

OPTIMAL TRADE POLICY UNDER BERTRAND COMPETITION AND INCOMPLETE INFORMATION

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This paper examines the optimal export policy under incomplete information. In the model considered, foreign consumers do not know the product quality of the domestic firm, which competes with the incumbent firm in the foreign market. Conditions are derived under which the game has a unique intuitive separating equilibrium in which an exporter can credibly signal its quality. We demonstrate that the welfare effect of the trade policy depends on two factors: the informational externality-reducing effect, and the strategic effect. When the product differentiation and the quality variance is large, the optimal trade policy is an export subsidy, which reduces the upward price distortion. Otherwise, the optimal policy is an export tax for strategic reasons.

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I. INTRODUCTION

When a firm tries to enter a new foreign market where there is an incumbent firm, the firm is potentially confronted with a serious entry barrier because many foreign consumers do not know the entrant's quality and may be loyal to the incumbent firm's products. In addition to firms' efforts to overcome the informational barrier, we can observe many examples of government intervention to support foreign market penetration by a firm with a new product, which is competing with a foreign incumbent firm. Even though direct government subsidization of exports is prohibited under unilateral trade rules, indirect

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government intervention in the form of export credit programs is widespread.

Reflecting the recent trends of international competition, there have been several studies that analyze the welfare effects of trade policy under oligopoly, and the effects of incomplete information on foreign market entry strategies. Eaton and Grossman (1986) examine optimal trade policy when the firms are engaged in Bertrand competition. They assume that a domestic firm and a foreign firm are competing with differentiated products in a third market. Based on these assumptions, they show that if a government is able to set its policy in advance of the firm's price decision, and if government policy commitments are credible, an export tax is the best policy to improve domestic social welfare, because the export tax gives the domestic firm Stackelberg leadership advantage. However, Eaton and Grossman do not consider the effect of incomplete information in their model.

Bagwell (1990)'s paper, which is most closely related to this paper, examines the effect of incomplete information on the market entry strategy when an entrant firm is engaged in Bertrand competition with an incumbent firm. He shows that when the product quality of the new entrant is unknown to consumers, and when the product of the low-quality type of the entrant is

identical with the incumbent firm's product, the high-quality entrant firm may not be able to enter the market profitably. This result, however, is based on his assumption of identical consumers and the assumption that the low-quality entrant's product and the incumbent's product are identical.

In addition, Bagwell (1991) examines the role of incomplete information in a monopoly model with more general assumptions such as a downward-sloping demand functions and that a low-quality firm is not a fly-by-night firm. Based on these assumptions, Bagwell shows that a high quality firm can always separate itself from the low quality firm through an upwardly distorted separating price. Therefore, he shows that an export subsidy generates a welfare-improving effect by enabling the market entry of the high quality firm with a less upwardly distorted separating price. Although the issue is not directly relevant to the market entry issue, there are other studies on Bertrand competition under incomplete information such as Ireland (1993) and Spulber (1995).

This paper examines how incomplete information about product quality influences the trade policy and bargaining strategies. Especially regarding the trade bargaining strategies, we focus on the influences of technology factors of the firm in each market and market characteristics on the bargaining strategies. The main difference between Bagwell (1990)'s paper and this paper lies in the followings: This paper assumes that the incumbent firm (I)'s product quality is different from that of the low-quality entrant firm (L) while Bagwell (1990) assumes that two firms' products are identical. When firms compete in price with homogeneous goods, they behave as perfectly competitive firms. However, Bertrand competition among homogeneous goods is an exceptional case, and therefore, the assumption of Bertrand competition among differentiated products

would be the more plausible one to describe the actual market structure. Moreover, we assume that the demand function is downward-sloping while

Bagwell (1990) assumes a discrete demand function, which is not a realistic assumption to describe actual consumers' behaviors. Our discussion focuses on the welfare effects of government intervention to correct the informational externality when firms are engaged in Bertrand competition while Bagwell (1990) does not discuss the effect of government intervention. However, the assumption that the entrant firm's product quality is unknown to consumers and the incumbent firm is common to Bagwell (1990)'s paper and this paper.

Based upon the assumptions, this paper demonstrates that under Bertrand competition with the incumbent firm, it is optimal for the high-quality firm (H) to signal its actual quality through an upwardly distorted price. The welfare effect of trade policy depends on two factors: the informational-externality-reducing effect, and the strategic effect, which gives the domestic firm the Stackelberg leadership advantage. If the government believes that the firm is likely to be the high-quality type, the informational externality reducing effect is dominant, and therefore, an export subsidy is the optimal policy. If the government believes that the firm is likely to be low-quality type, an export tax is the optimal policy to give the entrant firm the Stackelberg leadership advantage. In addition, if the quality difference between H and L, the cost of type H relative to type L, and the consumer's taste parameter is higher, the more likely it is that the optimal policy is an export subsidy.¹

Section II describes the model; Section III examines the equilibrium when the quality of L's and I's goods is different, and shows the existence of a unique separating equilibrium; Section IV discusses the welfare effects of government intervention under Bertrand competition and Section V concludes.

II. THE MODEL

Foreign consumers' preferences are described by

$$U = \begin{cases} \theta_a - p, & \text{if she buys a unit at price } p; \\ 0, & \text{if she does not buy} \end{cases}$$

where, a taste parameter, is uniformly distributed over the interval, $\theta \in [\underline{\theta}, \bar{\theta}]$, $\bar{\theta} = \underline{\theta} + 1$ and $\underline{\theta} \geq 0$. The incumbent (I) in the foreign market is producing a

low-quality product (q_I) with a low variable cost (C_I). A domestic firm which tries to enter the foreign market can be either a high-quality firm (H) with a high variable cost (C_H) or a low-quality firm (L) with a low variable cost (C_L). It is assumed that $C_H > C_L > C_I$ and $q_H > q_L > q_I$.²

The domestic entrant and the foreign incumbent set prices P^e and P^I simultaneously, where the superscript e of P^e designates the entrant, and I denotes the incumbent. When we assume temporarily that the quality of the entrant's product is known to foreign consumers, foreign consumers buy the product of the entrant only when the consumer surplus from purchasing that good is higher than the surplus from purchasing the incumbent's product: $(\theta q_i - P^e) - (\theta q_I - P^I) \geq 0$, where $i = H, L$. Hence, only a consumer whose taste parameter is higher than a critical value $\tilde{\theta} = \frac{P^e - P^I}{q_i - q_I}$ will buy the entrant's product. Then a consumer whose taste parameter is between $\tilde{\theta}$ and $\hat{\theta} = \frac{P^I}{q_I}$ will buy the incumbent's product, and a consumer whose taste parameter is lower than $\hat{\theta}$ will not buy any product. In addition, we assume that $P^e > P^I$.³

Therefore, based on the assumption of uniform distribution of the taste parameter, the demand functions of the entrant and the incumbent are defined as follows:

² In this paper, we assume that a high quality product involves a high marginal cost, and a quality level is not an endogenous variable. As a referee mentioned, the main difference of this paper's assumption from that of Bagwell (1990) is that the low quality product of the entrant firm is differentiated from the incumbent firm's product. Even when we assume that the incumbent firm's quality is higher than the low quality entrant firm, the basic result is same as the reverse case. Therefore, even if the marginal cost of the incumbent firm is higher than the low quality entrant firm, the result is same as the reverse case as long as two products are differentiated. When the marginal cost of the low quality entrant is same as the incumbent, two firms behave as if in a competitive market with zero profit. Therefore, the low quality entrant firm has always an incentive to mimic the quality firm, and we obtain a single pooling equilibrium as in Bagwell (1990)'s paper. This case of homogeneous products is rather unrealistic, and we assume differentiated products between the entrant and incumbent in this paper.

