Export Subsidies and Least-Developed Countries: Entry-Deterrence Model under Complete and Incomplete Information

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Abstract

This paper shows that export subsidies may be harmful when they are used to support a technologically inferior firm relative to the competing foreign firm in the exporting market. To explain this, we consider a three-period entry deterrence model, where, particularly, the firms producing a homogeneous good compete á la Bertrand if entry occurs. Under complete information, only a subsidy policy can deter entry. We also investigate if the 'no subsidy' policy can deter entry under incomplete information, where the government's policy on export subsidy is assumed to be unknown to the foreign firm. Following the Milgröm and Roberts (1982) model of limit pricing, in the separating equilibria, only the firm with a subsidy policy can deter entry. However, in the pooling equilibria, under a certain condition, even the firm without a subsidy policy can deter entry by setting the price which is different from its true monopoly price. The separating equilibria environment is preferred by the importing country than complete information due to the lower price.

Keywords: Export subsidies; least-developed countries; entry-deterrence model; WTO; strategic trade policy; trade and development; signaling model.

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I. INTRODUCTION

Many papers have discussed the various roles of export subsidies. Brander and Spencer (1985), the classic and seminal paper in this field using a Cournot duopoly model between a domestic firm and a foreign firm, formalized the idea that export subsidies by a domestic government can shift profits of the domestic firm from those of the foreign firm by manipulating the strategic relation between these firms. It implies that export subsidies are attractive as a strategic policy because they increase not only the profits of the domestic firm through a bigger market share but also its national welfare.

However, the World Trade Organization (hereafter WTO) disciplines the use of subsidies and prohibits export subsidies[1] because they could distort trade among its member countries. Some subsequent papers, inspired by Brander and Spencer (1985), strengthened this philosophy of regulating trade-distorting policy tools. Collie (1992) showed that export subsidies can deter the entry of foreign competitors with the Cournot oligopoly model, in the sense that such export subsidies increase the number of domestic firms and simultaneously, reduce that of the foreign firms. Collie and Hviid (1993) explored that under incomplete information on costs of firms, export subsidies play the role of a signal in order to reveal the competitiveness of the firm so that a large amount of subsidies by the domestic government may lead the foreign firm to lower its expectation of the marginal cost of the domestic firm. They pointed out that signaling of the firm's competitiveness, based on export subsidies, is similar to providing the first-mover advantage to the domestic firm, which has been already discussed in Brander and Spencer (1985).

Realizing that subsidies may play an important role in developing countries, however, the WTO allows an exception that least-developed countries (LDCs)[2] and developing countries with less than $1,000 per capita GNP are exempted from disciplines on prohibited export subsidies.[3] It implies that LDCs and certain

[1] Article 3.1 of the Agreement on Subsidies and Countervailing Measures under the WTO regulates that export subsidies and import substitution subsidies are prohibited. Export subsidies are defined as "subsidies contingent, in law or in fact, whether solely or as one of several other conditions, upon export performance."

[2] The United Nations designates countries with lowest indicators of socioeconomic development as LDCs. As of September 2012, there are 48 LDCs in the world.

[3] See Article 27.2 and Annex VII of the Agreement on Subsidies and Countervailing Measures.

developing countries have the flexibility to finance their exporters, consistent with their development needs.

In the real world, however, LDCs have considerable difficulty in exporting their products simply because these products are not competitive in a world market due to their low technology level. Without considering technology inferiority in LDCs, the simple permission of using export subsidies would not be helpful for those countries as designed and expected under the WTO disciplines on subsidies, as discussed above.

Therefore, the main objective of this paper is to explore the potential impacts of export subsidies in LDCs when exporting firms of LDCs are technologically inferior to foreign firms from more advanced countries in a third exporting market. Can the government of the LDC deter entry of technology leaders to the market by using export subsidies? If so, is it possible for the government to deter entry without providing export subsidies when the information on whether exporting firms are subsidized or not is uncertain?

In order to answer these research questions, we adopt a three-period entry deterrence model, where the firms are supposed to compete *á la* Bertrand if entry occurs.[4] In the model, there are three countries, including two exporting countries, home (an LDC) and foreign (a developed country), and a third importing country. We assume for simplicity that each exporting country has a single firm producing a homogeneous good. The domestic firm in the LDC takes the entire exporting market as a monopolist, first, and then faces the threat of the entry of the foreign firm from a technologically more advanced country. Then, can the export subsidy policy by the domestic government of the LDC deter the entry of the technologically advanced firm? The answer depends on the amount of export subsidies. If the amount of export subsidies is so low that it cannot overcome technological inferiority, then, entry is not deterred. However, if the amount of subsidies is large enough to win in this price competition, then the subsidy policy can deter entry. However, problems of such policy arise when subsidies are costly to the government of the LDC, whereas they are always helpful to the subsidized firm. Thus, if the government must spend a lot of subsidies to lead its domestic firm to be competitive with the foreign firm, it may be harmful to the national welfare of the LDC.

