Optimal Trade Policy with Horizontal Differentiation and Asymmetric Costs

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Abstract

This paper examines the optimal export policy under Bertrand competition when the products exhibit horizontal differentiation and production costs are asymmetric. The focus of this paper is on the product-differentiation effect in the determination of the optimal export policy. It shows that when the home firm incurs higher cost and the cost difference is sufficiently large, its optimal export policy under Bertrand competition is an export subsidy rather than an export tax. In contrast, when the cost difference is sufficiently small or negative, the optimal export policy is to tax. As a result, given the horizontal differentiation of the products being endogenously determined, we show that as the cost advantage gained by the home firm is switched into cost disadvantage sufficiently, the outcome of the game moves from Eaton-Grossman tax to Brander-Spencer subsidy under Bertrand price competition. It is in this sense that we generalize the theory of strategic trade policy and claim that the result of Eaton and Grossman (1986) turns out to be a special case of this paper.

Ⅰ. Introduction

In a seminal paper, Brander and Spencer (1985) develop a "third-market" model in which one home firm and one foreign firm produce homogeneous products and compete in a third-country market. They find that under Cournot quantity competition if the home country's government can credibly pre-commit itself to pursue a particular policy before firms make production decisions, then an export subsidy is optimal. Nevertheless, Eaton and Grossman (1986) show that the optimal export policy is an export tax rather than an export subsidy, when firms play Bertrand price competition and the products are differentiated. Since then, the theory of strategic trade policy has been extended to several directions, including: De Meza (1986) and Mai and Hwang (1988) demonstrate that government should offer higher subsidies to the more efficient firm under Cournot competition; Qiu (1994) studies the optimal export policy under asymmetric information on the production cost; Neary (1994) explores the optimality of export subsidies in oligopolistic markets, when home and foreign firms have asymmetric costs and the social cost of public funds exceeds unity; Maggi (1996) examines the optimal export policies by taking into account the capacity constraint; Bandyopadhyay *et al*. (2000) discuss the optimal export policies when there exists labor union; Zhou *et al*. (2002) investigates strategic trade and joint welfare-maximizing incentives towards investment in the quality of exports by an

LDC and a developed country; and Yang and Hwang (2003) study the optimal trade policy under homogeneous Bertrand competition. Miller and Pazgal (2005) explore the optimal trade policy by taking into account the delegated game, in which firms' owners choose incentive schemes for their managers, and then the managers compete in the product market.

It is worth emphasizing that although Eaton and Grossman's analysis considers differentiated products, the degree of product differentiation between the two firms is assumed to be unchanged. However, as time goes by, firms are generally capable of changing the characteristics of the products which exhibit horizontal differentiation in the long run.

In the real world, it can be easily observed that there exist many industries whose characteristics of products exhibit horizontally differentiated.[1] The industries of sedan, designed clothes, handbag, perfume etc., all have their own loyal customers for different products in each industry. For example, in the sedan industry, the traditional image of BENZ is that it is produced for old rich people such as C.E.O.s, while that of BMW is for young rich guys. The characteristics of these two products exhibit horizontal differentiation. Thus, the demands for BENZ and BMW are

[1] According the definition of Ferreira and Thisse (1996, p. 486), two products are said to be horizontally differentiated when both products have a positive demand whenever they are offered at the same price. Neither product dominates the other in terms of characteristics, and heterogeneity in preferences over characteristics explains why both products are present in the market. We can also find a similar definition in Lancaster (1979).

positive giving similar qualities and prices. Moreover, it is also the traditional view that BENZ produces high-priced products, while TOYOTA produces lower-priced products with good qualities. However, in recently years, BENZ starts to produce low-priced and small car named Smart, while TOYOTA produces high-priced car, Lexus. This demonstrates that the horizontal differentiation between the two producers has been changed and become less differentiated over time. In addition, Berry and Waldfogel (2003) study empirically the demand for the industries of newspaper and restaurant and indicate that the horizontal differentiation of newspaper can be represented by the differentiation in the format (tabloid vs. broadsheet), in politics (with editorials leaning to the left or right), and in the geographic focus, while that of restaurant is in type of cuisine, and in geography.

As is common in horizontal product differentiation models, such as MacLeod *et al*. (1985), Lederer and Hurter (1986), Greenhut *et al*. (1987), Anderson and De Palma (1988), De Fraja and Norman(1993), Bökem (1994), Eaton and Schmit (1994), and Shimizu (2002),consumers are characterized by their most preferred products and by the disutility that they incur when they buy a non-preferred product. As in Hotelling (1929), firms model this disutility as transport cost on the line. This disutility, in turn, is determined by the distance in the product space between that product and the most-preferred product of the consumer. Specifically, a consumer’s location can be interpreted as his most preferred product specification, and the firm's location as the characteristic of the product it produces. The distance between the firm's location and the consumer's location represents the difference of the characteristics between the firm and the consumer. Therefore, when the distance is not nil, the consumer will suffer a disutility which can be represented by the transportation cost. Allowing for a change in the characteristics of products, the price competition between firms becomes more severe if the products get to be more homogeneous, while lessened if more differentiated. This gives an incentive for the government to influence the choices of the characteristics of the firms for mitigating price competition via trade policies.

