

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

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To explore the export subsidy policies in technologically inferior countries, we consider an entry-deterrence model in which firms compete à la Bertrand if entry occurs. Under complete information, only a subsidy policy can deter entry. We also check whether a “no subsidy” policy can deter entry under incomplete information, in which the existence of an export subsidy policy is assumed to be unknown to the foreign firm. In the separating equilibria, it is optimal for the government not to provide export subsidies because they are financially burdensome given the technological inferiority of the domestic firm being subsidized. However, in the pooling equilibria, under certain conditions, even the firm that does not benefit from a subsidy policy can deter the entry of a more technologically advanced firm, thereby granting an incentive for the government to employ a policy of strategic ambiguity in order to prevent the disclosure of information about its export subsidies.

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I. Introduction

Many papers have discussed the various roles of export subsidies. As the classic and seminal paper in this field, Brander and Spencer (1985) employed a Cournot

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duopoly model involving a domestic firm and a foreign firm and then formalized the idea that the export subsidies provided by a government can increase the profits of the domestic firm at the expense of those of the foreign firm by manipulating the strategic relationship between these firms. This hypothesis suggests that export subsidies are attractive strategic policies because they not only increase the profits of domestic firms by giving them a larger market share but also enhance the welfare of the country.

However, the World Trade Organization (hereinafter WTO) disciplines its members for their use of subsidies and prohibits the issuance of export subsidies¹ because they can distort trade among its member countries. Inspired by Brander and Spencer (1985), some papers have supported the philosophy of regulating trade-distorting policy tools. For instance, by employing the Cournot oligopoly model, Collie (1992) showed that export subsidies can deter the entry of foreign competitors by increasing the number of domestic firms and simultaneously reducing the number of foreign firms in the market. Collie and Hviid (1993) explored the possibility that under incomplete information about costs, export subsidies play the role of signals that indicate the competitiveness of a firm; therefore, the large amount of subsidies issued by the domestic government may drive a foreign firm to reduce its estimates of the marginal costs of a given domestic firm. They added that signaling the competitiveness of a domestic firm based on its available export subsidies is similar to providing the domestic firm with a first-mover advantage as discussed in Brander and Spencer (1985).

Realizing the importance of subsidies in developing countries, the WTO stipulates that least developed countries (LDCs)² and developing countries with less than \$1,000 GNP per capita are exempted from its prohibition of export subsidies.³ Such exemption allows LDCs and some developing countries to finance their exporters, which is consistent with their development needs.

However, LDCs face extreme difficulties in exporting their products because these products have a low technology level and are therefore not competitive enough in the world market. Given their inferior technology, simply allowing LDCs to employ export subsidies will not help them gain a competitive position in the market.

Therefore, the main objective of this paper is to explore the potential impacts of

¹ Article 3.1 of the WTO Agreement on Subsidies and Countervailing Measures stipulates 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 the lowest indicators of socioeconomic development, such as income, economic vulnerability, and human assets, as LDCs. As of August 2018, there are 47 LDCs in the world.

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

export subsidies on LDCs when the exporting firms of these countries are technologically inferior to foreign firms from highly advanced countries that they are competing with in an exporting market. Can the government of LDCs deter the entry of technology leaders to such a market by using export subsidies? If so, is it possible for the government to deter entry without providing export subsidies when it is uncertain whether or not its own exporting firms are subsidized?

To answer these research questions, we adopt a three-period market entry-deterrence model in which firms compete *à la Bertrand* if market entry occurs.⁴ This model includes three countries, namely, the home exporting country (an LDC), a foreign exporting country (a developed country), and an importing country. For simplicity, we assume that each exporting country has a single firm producing a homogeneous good. The domestic firm in the LDC initially occupies the entire export market as a monopolist and then faces the threat of entry from a foreign firm based in a technologically more advanced country. In this context, can the export subsidy policy of the LDC government deter the entry of this technologically advanced firm? The answer depends on the amount of export subsidies provided by the LDC government to the LDC firm. If the export subsidies are too low that they cannot overcome the technological inferiority of the LDC firm, then the entry of the foreign firm cannot be deterred. However, if the amount of subsidies is high enough for the LDC firm to win in this price competition, then the subsidy policy can deter the entry of the foreign firm. However, even if such subsidies benefit the LDC firm, problems arise when these subsidies entail high costs for the LDC government. Specifically, providing many subsidies to enhance the competitiveness of the domestic LDC firm may harm the national welfare of the LDC.

This research offers several contributions to research and policy. Previous studies on strategic trade policy have shared differing views on export subsidies based on the traditional perspective toward the strategic and positive roles of export subsidies as discussed above. For example, Bagwell and Staiger (1997) revealed that in a natural monopoly market, exporting countries are indifferent about the outcomes of situations involving or not involving subsidies. Moore and Suranovic (1993) found that if lobbying costs are considered, then an export subsidy policy may not improve the national welfare of the subsidizing country. Kang (2006, 2009) considered various issues related to R&D subsidies and the impact of protecting intellectual property rights on R&D outcomes by extending the discussion to R&D subsidies. Etro (2010) showed how the endogenous entry of international firms into an integrated market affects the optimal subsidy in terms of domestic production.

