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Rules of Origin and Strategic Choice of Compliance

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Abstract

We consider exporters' strategic choice of whether to comply with rules of origin (ROO) in a free trade area (FTA). While the existing literature of ROO considers models of perfect or monopolistic competition, we consider an oligopolistic trade model. Our model consists of three final-good producers—one in an importing country and two in an exporting country—and one intermediate-good producer, which is in the importing country and has monopoly power. We show that, within the range of parameter values for which some exporters comply with ROO, the content rate affects the output of the final-good producer in the importing country and the country's social welfare in an U-shaped fashion. The content rate levels that allow the coexistence of compliers and non-compliers minimize social welfare.

Key words: Rules of origin (ROO), Compliance, Free trade area (FTA)

JEL classification: F12, F13, F15

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1 Introduction

In a free trade area (FTA), to distinguish between intraregional trade and outside trade, rules of origin (ROO) are required in such areas and, in fact, most of the FTAs have introduced some kind of ROO. [1] To enjoy duty-free access to a member country's market within an FTA, final-good producers must include a minimum fraction of intermediate-goods produced within the area. Thus, ROO is essentially similar to local content requirements (LCRs). [2] ROO limits the use of inputs produced outside the region, so it serves as a protecting device for less efficient countries. [3]

In an FTA, exporters are imposed with an external tariff upon exporting to the member country's market if they do not comply with ROO, so all exporters inside an FTA choose whether to comply with the ROO or not. There are exporters which comply with ROO but there are exporters which do not. For example, an empirical study conducted by Anson et al. (2005) points out that only 64% of exporters meet the ROO requirement in Mexico (i.e., NAFTA). [4]

The purpose of the paper is to consider the choice of exporters in an international Cournot oligopoly. The existing literature of ROO that focuses on the choice of exporters assumes perfect competition and monopolistic competition. In contrast to the existing literature, we introduce monopoly power of the intermediate-good producer and strategy among exporters.

To capture the roles of monopoly power of the intermediate-good producer and strategy among exporters, we present an oligopolistic trade model with ROO. [5] There is an FTA consisted of two countries—one with a final-good market (called the importing country) and one without (called the

[1] At least 87 regional trade areas (RTAs, including FTAs) have some type of ROO. See WTO (2002).

[2] LCR is the policy that imposes to entrant foreign firms a certain ratio of the procurement of local inputs to produce a final product locally (Hara and Nakanishi, 2001). Note that LCR policy crucially differs from ROO. These two regulations have different purposes. To protect the domestic producer (especially, intermediate good producers), LCR is employed in an FDI host country. ROO is imposed to the intra-region firm which wills to gain duty-free access in an RTA.

[3] For example, see Krueger (1993), Lopez-de-Silanes et al. (1996), Rodriguez (2001), Falvey and Reed (2002), and Takauchi (2010a). A Common feature of these studies are to emphasize a protecting nature of ROO. They generally adopt analytical framework of the local content protection model. Krueger (1993) points out that, using a numerical example, ROO possibly protect the U.S. auto and textile industries in NAFTA. Lopez-de-Silanes et al. (1996) suggested that ROO has two effects, rent-shifting and anti-competitive effects, in an imperfect competitive market. Also, Rodriguez (2001) employs multistage production model and examines trade-creating effect between FTA member countries. Although these studies mainly examine the effects of ROO's introduction and strengthening as a singular policy variable, Falvey and Reed (2002) and Takauchi (2010a) examine the relationship between ROO and other trade policies. Falvey and Reed (2002) examine the relationship between the final good importing country's tariff policy and ROO. Takauchi (2010a) mainly considers the policy interaction between ROO and the final good exporting country's subsidy/tax policies.

[4] Similarly, Hayakawa et al. (2009) indicates that utilization rate of ROO is not 100% in ASEAN countries. This fact also implies that compliers and non-compliers coexist.

[5] There is an another study that uses an oligopolistic trade model with ROO. Ishikawa et al. (2007) mainly considers a three-country Bertrand competition. However, they ommits the intermediate good market, focuses on the final good, and assumes the price-discrimination behavior of firms that produce a final good originating outside of the FTA.

exporting country). There is one intermediate-good producer and one final-good producer in the importing country. There are two final-good exporters in the exporting country. The final-good producer in the importing country exclusively uses the domestic intermediate good. To enjoy duty-free access, the exporters must use at least some amount of the intermediate good produced within the FTA, otherwise, they must pay the external tariff.

In this environment, we consider the following three-stage game: First, the exporters choose whether to comply with ROO or not. Second, the intermediate-good producer in the importing country monopolistically sets the price. Last, the final good producer in the importing country and the exporters compete *à la* Cournot in the importing country's market.

Our model offers three main results. First, for some combinations of the content rate of ROO and the external tariff rate, the equilibrium is such that one exporter complies with ROO while the other does not, which we call the "mixed regime." A key to this result is that the price of the local intermediate-good depends on whether the rival exporter complies with ROO. If the rival complies, it has to procure the intermediate good from the local producer. This raises the price of the local intermediate good, which makes it expensive for the exporter to comply with ROO. Conversely, if the rival chooses not to comply, it lowers the price of the intermediate good and makes it cheaper for the exporter to comply. This strategic substitution between exporters produces a mixed-regime equilibrium.

Second, we consider the relationship between the importing country's welfare and the content rate. We show that the content rate that induces a mixed-regime equilibrium is the worst policy for the importing country. A key to this result is a trade-off between the local intermediate-good producer's profits and tariff revenues from non-complying exporters. As the content rate goes up, the tariff revenues go up since the number of non-complying exporters goes up. On the other hand, the profit of the local intermediate-good producer goes down as the content rate goes up, since the producer's monopoly power goes down as the number of complying exporters goes down. Once the content rate reaches the level where one exporter switches to non-compliance, the monopoly rent of the local intermediate-good producer drops sharply since the monopoly price drops sharply.