As a referee suggested, when we assume that the quality level of low quality type entrant firm is lower than the incumbent firm, the entrance of the low quality type firm will have a different welfare implication to the incumbent firm. However, as there is no domestic consumption of the products, from the perspective of the domestic government, this assumption would not make significant change in its welfare implication of the trade policy. In addition, a referee suggested to use a general functional form instead of a specific demand function for a neat presentation of the results. We definitely agree with the idea that the proof with a general functional form is more desirable not only in terms of presentation but in its solidity of proof. However, in this model, the specific functional form is more convenient to present the results reflecting the technological properties.

³ The case $\frac{P^e - P^I}{q_i - q_I} < \frac{P^I}{q_I}$ is possible as a referee suggested. However, in this model, we assume that the demand of the incumbent firm and the entrant firm cannot be negative and the term in the square-root of the separating price should be non-negative. By these assumptions, the case $\frac{P^e - P^I}{q_i - q_I} < \frac{P^I}{q_I}$ is not considered in this model.

$$D^e = D_i^e(P^e, P^I) = \left(\bar{\theta} - \frac{P^e - P^I}{q_i - q_I} \right) \text{ where } i = H, L. \quad (1)$$

$$D^I = D^I(P^e, P^I) = \left(\frac{P^e - P^I}{q_i - q_I} - \frac{P^I}{q_I} \right). \quad (2)$$

Then the profit functions of two firms are respectively:

$$\Pi_i^e = (P^e - C_i) \left[\bar{\theta} - \frac{P^e - P^I}{q_i - q_I} \right] \quad (3)$$

$$\Pi_I = (P^I - C_I) \left[\frac{P^e - P^I}{q_i - q_I} - \frac{P^I}{q_I} \right]. \quad (4)$$

The two firms' reaction functions are:

$$P^e = R^e(P^I) = \frac{P^I + C_i + \Delta q_i \bar{\theta}}{2}, \quad P^I = R^I(P^e) = \frac{P^e q_I + C_I q_i}{2q_i} \quad (5)$$

where $\Delta q_i = q_i - q_I$, $i = H, L$.

From the above reaction functions, we can see that the two goods are strategic complements: The reaction functions are upward sloping. The Nash equilibrium price levels are:

$$P^{e*} = \frac{q_i(2C_i + C_I + 2\Delta q_i \bar{\theta})}{4q_i - q_I}, \quad P^{I*} = \frac{q_I(C_i + \Delta q_i \bar{\theta}) + 2q_i C_I}{4q_i - q_I},$$

where $i = H, L$. (6)

Substituting these Nash equilibrium prices into the profit functions, we obtain the Nash equilibrium profits of the two firms under complete information:

$$\Pi_H^e = \frac{(2\bar{\theta} \Delta q_i + C_i q_I - q_i(2C_i - C_I))^2}{\Delta q_i(4q_i - q_I)^2},$$

$$\Pi^I = \frac{q_i(\bar{\theta} \Delta q_i + q_I(C_i + C_I) - 2C_I q_I)^2}{q_I \Delta q_i(4q_i - q_I)^2} \text{ where } \Delta C_i = C_i - C_I, i = H, L \quad (7)$$

It can be easily shown that in the equilibrium the entrant charges a higher price than the incumbent and makes a higher profit under complete information.⁴

⁴ For the consistency of the model, we need to ensure that there is non-negative demand. The assumptions we need are:

i) $\bar{\theta} \Delta q_i \geq 2C_i q_I - q_i(C_i + C_I)$ where $i = H, L$ (This assumption means that the consumer

When the foreign consumers do not know the entrant's product quality, the sequence of moves is as follows: Nature decides the quality type of the entrant (H or L). The probability that the entrant is of the high-quality type is δ_H , and this is common knowledge. Then the firms decide their pricing strategies simultaneously, and consumers observe the price levels of both firms and update their beliefs about the product quality type of the entrant. Finally, based on their updated beliefs, the foreign consumers make their decision as to which product to purchase.

At the first stage, both the incumbent and the entrant choose prices to maximize profit:

$$P^I \in \arg \max (\delta_H \Pi_H^I(P^I, P_H^e), w(P_H^e) = 1) \\ + (1 - \delta_H) \Pi^I(P^I, P_L^e, w(P_L^e) = 0)) \quad (8)$$

where $w(P^e)$ is the consumers' posterior belief about the probability that the entrant's quality is high.

$$\hat{P}_i^e \in \arg \max_{P_i^e} \Pi_i^e(P^I, P_i^e) \text{ where } i = H \text{ or } L. \quad (9)$$

If the price of H is different from that of L , i.e., $P_H^e \neq P_L^e$, then the consumers' posterior belief about product quality is $w(P_H^e, P^I) = 1$ and $w(P_L^e, P^I) = 0$. If H 's price is the same as L 's, i.e., then the consumers' posterior beliefs about quality are the same as the prior beliefs ($w(P^e, P^I) = \delta_H$). Thus, the separating price signals the entrant's quality type while the pooling price provides no information about the actual quality type of the entrant.

When H and L set the pooling price, the consumers cannot update their beliefs about the entrant's quality type. Therefore, expected quality is: $q_E = \delta_H q_H + (1 - \delta_H) q_L$.

III. EQUILIBRIA OF THE MODEL

We determine the equilibrium strategy of a firm which tries to enter a foreign market under incomplete information about the entrant's product quality while the incumbent's product quality is known. We use Cho and Kreps' intuitive criterion as equilibrium refinement. First, we examine whether there exists a pooling equilibrium. When the demand function is downward-sloping, H can always credibly signal its quality and make a higher profit by deviating

heterogeneity is sufficient that the demand for the incumbent is non-negative.)

ii) $2\partial q_i \Delta q_i \geq q_i(2C_i - C_i) - C_i q_i$ where $i = H, L$ (This assumption guarantees non-negative demand for the entrant.)

from a pooling price to a separating price. The intuition behind this result is as follows: When the demand function is downward sloping and influenced by the quality level, the demand for L's product decreases more sharply than that for H's products with the same price increase. Therefore, when H increases its price higher than the critical value, L has no incentive to mimic H. Therefore, There is no pooling equilibrium that passes Cho and Kreps' intuitive criterion.⁵

Now, we define the separating equilibrium in which H separates itself from L by choosing a separating price, and consumers believe the firm to be H if they observe the separating price. Since the incumbent does not know the entrant's quality, the incumbent's profit function is based on the expected pricing strategy of the entrant. In the separating equilibrium, the profit function of the incumbent, H, and L are, respectively:

$$\begin{aligned}\Pi_H^e(P_S, w=1) &= (P_S^e - C_H) \left[\bar{\theta} - \frac{P_S^e - P^I}{q_H - q_L} \right] \\ \Pi^I(P_S, P^I, w=1) &= (P^I - C_I) \left[\delta_H \frac{P_S^e - P^I}{q_H - q_L} + (1 - \delta_H) \frac{P_L - P^I}{q_L - q_I} - \frac{P^I}{q_I} \right] \\ \Pi_L^e(P_L, w=0) &= (P_L^e - C_L) \left[\bar{\theta} - \frac{P_L^e - P^I}{q_L - q_I} \right]\end{aligned}\quad (10)$$

The profit maximizing firms' reaction functions are derived from the profit maximizing problem of each firm as follows.

The separating reaction function of H is derived from the self-selection condition of L:

$$\begin{aligned}\Pi_L^e(P_S^e, w(P_S^e)=1) &\leq \Pi_L^e(\hat{P}_L^e, w(\hat{P}_L^e)=0) \\ \Rightarrow (P_S^e - C_L) \left[\bar{\theta} - \frac{P_S^e - P^I}{q_H - q_L} \right] &\leq \frac{(P^I + \Delta q_L \bar{\theta} - C_L)^2}{4 \Delta q_L}\end{aligned}\quad (11)$$

where P_S^e is the separating price of the entrant firm.