This work also investigates the possibility for the government to deter the entry of foreign firms without providing any export subsidy to its exporting firms under

⁴ The key results of this paper also hold when quantity competition, rather than price competition, is adopted for the model after market entry. See the third part of Section 4.

incomplete information (which is not possible at all under complete information). Unlike Collie and Hviid (1993), the proposed entry-deterrence model assumes that the policy of the government for export subsidies is unknown to the foreign firm.⁵ Given the private nature of such information, only the domestic firm, as a recipient of the subsidy, is cognizant of such a policy. Meanwhile, as a market entrant, the foreign firm must decide on whether to enter the market despite not knowing the policy adopted by the government. In this situation, the price level set by the domestic firm in the previous period can act as a signal that allows the market entrant to infer the type of the incumbent. On the one hand, if the incumbent (domestic firm) receives subsidies, then it will try to demonstrate its competitiveness in order to deter entry by setting a low price. On the other hand, if the government does not subsidize the domestic firm, then this firm may try to pass itself off as competitive. Following the limit pricing model of Milgröm and Roberts (1982), the perfect Bayesian equilibrium concept for the subgame will be adopted by the firms in this context to deal with the aforementioned problem. In the separating equilibria, as the market entrant correctly infers the type of the domestic firm (i.e., whether or not the domestic firm receives subsidies and to what degree does it receive such subsidies), only a firm that benefits from a subsidy policy (i.e., a high level of subsidies) can deter entry. However, in the pooling equilibria, under certain conditions, even the firm *without* a subsidy policy can deter entry by setting a price for the relevant goods that differs from the true monopoly price. The price level in the separating equilibria is lower than that under complete information. The implication is that the subsidized firm wants to reduce the price to a reasonable level in order to deter entry, while the firm that does not benefit from subsidies cannot undercut its competitor by setting the same price.

This paper also offers implications for LDC policymakers and international organizations that aim to help these countries. We demonstrate that WTO must not 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 UNCTAD, need to work together to help LDCs catch up with technology leaders by designing various programs to disseminate advanced technologies and by allowing LDCs to disseminate cutting-edge technologies among their firms.

This paper is organized as follows. Section II illustrates the research model.

⁵ As pointed out by an anonymous referee, considering private information related to the technologies of firms is appropriate. However, many studies, including Qiu (1994), Brainard and Martimort (1996), Maggi (1999), and Grossman and Maggi (1999), have focused on the impact of asymmetric information on the cost parameters of firms, the demand conditions in the targeted industry, and the nature of oligopolistic conduct, among others. This paper only focuses on the impact of asymmetric information about the subsidy policy on both the domestic government/firm and the foreign firm.

Sections III and IV discuss the entry deterrence game involving an export subsidy policy under complete and incomplete information, respectively. Section V concludes the paper.

II. The Model

Following Brander and Spencer (1985), we consider two exporting countries, namely, a home country (no “*”) and a foreign country (“*”), which are assumed to export a single homogeneous good to a third importing country. We presume that the home country is an LDC and that the foreign country is a developed country with highly advanced technology that is designed to produce this good. Each of the two exporting countries has only one firm producing the good. We assume that the importing country does not impose tariffs on the good and that the demand for this good is significant enough to lead to the importation of all stocks supplied by these exporting firms.

In Bagwell and Staiger (1997), the natural monopoly market is examined based on the market structure of the importing country. In the entry-deterrence model, only a monopolist can enjoy profits while duopoly firms do not gain anything from the price competition. Suppose that a firm from the LDC initially gains monopoly power in the market of the third country. This specification is very compatible with the real situation being faced by LDCs in export markets because firms from LDCs are not technologically competitive and hence can only enjoy profits in a small market where only a single firm can be profitable. For example, suppose that a firm from Cambodia enjoys a monopolist's profit in the clothing market of Laos where domestic producers are technologically inferior to Cambodian producers. Therefore, Laos imports clothes from its neighbor, Cambodia. The monopolist firm from Cambodia then faces threat of entry from a foreign firm, such as a Chinese firm, which has better technology and can produce the same good at a lower cost. However, unlike Brander and Spencer (1985), we assume that if a foreign firm enters the market, then this firm will compete in price *à la* Bertrand with another foreign firm that is already operating in this market. The new entrant can win the price competition even without subsidies, while the incumbent firm cannot survive without receiving sufficient subsidies from its government because of its technological inferiority and high production costs.

Given that this paper examines the role of export subsidies in technologically inferior LDCs as well as the relationship between the export subsidy and entry deterrence policies of LDCs, we assume that only the domestic firm can only be supported by the LDC government through the use of export subsidies and that the foreign advanced country cannot employ an export subsidy policy. As discussed above, this scenario is highly realistic because the WTO prohibits its member

countries from offering export subsidies yet exempts LDCs from this prohibition.

To view the entry-deterrence model at its simplest form, the LDC government is assumed to issue two types of subsidies, namely, high- (s_H) and low-level subsidies (s_L). The exporter from the LDC knows the exact subsidy level that it will receive from the government. In the complete information scenario, the foreign firm is aware of the level of subsidies given to the exporter from the LDC. By contrast, in the incomplete information scenario, we assume that the foreign firm is not aware of the level of subsidies given to the exporter from the LDC yet is aware of the distribution of subsidies and produces estimations on the basis of this distribution, with θ and $(1-\theta)$ denoting that s_L and s_H are in place, respectively. Assume that all other issues are publicly known except for the level of export subsidy, which is private information available only to the exporter from the LDC. In other words, the export subsidy policy adopted by the LDC government is known to the exporter from the LDC yet is unknown to the foreign firm. However, despite lacking information about the type of subsidy, the foreign firm is aware of or has complete information on the price level set by the exporter from the LDC, which currently holds a monopolist position in the market of the third importing country. In these circumstances, the monopolist sends a signal to its potential rival by setting a price that demonstrates its circumstances even though such circumstances are determined by the LDC government. This “signal” significantly differentiates the entry-deterrence model from the existing signal models. Specifically, in this model, the government, which has its own objective function, serves as the entity that determines the status of the LDC firm, while in a normal scenario, the status of a firm is determined purely by market forces without any conscious function.