[4] The result of this paper also holds when the quantity competition is adopted for the model if entry occurs.

This research has contributions to both academic and policy fields. In the previous literature on strategic trade policy, there have been a number of works providing different views on export subsidies from the traditional one with a strategic and positive role of export subsidies, as discussed above. Bagwell and Staiger (1997) revealed that in the natural monopoly market, the exporting countries are indifferent between the result from a subsidy game and that from a game without subsidies. Moore and Suranovic (1993) even showed that if lobbying costs are considered, the export subsidy policy may not improve the national welfare. Kang (2006 and 2009) considered various issues of R&D subsidies and the protection of intellectual property rights on R&D outcomes, by extending this discussion to R&D subsidies. Moreover, Etro (2010) showed how the endogenous entry of international firms in an integrated market affects the optimal subsidy to domestic production.

This work also investigates if it is possible for the government to deter entry without providing any export subsidy to its exporting firms under incomplete information, while it was not at all under complete information. In the model, unlike Collie and Hviid (1993), the government's policy on export subsidy is assumed to be unknown to the foreign firm. Since it is private information, the domestic firm observes such policy. Thus, the foreign firm, as an entrant, has to make a decision on the entry without knowledge of what policy the government adopts. In this situation, the level of price set by the domestic firm in the previous period can play the role of a signal for the entrant to infer what type the incumbent is. On the one hand, if the incumbent (domestic firm) receives the subsidies, then it will try to show itself off to be competitive in order to deter entry by setting a low price. On the other hand, if the government does not subsidize, then the firm may try to cheat as if it could be competitive. Following the Milgröm and Roberts (1982) model of limit pricing, to deal with this problem, the perfect Bayesian equilibrium concept for the subgame will be adopted by the firms. In the separating equilibria, since the entrant infers the type of the domestic firm correctly, only the firm with a subsidy policy (the high level of subsidies) can deter entry. However, in the pooling equilibria, under a certain condition, even the firm without a subsidy policy can deter entry by setting the price, which is different from its true monopoly price. The level of price in the separating equilibria is lower than that under complete information. The intuition is that the subsidized wants to lower the price so sufficiently that it can deter entry, and the firm without subsidies cannot cheat by setting the same price.

This paper also provides implications for policymakers of LDCs and international organizations in order to help these countries. We verify that it is not proper for the WTO to simply allow LDCs to use export subsidies without considering the technology gap between LDCs and advanced countries. The WTO and other international organizations, such as the World Bank and the UNCTAD, need to work together in order for LDCs to catch up with technology leaders, by designing various programs to disseminate advanced technology, and for LDCs to embody the cutting-edge technology to their firms.

The paper is organized as follows. Section II illustrates the model that we will use. The entry deterrence game using the export subsidy policy under complete information is discussed in Section III and that under incomplete information is discussed in Section IV, respectively. Section V concludes.

II. THE MODEL

Following Brander and Spencer (1985), we consider two exporting countries, a home country (no "*") and a foreign country ("*"), which are assumed only to export a homogeneous good to a third importing country. We presume that the home country is a least-developed country, while the foreign country is a developed country having well advanced technology in order to produce this good. Each of the two exporting countries has only one firm producing the good. Let us assume that the importing country does not impose tariffs on the good and the demand of the good is big enough to import all of the goods supplied by these exporting firms.

As in Bagwell and Staiger (1997), the natural monopoly market will be discussed for the market structure of the importing country. Specifically, only a monopolist can enjoy the positive profits, whereas duopoly firms gain nothing through price competition. Suppose that a firm from the LDC initially gains the monopoly power in the market of the third country. This specification is very compatible with a real situation that LDCs face in the exporting markets because firms from LDCs are not technologically competitive and hence, they can enjoy positive profits in a small market where only a single firm can be profitable. For example, suppose that a firm from Cambodia enjoy a monopolist's profit in a clothing market of Laos, where domestic producers of Laos are technologically inferior to Cambodians. Thus, Laos

imports clothes from its neighbor, Cambodia. Now this monopolist from Cambodia faces a threat of entry by a foreign firm, for example a Chinese firm, which has better technology; therefore, the Chinese firm can produce the good with lower costs than the Cambodian. We also assume that if the foreign firm enters the market, unlike Brander and Spencer (1985), they are assumed to compete in price with each other *á la* Bertrand. It can win the race of price competition even without subsidies, while the incumbent firm cannot survive without sufficient subsidies from its government because it has technology inferiority with higher costs in order to produce the good.

Since this paper examines the role of export subsidies in LDCs with technology inferiority as well as the relationship between the export subsidy policy and entry deterrence, we assume, as above, that only the LDC's government can support its domestic firm using export subsidies, but that the foreign advanced country is unable to use the export subsidy policy. As discussed above, this setup is more realistic because the WTO prohibits its member countries to use export subsidies, however, LDCs are exempt from this prohibition.

