The Effects of Strategic Subsidies under FTA with ROO

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Abstract

This paper presents a model of a free trade area (FTA) with rules of origin (ROO) under an oligopolistic final goods market. Following the existing literature, we also consider ROO to serve as a protectionist device and mainly focus on the interaction between ROO and the subsidy policy. A paradoxical result is considered: if the government of the final goods exporter within the FTA is the first mover, it chooses export tax. Furthermore, we show that the profit of a firm located in the FTA increases due to a reduction in the external tariff.

JEL classifications: F12, F13, F15

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1. Introduction

In regional trade blocks, certain rules are required to determine whether a product can be considered "domestic" (produced inside the block) in order to qualify for free trade among member countries (Lopez-de-Silanes *et al*., 1996). Rules of origin (ROO) are rules that define the origin of a product by setting the minimum ratio of domestic (or intra-block produced) intermediates required to produce a product. This aspect of domestic content provision is mainly represented by the mechanisms of the local content requirement (LCR) — an important feature of ROO.

As a significant contribution to the context of LCR, Lahiri and Ono (1998, 2003) analyzed the effects of LCR in a model with an oligopolistic setting and summarized the basic implications derived from such a protectionist policy. Their analysis stated that the producers of final goods in a foreign country must satisfy a minimum level of LCR

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to supply goods to the market of the host country if both the countries serve as sources of intermediate goods. Therefore, if the price (productivity) of intermediate goods in a member country is higher (lower) than that of another member country in their FTA, ROO serves as a protectionist device for the less efficient country.

Several studies on ROO focus on their protectionist nature and mainly examine the effects of their introduction and tightening (e.g., an increase in the content rate) as a singular policy variable.[1]

Falvey and Reed (2002) is an exceptional study that examines the relationship between ROO and other trade policies. They constructed a three-country model (one country importing final goods and two others exporting final goods) with a perfect competitive framework and highlighted the relationship between ROO and the tariff policy imposed by the importing country. They showed that the importing country can benefit from introducing a tariff policy for final goods complementarily to ROO. However, their analysis is limited to the importing country's tariff policy. Thus, it is still unclear as to how the relationship between ROO and trade policies other than the tariff policy is established.

In the present paper, we mainly consider the interaction between ROO and the subsidy policy. Following the pioneering studies of Brander and Spencer (1985) and Eaton and Grossman (1986), the subsidy policy has been significantly examined in the arguments concerning the strategic trade policy.[2] However, existing studies on FTAs with ROO do not sufficiently examine the subsidy policy, despite the fact that it is important in terms of trade and similar to tariffs in a strategic trade policy. To fill this gap, we consider the effect of the exporting countries' subsidy policies in the presence of ROO.

We present a three-country (countries A and B have already formed an FTA, and outside the FTA is country O), three-firm (firms a, b, and o, located in countries A, B, and O, respectively) oligopolistic model in order to describe the effects of ROO and the subsidy policy. Country A is the country importing the final goods and countries B and O are the countries exporting the final goods. Firm a uses the intermediate goods produced internally and supplies the final goods in the domestic market. Firm b can gain duty-free access to the final goods market in country A if it procures more than the predetermined proportion of ROO. On the other hand, firm o exports the final goods under a given level of the external tariff imposed by country A.

In the abovementioned environment, we consider the following three-stage game. In the first stage, government B chooses a level of production subsidy for its firm. In

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[1] The literature on FTAs with ROO has mainly focused on the issue of LCR, and the generally adopted analytical framework is the local content protection (LCP) model. Three different definitions of ROO are found in the existing literature on FTAs with ROO that focuses on the issue of LCR. These are the cost- (or price-) based definition (Ju and Krishna, 2005), value addition-based definition (Krueger, 1999; Falvey and Reed, 2002), and physical content-based definition (Lopez-de-Silanes *et al*., 1996). Krishna and Krueger (1995) compared the results of the cost-based definition with that of the price-based definition. Ishikawa *et al*. (2007) omitted the direct effects or mechanism of ROO in the intermediate goods market. They exclusively focused on a situation that resulted from the presence of ROO in the final goods market and compared consumer surplus, profits, and the welfare of countries inside and outside the FTA in the absence of ROO as well as in its presence.

[2] For example, see Brander (1995).

the second stage, governments A and O independently and simultaneously choose the content rate of ROO and a level of production subsidy for the domestic firm. In the final stage, the firm chooses the quantity of supply. In equilibrium, government B imposes an export tax (a negative export subsidy) on its firm in order to decrease the content rate of ROO. Irrespective of whether or not the paradoxical result "export tax" holds, we also consider a different timing structure. In the first stage, government A chooses the content rate of ROO. In the second stage, governments B and O independently and simultaneously choose their respective level of production subsidy for their firms. The final stage is the same as that in the previous timing structure. In this case, government B offers a positive export subsidy for its firm. Further, we show that a counter-intuitive result holds with respect to a change in the profit of the firm in country B due to a change in the external tariff. A decrease in the external tariff helps firm b, which is located in the FTA.

