Welfare-reducing optimal tariff in vertically related markets

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Welfare-reducing optimal tariff in vertically related markets*

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Abstract

Tougher competition in an upstream market lowers the input price, production cost of downstream firms, and vertical inefficiency; hence, it is likely to raise the welfares of the final-good importer. However, if the final-good importer sets an optimal tariff on the final good, a happy ending may not occur. We show that if more than one firm exists upstream of the final-good importer, because tougher competition in upstream price competition raises the tariff of the final-good importer and dominates the lowering effect of the input price, the consumer and total surpluses of the final-good importer fall.

Key words: Optimal tariff; Upstream price competition; Vertically related markets; Consumer surplus; Total surplus

JEL classification: F13; F12; L13; D43

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1 Introduction

In modern international economies, offshore outsourcing and production fragmentation are becoming common; thus, trade in intermediate inputs is becoming more active.[1] This tendency makes the role of the upstream market more important in world trade. For example, several assembly industries need key inputs, such as batteries, motors, and condensers; hence, they produce their final goods by importing these key inputs from upstream markets. Input prices directly affect the production costs of downstream firms; thus, input prices determine the final-good price. Therefore, the factor of which competitive environment the upstream market is an issue of critical importance for the downstream firm's competitiveness.

To promote export activity at downstream firms, it is thus first necessary to lower upstream input prices. If input prices fall through an enhancement of upstream competition caused by an increase in market entry, then downstream production can become active because of the lowering production cost. At that time, if the import tariff (i.e., trade barrier) does not rise, because production becomes active as a result of the lowering effect of the production cost, export activity can be also promoted. However, it is not necessarily certain how the tariff policy of the final-good importer is affected by the enhancement of competition in the upstream market.

The purpose of this paper is to consider how the tariff policy of the final-good importer can be affected by competition in the upstream market. Furthermore, we consider how upstream competition affects the welfares of the final-good importer. In our study, although an increase in the number of upstream firms lowers the input price, it can raise the tariff rate of the final-good importer. Hence, we find that both the consumer and total surpluses of the final-good importer fall if the tariff increasing effect dominates the input price lowering effect.

[1] Greaney and Kiyota (2020) state that "the share of intermediate inputs in total imports increased from 56.9% in 1995 to 63.4% in 2011 for all industries" (p. 2034). Similarly, Johnson and Noguera (2012) mention that trade in intermediate inputs occupies two-thirds of international trade.

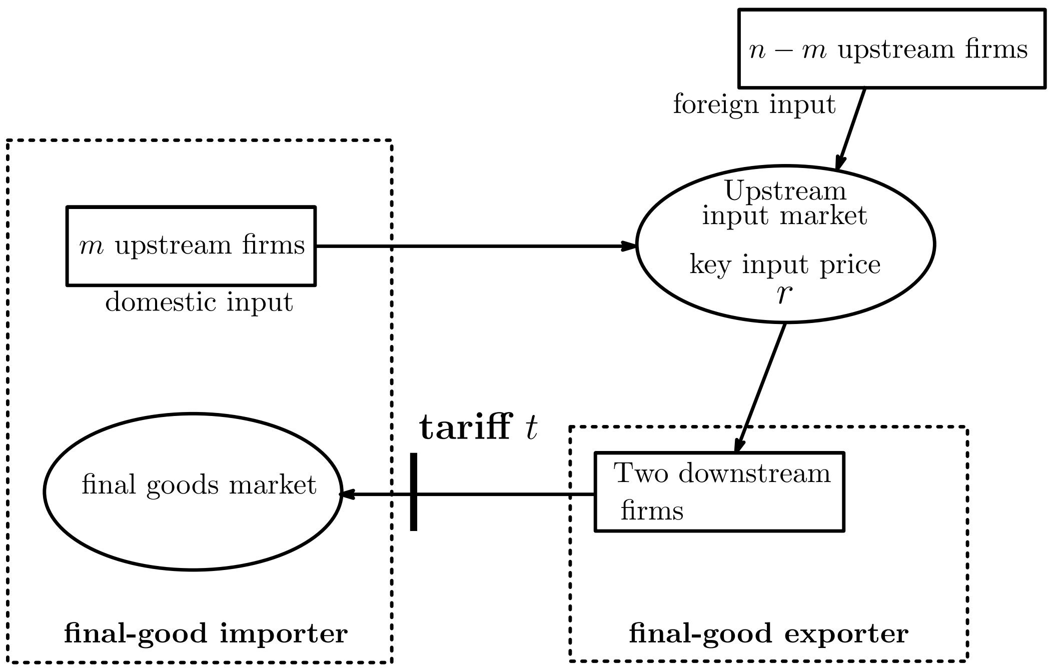

Figure 1: Market structure of the benchmark model

We consider a simple vertical production chain based on Brander and Spencer's (1984a) model that mainly considers import competition. There are two countries: one is a final-good importer and the other is a final-good exporter without a final-good market. There are n (> 2) upstream firms that engage in homogeneous price competition[2] and two downstream firms that supply differentiated goods. These downstream firms are located in the final-good exporter and pay a tariff when they export their products to the final-good importer. The m $(m < n)$ upstream firms belong to the final-good importer, and "$n - m$" upstream firms belong to a country other than those of the final-good importer and final-good exporter. Figure 1 illustrates this market structure.