For the model to be at its simplest, the LDC's government is assumed to have two levels of subsidies, high and low: s_H for the high level of subsidy and s_L for the low level of subsidy. The exporter of the LDC knows the exact subsidy level that it will receive from the government. In a setup of complete information, the foreign firm does observe the level of subsidies given to the exporter of the LDC. However, in one with incomplete information, we assume that the foreign firm does not observe the level of subsidies given to the exporter of the LDC; yet, it knows the distribution of subsidies, denoting θ to be the probability that s_L is used for the policy, and $(1-\theta)$ for s_H. Assume that all other things are publicly known, except the fact that the export subsidy policy is private information to the exporter of the LDC. That is, while the foreign firm does not know which policy the domestic government adopts, the domestic firm of the LDC has privately owned information on its government's export subsidy policy. However, the foreign firm can observe or has complete information on the price level set by the exporter of the LDC, which is the current monopolist in the third importing country's market, even though the foreign firm does not know the monopolist's type (the type of policy on export subsidy). In the circumstances described above, the monopolist sends a signal to its potential rival by

setting a price to show its type, even though its type is totally determined by the LDC's government.[5]

Consider a three-period model, in which the last period has two stages, as follows. The first period is a policy decision stage, where the government of the LDC will choose the export subsidy level out of the two alternatives (s_H, s_L); maximizing its domestic welfare, that is, the domestic firm's profits over all periods minus the cost of financing its export subsidies. We assume for simplicity that the LDC's government commits itself to maintaining the amount of export subsidies to its domestic firm at every period equally, after choosing its optimal export subsidies. Then, the government's problem is given as follows:

$$\max_{s} \ \pi^m(s) - sq^m(s) + [\pi(s) - sq(s)], \tag{1}$$

where s is the subsidy rate, with sq for the total amount of subsidies, π^m is a monopoly profit in the first period, q^m is the optimal level of monopoly output, π is an incumbent's (domestic firm's) profit in the second period, and q is an incumbent's optimal output after the entry decision of the foreign firm.[6] We also assume that the government and the firm do not discount the future value, i.e., $\delta = 1$, which is a reasonable assumption in this model, because both the domestic firm and the government places big weights on the outcome of the third period when they decide on their strategies.

The second period is for the monopolist from the LDC. The monopolist has to choose the level of price (p) of the exporting good in order to maximize profits over all periods by observing the subsidy policy from the government, as follows:

$$\max_{p} \ D(p)p - (c - s)D(p) + \pi(s), \tag{2}$$

where the linear demand function is assumed by $D(p) = a - p$ and the marginal cost, c, is also assumed to be positive and constant for simplicity.

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[5] This is the big difference between this model and the previous signaling models. In this model, as an entity to choose the agent's type, the government, which has its own objective function, plays this role, rather than the normal setup, where the type is given by nature without any objective function.

[6] π and q depend on whether entry occurs or not.

In the final period with two stages, by observing the price level of the monopolist, the foreign firm, as a potential entrant to this market, makes a decision on entry at the first stage. If it enters, then the entrant bears F as its fixed costs and they will compete in prices like a Bertrand fashion. Otherwise, the incumbent can keep its monopoly position. When entry occurs, the profit maximization problem of each firm is given as follows:

$$\text{(The incumbent monopolist) } \max_{p} [p-(c-s)]D(p,p^*); \text{ and} \tag{3}$$

$$\text{(The foreign firm) } \max_{p^*} (p^*-c^*)D(p^*,p)-F, \tag{4}$$

where $D(p,p^*)$ is the demand function that the incumbent monopolist faces and $D(p^*,p)$ is the demand function that the foreign firm faces. Therefore, the incumbent monopolist does not necessarily set the same price as in the second period. The entry decision by the potential entrant depends on the expected payoff in the Bertrand duopoly game.

Since the incumbent is from the LDC with technological inferiority, we assume that the marginal cost of the incumbent is bigger than that of the entrant: $c > c^*$. We can make further assumptions for economic senses: $a > c > s_H$, $0 < c - s_H < c^*$, and $s_L = 0$. The first and the second assumptions imply that even the biggest level of export subsidies does not entirely support the marginal cost; however, it is big enough to overcome the cost disadvantage of the incumbent firm from the LDC. The third one, $s_L = 0$, is a crucial assumption in this model, because it makes the incumbent unable to enjoy the monopolistic power when the foreign firm enters the market. If the low level of subsidies is not as much as for the incumbent monopolist to be able to compete with the foreign firm, the incumbent will lose the exporting market by the entrant. In this case, the 'no subsidy' policy is better to the government than any small positive amount of export subsidies. The government is worse in the latter in that, without any gain, it only spends subsidies as costs. Then, the government policy is narrowed down to subsidy (s_H) or 'no subsidy' $(s_L = 0)$ in this model. Accordingly, under incomplete information of the export subsidy policy, the foreign firm does not know what policy the government sets, but it knows what the levels of subsidies are. For convenience, we will name the incumbent that receives subsidies

as the high type denoted by *H*, and the one with 'no subsidy' as the low type denoted by *L*. We also assume that there is no cost of sending a signal.