This result is explained by the following logic. When regime shifts from all-compliers regime to mixed regime, the demand for the local intermediate good decreases and it becomes flatter. If the price of the local intermediate good is high, the decrease in demand is large. This is because, cost differences between complier and non-complier is large. In a mixed regime the demand for the local intermediate good is more elastic, so the price of the good becomes a cheaper. Since the number of complying exporter is half and the price of the local intermediate good falls, in a mixed regime the profit of the local intermediate-good producer decreases to less than half compared to that in all-compliers regime.

Third, we show that, within a regime where at least some exporters comply, the content rate affects the output of the final-good producer in the importing country in an U-shaped fashion. The direct affect of the content rate is to raise the exporters' costs. In ordinal Cournot games, if the rivals' costs go up, your own output goes up. Hence, one might think that a rise in the content rate always increases the output of the local final-good producer. In our model, however, a rise in the content rate may reduce the output of the local final-good producer, if the content rate is low. The reason is that, as the content rate goes up, the demand for the local intermediate good goes up, raising its price. This means higher costs for both the local producer and the exporter. But, if the content rate is low, exporters do not suffer much from it since they do not need to procure much of the intermediate good from the local supplier. Thus, the local producer suffers more than exporters from the higher price of the local intermediate good, thereby the local producer reduces its output.

In the above mentioned regimes, the social welfare of the importing country is U-shaped with respect to the content rate. The shape of the social welfare is determined by the profit of the local final-good producer. The reason is explained by the trade-off between consumer surplus and the profit of the local intermediate-good producer. An increase in the content rate increases the profit of the local intermediate-good producer but decreases the consumer surplus, and these two effects offset each other. Thus, when the content rate changes, a change in the social welfare mainly depends on the change in the local final-good producer's profit.

We obtain the following policy implication: When the combinations of the content rate of ROO and the external tariff rate cause a mixed regime, it is desirable for the importing country within the FTA to reduce the external tariff. The reason depends on the following two points. First, a policy which can be individually changed by the importing country is the external tariff of that country. Second, the welfare in a non-mixed regime where all exporters do not comply is the best for the country and in that regime the social welfare of the importing country is monotonically increasing with respect to the external tariff. Therefore, the most desirable policy for the importing country is to impose the highest tariff level which does not cause a mixed regime.

Here, we relate our model to the existing literature. There are several studies on ROO, which emphasize the protecting nature of ROO (For example, see Krueger, 1993; Lopez-de-Silanes et al., 1996; Rodriguez, 2001; Falvey and Reed, 2002; and Takauchi, 2010a). While these existing studies mainly assume that exporters comply with ROO, Ju and Krishna (2005) and Demidova and Krishna (2008) focus on the choice of exporters. [6] Ju and Krishna (2005) examines that, in a model of three-country perfect competition, all regimes arise depending on the level of the intermediate-good price. Demidova and Krishna (2008) introduces Melitz-type firm heterogeneity (Melitz, 2003) and shows that the mixed regime arises depending on the content rate of the ROO. The reason is that firms have different productivity. However, in their studies, the effects of the ROO requirement and the external tariff on the social welfare of the importing country are not considered, and the U-shaped relationship between the content rate of ROO and the social welfare of importing country is not found.

A seminal work by Lahiri and Ono (1998, 2003), a study on the optimal LCR policy under an oligopolistic market with host country's unemployment, is also related to our model. Although they used a similar form as our study in view of LCR, their studies are concerned to FDI policy against unemployment in the host country and did not consider the situation of FTA with ROO.

The remainder of this paper comprises six sections. Section 2 describes the model. Section 3 derives the equilibrium outcomes. Section 4 examines the strategic behavior of exporters and its effects for the other producers. Section 5 examines the welfare implication of the choice of the exporters, and section 6 offers concluding remarks. In this paper, all proofs are given in the Appendix.

2 The model

Consider a free trade area (FTA) consisted of two countries: one with a final good market and the other without it. We call a member country with a final good market "importing country" and the other member country without a final good market "exporting country." There are two producers, namely, an intermediate-good producer (labeled firm ℓ) and a final-good producer (labeled firm L) in the importing country. The firm ℓ produces an intermediate good for the local market, the firm L produces a final good and supplies the product to the local final-good market. On the other hand, there are two final-good exporters (firms F or exporters) that export the final good from the other member country within the FTA to the importing country's final good market. Let us suppose that both exporters face two alternatives: non-compliance with the ROO (labeled NC) and compliance with

[6] Also, Rosellón (2000) considers a long-term effect of ROO and analyzes it in static and dynamic situations. He examines the choice of the foreign firm in static situation (perfect competition in all goods and monopoly in final-good). However, his focus is long-term effects of ROO on the labor income and do not consider monopoly power in the intermediate-good producer and strategy among final-good exporters.

the ROO (labeled C). To enjoy duty-free access, both exporters must comply with the ROO of the FTA, that is, they must at least use a predetermined fraction of the intermediate-good produced within the region (i.e., the importing country), otherwise, they must pay the external tariff.

The inverse demand function of the final-good in the importing country is assumed to be linear: $p = a - bY$, where $Y \equiv y + z_1 + z_2$, and a, b are positive constants. The output of firm L is y, the outputs of exporter j are z_j, $j = 1, 2$.