Consider a three-period model in which the last period has two stages. The first period is the policy decision stage in which the government of the LDC chooses the export subsidy level from two alternatives (s_H, s_L), thereby maximizing its domestic welfare (i.e., the profits of the domestic firm in all periods minus the cost of financing its export subsidies). For simplicity, we assume that the LDC government commits itself to maintaining an equal amount of export subsidies to its domestic firm in each period after selecting the optimal level of subsidies. In this case, the problem of the government can be expressed as follows:

$$\max_s \pi^m(s) - sq^m(s) + \delta[\pi(s) - sq(s)], \quad (1)$$

where s is the subsidy rate, sq is the total amount of subsidies, π^m is the monopoly profit in the first period, q^m is the optimal level of monopoly output, π is the profit of the incumbent (domestic firm) in the second period, and q is the optimal output of the incumbent after the entry decision of the foreign firm.⁶

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

We assume that the government and the firm discount the future value (i.e., $\delta \in (0,1)$ is the discount factor).

The second period relates to the actions of the monopolist firm from the LDC, which must set a price level (p) for the export good that can maximize its profit over all periods after observing the subsidy policy of the government. This case can be expressed as follows:

$$\max_p D(p)p - (c-s)D(p) + \delta\pi(s), \quad (2)$$

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

In the final period that consists of two stages, after observing the price level of the monopolist, the foreign firm, as a potential entrant to this market, makes a decision with regard to its entry at the first stage. If this firm enters the market, then it bears F as its fixed costs. Afterward, both the incumbent and entrant firms compete in terms of price á la Bertrand. Otherwise, the incumbent maintains its monopoly position. When market entry occurs, the profit maximization problem of each firm is expressed as follows:

$$(\text{The incumbent LDC monopolist}) \max_p [p - (c-s)]D(p, p^*) \quad \text{and} \quad (3)$$

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

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

Given that the incumbent firm is from the technologically inferior LDC, we assume that the marginal cost of the incumbent is higher than that of the entrant, that is, $c > c^*$. We also make the following assumptions for economic senses: $a > c > s_H$, $0 < c - s_H < c^*$, and $s_L = 0$. The first and second assumptions imply that even the highest level of export subsidies does not entirely support the marginal cost; however, these subsidies are high enough to overcome the cost disadvantage of the firm. The third assumption, $s_L = 0$, plays a crucial role in the entry-deterrence model as it implies that the incumbent is unable to enjoy a monopolistic position when the foreign firm enters the market. If the low level of subsidies is not sufficient for the incumbent monopolist to compete effectively with the foreign firm, then the incumbent will lose its export market to the entrant. In this case, the “no subsidy” policy is better than the issuance of a small amount of export subsidies from the perspective of the government. The government places itself in a worse position in

the latter case such that its subsidies only entail costs and do not produce any gains. As a result, the government policy narrows down to the options of subsidy (s_H) or “no subsidy” ($s_L = 0$) in the entry-deterrence model. Accordingly, in a situation with incomplete information about the export subsidy policy, the foreign firm is unaware of the policy adopted by the government but knows about the levels of subsidies. For convenience, we denote the “high type” incumbent that receives high subsidies by H and the “low type” incumbent without any subsidy by L . We also assume that sending a signal about the subsidies does not entail any costs.

We adopt the perfect Bayesian equilibrium to analyze the signaling game among the firms in the second and third periods. We also assume a perfect subgame in the case of the LDC government because this government knows about all the outcomes of the ensuing game in terms of when a subsidy policy must be established.

III. Benchmark: The Case of Complete Information

In this section, we examine whether an export subsidy policy can increase the profits of the incumbent firm and deter the entry of the foreign firm under complete information. Given the availability of complete information, the foreign firm correctly assesses the export subsidy policy adopted by the LDC government. To explore this issue further, we attempt to identify the subgame perfect equilibrium (SPE).

3.1. Stage of Entry Decision

If the entrant starts to export its good, then its profit function is $\pi^* = (p^* - c^*)D(p^*, p) - F$ while that of each type of incumbent is $\pi = [p - (c - s)]D(p, p^*)$, $i = L, H$. Given that these firms compete with each other á la Bertrand, each of them faces a unique discontinuous demand function.

First, consider the game between the high type incumbent and the entrant. Given that $c - s_H < c^*$, that is, the incumbent gains a cost advantage over the entrant in producing the good, the incumbent sets the price of the good in the export market such that $p = c^*$ and then gains a monopolist position in the market. Therefore, the entrant does not gain from this competition and $\pi^* = -F < 0$. Meanwhile, by successfully predicting this outcome, the potential entrant decides not to enter this market. Given that the high type incumbent knows that it will win in this stage, it can choose the price at which it can maximize its monopoly profit similar to what is observed in the second period. Although the incumbent is technologically inferior ($c > c^*$), the high level of subsidy it receives from the government successfully

deters the entry of the foreign firm into the market.

Second, suppose that the low type incumbent and the entrant compete with each other in terms of price. Given that $c - s_L > c^*$ with $s_L = 0$, gaining an export subsidy cannot help the incumbent secure a cost advantage. Unlike in the first case, the equilibrium price that applies to the entire market will be $p^* = c > c^*$ and is set by the entrant. The profit of the entrant is given by $\pi^* = (c - c^*)(a - c) - F$. Assuming that the fixed cost F is not large enough to ensure a positive profit, $\pi^* > 0$, the “no subsidy” policy (i.e., the low level of subsidy) cannot deter the market entry of the foreign firm.

3.2. The Monopolist's Behavior

In the third period game, each type of incumbent chooses a price that will maximize its profit. Given that the entrant knows the type or status of each incumbent in this period, the monopolist will always pick the monopoly price in the equilibrium regardless of the action of the foreign firm because the incumbent cannot disguise its type through pricing under complete information.