There are two solutions of the binding condition of equation (11). We define the upper value solution as \bar{P}_S^e and the lower value solution as \underline{P}_S^e . Any price which is higher than \bar{P}_S^e or lower than \underline{P}_S^e ($P \geq \bar{P}_S^e, P \leq \underline{P}_S^e$) is potentially a separating best response. However, it is easily shown that only can pass the intuitive criterion.⁶

Hence, we obtain the following best response functions for H:

$$R_S^e(P^I) = \frac{P^I + \Delta q_H + C_L + \sqrt{\Delta q \Delta q_H (\bar{\theta})^2 - (P^I - C_L)^2 \Delta q / \Delta q_L}}{2} \quad (12)$$

⁵ Refer Appendix 1 for the formal proof of the non-existence of intuitive pooling equilibrium.

⁶ The formal proof that only passes the intuitive criterion is given in the Appendix 2.

where $\Delta q = q_H - q_L$, $\Delta q_H = q_H - q_I$, $\Delta q_L = q_L - q_I$.

From I 's expected profit function, we can derive the following:

$$R^I(P_S^e, P_L) = \frac{q_I(\delta_H \Delta q_L p_S^e + (1 - \delta_H) \Delta q_H P_L)}{2(q_L \Delta q_H - \delta_H q_I \Delta q)} + \frac{C_I}{2}. \quad (13)$$

The reaction function of L is:

$$R_L^e(P^I) = \frac{P^I + C_L + \Delta q_L \bar{\theta}}{2}. \quad (14)$$

The term inside the square root in the separating reaction function is a decreasing function of P^I . Therefore, when P^I is higher than the critical value, \tilde{P}^I , H 's separating reaction function is lower than H 's reaction function under complete information:

$$\begin{aligned} R_S^e(P^I) &= \frac{P^I + \Delta q_H \bar{\theta} + C_L + \sqrt{\Delta q \Delta q_H (\bar{\theta})^2 - (P^I - C_L)^2 \Delta q / \Delta q_L}}{2} \\ &\leq R_H^e(P^I) = \frac{P^I + C_H + \Delta q_H \bar{\theta}}{2}. \end{aligned} \quad (15)$$

H chooses the separating reaction function, $R_S^e(P^I)$, only when it is higher than H 's reaction function under complete information, $R_H^e(P^I)$. If $R_S^e(P^I) < R_H^e(P^I)$, there is no incentive for H to choose the separating reaction function because H can separate just by choosing $R_H^e(P^I)$ and H 's profit is maximized with $R_H^e(P^I)$. When H chooses a price higher than the separating price, L has no incentive to mimic H . Hence, when $P^I > \tilde{P}^I$, H 's reaction function is given by the complete information reaction function, $R_H^e(P^I)$, which is higher than the separating reaction function and, therefore, gives L no incentive to mimic H .

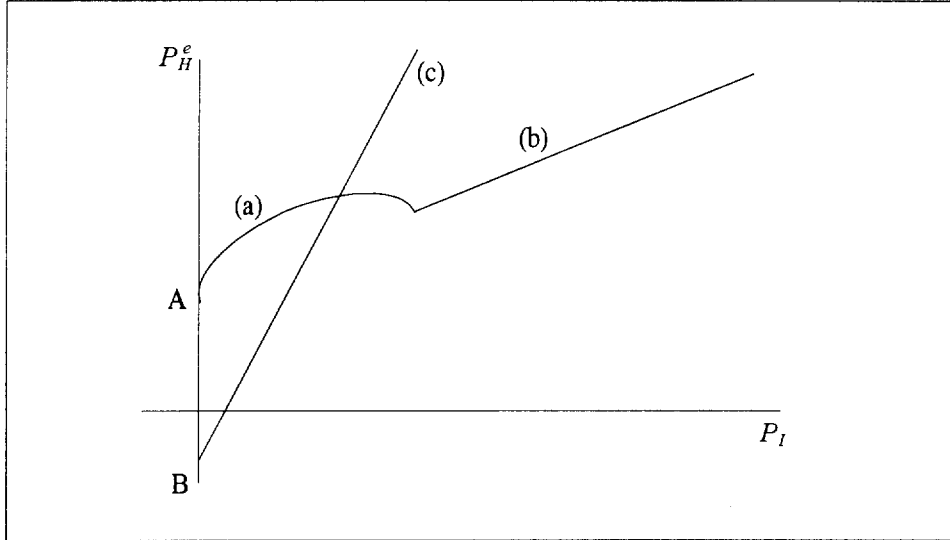
The critical value of the incumbent's price, \tilde{P}^I , can be obtained by solving (15):⁷

$$P^I \geq \tilde{P}^I = C_L + \sqrt{\Delta q_L \Delta q_H (\bar{\theta})^2 - (C_H - C_L)^2 \Delta q_L / \Delta q} \quad (16)$$

When the incumbent's price is higher than the critical value \tilde{P}^I , H 's reaction function is $R_H^e(P^I) = \frac{P^I + C_H + \Delta q_H \bar{\theta}}{2}$, which gives L no incentive to mimic H .

We can describe the conditions that have to be satisfied for the existence of a separating equilibrium with the help of a diagram, in which we plot the

⁷ No firm will choose a negative price in a one period game. So, we discard the negative interval of the incumbent's price, $P^I \leq C_L - \sqrt{\Delta q_L \Delta q_H (\bar{\theta})^2 - (C_H - C_L)^2 \Delta q_L / \Delta q} < 0$, which is derived from the above inequality.

[Figure 1] The Existence of the Unique Separating Equilibrium

reaction function for H , L , and I . We can reduce the diagram from three dimensions, (P_H^e, P_L^e, P^I) to two dimensions, (P_H^e, P^I) , by substituting $R_L^I(P_I)$ into $R^I(P_S^e, P_L^e)$ and then solving for P^I .

The following figure illustrates the reaction functions.:

$$(a): R_S^e(P^I) = \frac{P^I + \Delta q_H \bar{\theta} + C_L + \sqrt{\Delta q \Delta q_H (\bar{\theta})^2 - (P^I - C_L)^2 \Delta q / \Delta q_L}}{2}$$

$$(b): R_H^e(P^I) = \frac{P^I + C_H + \Delta q_H \bar{\theta}}{2}$$

$$(c): R^I(R_S^e) = \frac{q_q (2 \delta_H \Delta q_L P_S^e + (1 - \delta_H) \Delta q_H (C_L + \Delta q_L \bar{\theta})) + 2 C_I (q_L \Delta q_H - \delta_H q_1 \Delta q)}{4 (q_L \Delta q_H - \delta_H q_1 \Delta q) - (1 - \delta_H) \Delta q_H}$$

A: The intercept of (a) on the axis, B: The intercept of (c) on the axis

Proposition 1 There exists a unique intuitive separating equilibrium

Proof: The existence of a unique separating equilibrium can be proved by showing that: i) H 's reaction function (a) is concave,⁸ ii) the slope of (c) is steeper than that of (b), iii) $A > 0$ and $A > B$ (the intercept of H 's reaction function on the P_H^e axes should be higher than the intercept of the incumbent's reaction function on the P_H^e axes).