We adopt and use the perfect Bayesian equilibrium to analyze this game of firms because the fundamental game in the second and third periods is the signaling one. In addition, for LDC governments, we adopt a subgame perfection because the government knows all outcomes of the subsequent game as to when it is supposed to set a subsidy policy.

III. BENCHMARK: CASE OF COMPLETE INFORMATION

In this section, we check if the export subsidy policy can improve the incumbent firm's profits and deter entry of the foreign firm. Due to complete information, the foreign firm correctly observes the policy on export subsidy by the government of the LDC. In order to explore this, we try to find a subgame perfect equilibrium (SPE).

A. Stage of Entry Decision

If the entrant starts to export its good, then the profit function for the entrant is: $\pi^* = (p^* - c^*)D(p^*, p) - F$; and that for each type of the incumbent is: $\pi = [p_i - (c - s)]D(p_i, p^*)$, i = *L*, *H*. Since both firms play the price competition game *á la* Bertrand, each firm faces the discontinuous demand function of its own.

First, consider this game between the high type incumbent and the entrant. Since $c - s_H < c^*$, i.e., the incumbent gains a cost advantage over the entrant in producing the good, the incumbent sets the price of the exporting market such that $p = c^*$, and then, he monopolizes the market. Thus, the entrant does not gain from this competition and $\pi^* = -F < 0$. Predicting this, the entrant will not enter this market. Since the high type incumbent knows that it will win in this stage, it can choose the price which maximizes the monopoly profit as in the second period. Although the incumbent is technologically inferior $(c > c^*)$, the high level of subsidy deters the entry successfully.

Second, suppose that the low type incumbent and the entrant compete in price with each other. Since $c - s_L > c^*$, with $s_L = 0$, it will not improve the cost disadvantage at all. Contrary to the first case, the equilibrium price will be $p^* = c > c^*$, which is set by the entrant as that of the entire market. The profit for the entrant is given as follows: $\pi^* = (c - c^*)(a - c) - F$. Assuming that the fixed cost, *F*, is not big enough to have a positive profit, $\pi^* > 0$, one can show that the 'no subsidy' policy, i.e., the low level of subsidy, cannot deter the entry.

B. The Monopolist's Behavior

Understanding the results of the third period game, each type of the incumbent will choose a price to maximize its own type's profit. Because the entrant knows each type of the incumbent in the third period, no matter what the foreign firm does, the monopolist will always pick the monopoly price in the equilibrium. This is simply because the incumbent cannot disguise or cheat its type through pricing under complete information.

C. The Government's Policy

The government of the LDC will set a policy, which leads to bigger welfare between the two. If it chooses a subsidy policy, s_H, then it knows that its incumbent monopolist can keep the monopoly power in the third period; moreover, the national welfare with this policy is given as follows:

$$W_H = \frac{1}{2}[(a - c)^2 - {s_H}^2]. \tag{5}$$

For the 'no subsidy' policy, $s_L = 0$, since $\pi_L = 0$ in the third period; hence, the national welfare of the LDC is:

$$W_L = \frac{1}{4}(a - c)^2. \tag{6}$$

Depending on the values of parameters and the level of subsidy, the subsidy policy will be determined. If $c - c^* < s_H < \sqrt{\frac{1}{2}}(a - c)$, then the government always employs the

subsidy policy. However, $s_H > \sqrt{\frac{1}{2}}(a-c)$ implies that if there is a big difference between the two technologies, then the subsidy policy is not effective such that the 'no subsidy' policy is optimal. The intuition behind this is that even though the incumbent with technological inferiority can earn monopoly profits in both periods by the subsidy policy, as long as the technological differences between the two countries are so big that the amount of subsidies to deter entry exceeds the gain from doing so, the government should abandon the subsidy policy.

This result has very important implications. Brander and Spencer (1985) identified that a positive subsidy always brings more profits to the domestic firm in the Cournot competition and also increases welfare. However, in this entry-deterrence model, the subsidy policy may hurt national welfare if the domestic firm is really far behind the cutting-edge technology. From this result, we can also provide important policy implications to LDCs: governments of LDCs need to consider the technology gap between domestic firms and technology leaders in the world when they consider providing export subsidies to their domestic firms. Therefore, governments of LDCs must focus more on enhancing export and technology capacities of the domestic firms, rather than simply providing export subsidies to them. Summarizing the discussion above, one can have the following results:

Proposition 1 (Equilibrium under Complete Information)

Under complete information,

(i) positive subsidy policy: it can deter entry in the third period, thus the monopoly price is $p_H^m = \frac{1}{2}(a+c-s_H)$ *in both the second and third periods, and monopoly profits are* $\pi_H^m = \frac{1}{4}(a-c+s_H)^2$ *in both periods;*

