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ON THE EQUIVALENCE OF TARIFFS AND QUOTAS UNDER INCOMPLETE INFORMATION*

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Abstract

We evaluate the possibilities of the equivalence between tariffs and quotas under incomplete information of foreign technologies. We propose two possible criteria, the expected output and the expected price, for the government to set its quota permits. By using these criteria, we address the equivalence in domestic production. We show that equivalence in domestic quantity will depend on the curvature of demand function as well as on the likelihood of non-binding quotas.

Key words: Incomplete Information; Bayesian Nash Equilibrium; Cournot Competition; Homogeneous Good; Duopoly
JEL Classification: F12

I. *Introduction*

The equivalence of tariffs and quotas, an issue initiated by Bhagwati (1965, 1968), states that domestic prices are identical when a given level of imports is imposed under either a tariff regime or a quota regime. According to Bhagwati, the equivalence holds when domestic market is perfectly competitive. As long as there is some domestic monopoly power, the equivalence will not hold. In recent years, there has been a wide interest in comparing domestic prices under tariffs and quotas assuming the domestic market to be oligopolistic, as discussed by Itoh and Ono (1982, 1984), Krishna (1989), Hwang and Mai (1988), Dockner and Haug (1990), among others.

This paper discusses the equivalence of tariffs and quotas under asymmetric incomplete information. A domestic and a foreign firm are engaged in a quantity competition. The domestic firm faces incomplete information about technologies of the foreign firm, while the foreign firm has complete information about the domestic firm's technology.[1] Structurally,

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[1] As noted by Collie and Hviid (1993), the incomplete information on marginal costs is especially relevant for micro-electronics industry.

this game is an extension of Hwang and Mai (1988)[2] model with the additional complication of incomplete information. Since there is no well-defined quota that is equivalent to an import under tariff regime when there is incomplete information of foreign technologies, we recommend two different criteria, the expected output and the expected price under the tariff regime, for the government to set its quota permits. Our recommended quota permits act only as rule of thumb and can turn out to be non-binding, we thus have to consider the cases of binding and non-binding quotas separately.

By using our proposed criteria, we address the equivalence issue in a more limited sense, i.e., the equivalence in domestic production. We henceforth denote such limited version as the quantity equivalence, in contrast to the standard version, i.e., the price equivalence, as discussed in literature. Under the case of binding quotas, we show that quantity equivalence, in general, will fail to hold except in the linear demand case. Each criterion has its own bias depending on the curvature of demand function. Specifically, whether the domestic quantities under quota regime will be higher or lower than under tariff regime will depend on the difference between the price under quota regime and the expected price, as well as the difference between the slope under quota regime and the expected slope. Once the possibilities of non-binding quotas are taken into consideration, quantities in quota regime are higher under the linear demand. Intuitively, the importance of quotas as a protective measure diminishes once the likelihood of non-binding quotas is introduced.

The discussion of equivalence in domestic production is inevitable due to the dichotomy between the price and the quantity equivalence under incomplete information.[3] It, nevertheless, deserves our attentions from economic perspective. The concern for the domestic job losses has been one of the most frequently cited arguments against free trade. Since the domestic output is closely linked to the domestic employment, our discussions can address more directly to such a concern. In fact, as suggested by Ishikawa (1994), it is surprising that most studies have examined only the consumer prices. There are surging interests in exploring other interesting dimensions of equivalence, such as profits and/or economic welfare, as contained in Itoh and Ono (1982, 1984), Ishikawa (1994), and Konishi (1999).

Several papers during the 90's have considered the effect of asymmetric information on the strategic trade policy, such as Qiu (1994), Collie and Hviid (1993, 1994, 1999), Brainard and Martimort (1996, 1997), Kolev and Prusa (1999), among others. One of their major concerns is: whether policy implications under double/multiple imperfections, i.e., market and information imperfections, will be closer or away from the first best outcome than under single imperfection. Indeed, due to the different specifications of incomplete information, Brainard and Martimort (1996, 1997), Collie and Hviid (1999), Kolev and Prusa (1999) suggested the interventionist motive is weakened, while Collie and Hviid (1993, 1994) and Qiu (1994) confirmed that rent-shifting motive is strengthened under incomplete information. Our findings are closer to the latter view: the equivalence is weakened under incomplete information of foreign costs.

Comparing with Hwang and Mai (1988) result, where Cournot competition is the benchmark for the price equivalence, under incomplete information of foreign technologies

[2] Following Hwang and Mai (1988), we also disregard the distributional rent effect of quota rents.