Our focus is on the input (or procurement) cost of each firm. Let us assume that each firm has a constant marginal cost of production, which is normalized to zero. Note that firm L mainly procures intermediate goods from firm ℓ. We assume that firm F is relatively more technologically advanced as compared to firm L. In other words, firm F can employ inputs obtained from multiple sources; however, firm L can employ inputs obtained only from local sources (firm ℓ). [7] Thus, the profits of firms ℓ and L are represented by

$$\pi^{\ell} \equiv r^L x, \tag{1}$$

$$\pi^{L} \equiv (p - r^L)\, y, \tag{2}$$

where r^L denotes the price of the intermediate-good in the importing country and x denotes the output of the intermediate-good. Following Lahiri and Ono (1998, 2003), the input cost of exporters that comply with ROO becomes

$$\theta\, r^L + (1-\theta)\, \overline{r}.$$

A fraction, θ $(1 \geq \theta > 0)$ denotes a content rate of the ROO, which is imposed by the FTA. [8] In the above equation, $\overline{r}$ denotes a competitive price of the intermediate good outside the FTA and $r^L > \overline{r}$ always holds. For a better understanding, we assume that a competitive price of the intermediate-good $(\overline{r})$ is normalized to zero. The profit of each exporter j is given by

$$\pi_j^F \equiv \begin{cases} (p - \tau)\, z_j & \text{if exporter } j \text{ chooses } NC, \\ (p - \theta r^L)\, z_j & \text{if exporter } j \text{ chooses } C, \end{cases} \tag{3}$$

where τ (≥ 0) denotes the rate of the external tariff in the importing country and $j = 1, 2$.

[7] In our model, shipment cost does not have an essential role. Hence, for simplicity, we assume that a shipment cost does not exist.

[8] In our model, θ is an exogenous parameter.

3 Calculating equilibrium outcomes

In this section, we derive the equilibrium outcomes of the following game. Stage 1: The exporters (firms F) independently and simultaneously choose either NC or C. Stage 2: Firm ℓ sets the price of the local intermediate good, monopolistically. Stage 3: All final-good producers (firm L and two exporters) compete *à la* Cournot in the final good market of the importing country. We use the subgame perfect Nash equilibrium as the equilibrium concept. The game solved using backward induction.

In general, the procurement of intermediate good contains an aspect of technology choice. Since the exporters must procure the intermediate good under a given production technology, the exporters determine either NC or C in the first stage of the game.

First, we derive the equilibrium outcomes in each regime.

I. No-complier regime (NC, NC): From equations (2)–(3), the Cournot competition in the final-good market yields

$$y = \frac{a + 2\tau - 3r^L}{4b}, \qquad z_j = \frac{a + r^L - 2\tau}{4b}, \tag{4}$$

where $j = 1, 2$. Market clearing condition $y = x$ and equation (1) yield the following derived demand for the intermediate good:

$$r^L = \frac{a + 2\tau}{3} - \frac{4b}{3}\,x. \tag{5}$$

From equations (1) and (5), the output of intermediate-good is $x = (1/8b)(a+2\tau)$. Thus, the equilibrium price of intermediate-good becomes

$$r^L(NC, NC) = \frac{a + 2\tau}{6}. \tag{6}$$

Substituting equation (6) into equation (4), we obtain the equilibrium output of each firm, total supply Y, and the price of the final good p in (NC, NC).

$$\begin{aligned} y(NC, NC) &= \frac{a + 2\tau}{8b}, & z_j(NC, NC) &= \frac{7a - 10\tau}{24b}, \\ Y(NC, NC) &= \frac{17a - 14\tau}{24b}, & p(NC, NC) &= \frac{7(a + 2\tau)}{24}, \quad \text{and} \\ \pi^\ell(NC, NC) &= \frac{(a + 2\tau)^2}{48b}. \end{aligned} \tag{7}$$

The equilibrium profit of firms are $\pi^L(NC,NC) = b\big[y(NC,NC)\big]^2$ and $\pi_j^F(NC,NC) = b\big[z_j(NC,NC)\big]^2$, $j = 1, 2$.

II. All-compliers regime (C, C): From equations (2)–(3), the Cournot competition in the final-good market yields

$$y = \frac{a - (3-2\theta)r^L}{4b}, \qquad z_j = \frac{a + (1-2\theta)r^L}{4b}. \tag{8}$$

The market clearing condition $y + 2\theta z_j = x$ and equation (1) yield the following derived demand for the intermediate-good:

$$r^L = \frac{a(1+2\theta)}{3-4\theta+4\theta^2} - \frac{4b}{3-4\theta+4\theta^2}\,x. \tag{9}$$

From equations (1) and (9), the output of the intermediate good is $x = (a/8b)(1+2\theta)$, and the equilibrium price of the intermediate-good is

$$r^L(C,C) = \frac{a(1+2\theta)}{2(3-4\theta+4\theta^2)}. \tag{10}$$

Substituting equation (10) into equation (8), we obtain the equilibrium output of each firm, total supply Y, and price of the final-good p in (C, C).

$$\begin{aligned} y(C,C) &= \frac{3a(1-4\theta+4\theta^2)}{8b(3-4\theta+4\theta^2)}, & z_j(C,C) &= \frac{a(7-8\theta+4\theta^2)}{8b(3-4\theta+4\theta^2)}, \\ Y(C,C) &= \frac{a(17-28\theta+20\theta^2)}{8b(3-4\theta+4\theta^2)}, & p(C,C) &= \frac{a(7-4\theta+12\theta^2)}{8(3-4\theta+4\theta^2)}, \quad \text{and} \\ \pi^\ell(C,C) &= \frac{a^2(1+2\theta)^2}{16b(3-4\theta+4\theta^2)}. \end{aligned} \tag{11}$$

The equilibrium profit of firms are $\pi^L(C,C) = b\big[y(C,C)\big]^2$ and $\pi_j^F(C,C) = b\big[z_j(C,C)\big]^2$, $j = 1, 2$.

