L\}$, where the second term inside the bracket is the foreign firm’s best response function under unrestricted trade. It will be seen that this imposed restriction has a significant impact on the strategic behavior of the two firms in terms of the output and quality levels that they choose.


4Recall from the analysis in the section on Motta that in unrestricted free trade this is the output level of the foreign firm.
Lemma 1.

Given the qualities chosen by the two firms in the first stage, and the best response function of the home firm (in terms of qualities) in the second stage, the profit of the foreign firm is monotonically increasing for any output less than the quota.

Proof.

Simple calculations show that given the qualities chosen by the two firms in the first stage and the best response function of the home firm in terms of quantities in the second stage, the profits of the foreign firm in the second stage are monotonically increasing for any output level below $x_R = 0.4508$. The profit of the foreign firm in the second stage can be written as:

$$\pi_h = p_h x_h = (s_h - s_H x_h - s_L x_L) x_h.$$

Given the best response function of the home firm $x_L = (1 - x_h)/2$ and the qualities $s^*_H$ and $S^*_L$ chosen in the first period, it is easy to show that $\partial \pi_h / \partial x_h > 0$ for any $x_h < 0.5$. Thus, in equilibrium, the foreign firm will settle for producing at the level of the quota.

Proposition 3.

(a) In equilibrium, the foreign firm produces at the level of the quota.

(b) In equilibrium both firms downgrade their qualities as opposed to the free trade situation.

Proof.

As is shown in Lemma 1, given the qualities that the two firms choose in the first stage and given the home firms best response in quantities, the profit of the foreign firm is strictly increasing in its output for any $X_H \leq 0.5$. Since the quota $x_R = 0.4508$, so the foreign firm in an attempt to maximize profit will produce at the level of the quota.

Given that the foreign firm produces at the level of the quota and the best response of the home firm in terms of quantities, one finds that
in equilibrium the home firm produces an output of 0.2746 and the foreign firm produces an output of 0.4508. Going back to the first stage and solving the first-order conditions for the two firms – \( \frac{\partial \pi_H}{\partial s_H} = 0 \) and \( \frac{\partial \pi_L}{\partial s_L} = 0 \) (where \( m = \pi^*_i x_i - \frac{s_i^2}{2}, i=H,L \)), one obtains the equilibrium values of the two qualities \( s_H = 0.2476 \) and \( s_L = 0.0754 \). Thus, both the higher and lower quality are lower than those that would prevail under free trade as compared to the free trade scenario. \( s_H \) in that case was 0.2519 and \( s_L \) was 0.0902. As far as other key variables are concerned, one gets \( p_H = 0.1153 \) and \( p_L = 0.0207 \); \( x_H = 0.4508 \); \( x_L = 0.2747 \); \( \pi_H = 0.0213 \); \( \pi_L = 0.0028 \); and finally, \( \text{CS} = 0.0373 \).

The quantity restriction on the foreign firm decreases the competitive pressure on the domestic firm given the qualities chosen in the first stage. Moreover, following Aoki (1994) one knows that high quality is a strategic substitute for low quality. For the home firm, which produces the lower quality, marginal profits go down if the foreign firm lowers its quality, that is, \( \frac{\partial^2 \pi_L}{\partial s_H \partial s_L} < 0 \). So when the higher quality firm lowers its quality as a response to the quantitative restriction, the home firm, in order to maintain its market share, responds with a lower quality as

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<td>0.1153</td>
</tr>
<tr>
<td>( p_L )</td>
<td>0.0248</td>
<td>0.0234</td>
<td>0.0156</td>
<td>0.0207</td>
</tr>
<tr>
<td>( \Theta_H )</td>
<td>0.549</td>
<td>0.543</td>
<td>0.05</td>
<td>0.5492</td>
</tr>
<tr>
<td>( \Theta_L )</td>
<td>0.2746</td>
<td>0.2716</td>
<td>0.2496</td>
<td>0.2746</td>
</tr>
<tr>
<td>CS</td>
<td>0.04016</td>
<td>0.042</td>
<td>0.410</td>
<td>0.0373</td>
</tr>
</tbody>
</table>

Table II
Comparing the Three Previous Models with Restricted Cournot
well. Moreover, one knows that revenue for the home firm is linear in its own quality, while the cost function is quadratic in quality—thus lowering quality leads to higher profits while maintaining market share.

If one compares results obtained in this case with the results in Motta (1993) (see Table II), then as has been pointed out already, one finds that both the firms produce a lower quality in the restricted case than under Motta. However, both firms enjoy higher profits because of this lowering of quality for reasons that we discussed before. The curious thing is that even though the foreign firm produces a lower quality, it still charges a higher price—a result of the fact that since the home firm produces a lower quality, the foreign firm faces less competition and can charge a higher price for a lower quality. However, once again since the high quality is a strategic substitute for the low quality, the home firm is forced to charge a lower price for the lower quality that it produces. There is no discernible change in the extent of market coverage. However, consumer surplus is considerably lower—a direct consequence of higher firm profits in this scenario.  