(ii) 'no subsidy' policy: it cannot deter entry, because in the third period, the incumbent's price is $p=c$*, and then the new producer from the developed country has a positive profit* $\pi^* = (c-c^*)(a-c)-F>0$*, yet, the incumbent has no profits* $\pi = 0$*. In the second period, the monopoly price is* $p_L^m = \frac{1}{2}(a+c)$ *and its profit is* $\pi_L^m = \frac{1}{4}(a-c)^2$*;*

(iii) since $W_H = \frac{1}{2}[(a-c)^2 - s_H{}^2]$ *and* $W_L = \frac{1}{4}(a-c)^2$*, the decision on export subsidy policy depends on the values of parameters and the level of subsidy. Under the condition of* $c-c^* < s_H < \sqrt{\frac{1}{2}}(a-c)$*, the subsidy policy is always chosen; and*

(iv) if the level of the domestic technology is relatively too low, $s_H > \sqrt{\frac{1}{2}}(a-c)$*, then the subsidy policy may not be optimal.*

IV. CASE OF INCOMPLETE INFORMATION

This section discusses if the 'no subsidy' policy can deter entry under incomplete information, which means that all things are common knowledge except for the fact that the potential entrant does not know what kind of policy on subsidy the government will set. Let us set $\theta \in [0,1]$ to be the prior probability that the government chooses the 'no subsidy' policy and $H(p) \in [0,1]$ to be the posterior probability of the 'no subsidy' policy, which is created right after the foreign firm's observing the incumbent's price level in the second period but before entry decision. In order to focus on the signaling role of pricing in the second period, we assume for simplicity that the entrant realizes what type of policy is adopted when it enters the market

From the incumbent monopolist's viewpoint, it knows that a large amount of subsidies lowers the selling price and eventually results in entry-deterrence. Under incomplete information, it will try to show itself as being the high type. The game between firms in the second and third periods is a signaling model of limit pricing in order to discourage entry into a market. Considering what will happen in the third period, the incumbent monopolist signals its type through pricing in the second period. Further, the entrant will have beliefs on the incumbent types depending on the price which it observed. Thus, in order to solve this game, we use the perfect Bayesian equilibrium (PBE), as described by Milgröm and Roberts (1982). Moreover, we explore this game by focusing on separating and pooling equilibria, and also follow the steps of Tirole (1988) in order to solve this game.

A. The Separating Equilibria

In the separating equilibria, the price signal shows the exact type of the incumbent monopolist so that the potential entrant can infer the type correctly.

1) The Third Period

Consider the price competition game between the two firms after entry. Since it is assumed that the entrant realizes the type of the incumbent right after entry, the results are exactly the same as those under complete information. Before entry, however, since the potential entrant can observe only the price set by the monopolist, the entry decision depends on the expected profits based on the posterior probability on the 'no subsidy' policy. Therefore, the entrant's expected profit is given as follows: $\pi_E[H(p)] = H(p)[(c-c^*)(a-c)]-F$. Thus, it will enter as long as its expected profit is non-negative, $\pi_E[H(p)] \geq 0$.

2) The Second Period: The Incumbent's Signaling Game

For the separating equilibria, we need incentive-compatibility (IC) conditions for each type of the monopolist not to deviate from their own pricing. Because the entrant infers the exact type of the monopolist, it will not enter if it observes the price level set by the high type incumbent. Thus, from the low type's perspective, mimicking the high type's pricing seems attractive to the low type, because doing so guarantees the monopoly profits at the subsequent period. However, under the incentive-compatibility conditions, it would not be profitable for the low type domestic incumbent to set a price in the second period as low as the high type would do. In other words, for the low type, mimicking the high type is not profitable compared to the monopoly pricing.

From the high type's viewpoint, the incumbent has no reason to set a price as the low type in the second period because pricing as the low type will make the entrant enter the market. Thus, the high type has a strong incentive to distinguish itself from the low type and hence it sets a price in the second period at a sufficiently low level so as to deter entry, even though its pricing is not to maximize its monopoly profit in the period. The incentive-compatibility conditions for each type are given as follows:[7]

• Incentive-compatibility conditions for the separating equilibria

High type: $\pi_H^m(p) + \pi_H^m \geq \pi_H^m + \pi_H^d$; and (7)

Low type: $\pi_L^m + \pi_L^d \geq \pi_L^m(p) + \pi_L^m$. (8)

In the conditions above, $\pi_i^m(p)$ is the i type's monopoly profit if it sets the price, which is different from its own type's monopoly pricing, while π_i^m is the i type's

[7] Note that these incentive compatibility conditions are necessary and sufficient.

monopoly profit with profit maximizing price. In addition, π_i^d is the duopoly profit for each type, which can be obtained after entry.