When the number of upstream firms is greater than unity for the final-good importer, we show that an increase in the number of upstream firms decreases the final-good importer's

[2]The vertically related market model tends to assume Cournot competition upstream. By contrast, as Flath (2012) empirically showed, in 70 Japanese manufacturing industries from 1961 to 1990, the simple Bertrand specification for 35 industries compared with the simple Cournot specification is five industries. Hence, it is realistic to consider upstream price competition.

consumer and total surpluses. Although the unit cost of final-good exporting firm comprising the tariff and the input price, tariff rate rises and its effect dominates the lowering effect of input price if the number of upstream firms increases. This is because, if an upstream firm exists, the final-good importer tries to compensate for profit loss from the upstream firm caused by the lowering input price by raising its tariff rate. When the number of domestic upstream firms is sufficiently large, the final-good importer's incentive to raise its tariff rate becomes strong against a lowering input price. Hence, despite upstream competition becoming tougher, through increases of the unit cost of downstream firms caused by the rising tariff, the aggregate outputs of downstream firms decrease. This raises the final-good price and decreases consumer surplus, and, as a result, the final-good importer's total surplus decreases.

Our result has the following implication. Because competition facilitation that results from a new entrant in the upstream market lowers the input price, at a glance, it can result in welfare gain. However, the promotion of upstream competition can raise the tariff rate of the final good and result in a decrease in final-good imports and downstream production inefficiency; hence, it can lead to welfare loss. The final-good importer should be careful not to raise its tariff rate in response to an enhancement in upstream competition. This provides a new insight into the argument regarding the optimal tariff policy.

We extend the benchmark model to two cases. One is the case in which the upstream market is under homogeneous quantity competition and the other is the case in which a downstream oligopolist exists in the final-good importer. In both cases, we obtain a similar result to that obtained in the benchmark case; hence, our model has a certain robustness.

Although the study of the optimal tariff is wide-ranging, our study is mainly related to two strands. One is studies that consider the tariff as a means to seize rent under imperfect competition (Amir et al., 2022; Brander and Spencer, 1981; Brander and Spencer, 1984a, b; Chao and Yu, 2006; Choi, 1995; Katrak, 1977; Svedberg, 1979; Takauchi et al., 2024b). The other is studies that consider tariff policy in vertically related markets (Chen et al., 2004; Lahiri and Ono, 1999; Ishikawa and Lee, 1997; Ishikawa and Spencer, 1999; Spencer and Jones, 1992; Takauchi, 2014).[3] Katrak (1977) considers the optimal tariff for a foreign monopoly. Svedberg (1979) presents an optimal tariff for a foreign monopoly in a graphic manner. Brander and Spencer (1981) consider tariff policy in the case in which entry exists. Brander and Spencer (1984a) consider the optimal tariff for a foreign Cournot oligopoly. Brander and Spencer (1984b) consider a tariff war in two-way trade under general demand. Choi (1995) compares discriminatory tariffs and the Most Favored Nation clause. Chao and Yu (2006) consider an optimal tariff under an international mixed oligopoly. Amir et al. (2022) consider tariffs and other policies under an asymmetric Cournot oligopoly. Takauchi et al. (2024b) examine the effects of tariff and other industrial policies under an increasing marginal cost of firms. All of these studies provide interesting insights, but our study considers a vertical structure; hence, our study substantially differs from these studies.

Chen et al. (2004) consider the relationship between a firm's strategic outsourcing and tariff rate. Lahiri and Ono (1999) examine the role of a tariff in the case in which producers and sellers differ. Ishikawa and Lee (1997) consider the effects of tariffs on upstream and downstream markets. Ishikawa and Spencer (1999) consider a tariff applied to an imported intermediate good. Spencer and Jones (1992) consider tariff policy in the case in which the foreign firm is vertically integrated. Takauchi (2014) examines the role of tariff policy in a free trade area with rules of origin. These studies present fruitful results in vertical production chains, but, in their models, the upstream market is a monopoly or Cournot oligopoly; thus, they do not consider price competition. This crucially differs from our study.

This paper is organized as follows: In Section 2, we offer a benchmark model and in Section

[3] Additionally, Matsushima and Takauchi (2014) consider the port usage fee as a trade barrier similar to a tariff.

3, we present the analysis results. In Section 4, we discuss and extend the benchmark model. In Section 5, we conclude the paper. All proofs are reported in the Appendix.