A Possible Empirical Test

Feenstra (1985, 1988) examines the impact of U.S.-Japan trade restraints on the quality level of automobiles. Boorstein and Feenstra (1991) carry out a similar exercise. Feenstra provides a way for carrying out an empirical test of the theoretical results reported above. Levinsohn’s article (1988) analyzing the impact of tariffs and quotas on automobile quality suggests a (similar method for comparing quality level changes as a result of trade restrictions. Feenstra (1985, 1988) uses a hedonic

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What happens when the firms move sequentially (a la Stackelberg) in each stage is also looked at and there is a quantitative restriction on the foreign firm. The results obtained in the restricted Stackelberg scenario are identical to those obtained under the restricted Cournot scenario. Given this model it turns out that the mathematical problem in the restricted Stackelberg case is identical to the problem in the restricted Cournot case. For the sake of brevity, a detailed discussion is omitted.
regression model (see Griliches, 1971) to develop a quality index for automobiles. This is done by computing the predicted price from a hedonic regression using a number of variables that collectively serve as proxies for quality. These include \textit{continuous variables such as length (in feet), width (in feet), weight (in tons), horsepower (in 100 HPs), and binary discrete variables like transmission (whether 5-speed or automatic), power steering, power brakes, and air conditioning.} He does this for each model of U.S. or Japanese cars for individual years. He then goes on to calculate Laspeyers and Paasche indexes between pairs of years where the former uses the first period quantities and the latter the second period quantities as weights. Then, following Diewert (1976), the Fisher’s Ideal Index is computed as the geometric mean (square root of the product) of the Laspeyers and Paasche Indexes. The Fisher’s Index serves as a handy way of comparing qualities across various years. Increases (decreases) in the value of the Fisher’s Index correspond to quality upgrading (downgrading).

Most prior theoretical work, including Das and Donnenfeld (1987, 1989) and Krishna (1987, 1989), as well as empirical research such as Feenstra (1985, 1988), Boorstein and Feenstra (1991), Aw and Roberts (1986, 1988), have concluded in favor of quality upgrading following quantity restrictions. Feenstra (1985) reports a quality upgrade of 15.8\% (or 5.3\% per year) between 1981 and 1984 following the imposition of a VER by Japanese auto manufacturers. The corresponding increase in the quality of U.S. automobiles during the same time frame was 9.1\% (or 3\% per year). Boorstein and Feenstra (1991) also report quality upgrading in steel as a result of quantity restrictions. They find that over the 1969–74 period, where the U.S. had a voluntary restraint agreement in steel imports from Japan and the European community, there was a 7.4\% upgrade in the quality of U.S. steel. Aw and Roberts (1986, 1988) find similar upgrading in footwear and Anderson (1985) in cheese production.

These results are in stark contrast since a lowering of quality is found in this article. This result is dependent on the assumptions that
quality choice is endogenous and that the foreign firm always produces the higher quality. Most prior researchers have modeled quality choice in a monopolistic competition set-up. Looking at the U.S.-Japanese experience is not a valid test of these theoretical results. The qualities in the U.S.-Japanese case are perfect substitutes and one cannot make out a case that the Japanese (U.S.) producers produce a higher (lower) quality. In order to carry out a valid empirical test of the propositions, one would need to look at trade between two countries where one country clearly produces a lower quality product. India might be a good example. India has, since its independence in 1947, produced automobiles domestically. Starting in the early 1990s a process of economic liberalization was started allowing imported cars from Japan, U.S. and other countries. This case comes closer to the model developed because the foreign firm unambiguously produces the higher quality vehicle. In order to test this model one would have to look at the impact of a quantity restriction in such a scenario and see if it leads to quality downgrading.  

One would like to end by pointing out that in this model the quantity restriction acts like a facilitating device that allows both producers to downgrade their quality and reap larger profits at the expense of the consumer. As can be seen from Table 2, with a quantity restriction, profits for both firms are higher (as compared to unrestricted Cournot competition) while consumer surplus is lower. Again, this result depends on the string assumption that the foreign firm will produce the higher quality. The foreign firm can lower its quality with impunity since it is guaranteed that the domestic firm will not “leapfrog” and produce a higher quality than the foreign firm.  

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6 One article of interest in this regard is de Melo and Messerlin (1988). While not a direct test of these theoretical propositions, de Melo and Messerlin (1988), in looking at the impact of VERs negotiated by certain European countries and Japanese automakers, find quality upgrading in the French and German markets but quality downgrading in the Italian market.

7 Previous researchers such as Aoki (1994) and Aoki and Prusa (1997) have shown for any quality level chosen by a first mover, there are two best response qualities for
IV. CONCLUDING REMARKS

In this article focus is on how the timing of information revelation regarding quality and the timing of product market entry affect the qualities chosen by the two firms, as well as other key variables like prices, firm profitability, consumer surplus, and extent of market coverage. The analysis is carried out under the maintained assumption that the foreign firm always produces the high quality and the home firm produces the low quality.

One finds that when the competition in the second stage is simultaneous, revelation of information about the quality level chosen by the foreign firm, who moves first (i.e., sequential choices in the first stage), leads to a higher quality differential. The foreign firm chooses a higher quality, while the home firm chooses a lower quality than they would in a situation where the information is not revealed (i.e., simultaneous choice in the first stage).

However, the results are very different if the competition in the second stage is sequential and not simultaneous. From the perspective of the firms though, this scenario is desirable because firm profits are higher than in the models considered by Motta (1993) and Aoki (1994).

Finally, turning to the case where the foreign firm faces a restriction on the amount of quantity that it can produce, then irrespective of the mode of product market entry, the firms produce even lower qualities than they produce when there is sequential entry in the second stage. This is in stark comparison to previous findings in the literature showing quality upgrading due to quantitative restrictions. One finds that firms will definitely downgrade their qualities in the face of such restrictions.

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8Quality is really a catch-all phrase for innovations or R&D.
REFERENCES