The logic behind our results is as follows. When government B is the first mover, the content rate of ROO is high if the productivity of firm b is high. Government A (second mover) sets a higher content rate of ROO as the productivity of firm b increases. Government B imposes the export tax to earn tax revenue rather than offering an export subsidy. On the other hand, when government A is the first mover, the content rate of ROO is determined in the first stage so that government B's subsidy level does not directly affect the content rate of ROO. Government B is in a subsidy race with government O. Thus, if the former does not subsidize its firm, the market share of firm b decreases considerably. Therefore, government B subsidizes its firm.

Next, we examine the effects of the external tariff. The market share of firm o is relatively large (small) if the external tariff is relatively low (high). Government A sets a lower (higher) content rate of ROO because its effects on consumer surplus (domestic firm's profit) dominate any other effect. A positive correlation arises between the content rate of ROO and the external tariff such that the content rate of ROO decreases due to a decrease in the external tariff. The profit of firm b increases due to a decrease in the content rate of ROO.[3]

The paper is organized as follows. In section 2, we formulate the model and derive the results of the comparative statics at the final stage of the game. In section 3, we compare the results of the different timings in policy decisions and examine the effects of a change in the external tariff in each case. We conclude this paper in section 4.

2. The model

Suppose that an FTA comprises two countries, A and B. Only country A has a final goods market and we label the country outside the FTA as O. In country A, there exists unemployment and the government imposes a sufficiently high specific tariff t_m on imported intermediate goods.[4] The intermediate goods industry in country A is

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[3] However, when government A is the first mover, this effect weakens. Whether or not the profit of firm b increases due to a change in the external tariff depends on the price (i.e., less productivity) of the intermediate goods produced in country A.

[4] That is, $k^a > k^o$ and $k^a < k^o + t_m$.

inefficient as compared to that in foreign countries. That is, $k^a > k^o$, where k^a (k^o) is the price of the intermediate goods in country *A* (*O*). Thus, if there is no trade barrier, the intermediate goods industry in country *A* vanishes. Inefficient workers have a strong incentive to apply political pressure because trade liberalization is the cause of their unemployment. Hence, the party in power in country *A* cannot assist in the creation of employment opportunities. As a result, government *A* imposes a high import tariff on the imported intermediate goods to ensure that the final goods producer in country *A* uses the domestically produced intermediate goods. Thus, the final goods are produced by using only domestically produced intermediate goods. In country *B*, however, firm *b* faces ROO and chooses a mixed proportion of intermediate goods produced in countries *A* and *O*, because firm *b* is exempted from the external tariff if it procures more than the predetermined proportion of ROO. In countries *A* and *O*, the intermediate goods industries produce under perfect competition.

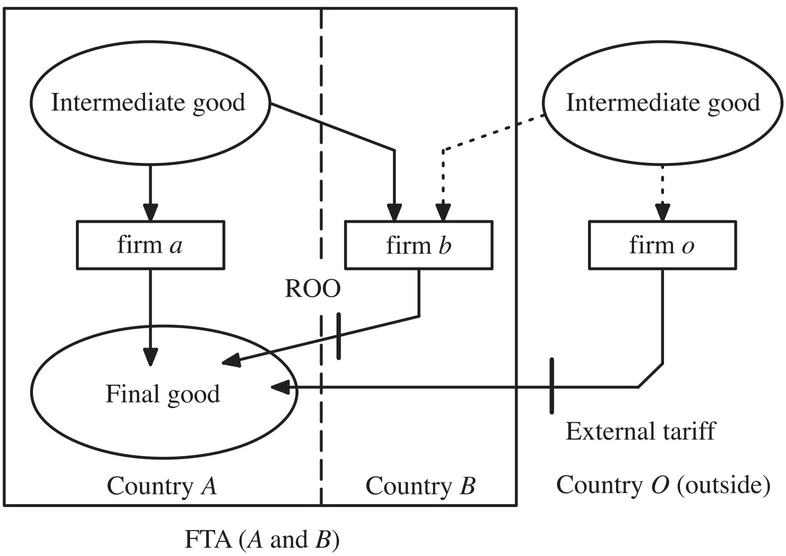

Figure 1 Trade structure

The market inverse demand function in country *A* is assumed to be linear: $p = p(X)$, $p'(X) < 0$, and $p''(X) = 0$, where *X* and *p* represent the industry output and prices, respectively. Consider an oligopolistic market comprising three firms. Each firm, denoted by i (= a,b,o), is located in country i. Let x^i denote the output of firm i. Thus, $X = x^a + x^b + x^o$. Further, we assume that one unit of intermediate goods is required to produce one unit of final goods. Thus, the net profits of firms *b* and *o* are

$$\pi^b \equiv (p(X) - c^b(\delta) + s^b)\ x^b, \qquad \pi^o \equiv (p(X) - k^o + s^o - t_x)\ x^o, \tag{1}$$

respectively, where s^j, $j = b,o$ denotes the export subsidy (tax) imposed by government j on firm j, and t_x is the fixed external tariff imposed on an outside country. Following Lahiri and Ono (1998, 2003), the marginal (average) cost of firm *b* becomes

$$c^b(\delta) \equiv \delta\ k^a + (1-\delta)\ k^o, \qquad k^a > k^o \geq 0, \tag{2}$$

where $\delta \in (0,1)$ is the content rate of ROO imposed by country *A*'s government. Note that only country *A* imposes a tariff on imported intermediates. Hence, the net profit of firm *a* is

$$\pi^a \equiv (p(X) - k^a)\ x^a. \tag{3}$$

As defined in equation (2), we assume that $k^a > k^o$, that is, the intermediate goods industry in country *A*, is less efficient.