2 Model

The model (or market structure) is illustrated in Figure 1. In the model, two countries exist: final-good importing and exporting countries. Hereafter, we call the final-good importing country the final-good importer. Similarly, we call the final-good exporting country the final-good exporter. To enable a better understanding, the final-good importer has no final-good producers and mainly imports foreign final goods. In Section 4, we relax this assumption and argue the case in which the final-good importer has a final-good oligopolist. The final-good importer imposes a common specific tariff t on the final-good exporting firms (if $t > 0$, this indicates a specific tariff; and if $t < 0$, this indicates an import subsidy). The final-good exporter has no final-good markets; however, it has two final-good exporting firms: A and B. These firms export horizontally differentiated goods to the final-good importer and they face the tariff.

In the upstream market, n (> 2) firms (i.e., input suppliers) exist and they engage in homogeneous price competition: m input suppliers belong to the final-good importer, and $n-m$ input suppliers are located in a country other than those of the final-good importer and final-good exporter.

To produce one unit of the final good, downstream firms A and B use one unit of input. The inverse market demand function of the final-good importer is given by

$$p_i = 1 - q_i - bq_j, \quad i \neq j, \quad i, j = A, B,$$

where p_i and q_i are the price and quantity supplied by firm i ($i = A, B$), respectively, and $b \in [0, 1)$ represents the degree of product substitutability. The profit of final-good exporting firm i ($i = A, B$) is $\Pi_i \equiv (p_i - r - t)q_i$, where r is the input price. For simplicity, we omit transportation costs.

Let the input price offered by supplier $k\,(k \in \{1,\ldots,n\})$ be r_k, supplier k's individual demand be x_k, and total demand be $q_A + q_B$. Because each downstream firm (i.e., final-good exporting firm) purchases the lowest input, the individual demand of input supplier k is $x_k = [q_A(r^l) + q_B(r^l)]/h$ if the supplier offers the lowest price $r_k = r^l$. Note that h is the number of input suppliers that offer the lowest price. When input supplier k offers a higher price than r^l, its demand is zero: $x_k = 0$. To obtain explicit solutions, we assume that the production cost of input supplier k is $(\lambda/2)x_k^2$, where $\lambda > 0$ is production efficiency.[4] The profit of upstream firm k $(\in \{1,\ldots,n\})$ is $\pi_k \equiv r_k x_k - (\lambda/2)x_k^2$.[5]

We consider the following three-stage game. In the first stage, the final-good importer chooses the level of tariff t. In the second stage, each input supplier k decides its price. In the third stage, the final-good exporting firm decides its exports. Because multiple Nash equilibria (range of prices) appear in the second stage of the game, we use the subgame perfect Nash equilibrium with the payoff-dominance criterion as the equilibrium concept.[6] The game is solved by backward induction.

3 Results

In the third stage of the game, each final-good exporting firm decides its export to maximize profit. The first-order conditions (FOCs) for profit maximization are $1 - 2q_A - bq_B - r - t = 0$

[4]This type of quadratic cost function was frequently used in previous studies. See, for example, the studies by Dastidar (1995), Delbono and Lambertini (2016b), Gori et al. (2014), Mizuno and Takauchi (2020, 2024), Takauchi and Mizuno (2022), and Takauchi et al. (2024a, b).

[5]In the real world, several manufacturing firms' technology can have decreasing returns to scale. For example, using the aggregate data of 34 manufacturing industries in the United States, Basu and Fernald (1997) found that a typical industry appears to have decreasing returns to scale.

[6]This concept is often used. For example, see the studies by Cabon-Dhersin and Drouhin (2014, 2020), Mizuno and Takauchi (2020, 2024), and Takauchi and Mizuno (2022).

and $1 - bq_A - 2q_B - r - t = 0$. These FOCs yield the following third-stage export:

$$q_i(r,t) = \frac{1-r-t}{2+b}, \quad i = A, B.$$

In the second stage, input suppliers decide their prices. According to Dastidar (1995),[7] if oligopolists have a convex cost, the Nash equilibria in a homogeneous price competition among them have an interval $[\underline{r}, \overline{r}]$. The lower input price $\underline{r}$ is derived from the following condition:

$$\pi_k(r,t;n) \equiv r\left(\frac{q_A(r,t)+q_B(r,t)}{n}\right) - \frac{\lambda}{2}\left(\frac{q_A(r,t)+q_B(r,t)}{n}\right)^2 \geq 0.$$

The upper input price $\overline{r}$ is derived from the following condition:

$$\pi_k(r,t;n) \geq \pi_k(r,t;1) \equiv r\left(q_A(r,t)+q_B(r,t)\right) - \frac{\lambda}{2}\left(q_A(r,t)+q_B(r,t)\right)^2,$$

where $\pi_k(r,t;1)$ is the monopoly profit of input supplier k.

Furthermore, the collusive input price r_{col} (which maximizes industry profit) is derived from $\text{argmax}_r\, \pi_k(r,t;n)$. These prices become

$$\underline{r} = \frac{\lambda(1-t)}{(b+2)n+\lambda}; \quad \overline{r} = \frac{\lambda(n+1)(1-t)}{n(b+\lambda+2)+\lambda}; \quad r_{col} = \frac{(1-t)\left((b+2)n+2\lambda\right)}{2((b+2)n+\lambda)}. \tag{1}$$

The above (1) yields Lemma 1.