On the other hand, when considering the importance of cost asymmetry between firms, Liang and Mai (2006) show that there exists a cost-advantage (cost-disadvantage) effect for firm incurring low (high) production cost when the two firms compete in the Hotelling model. This effect attracts the low cost firm to move closer to its rival to capture larger market share, while forces the high cost firm to get further away from its rival. Knowing the firms' location responses to relative cost structure, we can easily deduce the result that the government of the high (low) cost domestic firm can enlarge the product differentiation between the two firms by imposing a subsidy (tax) on its domestic firm. Based on the above analysis, it is crucial for the government to take into consideration the cost asymmetry between firms while deciding trade policies.

By recognizing the importance of horizontal differentiation and cost asymmetry of the products in the determination of government's trade policy, the purpose of this paper is to incorporate cost asymmetry into the horizontally differentiated model and to re-explore the optimal export policy under Bertrand price competition when the product characteristics are endogenously determined and the costs of firms are asymmetric.

The model involves a three-stage game. In the first stage, the home government determines its optimal export policy to maximize domestic welfare; in the second stage, each firm simultaneously selects a characteristic to maximize its profit; in the third stage, firms play Bertrand competition in a third-country commodity market. It is found that the optimal policy for the government of the high cost firm is an export subsidy, when the cost difference is sufficiently large. This surprising result can be derived from the following channel: The equilibrium characteristic of the low cost firm locates inside of the line segment due to the cost-advantage effect, while that of the high cost firm is at the endpoint caused by the cost-advantage effect in this case. The government of the high cost firm can improve its cost disadvantage and then force the rival firm moving farther apart via taking a subsidy export policy. This enlarges the product differentiation between the two products and then mitigates the extent of price competition. Consequently, the market share of the high cost firm increases and the price charged can be higher. The profits and domestic welfare are thus improved.

The remainder of the paper is organized as follows. Section Ⅱ sets up a horizontal product differentiation model and explores the firms' optimal characteristics. Section Ⅲ analyzes the optimal export policies under Bertrand competition. The final section concludes the paper.

Ⅱ. Basic Model and Optimal Characteristic

Consider a three-country framework, in which home firm d competes with foreign firm f in the third country. Products are assumed to be consumed in the third country only, and their marginal costs are asymmetric that can be exhibited by the difference between c_d and c_f. Products differ with respect to a one dimensional characteristic. The distribution of characteristics is analogous to the Hotelling (1929)-type linear city model as shown in Figure 1. The characteristic is measured by x_i ($i = d, f$), where the characteristics of the firms are located at x_d and x_f with $x_d \leq x_f$, along a line segment within the interval [0, 1]. Consumers are uniformly distributed in the line segment with unit density. Each point of the line segment represents the consumer's ideal characteristic resided at the point.

(Insert Figure 1 here)

Based on the well-known framework described by D'Aspremont *et al*. (1979), consumers have unit demands, and consumption yields a positive constant surplus r. Thus, each consumer buys if and only if the net utility generated from consumption is non-negative:[2]

$$u(x) = r - p_i - t(x - x_i)^2 \geq 0, i = d, f, \quad (1)$$

where $u(x)$ represents the utility level of the consumer x purchasing product i, r is the reservation price and is assumed to be large enough for every consumer would always buy one unit of either product; p_i is the price of product i; t denotes the marginal disutility per unit of distance per unit of product i; $t(x\text{-}x_i)^2$ measures the disutility of the distance between the characteristic of the product i and consumer x's ideal product characteristic.

When firms select their characteristics at $x_d \leq x_f$, the marginal consumer, who is indifferent between purchasing from either firm, is located at $\hat{x}$ as given by:[3]

$$\hat{x} = \left(\frac{x_d + x_f}{2}\right) + \left(\frac{p_f - p_d}{2t(x_f - x_d)}\right). \quad (2)$$

Using equation (2), we can derive total demand for final products for firms d

[2] Bökem (1994) and Lambertini (1997) have also employed the similar form of utility function.

[3] This can be derived by setting $u(\hat{x}) = r - p_d - t(\hat{x} - x_d)^2 = r - p_f - t(\hat{x} - x_f)^2$.

and f, respectively, as:

$$q_d = \int_0^{\hat{x}} 1dx = \hat{x}, \tag{3.1}$$

$$q_f = \int_{\hat{x}}^1 1dx = 1 - \hat{x}, \tag{3.2}$$

where q_i, $(i = d, f)$, denotes firm i's total demand.

Each firm's profit function can be expressed, respectively, as:

$$\pi_d = [p_d - (\tau + c_d)]\hat{x}, \tag{4.1}$$

$$\pi_f = [p_f - c_f](1 - \hat{x}), \tag{4.2}$$

where $\pi_i\,(i = d, f)$ denotes firm i's profits, and τ is the specific export tax rate imposed by home government.

The model consists of three stages. The home government determines its optimal export policy to maximize domestic welfare in the first stage; the two firms then simultaneously select their optimal characteristics of products to maximize their profits in the second stage; and finally these firms play Bertrand price competition in the third country market in the third stage. The sub-game perfect equilibrium of the model is solved by backward induction, beginning with the final stage.