III. Mixed regime (C, NC) (and/or (NC, C)): Without loss of generality, by symmetry exporters, we derive the outcomes in (C, NC). From equations (2)–(3), the Cournot competition in the final-good market yields

$$y = \frac{a + \tau - (3-\theta)r^L}{4b}, \tag{12}$$

$$z_1 = \frac{a + \tau - (3\theta-1)r^L}{4b}, \quad \text{and} \quad z_2 = \frac{a - 3\tau + (1+\theta)r^L}{4b}. \tag{13}$$

The market clearing condition $x = y + \theta z_1$ yields the following derived demand for the intermediate-good:

$$r^L = \frac{(a+\tau)(1+\theta)}{3-2\theta+3\theta^2} - \frac{4b}{3-2\theta+3\theta^2}\,x. \tag{14}$$

The output of intermediate-good is $x = (1/8b)(a+\tau)(1+\theta)$. The equilibrium price of the intermediate-good becomes as

$$r^L(C, NC) = r^L(NC, C) = \frac{(a+\tau)(1+\theta)}{2(3-2\theta+3\theta^2)}. \tag{15}$$

Substituting (15) into equations (12) and (13), we obtain the equilibrium output of each firm, total supply Y, and price of the final-good p in (C, NC) (and (NC, C)).

$$\begin{aligned}
y(C, NC) &= y(NC, C) = \frac{(a+\tau)(3-6\theta+7\theta^2)}{8b(3-2\theta+3\theta^2)}, \\
z_1(C, NC) &= z_2(NC, C) = \frac{(a+\tau)(7-6\theta+3\theta^2)}{8b(3-2\theta+3\theta^2)}, \\
z_2(C, NC) &= z_1(NC, C) = \frac{(7-2\theta+7\theta^2)\,a-(17-14\theta+17\theta^2)\,\tau}{8b(3-2\theta+3\theta^2)}, \\
Y(C, NC) &= Y(NC, C) = \frac{(17-14\theta+17\theta^2)\,a-(7-2\theta+7\theta^2)\,\tau}{8b(3-2\theta+3\theta^2)}, \\
p(C, NC) &= p(NC, C) = \frac{(a+\tau)(7-2\theta+7\theta^2)}{8(3-2\theta+3\theta^2)}, \quad \text{and} \\
\pi^\ell(C, NC) &= \pi^\ell(NC, C) = \frac{(a+\tau)^2(1+\theta)^2}{16b(3-2\theta+3\theta^2)}.
\end{aligned} \tag{16}$$

The equilibrium profit of firms are $\pi^L(C, NC) = b\big[y(C, NC)\big]^2$ and $\pi^F_j(C, NC) = b\big[z_j(C, NC)\big]^2$, $j = 1, 2$.

In our model, the prohibitive tariff rate depends on the content rate, θ, and it is monotonically increasing with respect to θ. Hereafter, let us assume the following assumption.

Assumption 1. *The external tariff is at least smaller than the prohibitive tariff level $\tau^{\max}$, that is,*

$$\gamma \equiv \frac{\tau}{a} \le \frac{7-2\theta+7\theta^2}{17-14\theta+17\theta^2} \equiv \tau^{\max}, \tag{17}$$

for cases, θ belongs to $[0, 1]$.

When this assumption holds, both exporters (firms 1 and 2) produce positive (or at least non-negative) quantities of the final good in any of the three regimes. [9]

From equations (6), (10), and (14), we immediately find the following properties of the local intermediate good price.

Remark 1. (*i*) *Local intermediate good prices in both all-compliers regime and mixed regime are inverted-U shaped with respect to the content rate;* (*ii*) *The profit of the local intermediate good producer is monotonically increasing with respect to the content rate.*

The shape of the local intermediate good prices is depicted in Figure 1.

Inserts Figure 1 here

Why does the price greatly rise in the all-compliers regime? The reason depends on the following logic. First, in a mixed regime, the number of compliers is half compared to that in the all-compliers regime. Thus, the demand for the local intermediate good is relatively small. Second, in a mixed regime, the demand for the local intermediate good is more elastic than that in the all-compliers regime, so the price of the good in the mixed regime may become cheaper (from equations (9) and (14)). In a mixed regime, the demand for the local intermediate good rapidly decreases as the price of the local intermediate good goes up. However, in the all-compliers regime, the demand slowly decreases as the price goes up. This is because, in a mixed regime, a non-complier exists. Since a non-complier does not buy the local intermediate good and strategic substitution works in the final good market, damages brought by a rise in the price of the local intermediate good is large. On the other hand, in the all-compliers regime, there is no non-complier. Since all exporters buy the local intermediate good, damages brought by a rise in the price of the local intermediate good are moderate.

Next, we consider the relationship between the price of the local intermediate good and the content rate. In a regime where at least one exporter complies, the price curve of the local intermediate good is inverted-U shaped with respect to the content rate. This is because, in each regime, the cost of compliers goes up and the demand for the local intermediate good goes down as the content rate goes up. Since a higher content rate decreases the demand to the extreme, the local intermediate-good producer slightly decreases the price of the good in order to increase the profit.

[9] The value of equation (17) is always lesser than 7/10.

4 Strategic behavior of the exporters

In this section, we examine strategic behavior of the exporters. From equations (7)–(17), we obtain the following 2×2 payoff matrix of the exporters.