Notice that $\pi_i^m = \frac{1}{4}[a-(c-s_i)]^2$ with $p_i^m = \frac{1}{2}(a+c-s_i)$, and that $\pi_H^d = (c^* - c + s_H)(a - c^*)$ with the price of $p = c^*$, while $\pi_L^d = 0$ with the price of $p = c$. Using this, one can easily show that $\pi_i^m > \pi_i^d$ for $i \in \{H, L\}$. Furthermore, one can also show that $\pi_i^m - \pi_i^m(p) \geq 0$, the difference between the maximized monopoly profit and the monopoly profit with the price level other than p_i^m, is a convex function in p and that it has the minimum, *0*, at $p = p_i^m = \frac{1}{2}(a+c-s_i)$. Since $s_H > s_L$, it holds that $p_L^m > p_H^m$. In addition, the following Lemma shows that the difference between the incumbent's profits in the monopoly and those in the duopoly is getting greater with the export subsidies.

Lemma: $(\pi_H^m - \pi_H^d) > (\pi_L^m - \pi_L^d)$.

***Proof*)** By definition, $\pi^m(s) - \pi^d(s)$ = $[\max_p (p-c+s)(a-p)]$ - $[\max_p (p-c+s)D(p,p^*)]$, where $D(p,p^*)$ is the demand that the incumbent faces in the duopoly market when the entrant wants to price its good at p^*. Using the envelope theorem, one can also show that $\frac{\partial}{\partial s}(\pi^m(s) - \pi^d(s))$ = $a - p - D(p,p^*) - (p-c+s)\frac{\partial D}{\partial p^*}\frac{\partial p^*}{\partial s}$. Since $a - p \geq D(p,p^*)$, it holds that $a - p - D(p,p^*) \geq 0$. In addition, the goods produced by the two firms are perfect substitutes, we can show that $\frac{\partial D}{\partial p^*} > 0$. Moreover, price competition implies that $\frac{\partial p^*}{\partial s} \leq 0$. In particular, we can have $\frac{\partial p^*}{\partial s} < 0$ in case of $p^* = c - s > c^*$. Thus, we can finally show that $\frac{\partial}{\partial s}(\pi^m(s) - \pi^d(s)) > 0$. **Q.E.D.**

Moreover, a single-crossing condition holds in this model: $\frac{\partial}{\partial p}\left[\pi_L^m(p) - \pi_H^m(p)\right] > 0$. It implies that the low type monopolist needs more costs than the high type one when

they want to lower the price. With this property, $\pi_H^m - \pi_H^m(p)$ and $\pi_L^m - \pi_L^m(p)$ cross each other only once.

Theorem: Let K be the set of prices satisfying (7) and (8) simultaneously, and assume that $(a-c) > s_H$. Then, there exists a set of prices such that the inequalities (7) and (8) hold, and that any $p \in K$ is less than p_H^m.

Proof) Since $\pi_L^m = \frac{1}{4}(a-c)^2$, $\pi_L^d = 0$, and $\pi_L^m(p) = (p-c)(a-p)$, the inequality (8) turns to be $\pi_L^m(p) = (p-c)(a-p) \le 0$, which implies $p \le c$ or $p \ge a$. Assuming that $(a-c) > s_H$ as before, one can show that $c < p_H^m = \frac{1}{2}(a+c-s_H)$. Let K_1 be the set of prices to solve the inequality (7). Notice that K_1 always exists because $\pi_H^m - \pi_H^m(p)$ is zero at $p_H^m = \frac{1}{2}(a+c-s_H) > c$. By a single-crossing condition, one can finally show that $c \in K_1$ and $a \notin K_1$. Thus, any price in *K* is strictly less than or equal to *c*. **Q.E.D.**

According to Theorem, one can show that p_H^m does not belong to K. In other words, although the low type of the incumbent cheats by setting the price of $p_H^m = \frac{1}{2}(a+c-s_H)$, the entrant does not believe it as the high type. In the separating equilibria, if the entrant observes any $p \in K$, then it will believe that the incumbent receives the high level of subsidies and thus, will not enter. If it observes any other prices, $p \notin K$, no one will believe that the monopolist receives export subsidies from its government and it will enter the market. Therefore, the incumbent will pick $\tilde{p}_H^m = \max_{p \in K} p$ as a reasonable price in order to distinguish itself from the low type. Thus, even though the high type incumbent is unable to set a price at the monopoly price, p_H^m, it can deter entry of the foreign firm by setting a price at $\tilde{p}_H^m$ and hence it can earn monopoly profits at the last period. The theorem above showed that $\tilde{p}_H^m = c$ and thus it is necessary and sufficient for the high type to price, such that $p = c$ in order to show that it is the high type and to deter entry.

3) The Government in the First Period

The government knows that only the positive subsidy policy deters entry, and the results will be exactly the same as those under complete information. This is simply

because in the separating equilibrium, the potential entrant exactly infers the incumbent's type.

4) The Importing Country

Consider national welfare of the importing country. No tariff is assumed to be imposed on any import good. Accordingly, its welfare is consumer surplus, which depends only on the level of the price of the good. Since the entrant can infer the type of the incumbent correctly, it is interesting to compare the importing country's welfare under complete information and that of the separating equilibria environment under incomplete information.