Maximizing each firm's profits with respect to its price and solving these first-order conditions, we obtain:

$$p_d = (1/3)\{2(\tau + c_d) + c_f + t(x_f - x_d)(2 + x_f + x_d)\}, \tag{5.1}$$

$$p_f = (1/3)\{(\tau + c_d) + 2c_f + t(x_f - x_d)(4 - x_f - x_d)\}. \tag{5.2}$$

Differentiating (5) with respective to x_d, and x_f, we have:

$$\partial p_d / \partial x_d = (-2t/3)(1+x_d) < 0, \tag{6.1}$$

$$\partial p_d / \partial x_f = (2t/3)(1+x_f) > 0, \tag{6.2}$$

$$\partial p_f / \partial x_d = (-2t/3)(2-x_d) < 0, \tag{6.3}$$

$$\partial p_f / \partial x_f = (2t/3)(2-x_f) > 0. \tag{6.4}$$

Equations (6) show that other things being equal, a rise in the characteristic of the home firm decreases both the prices of the domestic and foreign products via reducing the horizontal differentiation between the two products. In contrast, a rise in the characteristic of the foreign firm increases both prices via enlarging the horizontal differentiation between the two products.

Differentiating (5) with respective to τ gives:

$$\partial p_d / \partial \tau = 2/3 > 0, \tag{7.1}$$

$$\partial p_f / \partial \tau = 1/3 > 0. \tag{7.2}$$

Equations (7) demonstrate that other things being equal, a rise in the home export tax rate increases both the prices of the home and foreign products via increasing the marginal cost of the home firm.

Substituting (5) into (2) and (3) obtains:

$$q_d = \lfloor 1/6t(x_f - x_d) \rfloor \{-(\tau + c_d - c_f) + t(x_f - x_d)(2 + x_f + x_d)\}, \tag{8.1}$$

$$q_f = 1 - \lfloor 1/6t(x_f - x_d) \rfloor \{-(\tau + c_d - c_f) + t(x_f - x_d)(2 + x_f + x_d)\}. \tag{8.1}$$

We now turn to the second-stage problem with respect to the firms' optimal characteristics. Making use of the equilibrium in the third stage, the profit functions of firms d and f can be specified as follows:

$$\pi_d = \left[\frac{1}{18t(x_f - x_d)}\right]\left[-(\tau + c_d - c_f) + t(x_f - x_d)(2 + x_f + x_d)\right]^2, \tag{9.1}$$

$$\pi_f = \left[\frac{1}{18t(x_f - x_d)}\right]\left[(\tau + c_d - c_f) + t(x_f - x_d)(4 - x_f - x_d)\right]^2. \tag{9.2}$$

Differentiating (9) with respect to x_i, respectively, we can derive the profit-maximizing conditions for the two firms as follows:

$$\frac{\partial \pi_d}{\partial x_d} = \left[\frac{\hat{x}}{3(x_f - x_d)}\right]\left\{-(\tau + c_d - c_f) - t(x_f - x_d)(2 + 3x_d - x_f)\right\}, \tag{10.1}$$

$$\frac{\partial \pi_f}{\partial x_f} = \left[\frac{1-\hat{x}}{3(x_f - x_d)}\right]\left\{-(\tau + c_d - c_f) + t(x_f - x_d)(4 - 3x_f + x_d)\right\}. \tag{10.2}$$

By the assumptions $x_d \leq x_f$ and $x_i \leq 1$, the second term of the right-hand side in the brace of (10.1) is negative while the second term of (10.2) is positive. This second term can be named the competition effect, indicating that as the characteristic of the two firms move apart, the differentiation between the two products is increased and therefore the price competition is mitigated under Bertrand price competition. Thus, the competition effect attracts firms to move apart (i.e., become more differentiated). Moreover, the disutility of the distance between consumer's ideal characteristic and firm's characteristic will be larger if the marginal disutility is higher. This leads to the result that the consumer is willing to pay more for buying from the closer firm to compensate the disutility. Thus, the higher the marginal disutility, the stronger will be the competition effect. On the other hand, the first term of (10) denotes the cost difference effect. When the cost difference $\tau + c_d - c_f > (<) 0$, the characteristic of the home firm tends to stay away from (get closer to) that of the foreign firm due to its cost disadvantage (advantage), while the behavior of the foreign firm is reversed.

In what follows, we assume for simplicity the export tax rate be equal to zero initially, i.e., $\tau^o = 0$. Therefore, when the cost difference $c_d - c_f > 0$ and is sufficiently large such that the profit-maximizing condition of the characteristic for the foreign firm equals zero, it follows from (10) that $\left.\frac{\partial \pi_d}{\partial x_d}\right|_{\tau^o=0} < 0$ and $\left.\frac{\partial \pi_f}{\partial x_f}\right|_{\tau^o=0} = 0$.[4] Hence, as the home firm has severe cost disadvantage, both cost difference and competition effects attract it to locate as far away from the foreign firm as possible to reduce price competition. Consequently, the home firm selects to locate at the left endpoint. On the other hand, the cost difference effect attracts the foreign firm to move closer to the home firm due to its absolute cost advantage, while the competition effect tends to take apart to mitigate price competition. Thus, the foreign firm's equilibrium characteristic is determined by the balance of these two oppose effects and is located inside of the line segment by setting (10.2) equal to zero. Accordingly, we have:[5]

[4] We find from (10.2) that the first term in the brace is negative, while the second term is positive, when the cost difference $c_d - c_f > 0$. Thus, we have $\left.\frac{\partial \pi_f}{\partial x_f}\right|_{\tau^o=0} = 0$ in this case. Likewise, we can also find from (10.1) that the first and second terms in the brace are all negative so that $\left.\frac{\partial \pi_d}{\partial x_d}\right|_{\tau^o=0} < 0$.