3.3. The Government's Policy

The LDC government implements a policy that increases its own welfare and that of the exporting firm. If it chooses a subsidy policy, s_H , then the LDC government knows that its incumbent monopolist can maintain its monopoly power in the third period and that the welfare of the LDC in light of this policy is given by $W_H = \frac{1}{4}(1 + \delta)[(a - c)^2 - s_H^2]$. Meanwhile, in the “no subsidy” policy, $s_L = 0$, given that $\pi = 0$ in the third period, the welfare of the LDC is expressed as $W_L = \frac{1}{4}(a - c)^2$.

The optimal subsidy policy will be determined based on the values of parameters and the level of subsidy. We define $\bar{s}_H \equiv \sqrt{\frac{\delta}{1+\delta}}(a - c)$ as the highest subsidy rate at which the subsidy policy can effectively deter the entry of foreign firms. Conversely, if $c - c^* < \bar{s}_H$, then the LDC government can set a subsidy rate s_H that successfully deters the entry of foreign firms. Therefore, the subsidy policy is optimal. However, if $c - c^* \geq \bar{s}_H$, then this policy is not optimal. The logic behind this insight is discussed as follows. Although the technologically inferior incumbent can earn monopoly profits in both periods by adopting a subsidy, the LDC government must abandon its subsidy policy when the technological gap between the two countries remains very wide to the point that the cost of the subsidies aimed at deterring entry exceeds the expected gains.

This result has crucial implications. Brander and Spencer (1985) demonstrated that a positive subsidy always accrues more profits for the domestic firm in a Cournot competition and can enhance the welfare of the LDC. However, in the

entry-deterrence model, the subsidy policy may damage the national welfare if the domestic firm is very far behind in terms of cutting-edge technology. These findings also suggest important policy implications for LDCs. Specifically, LDC governments must consider the technology gap between domestic firms and global technology leaders when assessing the possibility of providing export subsidies to their domestic firms. Therefore, these governments must focus more on enhancing the export and technology capacities of their domestic firms instead of simply providing them with export subsidies. Based on the above discussion, we present the following results.

Proposition 1 (Equilibrium under Complete Information)

Under complete information,

- (i) *the positive subsidy policy can deter entry in the third period. Therefore, the monopoly price is $p_H^m = \frac{1}{2}(a+c-s_H)$ in both the second and third periods, while the monopoly profits are $\pi_H^m = \frac{1}{4}(a+c-s_H)^2$ in both periods;*
- (ii) *the “no subsidy” policy cannot deter entry in the third period. Therefore, the entrant from the developed country sets its price at $p^* = c$ and receives a positive profit $\pi^* = (c-c^*)(a-c) - F$, while the incumbent gains no profits $\pi = 0$ in the third period. In the second period, the incumbent charges a monopoly price $p_L^m = \frac{1}{2}(a+c)$ and reaps the profit $\pi_L^m = \frac{1}{4}(a+c)^2$;*
- (iii) *given that $W_H = \frac{1}{4}(1+\delta)[(a-c)^2 - s_H^2]$ and $W_L = \frac{1}{4}(a-c)^2$, the decision of the LDC government to adopt the export subsidy policy depends on the values of parameters and the level of subsidy. Under the condition of $c - c^* < \bar{s}_H$, a subsidy policy is always chosen;*
- (iv) *by contrast, if $c - c^* \geq \bar{s}_H$, then the “no subsidy” policy is optimal.*

IV. The Case of Incomplete Information

This section discusses whether the “no subsidy” policy can deter entry under incomplete information, which means that all issues are common knowledge except for the fact that the potential entrant does not know what type of subsidy policy the government will implement. Let $\theta \in [0,1]$ denote the prior probability for the government to choose the “no subsidy” policy and $H(p) \in [0,1]$ denote the *a posteriori* belief that the “no subsidy” policy is in place and will be updated immediately after the foreign firm becomes aware of the price level of the incumbent in the second period and before making an entry decision. To focus on the signaling role of pricing in the second period, we assume that the entrant only makes an accurate assessment of the type of adopted policy after its entry into the market.

The incumbent monopolist knows that having a large amount of subsidies can

reduce the sales price of the good and eventually deter the entry of foreign firms. Under incomplete information, the monopolist will try to demonstrate that it is a high type firm. In the second and third periods, the firms enter a signaling game of limit pricing in which they attempt to discourage each other from entering the market. Based on what will happen in the third period, the incumbent monopolist signals its type via pricing in the second period. Moreover, the entrant assesses the type of the incumbent by observing its set price. To assess this game, we use the perfect Bayesian equilibrium (PBE) described in Milgröm and Roberts (1982). Specifically, following the steps cited in Tirole (1988), we explore the separating and pooling equilibria.

4.1. The Separating Equilibria

In the separating equilibria, the price signal demonstrates the exact type of the incumbent monopolist in order for the potential entrant to infer its type correctly.

4.1.1 The Third Period

Consider the price competition game between the two firms after the entry of the foreign firm. When the entrant is assumed to accurately assess the type of the incumbent immediately after its entry, the results are exactly the same as those under complete information. However, before entry, given that the potential entrant only observes the second period price set by the monopolist, its entry decision depends on its expected profits, which in turn are based on the *a posteriori* probability of the “no subsidy” policy taking effect. Therefore, the expected profit of the entrant is given by $\pi_E[H(p)] = H(p)[(a-c)(c-c^*)] - F$. In this case, the entrant will enter the market as long as its expected profit is non-negative (i.e., $\pi_E[H(p)] \geq 0$).