Inserts Table 1 here

Using the above payoff matrix, we obtain the following proposition.

Proposition 1. *For all cases θ belongs to $(0, 1]$, the equilibrium (SPNE) is*

I. (C, C) *if* $\gamma \geq f_2(\theta)$ *holds;*

II. (NC, NC) *if* $f_1(\theta) \geq \gamma$ *holds; and*

III. (C, NC) *and* (NC, C) *if* $f_2(\theta) \geq \gamma \geq f_1(\theta)$ *holds,*

where

$$f_1(\theta) \equiv \frac{4\theta(1+3\theta)}{51-38\theta+39\theta^2}, \qquad f_2(\theta) \equiv \frac{4\theta(1+2\theta-\theta^2+4\theta^3)}{(3-4\theta+4\theta^2)(17-14\theta+17\theta^2)}.$$

The result of Proposition 1 is depicted in the following Figure 2 (θ-γ plane). [10]

Inserts Figure 2 here

When the rate of the external tariff is extremely high compared to the ROO requirement, the increased input price caused by compliance with the ROO has no meaning. That is, compliance dominates non-compliance. Conversely, when the rate of the external tariff is extremely small compared to the content rate of ROO, no exporter has an incentive to comply with the ROO. In this case, non-compliance dominates compliance.

However, when the rate of the external tariff is not too high, but not too small compared to the content rate of ROO, a mixed regime arises. The key to this result is as follows. When the external tariff is relatively high ($\gamma > f_1(\theta)$), each exporter prefers to comply if the rival does not. In this case, a jump in the input price caused by one exporter's compliance is no larger than the level of the external tariff. However, when all exporters comply, a jump in the input price surpasses the level of the external tariff. Furthermore, when the external tariff is relatively small ($f_2(\theta) > \gamma$), each exporter

[10] Note that $f_2(\cdot) \geq f_1(\cdot)$ holds for any cases, θ belongs to $[0, 1]$.

prefers not to comply if the rival does. Although the rate of the external tariff is relatively small, each exporter tries to pay the external tariff. This is because, if all exporters comply at once, the price of the intermediate good greatly increases. To prevent rapid increase in the input price and preserve profit, each exporter pays the external tariff if the rival complies. In an intermediate case ($f_2(\theta) > \gamma > f_1(\theta)$), thus, each exporter has an incentive to choose the option that is different from the other. This strategic substitution between two exporters causes a mixed regime.

Next, we examine the profit of the local final-good producer. From equations (7)–(16), and f_j, $j = 1, 2$, we obtain the following proposition.

Proposition 2. *For all cases* θ $(1 \geq \theta > 0)$ *and* γ $(\tau^{\max} \geq \gamma \geq 0)$*, the ranking in the profit of local final-good producer is* $\pi^L(NC, NC) \geq \pi^L(C, NC) = \pi^L(NC, C) \geq \pi^L(C, C)$.

Proposition 2 implies the following intuitive mechanism. If all exporters comply, the price of the local intermediate good becomes sufficiently high. This rising price effect harms both exporters and the local final-good producer. In the all-compliers regime, all exporters procure a predetermined fraction θ of the intermediate-good produced in the importing country, and at the same time, they procure the intermediate good from another source. Since the competitive intermediate good is cheaper than the local intermediate good, all exporters are more competitive than the local final good producer. Therefore, from the rising price effect in all-compliers regime, the output and profit of the local final good producer are smaller than those in any other regimes.

This result has an interesting meaning. In our model, the local final good producer prefers a relatively smaller protection. That is, the most desirable policy for the local final good producer is to reduce the external tariff from its initial level to $f_1(\theta)$ when the initial level of the external tariff is larger than $f_1(\theta)$. This point is in sharp contrast with the result of an ordinal Cournot competitive trade model.

If some exporters comply, the output and profit of each final good producing firm in each regime is not necessarily a decreasing function with respect to the content rate. In view of this, we obtain the following proposition.

Proposition 3. *If at least an exporter complies, the output of the local final-good producer is U-shaped with respect to the content rate of the ROO:* (*i*) *In the mixed regime,* 46.41% *of the content rate is detrimental to the local final good producer.* (*ii*) *In the all-compliers regime,* 50% *of the content rate prevents the production of the local final-good producer.*

Immediately, from the above proposition 3, we derive the following corollary.

Corollary 1. (*i*) *In the all-compliers regime, as the content rate changes, the interests of all final good producers move in the same direction as long as* θ *belongs to* $\left(\frac{2-\sqrt{3}}{2}, \frac{1}{2}\right)$. (*ii*) *In a mixed regime, as the content rate changes, the interest between the local final good producer and the non-complier move in the same direction as long as* θ *belongs to* $\left(2\sqrt{3}-3, 1\right]$*; When* θ *belongs to* $\left(0, 2\sqrt{3}-3\right]$*, the interest between local final-good producer and the complier move in the same direction due to a change in the content rate.*

The above results are depicted in the Figure 3.

Inserts Figure 3 here

Proposition 3 implies an interesting property of the model. This proposition states that in both all-compliers and a mixed regimes a positive content rate may be detrimental to the local final good producer. For example, in the all-compliers regime, a content rate of the ROO of 50% prevents the production of the local final-good producer.