[5] It is required that the term $c_d - c_f$ be no greater than $(4t/3)$ for the solution of x_f^* being a real solution,

$$x_d^* = 0, \text{ and } x_f^* = (1/3)\{2 + [4 - 3(\tau + c_d - c_f)/t]^{1/2}\} < 1, \quad \text{if } t < c_d - c_f \leq (4t/3). \tag{11}$$

Similarly, when the cost difference $c_d - c_f < 0$ and its absolute value is sufficiently large such that the profit-maximizing condition of the characteristic for the domestic firm equals zero, it can be seen from (10) that $\left.\frac{\partial \pi_d}{\partial x_d}\right|_{\tau^o=0} = 0$ and $\left.\frac{\partial \pi_f}{\partial x_f}\right|_{\tau^o=0} > 0$. The foreign firm has severe cost disadvantage, and selects to locate at the right endpoint of the line segment. On the other hand, the equilibrium characteristic of the home firm is located inside of the line segment by setting (10.1) equal to zero. Thus, we obtain:[6]

$$x_d^* = (1/3)\{1 - [4 + 3(\tau + c_d - c_f)/t]^{1/2}\} > 0, \text{ and } x_f^* = 1, \quad \text{if } (-4t/3) \leq c_d - c_f < (-t), \tag{12}$$

When the cost difference $c_d - c_f$ is sufficiently small (no matter whether its value is positive or negative), it follows from (10) that $\left.\frac{\partial \pi_d}{\partial x_d}\right|_{\tau^o=0} < 0$ and $\left.\frac{\partial \pi_f}{\partial x_f}\right|_{\tau^o=0} > 0$. This arises because the cost difference effect is so weak that the competition effect dominates. Thus, the two firms select to locate at the endpoints of the line segment. As a result, *the Principle of Maximum Differentiation* occurs. It can be found from (11) and (12) that this result arises when the condition $(-t) \leq c_d - c_f \leq t$ holds. Hence, we

while greater than (t) for x_f^* being less than unity. Thus, the condition $t < c_d - c_f \leq (4t/3)$ must be required for eq. (11).

[6] It is required that the term $c_d - c_f$ be no less than ($-4t/3$) for the solution of x_d^* being a real solution, while less than ($-t$) for x_d^* being greater than zero. Thus, the condition $(-4t/3) \leq c_d - c_f < (-t)$ must be required for eq. (12).

have:

$$x_d^* = 0, \text{and } x_f^* = 1, \text{if } -t \le c_d - c_f \le t. \tag{13}$$

Based on the above analysis, we can establish:

Proposition 1. *Assuming the export tax rate be equal to zero initially, we obtain*:

(i) *When the cost difference lies in between* $t < c_d - c_f \le (4t/3)$, *the home firm has severe cost disadvantage and selects to locate at the left endpoint, while the foreign firm could locate inside of the line segment*.

(ii) *When the cost difference lies in between* $(-4t/3) \le c_d - c_f < (-t)$, *the foreign firm has severe cost disadvantage and selects to locate at the right endpoint, while the home firm could locate inside of the line segment*.

(iii) *When the cost difference lies in between* $(-t) \le c_d - c_f \le t$, *the Principle of Maximum Differentiation holds*.

We are now in a position to examine the effects of home government's export tax on the equilibrium characteristics of the firms. Differentiating (11) - (13) with respect to τ, we yield:

$$\left.\frac{\partial x_d^*}{\partial \tau}\right|_{\tau^o=0} = 0, \qquad \text{if } \; t < c_d - c_f \le (4t/3),$$

$$= (\text{-}1/2t)\left[4 + 3(\tau + c_d - c_f)/t\right]^{-1/2} < 0 \qquad (14.1)$$

$$\text{if } (\text{-}4t/3) \le c_d - c_f < (\text{-}t),$$

$$= 0, \qquad \text{if } (\text{-}t) \le c_d - c_f \le t,$$

$$\left.\frac{\partial x_f^*}{\partial \tau}\right|_{\tau^o=0} = (\text{-}1/2t)\left[4 - 3(\tau + c_d - c_f)/t\right]^{-1/2} < 0,$$

$$\text{if } t < c_d - c_f \le (4t/3), \qquad (14.2)$$

$$= 0, \qquad \text{if } (\text{-}4t/3) \le c_d - c_f < (\text{-}t),$$

$$= 0, \qquad \text{if } (\text{-t}) \le c_d - c_f > 0 \le \text{t}.$$

When the cost difference lies in between $t < c_d - c_f \le (4t/3)$, the cost difference effect is strong enough to attract the foreign firm to move closer to the home firm due to cost advantage. An increase in the home export tax enlarges this cost difference effect leading to the result that the foreign firm moves closer to the home firm. On the other hand, the home firm still selects to locate at the left endpoint due to a worsened cost disadvantage. Similarly, when the cost difference lies in between $(\text{-}4t/3) \le c_d - c_f < (\text{-}t)$, an increase in the home export tax enhances the home firm's cost advantage. This will make the home firm moving closer to the foreign firm due to a stronger cost difference effect. However, the foreign firm is still located at right endpoint although its cost disadvantage is lessened. When the cost difference lies in between $(\text{-}t) \le c_d - c_f \le t$, the cost difference effect is so weak that an increase in the home export tax is unable to balance the competition effect. Hence, the Principle of Maximum Differentiation still holds. Accordingly, we have:

Proposition 2. *The effects of an increase in the home export tax on the firms' choices of characteristics evaluated at the initial value of the export tax rate equaling zero are as follows*:

(i) *When the cost difference lies in between* $t < c_d - c_f \leq (4t/3)$, *the home firm selects to locate at the left endpoint*, *while the foreign firm moves closer to its rival*.