Lemma 1. *(i)* $\underline{r} < \overline{r}$. *(ii)* $r_{col} > \overline{r}$ *iff* $\lambda < \dfrac{(2+b)n}{n-1}$.

Throughout the analysis, we use the upper price $\overline{r}$ as the input price: $r = \overline{r}$.

To ensure $r_{col} > \overline{r}$, we require the following.

Assumption 1. $\lambda < \dfrac{(2+b)n}{n-1}$.

In the first stage, the final-good importer decides t to maximize its total surplus:

$$W \equiv CS + \sum_{l=1}^{m} \pi_l + t(q_A + q_B), \tag{2}$$

[7] Dastidar (1995)-type price competition is often used in many studies. See, for example, the studies by Cabon-Dhersin and Drouhin (2014, 2020), Delbono and Lambertini (2016a, b), Gori et al. (2014), Mizuno and Takauchi (2020, 2024), and Takauchi and Mizuno (2022).

where $CS = (q_A^2 + 2bq_Aq_B + q_B^2)/2$ is consumer surplus. From (2) and the second-stage outcomes, the optimal import policy t^* becomes

$$t^* = \frac{\lambda(1 - 2m + n) + n}{n(b + 2\lambda + 3) - 2\lambda(m - 1)}. \tag{3}$$

Note that "$*$" denotes the equilibrium outcome.

To ensure positive equilibrium values, we make the following assumption.[8]

Assumption 2. $m < m_0 \equiv 1 + \dfrac{n(b + 2\lambda + 3)}{2\lambda}$.

The final-good export is

$$q_i^* = \frac{n}{n(b + 2\lambda + 3) - 2\lambda(m - 1)} > 0, \quad i = A, B.$$

The profit of the final-good exporting firm is $\Pi_i^* = (q_i^*)^2$.

The input price is

$$\overline{r}^* = \frac{\lambda(n + 1)}{n(b + 2\lambda + 3) - 2\lambda(m - 1)}. \tag{4}$$

The profit of input supplier k is $\pi_k^* = 2(n + 1)\,\overline{r}^* q_i^*$ for all $k \in \{1, \ldots, n\}$.

From (3), we establish Proposition 1.

Proposition 1. *(i) Suppose that* $m < (\lambda + \lambda n + n)/(2\lambda)$. *The optimal trade policy of the final-good importer is a tariff, that is,* $t^* > 0$.

(ii) Suppose that $m = (\lambda + \lambda n + n)/(2\lambda)$. *The optimal trade policy of the final-good importer is free trade, that is,* $t^* = 0$.

(iii) Suppose that $m > (\lambda + \lambda n + n)/(2\lambda)$. *The optimal trade policy of the final-good importer is an import subsidy, that is,* $t^* < 0$.

The logic behind Proposition 1 is as follows: When the number of domestic input suppliers m is large, it is important for the final-good importer to expand input demand. Because the size

[8] The second-order (sufficient) condition for welfare maximization is satisfied provided Assumption 2 holds.

of input demand depends on the volume of final-good exports, it is optimal to enhance the profit of the domestic input suppliers by expanding input demand because of the increase of final-good exports. Hence, to improve final-good exports, the final-good importer offers an import subsidy.

When the number of domestic input suppliers is small, input demand is not important for the final-good importer. Because the profit of the input supplier is relatively small compared with the total surplus, it is not desirable from the welfare viewpoint to protect input suppliers. Hence, it is optimal to impose a tariff on the final-good exporting firms to gain tariff revenue.

The following two lemmas are comparative statics results with respect to m and n.

Lemma 2. *(i) The optimal trade policy of the final-good importer, t^*, decreases as m increases. (ii-a) If $m = 0$, t^* decreases as n increases. (ii-b) If $m \geq 1$, t^* increases as n increases.*

Lemma 3. *(i) The input price, $\overline{r}^*$, increases as m increases. (ii) $\overline{r}^*$ decreases as n increases.*

We consider that m increases. Then, the final-good importer attempts to protect its domestic input suppliers through promoting final-good imports, that is, by enhancing input demand. Hence, the level of trade policy t^* decreases. Because input suppliers raise their prices according to the expanded input demand, the input price increases and the profit of the input suppliers also increases.

When n increases, because the international upstream market becomes more competitive, input price r falls ((ii) of Lemma 3). By contrast, this reduction in the input price reduces the profit of the input suppliers. Therefore, if the input supplier exists in the final-good importer, its total surplus can decrease because of the increase of n. Then, to prevent a decrease in the total surplus, the final-good importer attempts to gain revenue from trade policy through a rise in the level of trade policy. Therefore, t^* increases as n increases ((ii) of Lemma 2).

By substituting equilibrium outcomes into the definition of consumer surplus and (2), we obtain equilibrium consumer and total surpluses:

$$\left.\begin{aligned} CS^* &= \frac{(b+1)n^2}{[n(b+2\lambda+3)-2\lambda(m-1)]^2}, \\ W^* &= \frac{n}{n(b+2\lambda+3)-2\lambda(m-1)}. \end{aligned}\right\} \tag{5}$$

From (5), we establish Proposition 2.