In an ordinal Cournot competition, an increase in the rival's cost increases one's output and profit. Hence, one might think that an increase in the complier's cost increases the output and profit of the local final good producer. In fact, the rise in the content rate increases the demand for the local intermediate good, so the price of the good possibly increases. Both complier and the local final-good producer suffer loss from the rising price of the intermediate good. However, in our model, an increase in the content rate may reduce the output and profit of the local final good producer if the content rate is sufficiently low. The reason is explained by the cost of final good producing firms. If the content rate is sufficiently low, $\theta < (1/2)(2-\sqrt{3}) \simeq 0.134$, the compliers' damage brough by a rising price of the local intermediate good is sufficiently small. This is because compliers procure the local intermediate good at θ ratio, but, at the same time, they procure a cheaper intermediate good at $1-\theta$ ratio. In contrast to the compliers, the local final good producer uses only the local intermediate good. The cost advantage of compliers is sufficiently large. Hence, an increased price of the local intermediate good harms the local final good producer much more than compliers, so the output and profit of the compliers go up but the output and profit of the local final-good producer go down as the content rate goes up. When the content rate is at an intermediate level, $(1/2)(2-\sqrt{3}) \leq \theta \leq 1/2$, the cost advantage of compliers is small. As the content rate goes up, the cost advantage of compliers goes down. In this case, a rise in the content rate reduces both the outputs of compliers and the local final good producer.

When the content rate is sufficiently high, $\theta > 1/2$, the cost difference between compliers and local final good producer is sufficiently small. Furthermore, as mentioned in Remark 1, an increased price of the local intermediate good caused by a rise in the content rate becomes small if the content rate is high. [11] In this case an increase in the content rate does not raise the price of the local intermediate good, so an increased content rate increases the cost of the complier much more than that of the local final good producer. Thus, the output and profit of the compliers go down but those of the local final-good producer go up as the content rate goes up.

This mechanism is similar to that in mixed regime: (C, NC) and (NC, C). On the other hand, in a mixed regime, the changing price effect of the local intermediate good is relatively small. This is because, the number of exporters that buy the local intermediate good is half compared to that in the all-compliers regime. Thus, different from the all-compliers regime, an intermediate content rate ($\theta = 2\sqrt{3} - 3 \simeq 0.4641$) does not prevent the production of the local final good producer.

5 Welfare implication

In this section, let us compare the importing country's welfare level among three regimes: (I) No-complier regime (NC, NC), (II) all-compliers regime (C, C), and (III) mixed regime (C, NC) and/or (NC, C). The social welfare of the importing country in each regime is given by

$$W(NC, NC) = CS(NC, NC) + \pi^{\ell}(NC, NC) + \pi^{L}(NC, NC) + 2\tau z_j(NC, NC), \tag{18}$$

$$W(C, C) = CS(C, C) + \pi^{\ell}(C, C) + \pi^{L}(C, C), \tag{19}$$

$$W(C, NC) = CS(C, NC) + \pi^{\ell}(C, NC) + \pi^{L}(C, NC) + \tau z_2(C, NC), \tag{20}$$

where $CS(\cdot) = (b/2)\big[Y(\cdot)\big]^2$ is the consumer surplus, $\pi^{\ell}(\cdot)$ is the profit of the local intermediate-good producer (firm ℓ), $\pi^{L}(\cdot)$ is the profit of the local final-good producer (firm L), and $\tau z_j(\cdot)$ is the tariff revenue from non-complier. [12] Note that in all-compliers regime, no exporter is imposed the external tariff. Thus, the tariff revenue vanishes. In addition, $W(C, NC) = W(NC, C)$ always holds.

After comparing the above equations (18)–(20), we obtain the following proposition.

[11] Note that if $\theta > (1/2)(\sqrt{6} - 1) \simeq 0.7247$, the price of the local intermediate-good goes down as the content rate goes up. See Appendix.

[12] The welfare level in equilibrium is depicted in the appendix. See equations (A.6)–(A.8).

Proposition 4. *For all cases, θ $(1 \geq \theta \geq 0)$ and γ $(\tau^{\max} \geq \gamma \geq 0)$, the ranking in the social welfare of the importing country is $W(NC, NC) > W(C, C) > W(C, NC) = W(NC, C)$.*

We can explain the result of Proposition 4 from two sorces: the profit of the local intermediate-good producer and tariff revenue from the non-complier. The profit of the local intermediate good producer and tariff revenue significantly change according to regime switching (or change in the content rate). For example, for a given external tariff τ, as the content rate goes up, the tariff revenues increase since the number of non-complier increases. However, the profit of the local intermediate good producer goes down as the content rate goes up since the producer's monopoly power goes down as the number of compliers goes down. Once the content rate reaches the level where one exporter switches to non-compliance (on the point which is given by solving $\tau = f_2(\theta)$ with θ), the profit of the local intermediate-good producer drops sharply since the price of the good drops sharply. The relationship between the profit of the local intermediate good producer and the content rate is depicted in Figure 4.

Inserts Figure 4 here

The sharp drop of the price in the local intermediate good is based on the elasticity of the demand for the local intermediate good. As mentioned in Remark 1, in a mixed regime, the demand for the local intermediate good is half since a non-complier exists. Furthermore, there is a non-complier, so an increased price of the good reduces demand much more than in an all-compliers regime. This demand differences between a mixed regime and an all-compliers regime goes up as the content rate goes up. Since the content rate where one exporter switches to non-compliance is at an intermediate level, the demand differences between a mixed regime and an all-compliers regime are sufficiently large and at that level the price sharply drops.

What policy implication we obtain? In general, a policy that can be individually changed by a member country within an FTA is the external tariff in that country. Since it is difficult for a single member country to change the content rate of the ROO, here we focus on the relationship between the welfare of the importing country and the external tariff of that country.