[3] If, instead of domestic incomplete information on foreign costs, there is foreign incomplete information on domestic costs, quotas can be equivalent to imports under tariffs and it becomes possible to discuss price equivalence.

and, assuming Cournot competition and binding quotas, functional linearity stands out as a new benchmark for the quantity equivalence. Such a result is more in line with the findings in the strategic trade literature such as Brander and Spencer (1984a, 1984b), where the curvature of function serves as the benchmark for policy implications.

The format of this paper is organized as follows. Section 2 examines the equivalence issue under incomplete information of foreign technologies. The conclusions are contained in Section 3.

II. *Incomplete Information of Foreign Technologies*

There are two duopolistic firms, a domestic firm and a foreign firm and each of them produces a homogeneous good. The inverse domestic demand is given by

$$P=P(q_1+q_2) \text{ and } P_Q<0,\ Q=q_1+q_2, \tag{1}$$

where q_1 and q_2 denote the domestic output and the foreign firm's imports to domestic market. Assume there is asymmetric incomplete information that firm 1 and the domestic government are not sure whether firm 2 is of a high cost or a low cost type, while firm 2 knows exactly the cost type of firm 1. Firm 1 holds binomial belief that there is probability θ that firm 2 is of a high cost type and probability $1-\theta$ firm 2 belongs to the low cost type. We denote the cost functions of firm 1, and the high cost and low cost types of firm 2 as C^1, C^{2h} and C^{2l}, respectively. Thus, the strategy (q_1, q_{2h}, q_{2l}) and strategy space R^{3+}, the players firm 1, high and low types of firm 2, the belief and types (θ, $1-\theta$; C^{2h}, C^{2l}) and the profit function of each player together constitute the Bayesian game. Under the tariff regime, each firm maximizes its profit:

$$\max_{q_1} \pi^1=\theta[P(q_1+q_{2h})q_1-C^1(q_1)]+(1-\theta)[P(q_1+q_{2l})q_1-C^1(q_1)], \tag{2}$$

$$\max_{q_{2h}} \pi^{2h}=P(q_1+q_{2h})q_{2h}-C^{2h}(q_{2h})-tq_{2h}, \tag{3}$$

$$\max_{q_{2l}} \pi^{2l}=P(q_1+q_{2l})q_{2l}-C^{2l}(q_{2l})-tq_{2l}. \tag{4}$$

By differentiating with respect to q_1, q_{2h}, and q_{2l}, we derive the following first order conditions:

$$\pi^1_{q_1}=\theta[P^h+\overline{q}_1P^h_Q-C^1_{q_1}]+(1-\theta)[P^l+\overline{q}_1P^l_Q-C^1_{q_1}]=0, \tag{5}$$

$$\pi^2_{q_{2h}}=P^h+\overline{q}_{2h}P^h_Q-C^2_{q_{2h}}-t=0, \tag{6}$$

$$\pi^2_{q_{2l}}=P^l+\overline{q}_{2l}P^l_Q-C^2_{q_{2l}}-t=0. \tag{7}$$

We can solve for Bayesian Nash equilibrium outcome[4] $\overline{q}_1$, $\overline{q}_{2h}$, and $\overline{q}_{2l}$ using equations (5), (6), and (7). The second order conditions and stability conditions are assumed to be satisfied. When $t=0$, we can obtain domestic and foreign productions under free trade. For later references, we use q_1^*, q_{2h}^*, and q_{2l}^* to denote productions under free trade.

[4] We limit our discussions to the Cournot case since the concept of Bayesian Nash equilibrium can not be applied to conjecture other than Cournot. For the distinction between equilibrium and equilibrium outcome, we follow Gibbons (1991).

Now consider the case of a quota regime. Under incomplete information, the domestic firm as well as the domestic government are uncertain about the exact amount the foreign firm is going to export. Thus, under the quota regime, the government will have to conjecture a quota permit that is approximately close to the level of imports under the tariff regime. It follows that the foreign production simply may not be equal across both regimes, and we will have to focus on the equivalence of the domestic production. We propose the following two possible criteria as rule of thumb for setting the quota permits under incomplete information:

$$\tilde{q}_2 = \theta \bar{q}_{2h} + (1-\theta)\bar{q}_{2l}, \tag{8}$$

$$\tilde{q}_2 = D(\tilde{P}) - \bar{q}_1, \qquad \text{where } \tilde{P} = \theta P^h + (1-\theta)P^l. \tag{9}$$

The quota permit in equation (8) are based on the expected output under the tariff regime. In equation (9), the government issues its permit according to the expected price under the tariff regime. Both criteria are linear. Under the special case of linear demand, both criteria suggest the same permit level. In general, these two criteria will suggest different quota levels when the demand is nonlinear.