Proposition 2. *(i) If $m = 0$, consumer and total surpluses increase as n increases. (ii) If $m = 1$, consumer and total surpluses do not change as n increases. (iii) If $m > 1$, consumer and total surpluses decrease as n increases.*

To consider Proposition 2, we set Lemma 4.

Lemma 4. *(i) If $m = 0$, the unit cost of the final-good exporting firm, $\overline{r}^* + t^*$, decreases as n increases. (ii) If $m = 1$, $\overline{r}^* + t^*$ does not change as n increases. (iii) If $m > 1$, $\overline{r}^* + t^*$ increases as n increases.*

If the unit cost of the final-good exporting firms, $\overline{r}^* + t^*$, increases because of an increase in the number of input suppliers n, final-good exports decrease (Lemma 4). Then, because final-good exports decrease, consumer surplus decreases. The effect of a decrease in consumer surplus is dominant; hence, the total surplus also decreases (Proposition 2).

The intuition of Lemma 4 is as follows: An increase in n has two opposite effects for the optimal tariff t^*. A fall in the input price caused by an increase in n decreases (a) the profits of the domestic upstream firms; hence, it can result in welfare loss. Hence, the final good importer tries to raise its tariff to compensate for the loss in the profits of domestic upstream firms. This (a) is a tariff rising effect. By contrast, a fall in the input price caused by an increase in n lowers (b) the production cost of the foreign downstream firm; hence, that firm becomes more efficient. Because an increase in imports from an efficient final-good exporting firm can enhance welfare, the final good importer lowers its tariff. This (b) is a tariff lowering effect. When m

is large, because the degree of profit loss in the domestic upstream firms and the tariff raising incentive becomes stronger, (a) dominates (b). Furthermore, the effect of (a) becomes stronger as m becomes large. Thus, $\partial\left(\overline{r}^{*}+t^{*}\right)/\partial n>0$ holds for $m>1$.

Proposition 2 has the following policy implication. A final-good importer should not raise its tariff to gain benefits from upstream competition (e.g., an increase in the number of upstream firms). It seems that this implication has a certain significance. For example, it has been reported that, in recent years, India has raised tariffs for final goods in relatively broader areas.[9] However, we can say that if the benefits of competition in the upstream intermediate-goods markets potentially exist, the increase in tariffs for the final goods may spoil the benefits that could be obtained from upstream competition.

Downstream differentiated price competition. Does the difference in the competition mode affect the results of Proposition 2 (or Lemma 4)? Here, we consider a scenario where the final-good exporting firms, that is, downstream firms, engage in differentiated price competition. The demand function of the final good in this case becomes

$$q_i=\frac{1-b-p_i+bp_j}{1-b^2},\quad i\neq j\quad i,j=A,B.$$

If we use a similar approach to the previous one, we obtain the following optimal tariff, t^{p*}, for the final-good importer and the equilibrium input price, $\overline{r}^{p*}$:

$$t^{p*}=\frac{n(\lambda+1-b^2)+\lambda(1-2m)}{n(b+2\lambda+3-2b^2)-2\lambda(m-1)},$$
$$\overline{r}^{p*}=\frac{\lambda(n+1)}{n(b+2\lambda+3-2b^2)-2\lambda(m-1)}.$$

[9] In fact, in 2021, India raised tariffs on goods, including plastic products, leather products, solar inverters, and solar lanterns. See Shiino (2021).

The consumers surplus CS^{p*} and total surplus W^{p*} in the final-good importer become

$$CS^{p*} = \frac{(b+1)n^2}{[n(b+2\lambda+3-2b^2)-2\lambda(m-1)]^2},$$

$$W^{p*} = \frac{n}{n(b+2\lambda+3-2b^2)-2\lambda(m-1)}.$$

These outcomes yield the same result as that of Proposition 2 and Lemma 4. For example, if we differentiate the unit cost of downstream firms $\overline{r}^{p*} + t^{p*}$, with respect to n, we find that the condition of the unit cost to increase is the same as that in Lemma 4; that is, $\partial\left(\overline{r}^{p*} + t^{p*}\right)/\partial n = \frac{2(2+b+b^2)\lambda(m-1)}{[n(b+2\lambda+3-2b^2)-2\lambda(m-1)]^2} > 0$ for $m > 1$. The same applies to consumer and total surpluses:

$$\frac{\partial CS^{p*}}{\partial n} = -\frac{4(b+1)\lambda(m-1)n}{[n(b+2\lambda+3-2b^2)-2\lambda(m-1)]^3},$$

$$\frac{\partial W^{p*}}{\partial n} = -\frac{2\lambda(m-1)}{[n(b+2\lambda+3-2b^2)-2\lambda(m-1)]^2}.$$

Hence, the difference in competition modes does not affect our main results.