Given the content rate, the welfare level rises on the interval $\left[0, f_1(\theta)\right]$ as the tariff rate goes up because in the interval a no-complier regime holds and a higher tariff rate sufficiently increases the profits of local intermediate good and final good producers. On the other hand, the welfare level suddenly drops when the tariff rate exceeds $f_1(\theta)$. This is because, a mixed regime arises if the tariff rate exceeds $f_1(\theta)$. Although in a mixed regime the welfare level goes up as the tariff rate goes up, all the levels of the welfare in this regime fall below those in other regimes. Further, if the tariff rate reaches $f_2(\theta)$, the welfare level jumps up. Since in an all-compliers regime no exporter pays the external tariff, the welfare level is a constant for the tariff rate on the interval $[f_2(\theta), \tau^{\max})$.

From Proposition 2, the profit of the local final good producer drops as the number of compliers go up. Therefore, the welfare of the importing country and the profit of local final good producer are maximized at the highest tariff rate that does not cause a mixed regime. This result is depicted in Figure 5.

Inserts Figure 5 here

Summarizing the above consideration, we can derive the following proposition.

Proposition 5. *The most desirable policy for the importing country and the local final good producer is the same, which is to impose the highest tariff rate that does not cause a mixed regime.*

Finally, let us consider the relationship between the welfare level of the importing country and the content rate in both all-compliers and mixed regimes. Similar to the output and profit of the local final-good producer, the welfare function of the importing country is non-monotonic with respect to the content rate. Differentiating equations (19) and (20) with respect to θ, we establish the following proposition.

Proposition 6. *If at least an exporter complies, the social welfare of the importing country is U-shaped with respect to the content rate of ROO:* (*i*) *In all-compliers regime, the bottom of the social welfare for content rate is* $\theta = 1/2$. (*ii*) *In a mixed regime, the bottom of the social welfare for content rate is* $g(\theta)$, *where* $g(\theta) \equiv (-7 + 21\theta - 27\theta^2 + 15\theta^3 + 6\theta^4)/(-17 - 5\theta + 27\theta^2 - 31\theta^3 + 18\theta^4)$.

Proposition 6 shows that in the worst regime the social welfare of the importing country has a bottom. Similar to the profit of the local final-good producer, the social welfare is U-shaped with respect to the content rate in both all-compliers and mixed regimes. Since an increased content rate increases the cost of compliers and decreases production efficiency, the total output of the final good goes down as the content rate goes up. [13] Since the total output of the final good decreases, the consumer surplus always goes down as the content rate goes up. Conversely, as shown in Remark 1, the profit of the local intermediate good producer goes up as the content rate goes up. Hence, an increased

[13] This effect of the content rate is called as "anti-competitive effect of ROO." For example, see Lopez-de-Silanes et al. (1996) and Takauchi (2010a).

content rate decreases the consumer surplus but it increases the profit of the local supplier. As a result, a major part of these two effects offset each other and a change in the social welfare mainly depends on the change in the profit of the local final good producer.

In a mixed regime, the above mechanism basically holds. However, in a mixed regime, tariff revenue exists. Since for a given external tariff the exports of non-complier goes up as the content rate goes up, tariff revenue goes up (from Proposition 3 and Figure 3). A positive effect of an increased content rate relatively increases in a mixed regime, so the value of the content rate which minimizes the welfare level is smaller than in an all-compliers regime.

6 Conclusion

In this paper, we focus on monopoly power of the intermediate good producer and the strategic choice of exporters whether to comply with ROO or not. We present a simple trade model that generates a mixed regime (one exporter complies with the ROO but the other does not) in an international Cournot competition.

The existing literature that focuses on the choice of exporters has examined perfect competition and monopolistic competition and the effect of ROO on market access and welfare. However, in view of strategic behavior among exporters and market power of the intermediate-good producer, it seems that the mechanism and the effects of ROO need further examination. We believe that the model developed herein offers another reason of arising mixed regime from the view of strategic interaction among exporters and a distinctive welfare implication of ROO.

Our main findings are summarized in the following three points. First, under some combinations of content rate of ROO and the rate of the external tariff, a mixed regime arises between identical exporters. Second, if at least one exporter complies, the output and profit of the final-good producer which is located in the importing country within the FTA is U-shaped with respect to the content rate of the ROO. Especially, if all exporters comply, 50% of content rate of the ROO prevents the production of the final good producer. Lastly, surprisingly, when no exporter complies, the welfare level of the importing country is maximum compared to any other regimes. The welfare is minimized when complying and non-complying exporters coexist. If in many FTAs complying and non-complying exporters coexist, the status quo may be the worst for the importing country within FTAs.

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Appendix: proofs

Derivation of Remark: Differentiating local intermediate good price ($r^L(\cdot)$) with respect to θ, we obtain the following equation:

$$\frac{\partial r^L}{\partial \theta}(C, NC) = \frac{(a+\tau)(5-6\theta-3\theta^2)}{2(3-2\theta+3\theta^2)^2}, \qquad \frac{\partial r^L}{\partial \theta}(C, C) = \frac{a(5-4\theta-4\theta^2)}{(3-4\theta+4\theta^2)^2}.$$

Thus, we can find the following relations hold.

$$\frac{\partial r^L}{\partial \theta}(C, NC)\begin{cases} \geq 0 & \text{if} \quad \theta \leq (1/3)(2\sqrt{6}-3) \\ < 0 & \text{if} \quad \theta > (1/3)(2\sqrt{6}-3) \end{cases}, \qquad \frac{\partial r^L}{\partial \theta}(C, C)\begin{cases} \geq 0 & \text{if} \quad \theta \leq (1/2)(\sqrt{6}-1) \\ < 0 & \text{if} \quad \theta > (1/2)(\sqrt{6}-1) \end{cases}.$$

The above equation implies that the price of intermediate good in both cases (C, NC) and (C, C) have a single peked, that is, $(\partial r^L/\partial\theta)(C, NC) = 0$ at $\theta = (1/3)(2\sqrt{6}-3) \simeq 0.63299$ and $(\partial r^L/\partial\theta)(C, C) = 0$ at $\theta = (1/2)(\sqrt{6}-1) \simeq 0.72474$.