First, we focus on the effects of each policy variable, namely, δ, s^j, and t_x, at the final stage. From equations (1)–(3), the first-order profit maximization conditions become

$$0 = p(X) + p'(X)x^a - k^a, \tag{4}$$

$$0 = p(X) + p'(X)x^b - [c^b(\delta) - s^b], \tag{5}$$

$$0 = p(X) + p'(X)x^o - [k^o - s^o] - t_x. \tag{6}$$

From equations (4)–(6), we obtain the results of comparative statics on the firms' output x^i, industry output X, profits π^i, and consumer surplus CS at the final stage, as summarized in Tables 1 and 2.

The scale of the changes in outputs due to the tightening of ROO depends on the difference between the price of the intermediate goods inside and outside the FTA, that is, $\Delta k \equiv k^a - k^o > 0$.[5] The enforcement of ROO raises the marginal cost of firm *b* and decreases export x^b. If the other firms do not change their outputs, the price of the oligopolistic goods increases. Thus, the other firms try to increase their profits, leading to an increase in output. This is a rent-shifting effect due to the enforcement of ROO. However, this effect decreases the total output and increases consumer price, and as a result, it leads to a decrease in consumer surplus. This effect is anti-competitive.

An increase in the subsidy for firm *j* differs from the enforcement of ROO, since it causes an increase in the total output, thereby causing an increase in consumer surplus. Therefore, the production subsidy brings about a competitive effect. This point crucially differs from the effects of the tightening of the ROO. On the other hand, the external tariff has an effect similar to that of the ROO. An increase in the external tariff decreases the exports of firm *o*. This effect causes rent-shifting from firm *o* to the other firms. However, consumer surplus decreases due to an increase in the external tariff.

3. Intervention of other countries

In this section, we examine the relationship between ROO and the subsidy policy as well as the effects of a change in the external tariff. In section 3.1, when government *B*

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[5] To avoid the case of "not conforming to ROO," we hereafter assume that the difference in the intermediate goods prices Δk is sufficiently small.

determines the subsidy level, we can show that government B imposes an export tax on its firm. In section 3.2, by switching the timing of the game to a more realistic sequence of moves (i.e., first the ROO, and then the subsidies), we can easily verify that the result depends on the timing of the policy decision.

3.1 Case 1: Government B is the first mover

Let us consider the following three-stage game. Stage 1: The FTA member (government B) chooses the level of subsidy s^b. Stage 2: Governments A and O independently and simultaneously choose the levels of the policy variables. Government A chooses the level of $\delta \in (0,1)$ and government O chooses the level of subsidy s^o. Stage 3: Each firm independently and simultaneously chooses the output level. We use the subgame perfect Nash equilibrium as the equilibrium concept. The game is solved using backward induction. We have already examined the characteristics of the outcomes in the final stage; hence, we can begin the analysis in stage 2.

Country A's social welfare is assumed to be the sum of the producers' and consumers' surpluses, $\pi^a + CS$, and the input cost of both the domestic firm and firm b paid to country A, $k^a x^a + \delta k^a x^b$, and the tariff revenue, $t_x x^o$. This definition is the same as that used by Lahiri and Ono (1998, 2003), who assume the existence of unemployment. On the other hand, Country O's social welfare is equivalent to that of the net exporter of final goods because no unemployment exists. Hence, the objective functions of governments A and O are denoted by social welfare functions W^A and W^O, respectively.[6] Each government solves the following problem:

$$\max_{\delta \in (0,1)} W^A \equiv \pi^a + k^a x^a + \delta\, k^a x^b + CS + t_x x^o, \qquad \max_{s^o} W^O \equiv \pi^o - s^o x^o, \tag{7}$$

where $CS \equiv v(X) - p(X)X$, and $v(\cdot)$ is the utility of oligopolistic goods. Assuming $\delta \in (0,1)$, equation (7) yields reaction functions of both the governments, $\varphi^A(s^o, s^b)$ and $\varphi^o(\delta, s^b)$. Thus, we obtain

$$\frac{\partial \varphi^A}{\partial s^o}(s^o, s^b) = -\frac{7k^a - 3k^o}{(7k^a + k^o)3\Delta k} < 0, \qquad \frac{\partial \varphi^O}{\partial \delta}(\delta, s^b) = \frac{\Delta k}{3} > 0. \tag{8}$$

This result is summarized in proposition 1.

Proposition 1: (i) *Government A's (O's) reaction curve has a downward (upward) slope that does not depend on* s^b. (ii) *The slope of government A's reaction curve increases (decreases) due to an increase in the price* k^a *of the intermediate goods produced inside the FTA if* $(\mu + 4k^o)^2/(\mu - 6k^o)\mu > (\leq) 1/2$, *where* $\mu \equiv 7\Delta k$. (iii) *A sufficient condition for the equilibrium to be asymptotically stable is satisfied, i.e.,* $\left|\partial\varphi^A / \partial s^o\right|\left|\partial\varphi^O / \partial\delta\right| < 1$ *for all* $\Delta k > 0$.

[6] These social welfare functions are strictly concave with respect to the policy parameters. Thus, the level of the imposed policy is positive. We show that this feature holds (see Appendix).