Summarizing the levels of those prices for each case, one can have the following results:

- Under complete information, i) if the incumbent receives subsidies, the level of price is $p = \frac{1}{2}(a + c - s_H)$ in both second and third periods; and ii) if the government sets the 'no subsidy' policy, $p = \frac{1}{2}(a + c)$ in the second period, and $p^* = c$ in the third period.
- In the separating equilibria environment, i) if the incumbent is subsidized, $p = c$ in the second period, and $p = \frac{1}{2}(a + c - s_H)$ in the third period, and ii) if it is not subsidized, $p = \frac{1}{2}(a + c)$ in the second period, and $p^* = c$ in the third period.

As above, in the case that the domestic firm is supported by the export subsidy policy, the level of the price is lower under incomplete information in the second period than that under complete information. It is due to the fact that the high type incumbent wants to be distinguished from the low type in the separating equilibria environment. However, since the low type incumbent does not have any incentive to deviate from its monopoly pricing, the importing country's welfare does not change under both cases when the incumbent is a low type. In conclusion, the importing country prefers the separating equilibria environment to the case of complete information, simply because consumers can purchase the good at a lower price.

Proposition 2 (Separating Equilibria)
Let K be the set of prices such that (7) and (8) hold. In the separating equilibrium environment over the second and third periods,
(i) the high type of the incumbent sets any $p \in K$ *in the second period. Observing this, the potential entrant does not enter the market with belief* $H(p) = 0$*, and the unique reasonable price for the incumbent is* $\tilde{p}_H^m = c$ *with* $(a-c) > s_H$ *in the second period;*
(ii) the low type of the incumbent sets $p_L^m = \frac{1}{2}(a+c) \notin K$ *in the second period. Observing this, the potential entrant enters the market with belief* $H(p) = 1$*, pricing* $p^* = c$ *in the third period, and* $\pi^* = (c-c^*)(a-c) - F > 0$*;*
(iii), (iv) the same as the assertions in (iii) and (iv) of Proposition 1; and
(v) From (i) and (ii), if the incumbent is the high type, national welfare of the importing country is improved compared to that under complete information.

B. The Pooling Equilibria

1) The Entrant's Behavior
In the pooling equilibria, the potential entrant does not infer anything from the price signal of the monopolist in the entry decision stage. Accordingly, unlike the case of the separating equilibria, in particular, the high type incumbent's pricing in the second period cannot act as a signal to distinguish itself from the low type one. In this case, by the entrant's Bayesian updating after observing the price in the second period, its belief on the low type will be the same as the prior probability on the 'no subsidy' policy. That is to say, $H(p) = \theta$. Then, the expected profit for the potential entrant is given as follows: $\pi_E(\theta) = \theta[(c-c^*)(a-c)] - F$.

2) The Monopolist's Pricing in the Second Period
As discussed in the separating equilibria, the pooling equilibria of this game need to satisfy the incentive-compatibility conditions as well.

• **Incentive-compatibility conditions for the pooling equilibria**
High type: $\pi_H^m(p) + \pi_H^m \geq \pi_H^m + \pi_H^d$; and (9)
Low type: $\pi_L^m(p) + \pi_L^m \geq \pi_L^m + \pi_L^d$. (10)

Conditions (9) and (10) imply that for a price to be a pooling equilibrium, it has to deter entry for both types. The reason is as follows. Suppose that the pooling price in the second period does not deter entry. Then, for both types of the incumbent, choosing their static monopoly prices is better than using a pooling price as long as the pooling price is not their monopoly price. Since those are not the same, the pooling equilibrium does not exist. Accordingly, conditions (9) and (10) are satisfied, necessarily. As discussed in the case of the separating equilibria, a single-crossing condition makes both $\pi_H^m - \pi_H^m(p)$ and $\pi_L^m - \pi_L^m(p)$ cross only once.

Let J be the set of pooling prices to satisfy conditions (9) and (10).[8] After assuming $\pi_H^m - \pi_H^m(p_L^m) > (\pi_H^m - \pi_H^d)$ in order to make the setup more realistic and interesting, one can show that $p_L^m \notin J$. In the pooling equilibria, if the entrant observes any $p \in J$, it will assess the price with $H(p) = \theta$. Further, if $\pi_E(\theta) = \theta[(c - c^*)(a - c)] - F > 0$, it will enter; but it will not, otherwise. Thus, the entry decision depends on the value of θ for $p \in J$. However, by the necessary condition, the pooling equilibria hold only with θ such that $\pi_E(\theta) \le 0$. Define $\bar{\theta} \equiv \frac{F}{(c - c^*)(a - c)}$. Unlike the case of the separating equilibria, for $\theta \le \bar{\theta}$, even the low type incumbent can deter entry in pooling equilibria. In other words, for $\theta > \bar{\theta}$, pooling equilibria do not exist. If the potential entrant observes any $p \notin J$, its posterior belief on the low type of the incumbent is 1, i.e., $H(p) = 1$. Thus, it will always enter the market, even though the incumbent is the high type. In the pooling equilibria, the 'no subsidy' policy can deter the entry only when $\theta \le \bar{\theta}$. This is due to the fact that the potential entrant does not have enough information to evaluate the incumbent's type. However, the pooling equilibria do not exist for $\theta > \bar{\theta}$, and it would be better for both types to play their monopoly prices in the second period.