(ii) *When the cost difference lies in between* $(-4t/3) \leq c_d - c_f < (-t)$, *the foreign firm selects to locate at the right endpoint*, *while the home firm moves farther away from its rival*.

(iii) *When the cost difference lies in between* $(-t) \leq c_d - c_f \leq t$, *the Principle of Maximum Differentiation still holds*.

Ⅲ. Optimal Export Policy

In this section, we are going to explore the first-stage problem in which the home government determines the optimal export policy. Since the products are consumed in the third country market only, the domestic welfare is composed of home firm's profits and government's tax revenue. This can be obtained by considering (2), (3), and (5) – (10):

$$w_d = \pi_d(x_d, x_f, \tau) + \tau q_d(x_d, x_f, \tau), \tag{15}$$

where w_d denotes the domestic welfare.

Totally differentiating (15) with respect to τ and evaluating it at $\tau^o = 0$, we obtain:

$$\left.\frac{dw_d}{d\tau}\right|_{\tau^o=0} = \left[\left(\frac{\partial \pi_d}{\partial x_d}\right)\left(\frac{\partial x_d}{\partial \tau}\right) + \left(\frac{\partial \pi_d}{\partial x_f}\right)\left(\frac{\partial x_f}{\partial \tau}\right) + \left(\frac{\partial \pi_d}{\partial \tau}\right)\right] + q_d. \tag{16}$$

We need the following comparative-static effects by differentiating (8) and (9) with $\tau^o = 0$ to yield the optimal export policy:

$$\frac{\partial \pi_d}{\partial x_f} = \left(\frac{q_d}{3}\right)\left\{\left(\frac{c_d - c_f}{x_f}\right) + t(2 + 3x_f)\right\}, \tag{17.1}$$

$$\frac{\partial \pi_d}{\partial \tau} = \left(\frac{-2}{3}\right) q_d < 0. \tag{17.2}$$

In what follows, we discuss the determination of the optimal export policy under the above-mentioned three cases.

Case Ⅰ: The cost difference lies in between $t < c_d - c_f \leq (4t/3)$.

We recognize from (14) that the terms $\partial x_d / \partial \tau = 0$ and $\partial x_f / \partial \tau < 0$ in this case. Accordingly, (16) can be reduced to:

$$\left.\frac{dw_d}{d\tau}\right|_{\tau^o=0} = \left(\frac{\partial \pi_d}{\partial x_f}\right)\left(\frac{\partial x_f}{\partial \tau}\right) + \left(\frac{\partial \pi_d}{\partial \tau}\right) + q_d. \tag{18}$$

Recall that the initial value of the export tax rate is assumed to be equal to zero. Thus, we have $t < c_d - c_f \leq (4t/3)$ and $x_d^* = 0$ in this case. We find from (17) that $\partial \pi_d / \partial x_f > 0$ and $\partial \pi_d / \partial \tau = (-2/3) q_d < 0$, and from (14.2) that $\partial x_f / \partial \tau < 0$. Accordingly, equation (18) shows that the optimal export tax is determined jointly by the product-differentiation effect, the direct tax effect and the tax revenue effect, which are represented by the terms in the right-hand side of (18) in that order. The intuition behind these effects can be stated as follows. First of all, as an increase in the export tax attracts foreign firm to get closer to the home firm due to worsening the home firm's cost disadvantage, this will reduce home firm's profits by two factors. First, the price will fall via a stronger price competition caused by the reduction of the product differentiation; and secondly, the market share (i.e., output) of the home firm is reduced due to worsening cost disadvantage. Thus, the product-differentiation effect is negative. Next, the direct tax effect is also negative via increasing the cost of the home firm. Lastly, the tax revenue effect is positive due to the rise in tax revenue. Consequently, the optimal export tax is determined by these three effects.

Substituting (14) into (18), we can rewrite (18) as:

$$\left.\frac{dw_d}{d\tau}\right|_{\tau^o=0} = \left(\frac{-q_d}{3}\right)[(J-1)], \tag{18.1}$$

where $J = (1/2tx_f)[(c_d - c_f) + tx_f(2+3x_f)][4-3(c_d-c_f)/t]^{-1/2}$.

It follows from (11) that $[4-3(c_d-c_f)/t]^{-1/2} = (3x_f-2)^{-1} \geq 0$ as $\tau^o = 0$.[7] Calculating (18.1) along with the above relationship, we yield that J-1 = $[2tx_f(3x_f - 2)]^{-1}[(c_d - c_f) + tx_f(6\text{-}3x_f)] > 0$ for $2/3 \leq x_f \leq 1$. It then follows from (18.1) that $\left.\frac{dw_d}{d\tau}\right|_{\tau^o=0} < 0$. Since an increase in the export tax rate reduces the domestic welfare

[7] It can be verified from (11) that $x_f \geq 2/3$.

and the initial value of the export tax rate equals zero, the optimal export tax is negative accordingly. This implies that the product-differentiation effect and the direct tax effect outweigh the tax revenue effect. Intuitively, an export subsidy can force foreign firm to select a characteristic of its product farther away from that of the home firm, and then increase home firm's output via reducing the cost disadvantage faced by home firm. More differentiated products mitigate the price competition between the two firms. Both prices charged are higher. Thus, the home firm's output and profits increase, and the welfare of the home country improves. Consequently, the optimal export policy is an export subsidy rather than an export tax, when the cost disadvantage is large enough.