Government A considers both the domestic market and firm a, and it decreases the level of δ when government O raises its subsidy level. That is, government A tries to compensate for a loss in the profit of firm a by increasing consumer surplus. Government O, however, considers only firm o. Thus, it increases the level of subsidy and improves its own position when δ increases.

Next, we examine the change in the direction of the policy variables of both governments A and O due to a change in s^b. From equations (7) and (8), we obtain

$$\begin{pmatrix} (7k^a + k^o)3\Delta k & 7k^a - 3k^o \\ -\Delta k & 3 \end{pmatrix} \begin{pmatrix} d\delta / ds^b \\ ds^o / ds^b \end{pmatrix} = \begin{pmatrix} 9k^a + 3k^o \\ -1 \end{pmatrix}.$$

The change in the direction of each equilibrium value is respectively represented by

$$\frac{d\delta}{ds^b} = \frac{17k^a + 3k^o}{(35k^a + 3k^o)\Delta k} > 0, \qquad \frac{ds^o}{ds^b} = -\frac{6k^a}{35k^a + 3k^o} < 0. \tag{9}$$

Thus, from equation (9), we establish the following proposition.

Proposition 2: *The equilibrium level of δ increases but that of s^o decreases due to an increase in the subsidy level s^b of the FTA member.*

Furthermore, from the governments' reaction functions at equilibrium in stage 2, $\delta(s^b) = \varphi^A(s^o(s^b), s^b)$ and $s^o(s^b) = \varphi^O(\delta(s^b), s^b)$, we obtain

$$\frac{d\delta}{ds^b}(s^b) = \underbrace{\frac{\partial \varphi^A}{\partial s^o}(s^o, s^b)\frac{ds^o}{ds^b}(s^b)}_{indirect \quad effect} + \underbrace{\frac{\partial \varphi^A}{\partial s^b}(s^o, s^b)}_{direct \quad effect}, \tag{10}$$

and

$$\frac{ds^o}{ds^b}(s^b) = \underbrace{\frac{\partial \varphi^O}{\partial \delta}(\delta, s^b)\frac{d\delta}{ds^b}(s^b)}_{indirect \quad effect} + \underbrace{\frac{\partial \varphi^O}{\partial s^o}(\delta, s^b)}_{direct \quad effect}. \tag{11}$$

A change in the equilibrium values due to a change in s^b can be decomposed into a direct and an indirect effect. From equations (10) and (11), we obtain the following corollary.

Corollary 1: *The direction of the shift in the reaction curves is*

$$\frac{\partial \varphi^A}{\partial s^b} = \frac{105(k^a)^2 + 44k^a k^o + 3(k^o)^2}{(7k^a + k^o)(35k^a + 3k^o)\Delta k} > 0, \qquad \frac{\partial \varphi^O}{\partial s^b} = -\frac{1}{3} < 0.$$

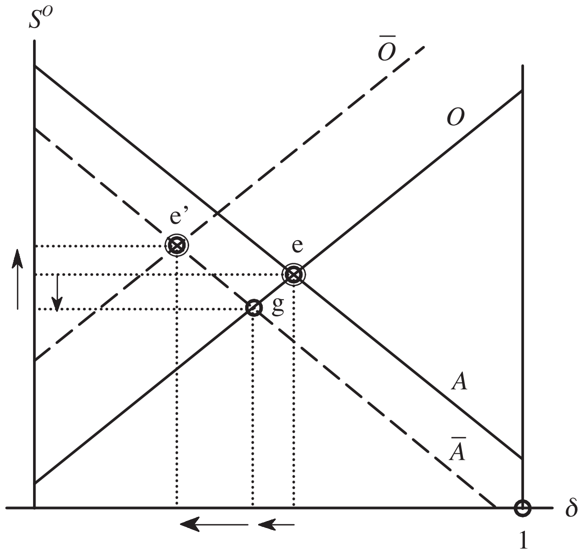

Figure 2 A change in each government's reaction curve due to a decrease in s^b

Figure 2 shows the direction of the shift in the reaction curves due to a decrease in s^b (or an increase in tax). Suppose that only line A (reaction curve of government A) shifts leftward first ($A \to \bar{A}$). In this case, the new equilibrium point is "g" if line O (reaction curve of government O) does not move. However, country O's welfare decreases considerably because δ and s^o decrease at point g. Thus, government O shifts up (increases s^o) line O to improve social welfare ($O \to \bar{O}$). As a result, the new equilibrium point becomes e'.

Next, we shall consider the move of the FTA member. We define country B's social welfare as being equivalent to the net exporter of the final goods: $W^B(s^b) \equiv \pi^b - s^b x^b$. Thus, we obtain the following proposition.

Proposition 3: *In the presence of ROO, the optimal policy for the FTA member is*

$$s^b = \frac{(5k^a + 3k^o)p' x^b}{15k^a} < 0. \tag{12}$$

This result is explained as follows. In order to reduce the content rate of ROO, government B commits itself to reducing the exports. That is, by increasing the marginal cost of firm b, government B decreases the marginal cost of the home country. If the productivity of firm b after subsidy/tax is imposed is high, the content rate of ROO is high. Government B is aware of this beforehand; it is preferable for government B to decrease the volume of exports of firm b and earn tax revenues. Thus, the optimal policy for government B becomes (export) tax.