In addition, there are possibilities of non-binding quotas, i.e., the prescribed quota might exceed the free trade import level of the high cost firm. For example, if the tariff and/or the probability of high cost firm are/is sufficiently low so that the expected output criterion prescribes a quota level very close to $\bar{q}_{2l}$, such a quota level might turn out to be non-binding for the high cost firm. From the perspective of domestic firm, it compares whether $\tilde{q}_2$ is greater or smaller than q^*_{2h} before solving its maximization problem.

If the quotas turn out to be non-binding, the inverse demand can be expressed as:

$$\tilde{P}^h(\tilde{q}_1 + q^*_{2h}) = P(\tilde{q}_1 + q^*_{2h}). \tag{10-a}$$

In the case of binding quotas, the inverse demand becomes:

$$\tilde{P}(\tilde{q}_1 + \tilde{q}_2) = P(\tilde{q}_1 + \tilde{q}_2). \tag{10-b}$$

If the prescribed quota permit is perceived to be non-binding for the high cost firm, the domestic firm has to solve the following maximization problem:

$$\tilde{\pi}^{1h} = \theta \tilde{P}(\tilde{q}_1 + \tilde{q}_2)\tilde{q}_1 + (1-\theta)\tilde{P}^h(\tilde{q}_1 + q^*_{2h})\tilde{q}_1 - C^1(\tilde{q}_1). \tag{11-a}$$

If quotas are always binding, the maximization problem can be expressed as:

$$\tilde{\pi}^1 = \tilde{P}(\tilde{q}_1 + \tilde{q}_2)\tilde{q}_1 - C^1(\tilde{q}_1). \tag{11-b}$$

The first order conditions for (11-a) and (11-b) can be written as (12-a) and (12-b):

$$\tilde{\pi}^{1h}_{\tilde{q}_1} = \theta \tilde{P} + (1-\theta)\tilde{P}^h + \theta \tilde{q}_1 \tilde{P}_Q + (1-\theta)\tilde{q}_1 \tilde{P}^h_Q - C^1_{\tilde{q}_1} = 0, \tag{12-a}$$

$$\tilde{\pi}^1_{\tilde{q}_1} = \tilde{P} + \tilde{q}_1 \tilde{P}_Q - C^1_{\tilde{q}_1} = 0. \tag{12-b}$$

By evaluating equations (12-a) and (12-b) respectively on $\bar{q}_1$, the optimal domestic output under the tariff regime, we are in a position to compare the amount of domestic production under the two regimes. Substituting equation (5) into equation (12-a) for the possibilities of non-binding quotas, we obtain the following expressions:

$$\left.\frac{d\tilde{\pi}^{1h}}{d\tilde{q}_1}\right|_{\tilde{q}_1=\bar{q}_1} = \{[\theta\tilde{P}+(1-\theta)\tilde{P}^h]-[\theta P^h+(1-\theta)P^l]\}$$
$$+\bar{q}_1\{[\theta\tilde{P}_Q+(1-\theta)\tilde{P}_Q^h]-[\theta P_Q^h+(1-\theta)P_Q^l]\}. \quad (13\text{-a})$$

Alternatively, substituting equation (5) into (12-b) for binding quotas, we obtain:

$$\left.\frac{d\tilde{\pi}^{1}}{d\tilde{q}_1}\right|_{\tilde{q}_1=\bar{q}_1} = \{\tilde{P}-[\theta P^h+(1-\theta)P^l]\}+\bar{q}_1\{\tilde{P}_Q-[\theta P_Q^h+(1-\theta)P_Q^l]\}. \quad (13\text{-b})$$

Since tariffs and quotas attract attentions mostly due to their protective nature, we start with the case of binding quotas and examine the possibilities of non-binding quotas subsequently. According to equation (13-b), the domestic quantities under the quota regime will be higher, identical, or lower than under the tariff regime will depend on whether the above expressions are greater, equal to, or smaller than zero. If the demand is linear, expressions on the right hand side of equation (13-b) will end up to be zero, and the domestic quantities will be identical across both regimes. In addition, the same domestic quantities in both regimes will imply that the domestic prices will be lower (higher) under quotas than under tariffs when the foreign firm is of a high (low) cost type. Under nonlinear demand, however, conclusions regarding domestic quantities can not be taken to infer anything about the domestic prices unless the quota permits happen to exactly capture the foreign output under tariff regime.