(Insert Figure 2 here)

We can use Figure 2 to illustrate this result. As the cost difference lies in between $t < c_d - c_f \leq (4t/3)$, the optimal characteristic of the home firm is located at the left endpoint, while that of the foreign firm is at inside of the line segment. Suppose that free trade emerges initially. The initial equilibrium is at point E. The price of the domestic (foreign) product is p_d (p_f), while the marginal consumer locates at $\hat{x}$. It can be found from Proposition 2 that an export subsidy increases the characteristic of the foreign firm, while keeps that of the home firm unchanged. We can yield that both prices rise to p_d^S and p_f^S, as the differentiation between the two firms is enlarged where the superscript "*S*" denotes the case in which the home government offers an export subsidy.[8] Meanwhile, the marginal consumer moves rightward to $\hat{x}^S$ while taking subsidy policy.[9] This will lead to an increase in the output of the home firm. The equilibrium moves to the point E^S. Accordingly, the profits of the home firm rise and the welfare of the home country improves due to a rise in both the price and the output of the home firm. Therefore, the optimal export policy is an export subsidy.

Consequently, we can establish:

Proposition 3. *When the cost difference lies in between $t < c_d - c_f \leq (4t/3)$ and the initial value of the export tax rate is assumed to be zero, a rise in the export subsidy (or a fall in the export tax) increases home firm's profits and hence welfare via enlarging the degree of the horizontal differentiation between the two products. Thus, the optimal export policy under Bertrand competition is an export subsidy.*

[8] It follows from (6.2), (7.1), (10.2), (14.1), and (14.2) that

$$dp_d / d\tau = (\partial p_d / \partial \tau) + (\partial p_d / \partial x_d)(\partial x_d / \partial \tau) + (\partial p_d / \partial x_f)(\partial x_f / \partial \tau)$$
$$= (5/3)(x_f - 1)(3x_f - 2)^{-1},$$

It can be found from (11) that $x_f \geq 2/3$, which leads to $dp_d/d\tau < 0$.Likewise, it follows from (6.4), (7.2), (10.1), (14.1), and (14.2)that $dp_f / d\tau = (4/3)(x_f - 1)(3x_f - 2)^{-1} < 0$.

[9] Substituting $x_d^* = 0$ into (2) and then differentiating (2) with respect to τ, we obtain:

$$d\hat{x} / d\tau = (1/2)(dx_f / d\tau) + [1/(2tx_f)][(dp_f / d\tau) - (dp_d / d\tau)]$$
$$+ (1/2t)(x_f)^{-2}(p_d - p_f)(dx_f / d\tau).$$

We find from (14.2) that $dx_f/d\tau < 0$, and calculate from footnote 4 that

$[(dp_f / d\tau) - (dp_d / d\tau)] = (1/3)(3x_f - 2)^{-1}(x_f - 1) < 0$, and

$p_d - p_f = (1/3)(tx_f)(2 - x_f) > 0$. Thus, we yield $d\hat{x} / d\tau < 0$.

This result is in sharp contrast to that derived in Eaton and Grossman (1986). In fact, this result replicates Brander and Spencer's under Cournot competition. The key factor is that an export subsidy is capable of forcing foreign firm to produce a more differentiated product while keeps the characteristic of the home firm remain unchanged, which will increase the output of the home firm and mitigate the price competition between the two firms. The increased output and price enhance home firm's profits. Since the domestic welfare includes the profits earned by home firm and tax revenue levied by the government, the increased profits can offset the loss of tax revenues and improve domestic welfare. In contrast, the differentiation between products remains unchanged in Eaton and Grossman (1986).

Case Ⅱ: The cost difference lies in between $(-4t/3) \leq c_d - c_f < (-t)$.

We recognize from (10) and (14) that the terms $\partial\pi_d / \partial x_d = 0$ and $\partial x_f / \partial\tau = 0$ in this case. Accordingly, (16) can be reduced to:

$$\left.\frac{dw_d}{d\tau}\right|_{\tau^o=0} = \left(\frac{\partial\pi_d}{\partial\tau}\right) + q_d. \tag{19}$$

It follows from (19) that the optimal export tax is determined by the direct tax effect and the tax revenue effect. Since $\partial\pi_d / \partial\tau + q_d = (1/3)\, q_d > 0$, the tax revenue effect outweighs the direct tax effect so that optimal export policy is an export tax.