i) The concavity of (a): When we take a second derivative of $R_S^e(P^I)$ with

respect to P^I , we obtain

$$\begin{aligned}\frac{d^2 R_S^e(a)}{dP^I} &= -\frac{(1 - \Delta q_H / \Delta q_L)^2 (P^I - C_L)^2}{2G^{3/2}} + \frac{(1 - \Delta q_H / \Delta q_L)}{2G^{1/2}} \\ &= -\frac{\Delta q_H (\Delta q)^2 (\bar{\theta})^2}{2\Delta q_L G^{3/2}} < 0\end{aligned}$$

where $G = \Delta q \Delta q_H (\bar{\theta})^2 - (P^I - C_L)^2 \Delta q / \Delta q_L > 0$

$$\Delta q = q_H - q_L, \Delta q_H = q_H - q_I, \Delta q_L = q_L - q_I.$$

ii) The slope of (c) is steeper than that of (b):

$$\frac{dR_H^e(C)}{dP^I} = 2 + \frac{3(1 - \delta_H)\Delta q_H}{2\delta_H \Delta q_L} > \frac{dP_H^e(b)}{dP^I} = \frac{1}{2}$$

iii) The intercepts of (a) and (c) on the P_H^e axes are, respectively,⁹

$$\begin{aligned}A &= \frac{\Delta q_H \bar{\theta} + C_L + \sqrt{(\Delta q_H \bar{\theta} - C_L)^2 - (\Delta q_H / \Delta q_L)(\Delta q_L \bar{\theta} - C_L)^2}}{2} \\ &= \frac{\Delta q_H \bar{\theta} + C_L + \sqrt{(q_H - q_L)(\Delta q_H \Delta q_L \bar{\theta}^2 - C_L^2) / \Delta q_L}}{2} 0] \\ B &= \frac{-1}{2\delta_H \Delta q_L} \left(\frac{2C_I(q_L \Delta q_H - \delta_H q_I \Delta q)}{q_I} + (1 - \delta_H)\Delta q_H(C_L + \Delta q_L \bar{\theta}) \right) < 0.\end{aligned}$$

Therefore, $A - B > 0$ QED.

IV. WELFARE EFFECT OF GOVERNMENT TRADE POLICY

In this section, we examine the optimal trade policy for the domestic government. We assume that: i) the government cannot verify the quality of the domestic product ex ante; however ii) the government can commit to a trade policy before firms move. When the government levies a specific export tax, t , the social welfare function is:

$$\begin{aligned}W(t) &= \delta_H \Pi_H^{EXP}(P_S^E(t)) + (1 - \delta_H) \Pi_L^{EXP}(P_L^E(t)) \\ &\quad + t(\delta_H D(P_S^E) + (1 - \delta_H) D(P_L^E))\end{aligned}\quad (17)$$

where t is a specific export tax. (If $t < 0$, it is an export subsidy.)

The welfare function can be rewritten as follows by substituting the profit functions into (17):

$$W(t) = \delta_H (P_S^e(t) - C_H - t) \left(\bar{\theta} - \frac{P_S^e(t) - P^I(t)}{\Delta q_H} \right) + (1 - \delta_H) (P_L^e(t) - C_L - t)$$

⁹ The assumptions of the non-negative demand of each type of firm assures .

$$\left(\bar{\theta} - \frac{P_L^e(t) - P^I(t)}{\Delta q_L} \right) + t \left(\delta_H \left(\bar{\theta} - \frac{P_S^e(t) - P^I(t)}{\Delta q_H} \right) + (1 - \delta_H) \left(\bar{\theta} - \frac{P_L^e(t) - P^I(t)}{\Delta q_L} \right) \right). \quad (18)$$

The optimal government policy can be determined by examining an infinitesimal change in policy evaluated at $t = 0$. (18) can be simplified as:

$$W(t) = \delta_H (P_S^e(t) - C_H) \left(\bar{\theta} - \frac{P_S^e(t) - P^I(t)}{\Delta q_H} \right) + (1 - \delta_H) (P_L^e(t) - C_L) \left(\bar{\theta} - \frac{P_L^e(t) - P^I(t)}{\Delta q_L} \right). \quad (18')$$

As we can observe from (18'), the expected tax revenue by the government is directly offset by the firm's tax payment, and therefore a tax has no direct effect on welfare. Hence, the first derivative of the welfare function with respect to tax is:

$$\begin{aligned} & \left. \frac{dW(P_S^e(t), P^I(t), P_L^e(t), t)}{dt} \right|_{t=0} \\ &= \frac{\partial W(\cdot)}{\partial P_S^e} \frac{d\hat{P}_S^e(t)}{dt} + \frac{\partial W(\cdot)}{\partial P_L^e} \frac{d\hat{P}_L^e(t)}{dt} + \frac{\partial W(\cdot)}{\partial P^I} \frac{d\hat{P}^I(t)}{dt} \end{aligned} \quad (19)$$

where " $\hat{\cdot}$ " denotes the equilibrium values.

By examining the sign of (19), the sign of optimal government policy can be determined.

Note that $\frac{dP_S^e(t)}{dt} > 0$, $\frac{dP_L^e(t)}{dt} > 0$.¹⁰

$$\frac{\partial W(\cdot)}{\partial P_L^e} = \frac{d\Pi_L}{dP_L} = 0 \quad (20)$$

by the envelope theorem.¹¹

$$\left. \frac{\partial W(\cdot)}{\partial} P_S^e \right|_{t=0} = \delta_H \left. \frac{d\Pi_H(P_S^e(t), P^I(t))}{dP_S^e} \right|_{t=0} < 0 \quad (21)$$

¹⁰ The export tax can be introduced into the model by letting $C_L = \bar{C}_L + t$ and $C_H = \bar{C}_H + t$. That is, the imposition of an export tax has the same effect as the increase of the cost. Therefore, the increase of cost caused by an export tax will increase the equilibrium price of H and L.

¹¹ L's profit is maximized at P_L and therefore, the first derivative of L's profit function with respect to P_L is zero.

The sign of the first derivative of H 's profit with respect to H 's separating price, P_S^e , is negative because H 's profit function is concave and the separating price is higher than H 's Nash equilibrium price under complete information: $P_S^e(t) > P(c(H), 1)$ where $P(c(H), 1)$ is H 's Nash equilibrium price under complete information.¹²

$$\frac{d\hat{P}^I(t)}{dt} = \frac{d\hat{P}^I(t)}{dP_H} \frac{dP_H(t)}{dt} > 0 \text{ because } \frac{dP_H(t)}{dt} > 0 \text{ and } \frac{d\hat{P}^I(t)}{dP_H} \quad (22)$$

since I 's reaction function is upward-sloping.

$$\frac{\partial W(\cdot)}{\partial \hat{P}^I} = \frac{\delta_H(P_S^e(t) - C_H)}{\Delta q_H} + \frac{(1 - \delta_H)(P_L^e(t) - C_L)}{\Delta q_L} > 0 \quad (23)$$

Therefore, the first derivative of the welfare function with respect to the export tax can be rewritten as follows:

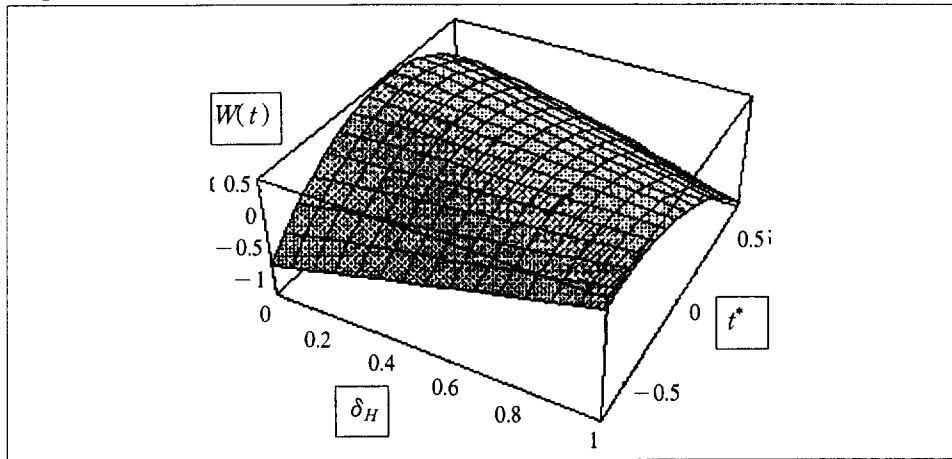
$$\begin{aligned} & \left. \frac{dW(P_S^e(t), P^I(t), P_L^e(t), t)}{dt} \right|_{t=0} \\ &= \delta_H \frac{\partial \Pi_H(\cdot)}{\partial P_S^e} \frac{d\hat{P}_S^e(t)}{dt} + \frac{\partial w(\cdot)}{\partial P^I} \frac{d\hat{P}^I(t)}{dt} \quad (24) \\ & \quad - \quad + \quad + \quad + \end{aligned}$$

Therefore, the sign of the above first derivative of the welfare function is decided by the magnitude of δ_H . If δ_H is sufficiently large, then the sign of the first derivative of the welfare function with respect to the export tax is negative; otherwise, the sign is positive.