Finally, we shall examine the influence of government B's tax policy on country O. Using equations (6) and (7), we obtain

$$s^o = -\frac{2p'x^o}{3} > 0. \tag{13}$$

From equations (7) and (13), we obtain

$$\frac{\partial W^O}{\partial s^b} = -\frac{(53k^a + 3k^o)x^o}{3(35k^a + 3k^o)} < 0.$$

Thus, we establish the following proposition.

Proposition 4: *In the presence of ROO, the social welfare of country O is monotonically decreasing with s^b.*

Thus, the social welfare of country O improves as compared to the case of non-intervention ($s^b = 0$) because government B chooses a tax policy (proposition 3).

Effects of the external tariff: In this game, we observe counter-intuitive results with respect to a change in the firm's profit due to a change in the external tariff. Let us first consider the results obtained in stage 2 of the game. Using solutions $\delta(s^b,t_x)$ and $s^o(s^b,t_x)$, and equation (7), we can easily find that

$$\begin{pmatrix} 3(3k^a + k^o) & 7k^a - 3k^o \\ -\Delta k & 3 \end{pmatrix} \begin{pmatrix} d\delta/dt_x \\ ds^o/dt_x \end{pmatrix} = \begin{pmatrix} 11k^a - 7k^o \\ -3 \end{pmatrix}$$

Thus, we obtain

$$\frac{d\delta}{dt_x} = \frac{3(9k^a - 5k^o)}{(17k^a + 3k^o)\Delta k} > 0, \qquad \frac{ds^o}{dt_x} = -\frac{8(k^a + k^o)}{17k^a + 3k^o} < 0. \tag{14}$$

The intuition for this result is as follows: The rise in t_x implies that firm o becomes less efficient and firm a becomes more efficient. This effect provokes government A to enhance the competitiveness of firm a. Hence, government A increases δ. On the other hand, government O's incentive to encourage firm o becomes small. This is because the competitiveness of firm o decreases due to an increase in t_x.

Next, we consider the first stage. From equation (12), we obtain[7]

$$\frac{ds^b}{dt_x} = \frac{7(5k^a + 3k^o)(35k^a + 3k^o)\Delta k}{15k^a(17k^a + 3k^o)(20k^a + 3k^o)} > 0. \tag{15}$$

Furthermore, using (4)–(6), (14), and (15), we obtain

$$\frac{d\pi^a}{dt_x} = \frac{2}{5}\left\{\frac{1265(k^a)^2 + 109k^a k^o + 6(k^o)^2}{(17k^a + 3k^o)(20k^a + 3k^o)}\right\}x^a > 0, \quad \frac{d\pi^b}{dt_x} = \frac{-14(35k^a + 3k^o)\Delta k}{(17k^a + 3k^o)(20k^a + 3k^o)}x^b < 0,$$

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[7] In this stage of the game, $x^i = x^i(\delta(s^b(t_x),t_x), s^o(s^b(t_x),t_x), s^b(t_x),t_x)$, $i = a,b,o$.

$$\frac{d\pi^o}{dt_x} = -\frac{6}{5}\left\{\frac{20k^a(20k^a+3k^o)+7(5k^a+3k^o)\Delta k}{(17k^a+3k^o)(20k^a+3k^o)}\right\} x^o < 0.$$

Thus, we establish the following proposition.

Proposition 5: *In the presence of ROO, the external tariff reduction decreases (increases) the profit of firm a (firm o). However, it increases the profit of firm b.*

Intuitively, firm *b* is likely to benefit (suffer losses) from an increase (decrease) in the external tariff because the external tariff is imposed on the firm outside the FTA. However, proposition 5 indicates a contradictory result. This intuition is as follows. The market share of firm *o* is relatively large (small) if the external tariff is relatively low (high). Then, government *A* sets a lower (higher) content rate of ROO because the effects on consumer surplus (domestic firm's profits) dominate any other effect. A positive correlation arises between the content rate of ROO and the external tariff such that the content rate of ROO decreases due to a decrease in the external tariff. The market share of firm *b* increases due to a decrease in the content rate of ROO. Therefore, the profit of firm *b* strictly increases due to a reduction in the external tariff.

3.2 Case 2: Inverse timing

In this subsection, we discuss an alternative situation that has a different timing from that in section 3.1. Let us consider the following inverse timing game. Stage 1: Government *A* chooses the level, $\delta \in (0,1)$. Stage 2: Governments *B* and *O* independently and simultaneously choose the levels of the subsidy. Stage 3: Each firm independently and simultaneously chooses the output level.

In stage 2 of this game, governments *B* and *O* maximize social welfare:

$$W^B \equiv \pi^b - s^b x^b, \qquad W^O \equiv \pi^o - s^o x^o. \tag{16}$$

We define the policy reaction functions as $s^b = \vartheta^B(s^o,\delta)$ and $s^o = \vartheta^O(s^b,\delta)$. Applying a method similar to that used in section 3.1, from equation (16), we obtain

$$\frac{\partial \vartheta^B}{\partial s^o}(s^o,\delta) = -\frac{1}{2}, \qquad \frac{\partial \vartheta^O}{\partial s^b}(s^b,\delta) = -\frac{1}{2}. \tag{17}$$

Thus, equation (17) yields the following proposition.