(Insert Figure 3 here)

This result can be illustrated by Figure 3. As the cost difference lies in between $(-4t/3) \le c_d - c_f < (-t)$, the optimal characteristic of the home firm is located inside of the line segment, while that of the foreign firm is at the right endpoint. Similar to Figure 2, the initial equilibrium is at point E. we find from Proposition 2 that an export tax reduces the characteristic of the home firm, while keeps that of the foreign firm unchanged. We can figure out that both prices rise to p_d^{τ} and p_f^{τ}, as the differentiation between the two firms is increased where the superscript "$\underline{\tau}$" denotes the case in which the home government imposes an export tax.[10] On the other hand, the marginal consumer moves rightward to $\hat{x}^{\tau}$ while taking export tax policy.[11] This will result in the reduction of the output of the home firm. The equilibrium moves to the point E^{τ}. Accordingly, the profits of the home firm rise and the welfare level of the home country improves because the impact of the rise in price outweighs that of the reduction in the output of the home firm. Therefore, it is optimal for the home country

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[10] It follows from (6.1), (7.1), (10.1), (14.1), and (14.2) that

$$dp_d / d\tau = (\partial p_d / \partial \tau) + (\partial p_d / \partial x_d)(\partial x_d / \partial \tau) + (\partial p_d / \partial x_f)(\partial x_f / \partial \tau)$$
$$= (3 - 5x_d)[3(1 - 3x_d))^{-1},$$

Moreover, it can be found from (12)(12)(12) that $x_d \le 1/3$, leading to $dp_d/d\tau > 0$.

Likewise, it follows from (6.3), (7.2), (10.2), (14.1), and (14.2) that

$$dp_f / d\tau = (3 - 4x_d)[3(1 - 3x_d)^{-1} > 0.$$

[11] Substituting $x_f^* = 1$ into (2) and then differentiating (2) with respect to τ, we obtain:

$$d\hat{x} / d\tau = (1/2)(dx_d / d\tau) + [1/2t(1 - x_d)][(dp_f / d\tau) - (dp_d / d\tau)]$$
$$+ (1/2t)(x_d)^{-2}(p_d - p_f)(dx_d / d\tau).$$

We find from (14.2) that $dx_f/d\tau < 0$, and calculate from footnote 6 that $[(dp_f / d\tau) - (dp_d / d\tau)] = [3(1 - 3x_d)]^{-1}(x_d) > 0$, and $p_d - p_f = (-1/3)[t(1 - x_d)](1 + x_d) < 0.$ Thus, we yield that $d\hat{x} / d\tau < 0.$

to select an export tax policy.

We can thus establish:

Proposition 4. *When the cost difference lies in between* $(-4t/3) \leq c_d - c_f < (-t)$ *and the initial value of the export tax rate is assumed to be zero, a rise in the export tax increases home firm's profits and welfare via enlarging the degree of the horizontal differentiation between the two products. Thus, the optimal export policy is an export tax under Bertrand competition.*

This result is opposite to that in Proposition 3. In this case, a rise in export tax increases the differentiation of the products via reducing the cost advantage of the home firm. This mitigates the price competition and raises prices. This result resembles Eaton and Grossman (1986)'s.

Case Ⅲ: The cost difference lies in between $(-t) \leq c_d - c_f \leq t$.

Recall from (14) that the terms $\partial x_d / \partial \tau = \partial x_f / \partial \tau = 0$ and from (13) that $x_d^* = 0$ and $x_f^* = 1$ in this case. This arises because the cost difference effect of location decision is so weak that the competition effect prevails. An increase in the export tax of the home government is unable to change the two firms' locations because the cost difference between the two firms and the cost difference effect are still very small.

Therefore, the two firms select to locate at the opposite endpoints of the line segment to maximize horizontal differentiation between their products. Substituting these terms, $\partial x_d / \partial \tau = \partial x_f / \partial \tau = 0$, into (16), we have:

$$\left. \frac{dw_d}{d\tau} \right|_{\tau^o = 0} = \left(\frac{\partial \pi_d}{\partial \tau} \right) + q_d. \tag{20}$$

We see from (20) that the product-differentiation effect is vanished such that the optimal export policy is determined by the direct tax effect and the tax revenue effect only. Since $\partial \pi_d / \partial \tau + q_d = (1/3)\, q_d > 0$, the tax revenue effect outweighs the direct tax effect. Therefore, the optimal export policy is an export tax.

Consequently, we can establish the following proposition:

Proposition 5. *When the cost difference lies in between* $(-t) \le c_d - c_f \le t$ *such that the two firms are located at the opposite endpoints of the line segment and the initial value of the export tax rate is assumed to be zero, the horizontal differentiation between the two products remains unchanged irrespective of the export policy imposed by the government. As a result, the optimal trade policy is an export tax under Bertrand competition.*

Our result is similar to the one derived by Eaton and Grossman (1986), in which the optimal trade policy is an export tax under Bertrand competition by assuming the differentiation between the two products to be unchanged. The intuition behind

Proposition 5 is as follows. When the cost difference lies in between $(-t) \leq c_d - c_f \leq t$, the Principle of Maximum Differentiation holds, i.e., the location of each firm's characteristic lies at the endpoints of the line segment irrespective of a change in the export tax. Hence, the differentiation between the two products remains unchanged in this case.

From the above analysis, we can conclude that the well-known result of Eaton and Grossman (1986) turns out to be a special case of ours.

Ⅳ. Concluding Remarks

This paper has examined the optimal export policy under Bertrand competition when the products exhibit horizontal differentiation and production costs are asymmetric. The focus of this paper is on the product-differentiation effect in the determination of the optimal export policy. This effect demonstrates that the price competition between firms becomes more severe if the products get to be closer, while lessened if more differentiated. This gives an incentive for the government to influence the choices of the characteristics of the firms in order to mitigate price competition via trade policies.