The welfare function is strictly concave. Therefore, if the sign of the first derivative of the welfare function with respect to the tax is negative evaluated at $t=0$, the welfare function is maximized with a negative tax, that is a positive subsidy, and vice versa. Therefore, when δ_H is significantly high, the optimal trade policy would be an export subsidy. When δ_H is relatively small, it would be optimal to offer an export tax. The intuition is as follows: when it is more likely that the firm is a high-quality firm, the incentive for L to mimic H becomes larger, and in that case, H can separate itself from L through upward price distortion. This upward price distortion decreases social welfare, and therefore, a government export subsidy improves social welfare by reducing the price distortion.

¹² The concavity of H 's profit function is easily proven as follows:

$$\frac{d^2 \Pi_H(\hat{P}_S^e(t), P^I(t))}{dP_S^e} = \frac{-2}{\Delta q_H} < 0$$

[Figure 2] Optimal Trade Policy With Respect To δ_H 

However, if δ_H is low, i.e., if the firm is likely to be of type L, then social welfare is improved by an export tax which gives the firm a strategic advantage. The above result is confirmed by a simulation of the optimal trade policy:¹³

The above simulation result shows that when the prior belief is high, i.e., when the government believes that the domestic firm is likely to be of the high-quality type, social welfare is maximized with a negative export tax, i.e., a positive export subsidy. When the prior belief is low, i.e., when the government believes the firm is likely to be of the low-quality type, social welfare is maximized with a positive export tax.

The above simulation result shows the relationship between the optimal tax and prior beliefs. When the consumers' prior beliefs about high quality are high, it is optimal for the government to offer an export subsidy; if the prior beliefs are lower, it is optimal to levy an export tax.

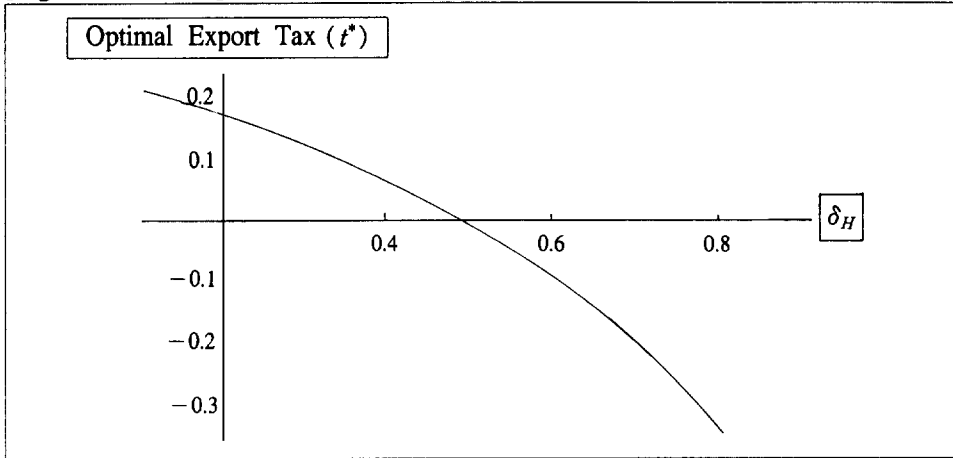
The intuition behind this result is that when the government believes the firm is likely to be of the high-quality type, an export subsidy is the best policy, because the export subsidy reduces the upward distortion of H's separating price, which is caused by the informational externality. When the government believes the firm is likely to be of the low-quality type, it is optimal to levy an export tax because the export tax gives a Stackelberg leadership advantage to the domestic firm.

¹³ The optimal tax cannot be determined analytically because there is a tax term within the square root term in the welfare function. Therefore simulation is used to show the optimal trade policy by solving the social welfare maximization problem with respect to the export tax using the specific parameter values.

The parameter values used in this simulation satisfy the non-negative demand assumption. For the details of the parameter values used in the simulation, see Appendix 2.2. For the simulation of the optimal tax with respect to the prior belief, the following parameter values are used: .

$q_H = 2, q_L = 1.5, q_I = 1, C_L = 0.5, C_I = 0.3, \bar{\theta} = 1.9.$

[Figure 3] The Optimal Trade Policy With Respect To Prior Belief



Now, we will examine the effect of other technology variables on the optimal trade policy. First, when the quality difference between H and L is larger, the price distortion of the separating price becomes larger as follows:¹⁴

$$\begin{aligned} \frac{\partial(R_S^e - R_H^e)}{\partial q_H} &= \frac{\bar{\theta}}{2} + \frac{\Delta q_L(2\Delta q_H - \Delta q_L)\bar{\theta}^2 - (P^I - C_L)^2}{2A} \\ &\geq \frac{\bar{\theta}}{2} + \frac{\Delta q_L \Delta q \bar{\theta}^2}{2A} > 0 \end{aligned} \quad (25)$$

where $A = \sqrt{\Delta q \Delta q_H (\bar{\theta})^2 - (P^I - C_L)^2 \Delta q / \Delta q_L}$

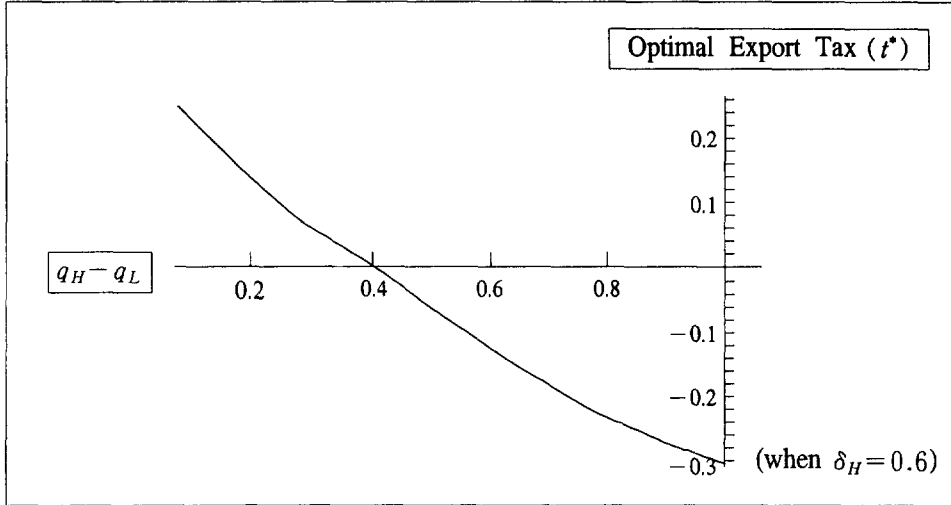
Therefore, when ' $q_H - q_L$ ' is larger, the optimal policy is a larger export subsidy, which mitigates the price distortion.

This result is confirmed by the simulation result shown in Figure 4, which is obtained by solving the social welfare maximization problem with respect to the export tax.¹⁵

Figure 4 shows that if the quality difference between H and L is large, it is optimal for the government to offer an export subsidy; if the quality difference

¹⁴ By keeping q_L fixed, the increase of q_L corresponds to an increase of $(q_H - q_L)$. The term in the square root (A) should be non-negative, and from that condition, we derive the feasible interval of the incumbent's price as follows: $0 \leq P^I \leq C_L + \bar{\theta} \sqrt{\Delta q_L \Delta q_H}$. When we substitute the maximum available incumbent's firm's price into the left hand side of the above inequality, we obtain the positive sign of the derivative.