4.1.2. The Second Period: The Incumbent’s Signaling Game

For the separating equilibria, we observe incentive-compatibility (IC) conditions in order for each type of monopolist to avoid deviating from its own pricing. By precisely inferring the type of monopolist in this equilibrium, the entrant will not enter the market only when it observes the price level set by a high type incumbent. Therefore, from the perspective of the low type firm, mimicking the pricing of the high type firm seems an attractive option because doing so guarantees monopoly profits in the subsequent period. However, under IC conditions, setting a low price in the second period (as the high type firm would) will not be profitable for the low type incumbent. In other words, for the low type firm, mimicking the high type price in the second period is not as profitable as monopoly pricing.

The high type incumbent has no reason to set a price in the same way as the low type would in the second period because such pricing will only lure the entrant into

the market. Therefore, the high type incumbent has a strong incentive to distinguish itself from the low type incumbent and hence sets a sufficiently low price in the second period to deter entry and not to maximize its monopoly profit in the second period. The IC conditions for each type are given as follows:

- IC conditions for the separating equilibria

$$\text{High type: } \pi_H^m(p) + \delta\pi_H^m \geq \pi_H^m + \delta\pi_H^d, \text{ or } \pi_H^m - \pi_H^m(p) \leq \delta(\pi_H^m - \pi_H^d) \text{ and } (5)$$

$$\text{Low type: } \pi_L^m + \delta\pi_L^d \geq \pi_L^m(p) + \delta\pi_L^m, \text{ or } \pi_L^m - \pi_L^m(p) \geq \delta(\pi_L^m - \pi_L^d). \quad (6)$$

In the above conditions, $\pi_i^m(p)$ denotes the monopoly profit of the i type when setting the price p , which may be different from the monopoly price p_i^m of its own type. Note that $\pi_i^m(p) = (a-p)(p-c+s_i)$ is strictly concave in p . π_i^m denotes the monopoly profit of the i type based on a profit maximizing price. π_i^d is the duopoly profit of each type that can be obtained after entry. Note that $\pi_i^m = \frac{1}{4}[a-(c-s_i)]^2$ with $p_i^m = \frac{1}{2}(a+c-s_i)$, $\pi_H^d = (a-c^*)(c^*-c+s_H)$ with the price of $p=c^*$, and $\pi_L^d=0$ with the price of $p=c$. Therefore, one can easily observe that $\pi_i^m > \pi_i^d$ for $i \in \{H, L\}$, that $\pi_i^m - \pi_i^m(p) \geq 0$, that the difference between the maximized and monopoly profits with a price level other than p_i^m is a strictly convex function in p , and that such difference is at its minimum, 0, at $p = p_i^m = \frac{1}{2}(a+c-s_i)$. Given that $s_H > s_L = 0$, it holds that $p_L^m > p_H^m$.

The following single-crossing condition holds in this model: $\frac{\partial}{\partial p}[\pi_L^m(p) - \pi_H^m(p)] > 0$. This condition implies that while the profit of the low type monopolist is lower than that of the high type monopolist at a given price, the gap between these two firms becomes narrower. With this property, $\pi_H^m - \pi_H^m(p)$ and $\pi_L^m - \pi_L^m(p)$ cross each other only once. As a result, we obtain the following Theorem.

Theorem. Let K denote the set of prices satisfying (5) and (6) simultaneously, only if these prices exist. Then, for $s_H < (a-c)\sqrt{\delta}$, any $p \in K$ is strictly less than p_H^m .

Proof: Given that $\pi_L^m = \frac{1}{4}(a-c)^2$ and $\pi_L^d = 0$, the inequality (6) can be rewritten as $\pi_L^m(p) \leq (1-\delta)\frac{1}{4}(a-c)^2$, where $\pi_L^m(p) = (a-p)(p-c)$. With $\delta \in (0,1)$, two price levels can yield $\pi_L^m(p) = (1-\delta)\frac{1}{4}(a-c)^2$. Let \bar{p} denote the lower level of these two price levels. In the case of a single-crossing condition, \bar{p} denotes the maximum of K . Upon calculation, we obtain $\bar{p} = \frac{1}{2}[(a+c) - (a-c)\sqrt{\delta}]$. Given that $p_H^m = \frac{1}{2}(a+c-s_H)$, we find that $p_H^m - \bar{p} = \frac{1}{2}[(a-c)\sqrt{\delta} - s_H] > 0$ for $s_H < (a-c)\sqrt{\delta}$.

The above theorem implies that the separating equilibria can exist when the subsidy rate is sufficiently low. In such equilibria, although the low type incumbent feigns being a high type by setting the price at $p_H^m = \frac{1}{2}(a + c - s_H)$, the entrant does not believe it to be a high type firm. Specifically, in the separating equilibria, if the entrant observes any $p \in K$, then it will believe that the incumbent receives a high level of subsidies and will therefore not enter the market. By contrast, if the entrant observes any other prices not belonging to K , $p \notin K$, then it will believe that the monopolist does not receive export subsidies from its government and will therefore enter the market. Given that $\pi_H^m(p)$ strictly increases in $p \in K$, the high type incumbent will select $p' = \max_{p \in K} p$ as a reasonable price in order to distinguish itself from the low type incumbent. In other words, even though the high type incumbent is unable to set a monopoly price p_H^m , this firm can deter the entry of a foreign firm by setting the price at p' and can therefore earn monopoly profits in the final period. Therefore, the high type incumbent must choose p' in order to show that it is truly a high type firm and to deter the entry of the foreign firm. In other words, the IC condition with $s_H < (a - c)\sqrt{\delta}$ holds for the separating equilibria. If the subsidy rate is too high (i.e., $s_H \geq (a - c)\sqrt{\delta}$), then p_H^m will be too low and belong to K . Contrary to the IC condition, these findings suggest that p_H^m deters entry.