4 Discussion and extension

4.1 Upstream quantity competition

Does the upstream competition mode change our main result? To answer this, we introduce homogeneous quantity competition in the upstream market. With the exception of quantity competition in the upstream market, the model is the same as that in the previous section.

From the third-stage exports of final-good exporting firms, $q_i(r,t)$ for $i = A, B$, we obtain $q_A(r,t) + q_B(r,t) = Y = \sum_{k=1}^{n} y_k$, where y_k is the output of each input supplier k and Y denotes the aggregate outputs. By solving $q_A(r,t) + q_B(r,t) = Y$ with respect to r, we obtain $r = [2 - 2t - (2+b)Y]/2$. Because the profit of input supplier k ($\in \{1, \ldots, n\}$) is $\pi_k^C \equiv ry_k - (c/2)y_k^2$, the second-stage input price becomes $r(t) = \frac{(1-t)(b+2c+2)}{b(n+1)+2(c+n+1)}$. Using $r(t)$ and second-stage outcomes, the welfare maximizing trade policy becomes

$$t^{C*} = \frac{n(b+2c+n+2) - 2m(b+c+2)}{n(b(n+2)+4c+3n+4) - 2m(b+c+2)}, \tag{6}$$

where "C" denotes upstream Cournot competition.

From (6), Proposition 3 holds.

Proposition 3. *Suppose that there is homogeneous quantity competition in the international upstream market. The optimal trade policy of the final-good importer is a tariff, that is,* $t^{C*} > 0$.

The logic behind Proposition 3 is relatively intuitive. The relaxation in upstream competition incentivizes the final-good importer to protect domestic input suppliers through expanding input demand weaker. Hence, for the final-good importer, the incentive to gain tariff revenue becomes stronger. As a result, the final-good importer can offer an import subsidy only when the number of upstream firms is small.

The equilibrium input price is

$$r^{C*} = \frac{n(b+2c+2)}{n(b(n+2)+4c+3n+4)-2m(b+c+2)}. \tag{7}$$

The equilibrium welfares are

$$\left.\begin{aligned} CS^{C*} &= \frac{(b+1)n^4}{[n(b(n+2)+4c+3n+4)-2m(b+c+2)]^2}, \\ W^{C*} &= \frac{n^2}{n(b(n+2)+4c+3n+4)-2m(b+c+2)}. \end{aligned}\right\} \tag{8}$$

From (8), we establish Proposition 4.

Proposition 4. *Suppose that there is homogeneous quantity competition in the international upstream market. (i) If* $m > \frac{n(b+2c+2)}{2(b+c+2)}$*, consumer and total surpluses decrease as* n *increases. (ii) If* $m = \frac{n(b+2c+2)}{2(b+c+2)}$*, consumer and total surpluses do not change as* n *increases. (iii) If* $m < \frac{n(b+2c+2)}{2(b+c+2)}$*, consumer and total surpluses increase as* n *increases.*

For upstream quantity competition, we also find a similar feature of the unit cost in the final-good exporting firms with price competition. From (6) and (7), we find

$$\frac{\partial\left(r^{C*}+t^{C*}\right)}{\partial n} = \frac{2(b+2)n[2m(b+c+2)-n(b+2c+2)]}{[n(b(n+2)+4c+3n+4)-2m(b+c+2)]^2}.$$

This equation yields the critical value $n(b + 2c + 2)/(2(b + c + 2))$; hence, we find a similar comparative statics result with price competition in the welfares (Proposition 4).

4.2 Final-good importer with a downstream oligopolist

We introduce a downstream firm located in the final-good importer in our model. For simplicity, we consider homogeneous quantity competition (i.e., $b = 1$) in the final-good market. Hence, the inverse market demand of the final good is $p = 1 - q_H - q_A - q_B$. We assume that $\lambda < 8n/(3n - 3) \equiv \bar{\lambda}_{ho}$, which guarantees that the collusive input price is larger than the highest price in the Nash equilibria in the upstream market. Additionally, we suppose that $m < (2n\lambda + n\lambda)(10n + \lambda + n\lambda)/(4n\lambda) \equiv m_{ho}$, which is the second-order condition in the first stage.

By applying a similar calculation to that in the previous section, we derive the optimal trade policy:

$$t^*_{ho} = \frac{n[6n + 5\lambda(1 + n) - 6\lambda m]}{\lambda^2 + 2\lambda n(\lambda - 2m + 6) + (\lambda^2 + 12\lambda + 20)n^2}.$$

By considering the sign of t^*_{ho}, we obtain the following proposition.

Proposition 5. *Suppose that one downstream firm exists in the importing country, and all downstream firms produce a homogeneous product and compete in quantity. (i) If* $m < \frac{6n+5\lambda(1+n)}{6\lambda} \equiv m^t_{ho}$*, the optimal trade policy of the final-good importer is a tariff, that is,* $t^*_{ho} > 0$*. (ii) If* $m = m^t_{ho}$*, the optimal trade policy of the final-good importer is free trade, that is,* $t^*_{ho} = 0$*. (iii) If* $m > m^t_{ho}$*, the optimal trade policy of the final-good importer is an import subsidy, that is,* $t^*_{ho} < 0$.