¹⁵ If δ_H is close to zero in the simulation, the optimal trade policy is a positive export tax regardless of quality difference. If δ_H is close to 1, the optimal policy is always a positive subsidy. Thus, when the value of δ_H is chosen in a medium range, the sign of the optimal policy flips when the quality difference changes.

[Figure 4] The Optimal Trade Policy With Respect To ' $q_H - q_L$ '

is small, it is optimal to levy an export tax. The intuition behind this result is that when H's quality is high relative to L, the upward distortion of the separating price is large. Therefore, it is optimal to offer an export subsidy, which alleviates the upward distortion of price. However, if the quality difference between H and L is small, it is optimal to levy an export tax.

The intuition behind this result is that when the quality difference between H and L is larger, the incentive for L to mimic H becomes larger. Therefore, a larger distortion of the separating price is required in order to prevent L from mimicking. Therefore, it is optimal for the domestic government to offer an export subsidy to mitigate the price distortion. When the Stackelberg leadership price level under Bertrand competition is higher than the upwardly distorted separating price level, the optimal trade policy is a positive export tax even if the government believes the firm is likely to be of the high-quality type. When the quality difference between H and L is very small, the Stackelberg leadership price level is higher than the separating price and in that case, an export subsidy is the optimal trade policy.¹⁶

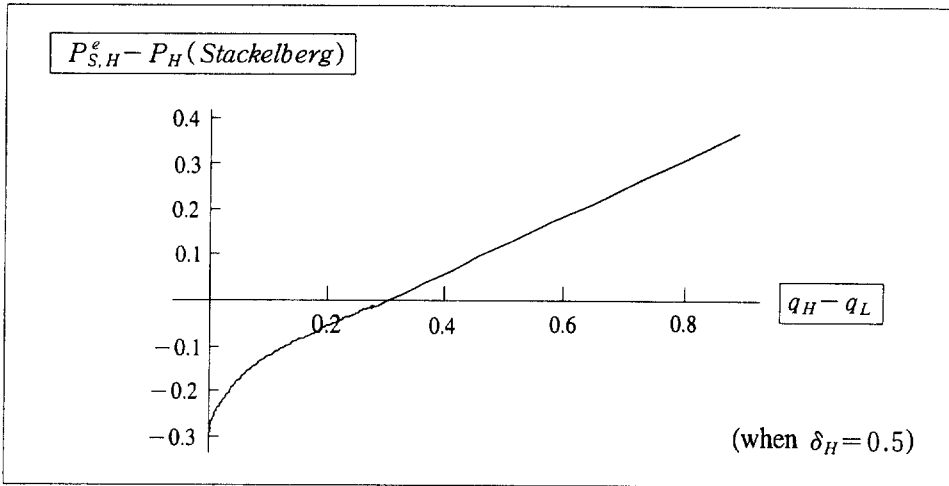
The above simulation result shows that if the quality difference between H and L is large, the separating price becomes higher than the Stackelberg leadership

¹⁶ H's Stackelberg leadership price level under complete information is

$$P_H(\text{Stackelberg}) = \frac{2q_H \Delta q_H \bar{\theta} + C_L q_H + C_H (2q_H - q_L)}{2(2q_H - q_L)}, \text{ while H's separating price is}$$

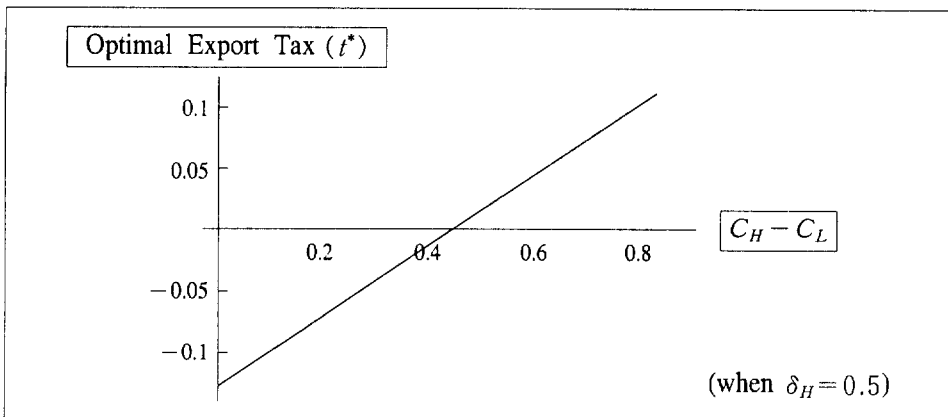
$$P_S^e = \frac{P' + \Delta q_H \bar{\theta} + C_L + \sqrt{(\Delta q \Delta q_H \bar{\theta})^2 - (P' - C_L)^2 \Delta q / \Delta q_L}}{2} \text{ where } P' = \frac{B + \sqrt{B^2 - AD}}{A}$$

Because these two price levels cannot be compared analytically, we use a simulation to compare them. The simulation results show that $P_H(\text{Stackelberg}) > P_{S,H}^e$ only when the quality difference between H and L is very small as in Figure 3.

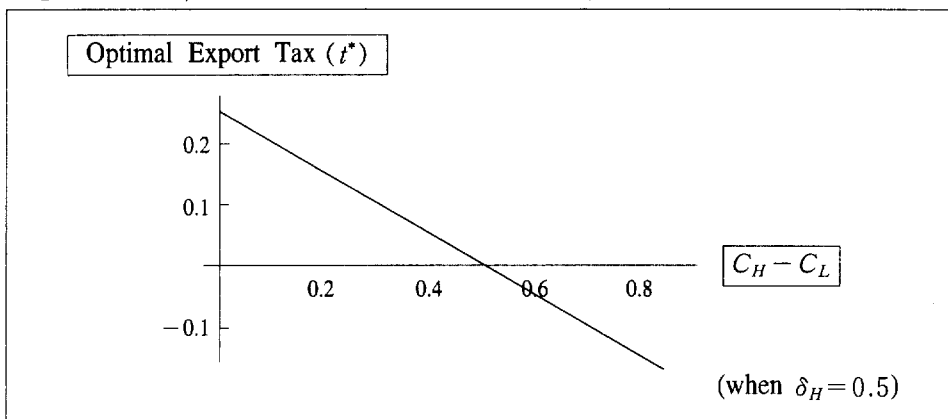
[Figure 5] ' $P_{S,H}^e - P_H(\text{Stackelberg})$ ' With Varying ' $q_H - q_L$ '

price. However, when the quality difference is low, the Stackelberg leadership price is higher than the separating price. In that case, the optimal trade policy is an export tax, which moves the separating price closer to the Stackelberg leadership price.

If the cost difference between H and L, $C_H - C_L$, is relatively low, the upward distortion of the separating reaction function is higher as shown in the following:¹⁷ $\frac{\partial(R_S^e - R_H^e)}{\partial C_H} = \frac{1}{2} < 0$. Therefore, if the marginal cost of H is relatively low, it is optimal for the domestic government to offer an export subsidy to reduce the price distortion. This result is supported by the simulation results in Figure 6.