4.1.3. The Government in the First Period

The government knows that only a positive subsidy policy can deter the entry of foreign firms because in the separating equilibrium, the potential entrant precisely infers the incumbent's type by observing the second period price. Unlike the case with complete information, when the government provides the incumbent with a high level of subsidies, this firm chooses p' instead of the monopoly price p_H^m in the second period. Therefore, the welfare of the LDC in light of the subsidy policy can be expressed as $W_H^S = \frac{1}{4}[(a - c)^2 - \delta s_H^2]$. When the "no subsidy" policy is chosen, the welfare of the LDC is expressed as $W_L^S = \frac{1}{4}(a - c)^2$. Given that $W_H^S < W_L^S$ with $s_H > 0$, the "no subsidy" policy is optimal. Unlike the case with complete information, the LDC government adopts the "no subsidy" policy when the separating equilibrium in the decisions after the first period is expected to exist, in which the entrant can accurately infer the type of the incumbent similar to the case with complete information.

Proposition 2 (Separating Equilibria)

Let K be the set of prices such that (5) and (6) hold. In the separating equilibrium environment over the second and third periods,

- (i) the high type incumbent chooses $\bar{p} = \frac{1}{2}[(a + c) - (a - c)\sqrt{\delta}]$ for $s_H < (a - c)\sqrt{\delta}$ in the second period. To this end, the potential entrant does not enter the market with the belief that $H(p) = 0$;
- (ii) the low type incumbent chooses $p_L^m = \frac{1}{2}(a + c) \notin K$ in the second period. To this

end, the potential entrant enters the market with the belief that $H(p)=1$ and charges $p^*=c$ in the third period; and
 (iii) given that $W_H^S = \frac{1}{4}[(a-c)^2 - \delta s_H^2]$ with the subsidy policy and $W_L^S = \frac{1}{4}(a-c)^2$ with the “no subsidy” policy, the latter is always selected.

4.2. The Pooling Equilibria

4.2.1. The Entrant’s Behavior in the Third Period

In the pooling equilibria, the potential entrant does not infer anything from the price signal of the monopolist at the entry decision stage. Unlike the separating equilibria, the pricing of the high type incumbent in the second period cannot act as a signal that distinguishes this firm from the low type firm. In this case, since the entrant applies Bayesian updating to improve its prior probability after observing the second period price, its belief on the low type firm will be the same as its prior probability in light of the “no subsidy” policy. In other words, $H(p)=\theta$. Consequently, the expected profit of the potential entrant is given as $\pi_E[\theta]=\theta(a-c)(c-c^*)-F$.

4.2.2. The Monopolist’s Pricing in the Second Period

As discussed in terms of the separating equilibria, the pooling equilibria of this game also need to satisfy the IC conditions.

- IC conditions for the pooling equilibria

$$\text{High type: } \pi_H^m(p) + \delta\pi_H^m \geq \pi_H^m + \delta\pi_H^d, \text{ or } \pi_H^m - \pi_H^m(p) \leq \delta(\pi_H^m - \pi_H^d) \text{ and (7)}$$

$$\text{Low type: } \pi_L^m(p) + \delta\pi_L^m \geq \pi_L^m + \delta\pi_L^d, \text{ or } \pi_L^m - \pi_L^m(p) \leq \delta(\pi_L^m - \pi_L^d). \quad (8)$$

Conditions (7) and (8) imply that in order to represent a pooling equilibrium, the price must deter the entry of both types of incumbent firms. Suppose that the pooling price in the second period does not deter entry. Therefore, for both types of incumbent firms, the selection of static monopoly prices is more effective than the use of a pooling price as long as the pooling price is not the monopoly price. Given that these two prices are dissimilar, the pooling equilibrium does not exist. Accordingly, conditions (7) and (8) are satisfied. As discussed in the case of the separating equilibria, a single-crossing condition allows $\pi_H^m - \pi_H^m(p)$ and $\pi_L^m - \pi_L^m(p)$ to cross only once.

Let J be the set of pooling prices that satisfy conditions (7) and (8). In the pooling equilibria, if the entrant observes any $p \in J$, then it will assess the price with $H(p)=\theta$. Furthermore, if $\pi_E[\theta]=\theta(a-c)(c-c^*)-F > 0$, then the entrant will enter the market but will not otherwise. Therefore, the entry decision of this

firm depends on the value of θ for $p \in J$. However, the pooling equilibria hold only with θ such that $\pi_E[\theta] \leq 0$. We define $\bar{\theta} \equiv \frac{F}{(a-c)(c-c^*)}$. Unlike the case of the separating equilibria, for $\theta \leq \bar{\theta}$, even the low type incumbent can deter entry in the pooling equilibria. In other words, the pooling equilibria do not exist in the case of $\theta > \bar{\theta}$. If the potential entrant observes any $p \notin J$, its *a posteriori* belief on the low type incumbent is 1 (i.e., $H(p)=1$). Therefore, this entrant enters the market even if the incumbent is of the high type. In the pooling equilibria, the “no subsidy” policy can deter entry only when $\theta \leq \bar{\theta}$ because the potential entrant does not have enough information to evaluate the type of the incumbent. However, the pooling equilibria do not exist for $\theta > \bar{\theta}$, and it would be better for both types of incumbents to set their monopoly prices in the second period.