If the domestic government sets its quota permit according to criterion 1, the expected output, the quantity equivalence will hold under the linear demand.[5] If instead, the government follows criterion 2, the first part of equation (13-b) will disappear and the difference between the demand slope under the quota regime and the expected slope under the tariff regime remains as long as the demand is nonlinear. This leads to the following proposition:

Proposition 1. Assuming duopolistic firms engage in Cournot competition under incomplete information of the foreign firm's technologies, the domestic quantities under tariffs and quotas will be identical under the linear demand if the government follows the expected output or expected price criterion in setting its quota permit and such a quota is perceived to be binding. The domestic prices will be lower (higher) under quotas than under tariffs when the foreign firm is of a high (low) cost type. When the demand is nonlinear and the government follows the expected price criterion, the domestic quantities under the quota regime will be higher (lower) than under the tariff regime if the slope at the optimum quota price is greater (smaller) than the expected slope under tariffs.

Next, consider the case of non-binding quotas. Under the linear demand, all the derivative terms of (13-a) vanish. Through the inequality $\theta\tilde{P}+(1-\theta)\tilde{P}^h>\tilde{P}$ and equality $\tilde{P}=\theta P^h+(1-\theta)P^l$, we know the right hand side of equation (13-a) is positive, this suggests the domestic quantities are higher under the quota regime. If we take one step further, the domestic prices will be lower under the quota regime if the foreign firm turns out to be a high cost type. Thus, the benchmark for the quantity equivalence has been perturbed once the likelihood of non-binding quotas is introduced. Clearly, the possibilities of non-binding quotas diminish the protective nature of quotas, as compared with tariffs. We can summarize our

[5] As a referee pointed out, the linearity of demand is a sufficient but not a necessary condition. There still exist such possibilities that terms in the two brackets cancel out each other while the demand is nonlinear.

findings with a corollary:

Corollary 1: If the quotas are non-binding for the high cost firm, the domestic quantities are higher under quotas than under tariffs when the demand is linear. The domestic prices will be lower under quotas than under tariffs when the foreign firm is of a high cost type.

The fact that quantity equivalence fails to hold for a nonlinear demand is not surprising since a linear policy criterion will certainly fail to capture the nonlinear nature of market demand. More importantly, whether domestic quantities will be higher or lower under tariffs than under quotas will depend on 1) the difference between the price under quota regime and the expected price, and 2) the difference between the slope under quota regime and the expected slope. Contrasting with Hwang and Mai (1988) result, where Cournot competition serves as the benchmark for the price equivalence regardless of the functional form, under incomplete information of foreign costs and, assuming Cournot competition, the functional form becomes a benchmark for quantity equivalence.

Incomplete information sheds new light to the equivalence between tariffs and quotas. Under the quota regime, the importance of foreign incomplete information diminishes since the domestic firm cares less about what happens abroad. Thus, if information is quite costly, the domestic firm will generally prefer the quota regime since the need to conjecture is reduced.

III. *Conclusions*

We discuss two alternative criteria, the expected output and the expected price, that government follows in prescribing its quotas under domestic incomplete information of foreign technologies. Under this type of incomplete information, it is no longer appropriate to discuss the equivalence in domestic prices simply because the foreign production may not be equal. Thus, we examine whether the domestic production under quotas will be equivalent to the domestic production under tariffs. In addition, the possibilities of non-binding quotas set in and we have to address cases of binding and non-binding quotas separately. Under the case of binding quotas, we show that Cournot competition is not sufficient to guarantee the quantity equivalence of tariffs and quotas except in the linear demand case. As long as the demand is nonlinear, each criterion will have its own bias depending on the concavity and convexity of demand and the first derivatives of demand. Taken together, the benchmark for quantity equivalence becomes more restrictive than the benchmark for price equivalence, instead of Cournot competition as suggested by Hwang and Mai (1988), it now requires the functional linearity under Cournot competition. In addition, once the likelihood of non-binding quotas is taken into account, we see the diminishing importance of quotas as a protective measure, i.e., domestic quantities under quotas are higher when demand is linear.

Under incomplete information of foreign technologies and binding quotas, the quantity equivalence will hold as a special case of linearity and it generally will fail to hold under nonlinear cases. Since most discussions of the policy implications under incomplete information are based on linear function, it is worth examining whether the policy implications derived under different context may also subject to the above qualifications. For example, our framework can be used to address whether the voluntary export restraints are voluntary, an issue initiated by Harris (1985), and examine whether VER and free trade are equivalent

under incomplete information of foreign costs. However, results derived under such a context are, most likely, a special case of linearity.[6]

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[6] Mai and Hwang (1988) presented a linear variant of Hwang and Mai (1988) with each firm producing nonhomogeneous products and showed that VER and free trade are equivalent under Cournot competition. Since our model is basically an incomplete information version of Hwang and Mai (1988), such discussion can be further pursued.

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