Proposition 1': (i) *Government B's (O's) reaction curve has a downward slope.*
(ii) *A sufficient condition for the equilibrium to be asymptotically stable is satisfied, i.e.,* $\left|\partial\vartheta^B/\partial s^o\right|\left|\partial\vartheta^O/\partial s^b\right| = 1/4 < 1.$

Next, we consider a change in the direction of the policy variables s^j. From equation (16), we obtain

$$\begin{pmatrix} 1 & 3 \\ 3 & 1 \end{pmatrix} \begin{pmatrix} ds^o/d\delta \\ ds^b/d\delta \end{pmatrix} = \begin{pmatrix} -3\Delta k \\ \Delta k \end{pmatrix}.$$

Thus, the change in the direction of each equilibrium value is respectively represented by

$$\frac{ds^b}{d\delta} = -\frac{5\Delta k}{4} < 0, \qquad \frac{ds^o}{d\delta} = \frac{3\Delta k}{4} > 0. \tag{18}$$

This result is stated as

Proposition 2': *The equilibrium level of s^o increases but that of s^b decreases due to an increase in the level of δ.*

The market share of firm *b* decreases if δ increases. This rising inefficiency discourages government *B*'s incentive to subsidize firm *b*. On the other hand, the market share of firm *o* expands due to an increase in δ. Thus, government *O* increases the subsidy level in order to strengthen the competitiveness of firm *o*.

Using equation (18), and the governments' reaction functions $s^b(\delta) = \vartheta^B(s^o(\delta), \delta)$ and $s^o(\delta) = \vartheta^O(s^b(\delta), \delta)$, we obtain the following corollary.

Corollary 1': *The direction of the shift in the reaction curves is*

$$\frac{\partial \vartheta^B}{\partial \delta} = -\frac{7\Delta k}{8} < 0, \qquad \frac{\partial \vartheta^O}{\partial \delta} = \frac{\Delta k}{8} > 0.$$

In a different timing structure, the following result holds.

Proposition 3': *In the presence of ROO, the optimal policy for the FTA member is*[8]

$$s^b = -\frac{2p'x^b}{3} > 0.$$

It is clear that an important implication is included in proposition 3'. That is, in a more realistic sequence of moves, the ROO create an incentive for export subsidies for the FTA member. In this timing structure, government *B*'s subsidy level does not directly affect the content rate of ROO because this content rate is determined in the first stage. Furthermore, government *B* is in a subsidy race with government *O*. Hence, if government *B* does not subsidize its firm, the market share of firm *b* considerably decreases. Therefore, government *B* offers a positive export subsidy for its firm.

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[8] Similarly, the optimal subsidy formula for government *O* is $s^o = -(2p'x^o)/3 > 0$.

Finally, we derive the optimal level of δ. In the first stage, from equation (7), we obtain the following implicitly determined optimal δ:

$$\delta = \frac{3(p + p'x^o + 3t_x)\Delta k - (5k^a + 3k^o)p'x^b}{15k^a \Delta k}. \tag{19}$$

Effects of the external tariff: Here, we also examine the effects of the reduction in the external tariff on each firm's profit. From equation (16), we derive the following results:

$$\frac{ds^b}{dt_x} = \frac{3}{4} > 0, \qquad \frac{ds^o}{dt_x} = -\frac{5}{4} < 0. \tag{20}$$

Equation (20) arises from a mechanism similar to those in equations (14) and (15).

In the first stage, from equation (19), we obtain

$$\frac{d\delta}{dt_x} = \frac{3(19k^a - 11k^o)}{(65k^a + 15k^o + 6)\Delta k} > 0. \tag{21}$$

The intuition for equation (21) is the same as that for equation (14). That is, government A increases δ when firm o becomes less efficient (i.e., a rise in t_x). Using equations (1)–(3), (20), and (21), we obtain

$$\frac{d\pi^a}{dt_x} = \frac{3}{2}\left(\frac{61k^a - 9k^o + 3}{65k^a + 15k^o + 6}\right) x^a > 0, \qquad \frac{d\pi^o}{dt_x} = -\frac{3}{2}\left(\frac{77k^a + 87k^o + 15}{65k^a + 15k^o + 6}\right) x^o < 0,$$

$$\frac{d\pi^b}{dt_x} = \frac{3}{2}\left(\frac{-49k^a + 81k^o + 6}{65k^a + 15k^o + 6}\right) x^b.$$

Thus, we establish the following proposition.

Proposition 5': *In the presence of ROO, the reduction in the external tariff decreases (increases) the profit of firm a (firm o). However, it increases the profit of firm b if* $k^a > 3(27k^o + 2)/49$ *holds.*

Proposition 5' indicates that the results are similar to those observed in proposition 5 in section 3.1. On the other hand, when government A is the first mover, the effects of a decrease in δ due to a decrease in the external tariff weakens. Whether or not the profit of firm b increases due to a change in the external tariff depends on the price of the intermediate goods produced in country A. When k^a is sufficiently small, the inefficiency of production in firms a and b is small. Government A slightly raises δ because the effects on consumer surplus dominate any other effect. Therefore, the profit of firm b increases due to an increase in the external tariff. However, a large k^a implies that the inefficiency of production in firms a and b is relatively large. Then, government

A sufficiently raises δ due to an increase in t_x. Because of this, the effect of a decrease in s^b due to an increase in t_x offsets the effect of an increase in s^b due to an increase in t_x. Thus, if k^a is sufficiently large, an increase in t_x decreases s^b. As a result, firm b's profits also decrease.