4.2.3. The Government's Behavior

In the pooling equilibria environment, the government sets a policy that engenders a higher level of national welfare. Let W_H^P be the national welfare of the LDC when the government adopts the subsidy policy in the pooling equilibria environment. W_H^P is expressed as

$$W_H^P = [\pi_H^m(p) - s_H(p)] + \delta[\pi_H^m - s_H(a - p_H^m)], \text{ such that } p \in J \text{ and } \theta \leq \bar{\theta}. \quad (9)$$

Under the same condition applied to (9), when the government does not establish a subsidy policy, one can show that $W_L^P = \pi_L^m(p) + \delta\pi_L^m$. By definition, $\pi_H^m(p) - s_H(a - p) = \pi_L^m(p)$ and $\pi_H^m - s_H(a - p_H^m) < \pi_L^m$ with $p_i^m = \frac{1}{2}(a + c - s_i)$, $i \in \{L, H\}$. Therefore, it is clear that $W_H^P < W_L^P$. To maximize the national welfare, the LDC government adopts the “no subsidy” policy.

Proposition 3 (Pooling Equilibria)

Let J be the set of prices that satisfy conditions (7) and (8). In the pooling equilibria environment,

- (i) both types of incumbents select any pooling price $p \in J$;
- (ii) the potential entrant does not enter the market if the prior probability of the “no subsidy” policy is $\theta \leq \bar{\theta}$; and
- (iii) the government chooses the “no subsidy” policy.

This result implies that the government can deter entry even without providing subsidies to the incumbent if the potential entrant has previously assessed the low prior probability of the “no subsidy” policy. In the real world, a potential entrant may be unaware of whether the incumbent is subsidized or not due to its uncertainty about the policies of the LDC government. However, this uncertainty may result from a policy of strategic ambiguity, which entails intentional ambiguity

about the existence of export subsidies that allows the government to successfully deter the market entry of foreign competitors without providing information about export subsidies.

4.2.4. Comparison

When incomplete information about the subsidy policy is available, the “no subsidy” policy is considered optimal for the LDC government. However, the assessments of the results differ depending on whether the environment is constituted by the separating or pooling equilibria in the second and third periods. In the separating equilibria environment, the high type incumbent sets a sufficiently low price level to distinguish itself from the low type incumbent and to subsequently deter the entry of foreign firms. However, the profits derived from this strategy are lower than the profits from monopoly pricing. This strategy also requires a sufficiently large amount of subsidies, thereby making the subsidy policy less attractive. Unlike the separating equilibria environment, the “no subsidy” policy can deter entry in the pooling equilibria environment.

4.3. Assessing the Sensitivity of the Result to the Nature of the Competition

We examine whether the aforementioned result is sensitive to the mode of competition and the price versus quantity of the good. As a subsidy, the optimal policy of a general strategic trade model is sensitive to the nature of the competition involved as shown in Eaton and Grossman (1986). With everything else being equal, we check the robustness of the result by assuming that the firms are competing in a Cournot fashion than engaging in a Bertrand competition. For simplicity, we assume that the parties do not discount the future value (i.e., $\delta = 1$).

First, consider the case of complete information. By solving (3) and (4) with respect to the quantity of the good instead of its price, one can determine the Nash output levels under Cournot competition as follows:

$$q_i = \frac{1}{3}[a - 2(c - s_i) + c^*] \quad \text{and} \quad q^* = \frac{1}{3}[a + (c - s_i) - 2c^*]. \quad (9)$$

By using these output levels, one can show the following key outcomes of this game, including the price and profits in each case: $p = \frac{1}{3}[a + (c - s_i) + c^*]$, $\pi_H^d = \frac{1}{9}[a - 2(c - s_H) + c^*]^2$, and $\pi_L^d = \frac{1}{9}[a - 2c + c^*]^2$. Therefore, the government can deter entry in the third period by employing a positive subsidy policy similar to a Bertrand competition. Therefore, the result obtained under Bertrand competition in the case of complete information also holds under Cournot competition.

We now extend the Bertrand competition to the case of incomplete information.

The expected profit of the entrant in light of its *a posteriori* belief can be expressed as $\pi_E[H(p)] = \frac{1}{9}[a + (c - s_H) - 2c^*]^2 + \frac{1}{9}H(p)s_H^2 - F$. We consider the case where $\pi_E[H(p)] \geq 0$ but $\frac{1}{9}[a + (c - s_H) - 2c^*]^2 \leq F$. In this case, Proposition 2 (separating equilibria) still holds with prices satisfying (5) and (6), while Proposition 3 (pooling equilibria) still holds with prices satisfying (7) and (8) because the IC conditions (5) to (8) under Cournot competition are identical to those under Bertrand competition even though a change in the mode of competition will alter π_H^d and π_L^d . Therefore, when applied to Bertrand competition, our findings are not sensitive to the mode of competition.

V. Conclusions

Even though the WTO allows LDCs to offer export subsidies, these countries experience practical difficulties in offering such subsidies due to various reasons, such as limited financial resources, poor management of subsidies, and inefficient outcomes of these subsidies. Motivated by these issues, this paper focuses on the potential technology inferiority of LDCs and evaluates the effectiveness of export subsidies by exploring the relationship between designing an export subsidy policy to boost the export market of an LDC and ensuring the entry deterrence of foreign firms in a dynamic context.

Since Brander and Spencer (1985), many researchers have argued that positive export subsidies increase the profits of the subsidized firm by ensuring the expansion of its market share. We show that a domestic firm (a monopolist) faces threat of entry from a foreign firm that has technological advantage in the production process. In Section 3, we show that under complete information, a subsidy policy deters the entry of foreign firms whereas a “no subsidy” policy does not. In the latter case, the incumbent loses its entire market share after the entry of the foreign firm. Therefore, the incumbent firm from the LDC can only retain its monopoly power in each period by obtaining a large amount of government subsidies. However, when a significant technological gap between two countries is observed, issuing export subsidy policies is harmful and ineffective given the financial burden involved.