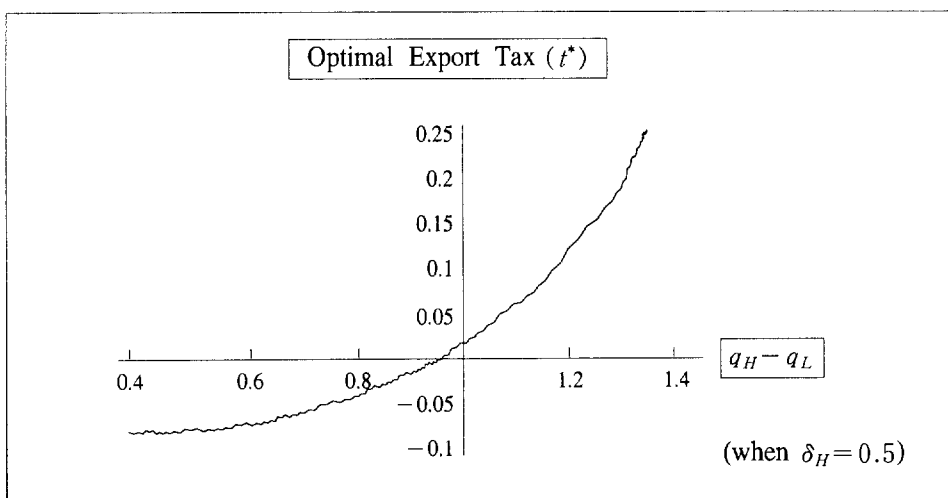
[Figure 6] The Optimal Trade Policy With Respect To ' $C_H - C_L$ '

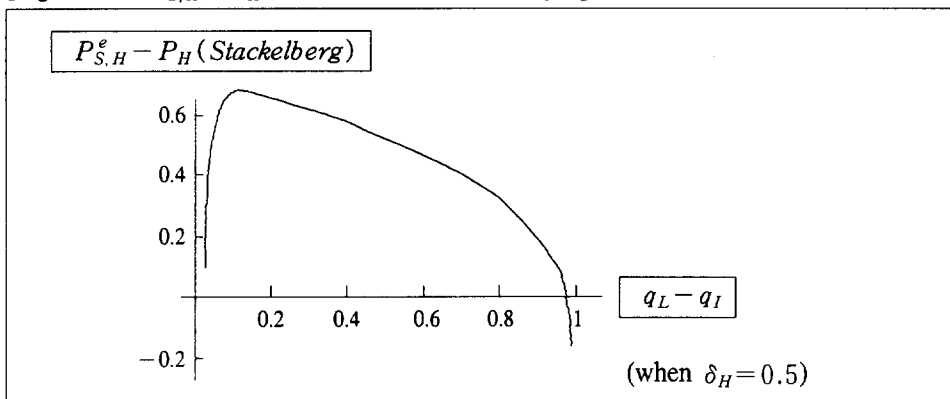
¹⁷ By keeping C_L fixed, a rise in C_H corresponds to an increase in ' $C_H - C_L$ '.

[Figure 7] ' $P_{S,H}^e - P_H(\text{Stacklberg})$ ' With Varying ' $C_H - C_L$ '

When the cost difference between H and L is small, the upward distortion of the separating price is large, and as a result, the separating price is higher than H's Stackelberg leadership price. (See Figure 7). In that case, it is optimal for the government to offer an export subsidy. However, when H's marginal cost is high relative to L, the separating price is lower than H's Stackelberg leadership price, and therefore, it is optimal for the government to levy an export tax as shown in Figure 6.

When L's quality is high relative to that of the incumbent (I), H's Stackelberg leadership price is higher than the separating price as shown in the following. Therefore, it is optimal for the government to levy an export tax, and therefore giving the Stackelberg leadership advantage to the firm. If the quality difference between L and I is low, it is optimal to offer an export subsidy

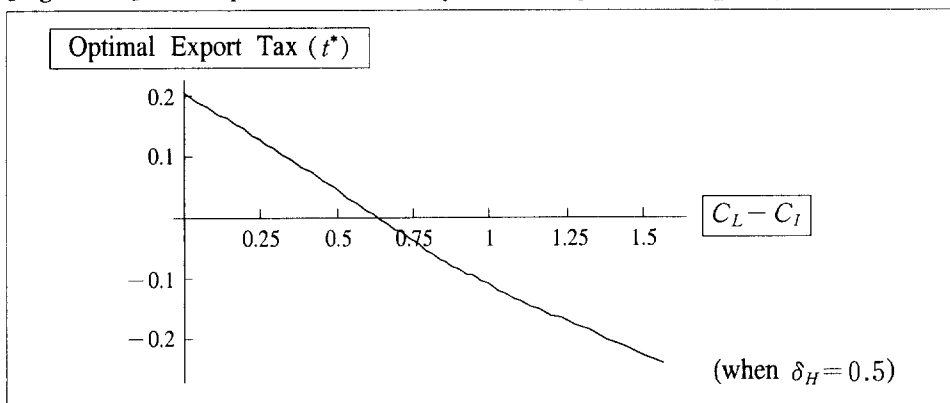
[Figure 8] The Optimal Trade Policy With Respect To ' $q_H - q_L$ '

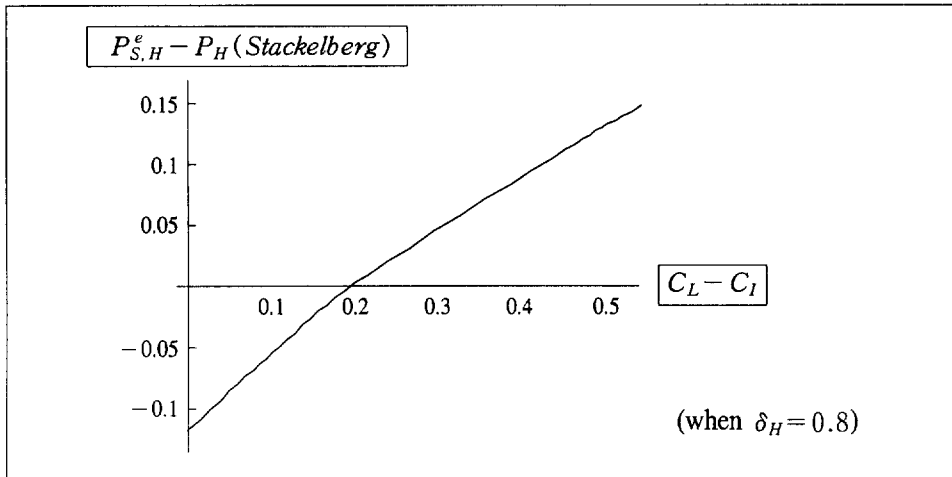
[Figure 9] ' $P_{S,H}^e - P_H(\text{Stackelberg})$ ' With Varying ' $q_L - q_I$ '

because H's relative profit margin is higher than L's. However, if the quality difference between L and I is close to zero, the separating price gets closer to the Stackelberg leadership price level. In that case, the optimal policy would be a lower subsidy as shown in the above diagram.

The above simulation result shows that when the quality difference between L and I is large, $P_H(\text{Stackelberg}) > P_{S,H}^e$. In other cases, the separating price is higher than the Stackelberg leadership price level. However, when the quality difference between L and I is very low, the separating price gets closer to the Stackelberg leadership price, i.e., $P_H(\text{Stackelberg}) \cong P_{S,H}^e$.

When L's marginal cost is high relative to I, the upward distortion of the separating price is large, and therefore, it is optimal for the government to offer a higher export subsidy to alleviate the price distortion. If L's marginal cost is low relative to I, the separating price is lower than the Stackelberg leadership price as shown in the following diagram, and an export tax is the best policy to give the firm the Stackelberg leadership advantage.

[Figure 10] The Optimal Trade Policy With Respect To ' $C_L - C_I$ '

[Figure 11] ' $P_{S,H}^e - P_H(\text{Stackelberg})$ ' With Varying ' $C_L - C_I$ '

The above simulation result shows that if the cost difference between L and I is relatively large, the separating price is higher than H's Stackelberg leadership price level.

V. CONCLUDING REMARKS

This paper examined how governments could help exporters overcome informational barriers to entry into foreign markets. In the model considered, foreign consumers know the quality of a locally produced good, but initially do not know how it compares with the quality of an imported goods. The exporter and the local incumbent compete in prices. The papers derives conditions under which the game has a unique separating intuitive equilibrium in which an exporter of high-quality goods raises its price above the full-informational best response in order to signal quality to foreign consumers. Government policy in this situation affects both the signaling distortion and competition between two firms. The signaling distortion can be reduced by providing the firm with an export subsidy. However, for strategic reasons, it is best to levy an export tax.