Our analysis shows that whether the optimal trade policy is an export tax or not is uncertain, depending on the degree of horizontal product differentiation as well as the magnitude of cost asymmetry. In particular, we demonstrate that when the cost difference lies in between $t < c_d - c_f \leq (4t/3)$ such that the foreign firm is located closer to the home firm due to its cost advantage, the optimal export policy of the home country under Bertrand competition is an export subsidy. This result is in sharp contrast to Eaton and Grossman (1986). As Maggi (1996) and Miller and Pazgal (2005) pointed out, a potentially damaging criticism raised against theories of strategic trade policy is the exact nature of competition: if firms compete in quantities, the optimal policy tends to be a subsidy to the home country (Brander and Spencer (1985)), but if firms compete in prices, the optimal policy tends to be a tax (Eaton and Grossman (1986)). Given the horizontal differentiation of the products been endogenously determined, our paper shows that as the cost advantage gained by the home firm is switched into cost disadvantage sufficiently, the outcome of the game moves from Eaton-Grossman tax to Brander-Spencer subsidy under Bertrand price competition. It is in this sense that we generalize the theory of strategic trade policy and claim that the result of Eaton and Grossman turns out to be a special case of ours.

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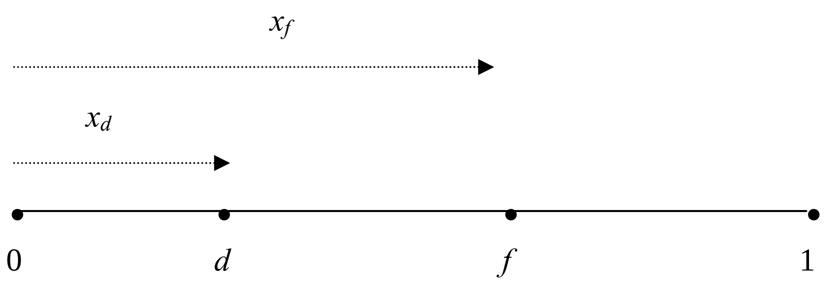

Figure 1. The Characteristic Line Space

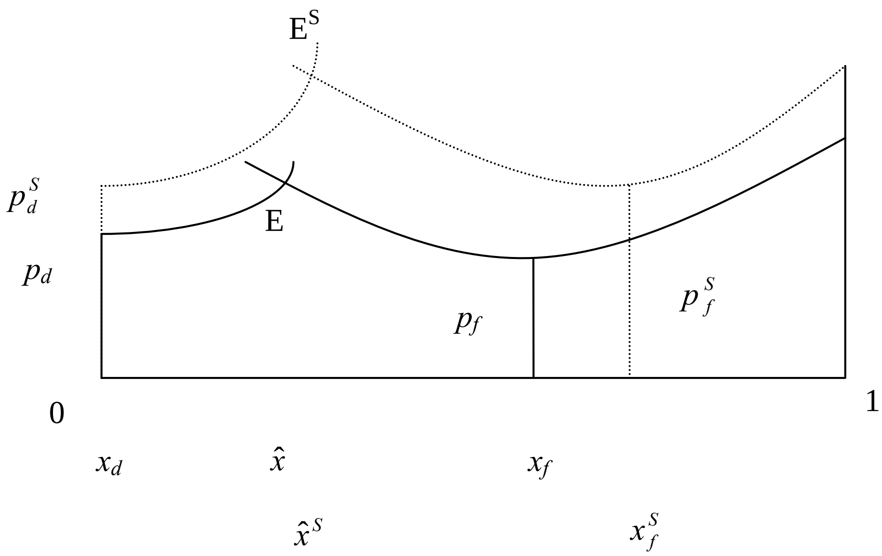

Fig.2. A Case of Optimal Export Subsidy

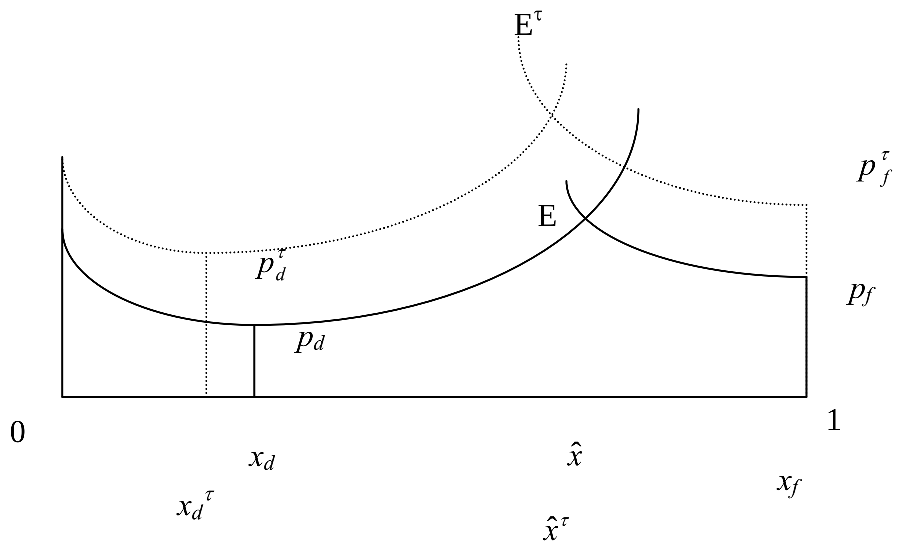

Fig.3. A Case of Optimal Export Tax