Taking into account the presence of a downstream firm located in the importing country, the final-good importer chooses to impose a tariff when the number of input suppliers located in the final-good importer is small. Because this result is consistent with Proposition 1, the intuition behind both is shared.

Next, we consider the effect of n on consumer and total surpluses. In equilibrium, consumer and total surpluses are as follows:

$$CS_{ho}^{*} = \frac{2n^2[\lambda + (\lambda + 6)n]^2}{[\lambda^2 + 2\lambda n(\lambda - 2m + 6) + (\lambda^2 + 12\lambda + 20)n^2]^2},$$
$$W_{ho}^{*} = \frac{2n(\lambda m + 4n)}{\lambda^2 + 2\lambda n(\lambda - 2m + 6) + (\lambda^2 + 12\lambda + 20)\, n^2}.$$

By differentiating these surpluses with respect to n, we obtain the following derivatives:

$$\frac{\partial CS_{ho}^{*}}{\partial n} = \frac{4\lambda n[\lambda + (\lambda + 6)n]\left[\lambda^2(n^2 + 2n + 1) + \lambda(12n^2 + 12n) + 52n^2 - m(4\lambda n^2 + 24n^2)\right]}{[\lambda^2 + 2\lambda n(\lambda - 2m + 6) + (\lambda^2 + 12\lambda + 20)n^2]^3},$$
$$\frac{\partial W_{ho}^{*}}{\partial n} = \frac{2\lambda[\lambda + (\lambda + 6)n][\lambda m(1 - n) - 2n(3m - 4)]}{[\lambda^2 + 2\lambda n(\lambda - 2m + 6) + (\lambda^2 + 12\lambda + 20)n^2]^2} < 0.$$

We define the following thresholds:

$$m_{ho}^{CS} \equiv \frac{\lambda^2 + (\lambda^2 + 12\lambda + 52)n^2 + 2\lambda(\lambda + 6)n}{4(\lambda + 6)n^2},$$
$$m_{ho}^{W} \equiv \frac{8n}{(\lambda + 6)n - \lambda}.$$

Then, we obtain the result of the comparative statics as follows.

Proposition 6. *Suppose that one downstream firm exists in the importing country, and all downstream firms produce a homogeneous product and compete in quantity. (i) Consumer surplus decreases with* n *if* $m > m_{ho}^{CS}$*; and total surplus decreases with* n *if* $m > m_{ho}^{W}$*. (ii) Consumer surplus does not change with* n *if* $m = m_{ho}^{CS}$*; and total surplus does not change with* n *if* $m = m_{ho}^{W}$*. (iii) Consumer surplus increases with* n *if* $m < m_{ho}^{CS}$*; and total surplus increases with* n *if* $m < m_{ho}^{W}$*.*

We can confirm that Proposition 6 is consistent with Proposition 2. Thus, the intuition behind Proposition 6 is the same as that behind Proposition 2.

5 Conclusion

In this paper, we considered a final-good importer with upstream firms, and showed that upstream competition can decrease the final-good importer's consumer and total surpluses. In the upstream markets, the input price falls as the number of upstream firms increases. By contrast, if the upstream firms exist in the final-good importer, the level of its tariff increases as the number of upstream firms increases. The unit cost of the final-good exporting firms (downstream firms) is the sum of the level of tariff (trade policy) and input price. When the number of upstream firms increases, the input price falls, but the level of trade policy rises. Hence, an increase in the number of input suppliers has conflicting effects. If the final-good importer has firms upstream, as the cost-increasing effect is dominant, an increase in the number of upstream firms increases the cost of final-good exporting firms and decreases their export volumes. Because imports of the final good decrease and the price increases, consumer surplus falls. Furthermore, the final-good exporting firms become less efficient; hence, the total surplus also decreases. When (i) upstream competition in quantity exists and (ii) an oligopolist exists in the final-good importer, this result essentially holds.

Our model is limited to the "importing country case." Therefore, extending our model to a two-way two-country trade model may be fruitful. However, this topic is beyond the scope of our analysis and remains an issue for future research.

Appendix: Proofs

Proof of Lemma 1. (i) Simple algebra yields

$$\overline{r} - \underline{r} = \frac{(b+2)\lambda n^2(1-t)}{(bn+\lambda+2n)(bn+\lambda+\lambda n+2n)} > 0.$$

(ii) From (1), we obtain

$$r_{col} - \overline{r} = \frac{(b+2)n(1-t)(bn+\lambda-\lambda n+2n)}{2(bn+\lambda+2n)(bn+\lambda+\lambda n+2n)}.$$

By solving $r_{col} - \overline{r} > 0$ with respect to λ, we obtain Part (ii). □