4. Conclusion

Several existing studies on ROO mainly focus on the effects of ROO themselves and do not sufficiently consider ROO and other trade policies interact (for example, see Lopez-de-Silanes *et al*., 1996, Krueger, 1999, and Ju and Krishna, 2005). To fill this gap, we mainly examined the interaction between ROO and the subsidy policy. We presented a three-country, three-firm oligopolistic framework in order to describe this policy interaction. Our findings are summarized in the following three points.

First, if the government of the final goods exporter within the FTA (government B) is the first mover, it chooses export tax. To reduce the content rate of ROO, government B commits itself to decreasing the exports of the domestic firm. Second, government B offers a positive export subsidy to its firm if the ROO is set first. It suggests that ROO creates an incentive for export subsidies of the FTA member. In this case, government B does not directly affect the content rate of ROO and is in a subsidy race with the government of the outside country. Hence, government B offers a positive export subsidy for its firm. Third, a reduction in the external tariff helps firm b, which is located in the FTA. Generally speaking, in our model, when the efficiency of production in the firms located in the FTA is sufficiently low, the content rate of ROO sufficiently rises due to an increase in the external tariff. Then, the profit of firm b also decreases due to an increase in the external tariff.

Appendix

Proof of concavity: Twice differentiating the welfare function $W^A(W^O)$ with respect to $\delta(s^o)$, we obtain

$$\frac{\partial^2 W^A}{\partial \delta^2} = \frac{3(8k^a - \Delta k)\Delta k}{16p'} < 0, \qquad \frac{\partial^2 W^O}{\partial [s^o]^2} = \frac{3}{8p'} < 0.$$

Thus, the welfare function of country A (O) is strictly concave. QED

Proof of proposition 1: (i) From equation (7), we obtain the following identities:

$$\begin{aligned} 0 = &-p'\Delta k \cdot X(\varphi^A(s^o,s^b),s^o,s^b) - \Delta k \cdot p(X(\varphi^A(s^o,s^b),s^o,s^b)) + 3k^A\Delta k \cdot \varphi^A(s^o,s^b) \\ &+p'\Delta k \cdot x^a(\varphi^A(s^o,s^b),s^o,s^b) + 4p'\Delta k \cdot x^b(\varphi^A(s^o,s^b),s^o,s^b) - t_x \Delta k \end{aligned} \tag{A1}$$

$$0 = -3p(X(\delta,\varphi^O(\delta,s^b),s^b)) - p'x^o(X(\delta,\varphi^O(\delta,s^b),s^b) + 3k^o + 3t_x . \tag{A2}$$

Differentiating (A1) ((A2)) with respect to s^o (δ), we obtain

$$\left[-2p'\Delta k\frac{\partial X}{\partial \delta} + p'\Delta k\frac{\partial x^a}{\partial \delta} + 4p'k^a\frac{\partial x^b}{\partial \delta} + 3k^a\Delta k\right]\frac{\partial \varphi^A}{\partial s^o} = 2p'\Delta k\frac{\partial X}{\partial s^o} - p'\Delta k\frac{\partial x^a}{\partial s^o} - 4p'k^a\frac{\partial x^b}{\partial s^o},$$

$$-\left[3p'\frac{\partial X}{\partial s^o} + p'\frac{\partial x^o}{\partial s^o}\right]\frac{\partial \varphi^O}{\partial \delta} = 3p'\frac{\partial X}{\partial \delta} + p'\frac{\partial x^o}{\partial \delta}.$$

The elements of Tables 1 and 2 are the partial derivatives of the variables in the first row with respect to the variables in the first column, e.g., the combination x^a and δ denotes $(\partial x^a/\partial \delta) = -(\Delta k/4p')$.

Table 1: Effects of policy changes on equilibrium outputs

	x^a	x^b	x^o	X
δ	$-\Delta k/4p' > 0$	$3\Delta k/4p' < 0$	$3\Delta k/4p' > 0$	$\Delta k/4p' < 0$
s^o	$1/4p' < 0$	$1/4p' < 0$	$-3/4p' > 0$	$-1/4p' > 0$
s^b	$1/4p' < 0$	$-3/4p' > 0$	$1/4p' < 0$	$-1/4p' > 0$
t_x	$-1/4p' > 0$	$-1/4p' > 0$	$3/4p' < 0$	$1/4p' < 0$

Table 2: Effects of policy changes on equilibrium profits and consumer surplus

	π^a	π^b	π^o	CS
δ	$-(f^a\Delta k/4p') > 0$	$3f^b\Delta k/4p' < 0$	$-(f^o\Delta k/4p') > 0$	$-(X\Delta k/4) < 0$
s^o	$f^a/4p' < 0$	$f^b/4p' < 0$	$-(3f^o/4p') > 0$	$X/4 > 0$
s^b	$f^a/4p' < 0$	$-(3f^b/4p') > 0$	$f^o/4p' < 0$	$X/4 > 0$
t_x	$-(f^a/4p') > 0$	$-(f^b/4p') > 0$	$f^o/4p' < 0$	$-X/4 < 0$

[i] We define that $f^a \equiv p - p'x^a - k^a > 0$, $f^b \equiv p - p'x^b - [c^b(\delta) - s^b] > 0$, and $f^o \equiv p - p'x^o - [k^o - s^o] - t_x > 0$.