When it is likely that the export is of low quality, an export tax is the optimal policy: in the limit, when the firm is almost surely a low-quality type, the only rationale for government intervention is its strategic effect. For given priors by the government, the size of the signaling distortion becomes important. With a small distortion, an export tax is again optimal since the strategic effect is then dominant. When it is large enough to dominate the strategic effect, a subsidy becomes optimal. A subsidy tends to be optimal when the variance of the export good's quality is high, the exporter's cost variance is small, the degree of product differentiation between entrant and incumbent is large, and the

foreign import tariff is high.

Our model can be used to explain a subsidy for infant-import industry protection in less-developed countries. In these less developed countries, the incumbents in markets for experienced goods such as capital goods are often foreign companies, and potential domestic entrants are the ones facing informational barriers to entry. Hence, a subsidy given to infant industries, which face informational barriers, can be understood in the context of this paper.

An extension of our model to consider the effect of bilateral incomplete information would produce more insights on the foreign market penetration process, and this remains for future studies.

Appendix 1. The Proof of the Non-existence of the Pooling Equilibrium

Suppose there exists a pooling equilibrium in which H and L set price P_P^E . Suppose that H chooses a deviation price, $P' (> P_P^E)$ such that

$$(A1) \quad \Pi_L^{EXP}(P', q_L, w=1) = \Pi_L^{EXP}(P_P^E, q_L, w=\delta_H)$$

where w is the consumers' posterior belief about product quality. Then any $P \geq P'$ is equilibrium dominated for L and consumers should believe when they see that they are facing H.

Now, we check whether there is any incentive for H to deviate from the pooling strategy to the deviation strategy, P' , with the deviation payoff higher than the pooling payoff as in (A2).

$$(A2) \quad \Pi_H^{EXP}(P', w=1) - \Pi_H^{EXP}(P_P^E, w=\delta_H) > 0$$

If (A2) turns out to be positive, there is an incentive for H to deviate from the pooling equilibrium. When we substitute (A1) into (A2), (A2) can be rewritten as

$$\begin{aligned} (A3) \quad & \Pi_H^{EXP}(P', w=1) - \Pi_H^{EXP}(P_P^E, w=\delta_H) \\ &= \Pi_H^{EXP}(P', w=1) - \Pi_L^{EXP}(P', w=1) - \Pi_H^{EXP}(P_P^E, w=\delta_H) \\ &+ \Pi_H^{EXP}(P_P^E, w=\delta_H) = (P' - C_H - S)D(P', w=1) \\ &- (P' - C_L - S)D(P', w=1) - (P_P^E - C_H - S)D(P_P^E, w=\delta_H) \\ &+ (P_P^E - C_L - S)D(P_P^E, w=\delta_H) \\ &= (C_H - C_L)(D(P_P^E, w=\delta_H) - D(P', w=1)) > 0. \end{aligned}$$

Therefore, H has an incentive to deviate from the pooling equilibrium to price P' , at which consumers believe that the firm is H. Hence, the pooling equilibrium fails to pass Cho and Kreps' intuitive criterion. QED.

Appendix 2. The Proof that only \bar{P}_s^e Passes the Intuitive Criterion

The interval of the separating price is given as $P \in (P > \bar{P}_s^e \text{ or } P < \underline{P}_s^e)$. Among these separating price, the sequentially rational separating price is the price which provides the maximum available profit. Therefore, the separating price which is closest to the optimal Nash equilibrium price under complete information is the sequentially rational separating price. The Nash reaction function for the entrant firm under complete information is given in (5). Therefore, what we have to check is which separating price is closest to this reaction function under complete information.

It is easily shown that \bar{P}_s^e is closer to the Nash response function of the entrant firm under complete information, than as follows:

$$\begin{aligned} & | \underline{P}_s^e - R^e(P^I) | - | \bar{P}_s^e - R^e(P^I) | \\ &= \left| \frac{C_H - C_L + \sqrt{\Delta q \Delta q_H (\bar{\theta})^2 - (P^I - C_L)^2 \Delta q / \Delta q_L}}{2} \right| \\ &- \left| \frac{C_H - C_L - \sqrt{\Delta q \Delta q_H (\bar{\theta})^2 - (P^I - C_L)^2 \Delta q / \Delta q_L}}{2} \right| > 0 \end{aligned}$$

Therefore, $| \underline{P}_s^e - R^e(P^I) | > | \bar{P}_s^e - R^e(P^I) |$. Hence, \bar{P}_s^e is closer to $R^e(P^I)$ than \underline{P}_s^e is, and therefore, \bar{P}_s^e is the sequentially rational separating price. As the pooling price is proved to be non-intuitive, \bar{P}_s^e is the unique intuitive separating price. QED.

REFERENCES

- Ali, A., and R. Camp (1993), "The Relevance of Firm Size and International Business Experience to Market Entry Strategies," *Journal of Global Marketing*, 6, 91-111.
- Bagwell, K. (1990), "Informational Product Differentiation as a Barrier to Entry," *International Journal of Industrial Organization*, 8, 207-223.
- (1991), "Optimal Export Policy for a New-Product Monopoly," *American Economic Review*, 81, 1156-1169.
- Bagwell, K., and R.W. Staiger (1989), "The Role of Export Subsidies when Product Quality is Unknown," *Journal of International Economics*, 27, 69-89.
- Bagwell, K., and M. Riordan (1991), "High and Declining Prices Signal Product Quality," *American Economic Review*, 81, 224-239.
- Chen, M.L. (1991), "The Role of R&D Subsidies when Product Quality is Unknown," *Journal of International Economics*, 31, 251-270.
- Collie, D. (1994), "Endogenous Timing in Trade Policy Games," *Weltwirtschaftliches Archiv*, 191-209.
- Das, S., and S. Donnenfeld (1987), "Trade Policy and Its Impact on Quality of Imports," *Journal of International Economics*, 23, 77-95.
- Erramilli, K.M., and C.P. Rao (1993), "Service Firm's International Entry-Mode Choice: A Modified Transaction-Cost Analysis Approach," *Journal of Marketing*, 57, 19-38.
- Export-Import Bank of the United States (1992), *Annual Report of the Export-Import Bank of the United States*.
- Eaton, J., and G. Grossman (1986), "Optimal Trade and Industrial Policy under Oligopoly," *Quarterly Journal of Economics*, 103, 767-787.
- Ireland, N. (1993), "The Provision of Information in a Bertrand Oligopoly," *The Journal of Industrial Economics*, 51, 61-76.
- Martin, S. (1995), "Oligopoly Limit Pricing: Strategic Substitute, Strategic Complements," *International Journal of Industrial Organization*, 13, 41-65.
- Mayer, W. (1984), "The Infant Industry Argument," *Canadian Journal of Economics*, 17, 249-69.
- Motta, M. (1993), "Endogenous Quality Choice: Price vs. Quantity Competition," *The Journal of Industrial Economics*, 51, 113-131.
- Shieh, S. (1993), "Incentives for Cost-reducing Investment in a Signaling Model of Product Quality," *Rand Journal of Economics*, 24, 466-477.
- Smith, A. (1987), "Strategic Investment, Multinational Corporations and Trade Policy," *European Economic Review*, 31, 89-96.
- Spulber, D. (1995), "Bertrand Competition when Rivals' Costs are Unknown," *The Journal of Industrial Economics*, 53, 1-11.
- Tirole, J. (1988), *The Theory of Industrial Organization*, MA: MIT Press.
- Trade Promotion Coordinating Committee (1995), "National Export Strategy;

Meeting Foreign Competition," Third Annual Report to the United States Congress.