3) The Government's Behavior

In the pooling equilibria environment, the government also sets any policy that engenders higher welfare. Let W_H^p be the government's welfare when it gives a high level of subsidies in the pooling equilibria environment. Then, one can show the following equation:

[8] As long as $2(a - c) \ge s_H$ and is a single-crossing condition, the set of J always exists.

$$W_H^p = \left[\pi_H^m(p) - s_H(a-p)\right] + \left[\pi_H^m - s_H\left(a - p_H^m\right)\right] \text{ such that } p \in J \text{ and } \theta \le \overline{\theta}. \quad (11)$$

Similarly, under the same condition (11), even when the government does not provide the subsidy policy, one can define that $W_L^p = \pi_L^m(p) + \pi_L^m$.

Proposition 3 (Pooling Equilibria)
Let J be the set of prices to satisfy conditions (9) and (10). In the pooling equilibria environment,
(i) both types of the incumbent pick any pooling price $p \in J$*;*
(ii) the potential entrant does not enter if the prior probability on the 'no subsidy' policy is $\theta \le \overline{\theta}$*; and*
(iii) the government chooses the policy on subsidy, depending on W_H^p *and* W_L^p*.*

This result implies that the government can deter entry even without setting the 'no subsidy' policy if the potential entrant has a low prior probability on the 'no subsidy' policy. In the real world, a potential entrant may be unaware of whether the incumbent is subsidized or not due to the uncertainty on policies of LDCs. However, this uncertainty could be a policy of strategic ambiguity, which is a practical policy of being intentionally ambiguous on publicly announcing the information of export subsidies, because the government could successfully deter entry of foreign competitors without providing information on export subsidies.

V. CONCLUSIONS

Even though the WTO allows LDCs to use export subsidies, they have practical difficulty using export subsidies in reality, due to various reasons, such as limited resources of financing, poor management of subsidies, and ineffective outcomes from export subsidies. As motivated from these practical difficulties, this paper focused on technology inferiority that LDCs might have, and also evaluated the effectiveness of export subsidies by exploring the relationship between the export subsidy policy and entry deterrence for the exporting market in a dynamic context.

Since Brander and Spencer (1985), many papers argued that positive export subsidies augment the profit of the subsidized firm through the expansion of its market share. We considered that a domestic firm (monopolist) faces the threat of entry of a foreign firm which, for example, has a technological advantage in production. In Section III, we discussed that under complete information, only the subsidy policy can deter entry, whereas the 'no subsidy' policy cannot, and the incumbent loses the whole market share after entry. In this case, the only way to keep the monopoly power of the incumbent from the LDC in each period is through government provision of the high level of subsidies for its firm. However, since it is financially burdensome for the government of the LDC to provide export subsidies, this paper demonstrated that when there is a big technological difference between the two countries, the export subsidy policy is harmful and ineffective.

In terms of WTO disciplines on subsidies, this result showed that it is not proper for the WTO to simply allow LDCs to use export subsidies without considering the technology inferiority of LDCs. The WTO and other international organizations, such as the World Bank and the UNCTAD, need to work together in order for LDCs to catch up with technology leaders, by designing various programs to disseminate advanced technology as well as for LDCs to embody the cutting-edge technology to their firms. Advanced countries, eager to provide foreign aids to poor countries in the world, must engage more actively to disseminate technology and coordinate their activities of foreign aids and technology diffusion together in order to help LDCs' economic development.

Section IV described the conditions under which even the 'no subsidy' policy can deter entry under incomplete information. In the proper subgame, the separating equilibria do not provide conditions where entry is deterred for the low type, while

the pooling equilibria pricing can deter entry only when the prior probability on the 'no subsidy' policy is sufficiently low. It implies that the government of the LDC has an incentive to use a policy of strategic ambiguity not to disclose information on export subsidies.

This paper used a setup of incomplete information as to whether the incumbent from the LDC was subsidized or not. The potential entrant from an advanced country cannot observe the policy on the export subsidy of the LDC's government, but all others are assumed to be publicly known. Both the incumbent and the government from the LDC knew the foreign firm's belief structure on this private information in this model. As a possible extension of this paper, we can relax this assumption so that both the incumbent and the government from the LDC do not know the entrant's belief structure. Specifically, the foreign firm will not know what policy the government will adopt, and the monopolist and the government will not know the belief of the foreign firm regarding the government's policy. We will leave this topic for future work.

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