Using the results of comparative statics (table 1) and rearranging the above equations, we obtain equation (8).
(ii) We define $F = 7k^a - 3k^o > 0$ and $L = (7k^a + k^o)3\Delta k = 3(7[k^a]^2 - 6k^a k^o - [k^o]^2) > 0$. Differentiating the slope of government A's reaction curve with respect to k^a, we obtain $-7/L + 6F^2/L^2$. Rearranging this expression, $2(7k^a - 3k^o)^2/(7k^a + k^o) >(\leq) 7\Delta k$ holds. Therefore, we obtain $(\mu + 4k^o)^2/(\mu - 6k^o)\mu >(\leq) 1/2$.
(iii) From equation (8), statement (iii) clearly holds. QED
Derivation of equation (12): From government B's objective function, we obtain

$$\frac{\partial W^B}{\partial s^b} = -\frac{60k^a(p-\delta\Delta k - k^o)}{4(35k^a + 3k^o)p'} - \frac{12k^a}{4(35k^a + 3k^o)p'}p'x^b - x^b\Delta k\cdot\left(\frac{d\delta}{ds^b}\right) = 0.$$

Using this equation and equation (9), we obtain equation (12).

Proof of proposition 4: Considering the conditions for maximizing a firm's profits and the national welfare of country O, we obtain

$$\frac{\partial W^O}{\partial s^b} = -\frac{12k^a}{4(35k^a + 3k^o)p'}p'x^o + \frac{p - k^o - t_x}{2p'} = \frac{-(41k^a + 3k^o)p'x^o - (35k^a + 3k^o)s^o}{2(35k^a + 3k^o)p'}.$$

Substituting equation (13) into the above equation, we obtain proposition 4. QED

Proof of proposition 5: Differentiating each firm's equilibrium profit with respect to the external tariff, we obtain

$$\frac{d\pi^a}{dt_x} = p'x^a\left(\frac{dX}{dt_x}\right) + (p - k^a)\cdot\left(\frac{dx^a}{dt_x}\right), \tag{A3}$$

$$\frac{d\pi^b}{dt_x} = p'x^b\left(\frac{dX}{dt_x}\right) + (p - c^b(\delta) + s^b)\cdot\left(\frac{dx^b}{dt_x}\right) - \Delta k\cdot x^b\left\{\frac{d\delta}{dt_x} + \frac{d\delta}{ds^b}\left(\frac{ds^b}{dt_x}\right)\right\} + x^b\left(\frac{ds^b}{dt_x}\right), \tag{A4}$$

$$\frac{d\pi^o}{dt_x} = p'x^o\left(\frac{dX}{dt_x}\right) + (p - k^o + s^o - t_x)\cdot\left(\frac{dx^o}{dt_x}\right) + x^o\left\{\frac{ds^o}{dt_x} + \frac{ds^o}{ds^b}\left(\frac{ds^b}{dt_x}\right)\right\} - x^o. \tag{A5}$$

Similarly, differentiating equilibrium outputs with respect to the external tariff, we obtain

$$\frac{dx^a}{dt_x} = \frac{1}{4p'}\left\{\frac{-52k^a + 4k^o}{17k^a + 3k^o} + \frac{12k^a}{35k^a + 3k^o}\left(\frac{ds^b}{dt_x}\right)\right\},\ \frac{dx^b}{dt_x} = \frac{1}{4p'}\left\{\frac{56k^a - 56k^o}{17k^a + 3k^o} + \frac{-60k^a}{35k^a + 3k^o}\left(\frac{ds^b}{dt_x}\right)\right\},$$

$$\frac{dx^o}{dt_x}=\frac{1}{4p'}\left\{\frac{48k^a+48k^o}{17k^a+3k^o}+\frac{36k^a}{35k^a+3k^o}\left(\frac{ds^b}{dt_x}\right)\right\},\ \frac{dX}{dt_x}=\frac{1}{4p'}\left\{\frac{52k^a-4k^o}{17k^a+3k^o}+\frac{-12k^a}{35k^a+3k^o}\left(\frac{ds^b}{dt_x}\right)\right\}.$$

Plugging the above equations into (A3)–(A5) and using the FOCs of firms b and o, equations (9), (14), and (15), we obtain proposition 5. QED

Derivation of equation (17): From equation (16), we obtain the following FOCs

$$0=-3p-p'x^b+3\delta\,\Delta k+3k^o,\quad 0=-3p-p'x^o+3k^o+3t_x\,.$$

Using these FOCs, we obtain equation (17).

Derivation of equation (19): The FOC for government A's welfare maximizing is given by $\frac{\partial W^A}{\partial \delta}=-\frac{3\Delta k}{8p'}p+\frac{3\Delta k}{8p'}p'x^a+k^a x^b+\frac{15\Delta k}{8p'}\delta\,k^a-\frac{3\Delta k}{8p'}p'X-\frac{9\Delta k}{8p'}t_x=0,$

From this FOC, we obtain equation (19).

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