The case with complete information shows that without considering their technology inferiority, simply issuing export subsidies to LDC firms cannot enhance their export capacity. In this case, the WTO, as the main global forum where trade issues are discussed and as the international organization that regulates the trade policies of its member countries, needs to consider the technology gaps between LDCs and developed countries instead of simply allowing LDCs to issue export subsidies. In order for the WTO to meet its developmental goals, LDCs must be given the right to adopt more customized measures and be treated differently

from other WTO member countries. When granting these rights, the WTO can guarantee that all member countries are on a level playing field by considering the technology gaps among them.

The WTO and other international organizations, such as the World Bank and UNCTAD, must also work together to support LDCs in their catch up with technology leaders by designing various programs to disseminate advanced technologies and by allowing LDCs to disseminate such technologies to their firms. Advanced countries, which are eager to provide foreign aid to poor countries around the world, must actively engage themselves in the dissemination of technologies as well as coordinate their foreign aid and technology diffusion activities to support the economic development of LDCs. A practical way to pursue this type of coherent policy is to incorporate these goals into foreign aid programs, such as the Official Development Assistance program of Aid for Trade, which is designed to provide technical assistance to LDCs and to build their trade capacity with the help of international organizations. To improve the export competitiveness of LDCs, international organizations must focus on domestic productivity, trade costs, and effective market access, which are determined by the extent to which unilateral, regional, or multilateral trade reforms are implemented (OECD, 2006).

Since Qiu (1994), many studies on the strategic trade policy have focused on the available asymmetric information related to the cost parameters of firms, the demand conditions in targeted industries, and the nature of oligopolistic conducts, among others. However, this paper focuses on the subsidy policies of domestic governments and the related asymmetric information available to domestic and foreign firms. Section 4 shows that when incomplete information about a subsidy policy is available, the “no subsidy” policy is optimal for the LDC government in both separating and pooling equilibria. However, different logics apply to this optimal policy in both types of equilibria. Specifically, in the separating equilibria environment, the high type incumbent sets a sufficiently low price level to distinguish itself from the low type incumbent in order to deter the entry of foreign firms. However, the profits derived from this strategy is lower than the profits derived from monopoly pricing. This strategy also requires a sufficiently large amount of subsidies, thereby making the subsidy policy less attractive to the government. Therefore, the “no subsidy” policy is optimal for the LDC government because export subsidies are financially burdensome given the technological inferiority of LDC firms. However, unlike the separating equilibria environment, the LDC government can deter the entry of a foreign firm from a more advanced country with better technologies by employing the “no subsidy” policy in the pooling equilibria environment.

This paper examined a scenario with incomplete information about whether the incumbent firm from the LDC is subsidized or not. In this context, the potential entrant from an advanced country is not aware of the export subsidy policy of the

LDC government, but all other relevant factors are assumed to be publicly known. In the entry-deterrence model, the incumbent firm and the LDC government know the foreign firm's assessment of such private information. As a possible direction for future research, we can relax the parameters of this assumption in order for both the incumbent and the LDC government to be unaware of the entrant's perspective toward this issue. Specifically, the foreign firm is not aware of the policy that the government will adopt, while the monopolist and the government are not aware of the perspective of the foreign firm toward the policy of the government. We will leave these topics to be examined in future work.

References

- Bagwell, K. and R. W. Stager (1996), "Reciprocal Trade Liberalization," mimeo.
- _____ (1997), "Strategic Export Subsidies and Reciprocal Trade Agreements: The Natural Monopoly Case," *Japan and the World Economy*, 9, 491–510.
- Brainard, S. L. and D. Martimort (1996), "Strategic Trade Policy Design with Asymmetric Information and Public Contracts," *Review of Economic Studies*, 63, 81–105.
- Brander, J. A. and B. J. Spencer (1985), "Export Subsidies and International Market Share Rivalry," *Journal of International Economics*, 18, 83–100.
- Collie, D. (1992), "Export Subsidies, Entry Deterrence and Countervailing Tariffs," *The Manchester School*, LX, 136–151.
- Collie, D. and M. Hviid (1993), "Export Subsidies as Signals of Competitiveness," *The Scandinavian Journal of Economics*, 95, 327–339.
- Eaton, J., and G. M. Grossman (1986), "Optimal Trade and Industrial Policy under Oligopoly," *Quarterly Journal of Economics*, 101, 383–406.
- Etro, F. (2010), "Endogenous Market Structures and International Trade," mimeo.
- Grossman, G. M. and G. Maggi (1999), "Free Trade vs. Strategic Trade: A Peek into Pandora's Box," In edited by R. Sato, R. V. Ramachandran, and K. Mino, *Global Competition and Integration*, Springer Science+Business Media, LLC.
- Kang, M. (2006), "Trade Policy Mix: IPR Protection and R&D Subsidies," *Canadian Journal of Economics*, 39, 744–757.
- _____ (2009), "Understanding Agreements on TRIPS and Subsidies in Tandem," *Open Economics Review*, 20, 225–240.
- Maggi, G. (1999), "Strategic Trade Policy under Incomplete Information," *International Economic Review*, 40, 571–594.
- Milgröm, P. and J. Roberts (1982), "Limit Pricing and Entry Under Incomplete Information: An Equilibrium Analysis," *Econometrica*, 50, 443–459.
- Moore, M. O. and S. M. Suranovic (1993), "Lobbying and Cournot-Nash Competition: Implications for Strategic Trade Policy," *Journal of International Economics*, 35, 367–376.
- Organization for Economic Cooperation and Development (2006), *Aid for Trade: Making it Effective*, Paris: OECD.
- Qiu, L. D. (1994), "Optimal Strategic Trade Policy under Asymmetric Information," *Journal of International Economics*, 36, 333–354.
- Tirole, J. (1988), *The Theory of Industrial Organization*, MIT Press.