Proof of Proposition 1. From (3), the critical value $t^* = 0$ is $m = (\lambda+\lambda n+n)/(2\lambda)$. This value is smaller than m_0, that is, $m_0 - (\lambda+\lambda n+n)/(2\lambda) = (2n+bn+\lambda+n\lambda)/(2\lambda) > 0$. Hence, Proposition 1 holds. □

Proof of Lemma 2. By differentiating (3) with respect to m and n, we obtain

$$\frac{\partial t^*}{\partial m} = -\frac{2\lambda(n(b+\lambda+2)+\lambda)}{[n(b+2\lambda+3)-2\lambda(m-1)]^2} < 0,$$
$$\frac{\partial t^*}{\partial n} = \frac{\lambda(b(2m-1)+2(\lambda+2)m-1)}{[n(b+2\lambda+3)-2\lambda(m-1)]^2}.$$

These imply Lemma 2. □

Proof of Lemma 3. By differentiating (4) with respect to m and n, we obtain

$$\frac{\partial \overline{r}^*}{\partial m} = \frac{2\lambda^2(n+1)}{[n(b+2\lambda+3)-2\lambda(m-1)]^2} > 0.$$
$$\frac{\partial \overline{r}^*}{\partial n} = -\frac{\lambda(b+2\lambda m+3)}{[n(b+2\lambda+3)-2\lambda(m-1)]^2} < 0.$$

Hence, Lemma 3 holds. □

Proof of Lemma 4. By differentiating $\overline{r}^* + t^*$ with respect to n, we obtain

$$\frac{\partial\left(\overline{r}^*+t^*\right)}{\partial n} = \frac{2(b+2)\lambda(m-1)}{[n(b+2\lambda+3)-2\lambda(m-1)]^2}.$$

This implies Lemma 4. □

Proof of Proposition 2. By differentiating (5) with respect to n, we obtain

$$\frac{\partial CS^*}{\partial n} = -\frac{4(b+1)\lambda(m-1)n}{[n(b+2\lambda+3)-2\lambda(m-1)]^3}; \quad \frac{\partial W^*}{\partial n} = -\frac{2\lambda(m-1)}{[n(b+2\lambda+3)-2\lambda(m-1)]^2}.$$

These imply Proposition 2. □

Proof of Proposition 3. From (6), by solving the inequality $t^{C*} \geq 0$ with respect to m, we obtain $m \leq n(b+2c+n+2)/(2(b+c+2))$. As $n-n(b+2c+n+2)/(2(b+c+2)) = (2+b-n)n/(2(c+b+2))$, $t^{C*} < 0$ can appear if $n < 3$. These imply Proposition 3. □

Proof of Proposition 4. By differentiating (8) with respect to n, we obtain

$$\frac{\partial CS^{C*}}{\partial n} = \frac{4(b+1)n^3[n(b+2c+2)-2m(b+c+2)]}{[n(b(n+2)+4c+3n+4)-2m(b+c+2)]^3},$$
$$\frac{\partial W^{C*}}{\partial n} = \frac{2n[n(b+2c+2)-2m(b+c+2)]}{[n(b(n+2)+4c+3n+4)-2m(b+c+2)]^2}.$$

From the numerator of the equations,

$$\text{sign}\left\{\partial CS^{C*}/\partial n\right\} = \text{sign}\left\{\partial W^{C*}/\partial n\right\} = \text{sign}\left\{n(b+2c+2)-2m(b+c+2)\right\}.$$

Moreover, $n - n(b+2c+2)/(2(b+c+2)) = n(b+2)/(2(b+c+2)) > 0$. Hence, $\partial CS^{C*}/\partial n <(>)0$ if $m >(<)\ n(b+2c+2)/(2(b+c+2))$. □

Proof of Proposition 5. The sign of t^*_{ho} only depends on the terms in the numerator: $-6\lambda m + 6n + 5\lambda(1+n)$. Note that the denominator is positive because the second-order condition in the first stage must be satisfied. By solving $-6\lambda m + 6n + 5\lambda(1+n) > 0$ for m, we obtain the following inequality: $m < [6n + 5\lambda(1+n)]/(6\lambda) \equiv m^t_{ho}$. Additionally, a comparison of m^t_{ho} and m_{ho} yields $m_{ho} > m^t_{ho}$, which implies Proposition 5. □

Proof of Proposition 6. First, we consider the effect of n on CS^*_{ho}. From the second-order condition in the first stage, the denominator of $\partial CS^*_{ho}/\partial n$ is positive. Then, the sign of $\partial CS^*_{ho}/\partial n$ only depends on the terms in the numerator. Hence, we solve $\partial CS^*_{ho}/\partial n < 0$ for m and obtain $m > m^{CS}_{ho}$. By comparing m^{CS}_{ho} and m_{ho}, we obtain the first part of the proposition.

Second, we consider the effect of n on W^*_{ho}. The sign of $\partial W^*_{ho}/\partial n$ only depends on the terms in the numerator. Hence, we solve $\partial W^*_{ho}/\partial n < 0$ for m and obtain $m > m^W_{ho}$. By comparing m^W_{ho} and m_{ho}, we obtain the second part of the proposition. □

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