Further, from the profit of the local intermediate good producer, we obtain

$$\frac{\partial \pi^\ell}{\partial \theta}(C, C) = \frac{a^2(1+\theta-2\theta^2)}{b(3-4\theta+4\theta^2)^2} \geq 0 \quad \text{and} \quad \frac{\partial \pi^\ell}{\partial \theta}(C, NC) = \frac{(a+\tau)^2(1-\theta^2)}{2b(3-2\theta+3\theta^2)^2} \geq 0.$$

Thus, profit of the local intermediate good producer increases due to an increase in θ.

Proof of Proposition 1: From equations (7)–(16), we derive the payoff matrix of the exporters. First, let us consider exporter 1. Comparing the cases (NC, NC) and (C, NC), the following indifference condition holds:

$$\pi_1^F(NC, NC) = \pi_1^F(C, NC) \;\Leftrightarrow\; \frac{\tau}{a} = \frac{4\theta(1+3\theta)}{51-38\theta+39\theta^2} \equiv f_1(\theta) \tag{F.1}$$

Similarly, comparing the cases (NC, C) and (C, C), the following condition holds:

$$\pi_1^F(NC, C) = \pi_1^F(C, C) \;\Leftrightarrow\; \frac{\tau}{a} = \frac{4\theta(1+2\theta-\theta^2+4\theta^3)}{(3-4\theta+4\theta^2)(17-14\theta+17\theta^2)} \equiv f_2(\theta) \tag{F.2}$$

Note that exporters are symmetric, then (F.1) and (F.2) are valid for expoter 2 ((F.1) coressponds to exporter 2's (NC, NC) and (NC, C) cases, and (F.2) coressponds to exporter 2's (C, NC) and (C, C)

cases). Thus, we obtain

$$\text{exporter 1} \begin{cases} \gamma \geq f_1(\theta) & \Rightarrow & \pi_1^F(C, NC) \geq \pi_1^F(NC, NC), \\ \gamma \leq f_1(\theta) & \Rightarrow & \pi_1^F(NC, NC) \geq \pi_1^F(C, NC), \\ \gamma \geq f_2(\theta) & \Rightarrow & \pi_1^F(C, C) \geq \pi_1^F(NC, C), \\ \gamma \leq f_2(\theta) & \Rightarrow & \pi_1^F(NC, C) \geq \pi_1^F(C, C). \end{cases}$$

$$\text{exporter 2} \begin{cases} \gamma \geq f_1(\theta) & \Rightarrow & \pi_2^F(NC, C) \geq \pi_2^F(NC, NC), \\ \gamma \leq f_1(\theta) & \Rightarrow & \pi_2^F(NC, NC) \geq \pi_2^F(NC, C), \\ \gamma \geq f_2(\theta) & \Rightarrow & \pi_2^F(C, C) \geq \pi_2^F(C, NC), \\ \gamma \leq f_2(\theta) & \Rightarrow & \pi_2^F(C, NC) \geq \pi_2^F(C, C). \end{cases}$$

For all θ belonging to $(0, 1]$, C becomes a dominant strategy for both exporters if $\gamma \geq f_2(\theta)$. Second, for all θ belonging to $(0, 1]$, NC becomes a dominant strategy for the exporters if $\gamma \leq f_1(\theta)$. Finally, for all θ belonging to $(0, 1]$, (C, NC) and (NC, C) is the equilibrium if $f_2(\theta) \geq \gamma \geq f_1(\theta)$ holds. Q.E.D.

Proof of Proposition 2: First, comparing (NC, NC) and (C, C), we obtain

$$\pi^L(NC, NC) = \pi^L(C, C) \Leftrightarrow \frac{\tau}{a} = -\frac{4\theta(1-\theta)}{3 - 4\theta + 4\theta^2} \equiv q_1(\theta).$$

Note that $q_1(\theta)$ is non-positive for all θ belonging to $[0, 1]$, and $\pi^L(NC, NC) > \pi^L(C, C)$ holds if $\gamma(= \tau/a) > q_1(\theta)$. Thus, we can immediately find that $\pi^L(NC, NC) \geq \pi^L(C, C)$ for all $(\theta, \gamma) \in [0, 1] \times [0, \tau^{\max}]$.

Next, comparing (NC, NC) and (C, NC), we obtain

$$\pi^L(NC, NC) = \pi^L(C, NC) \Leftrightarrow \frac{\tau}{a} = -\frac{4\theta(-1+\theta)}{(-3+\theta)(1+\theta)} \equiv q_2(\theta)$$

Note that $q_2(\theta)$ is non-positive for all θ belonging to $[0, 1]$, and $\pi^L(NC, NC) > \pi^L(C, NC)$ holds if $\gamma > q_2(\theta)$. Thus, we can immediately find that $\pi^L(NC, NC) \geq \pi^L(C, NC)$ for all $(\theta, \gamma) \in [0, 1] \times [0, \tau^{\max}]$.

Finally, comparing (C, NC) and (C, C), we obtain

$$\pi^L(C, NC) = \pi^L(C, C) \Leftrightarrow \frac{\tau}{a} = -\frac{4\theta(-3 + 3\theta - 2\theta^2 + 2\theta^3)}{(3 - 4\theta + 4\theta^2)(3 - 6\theta + 7\theta^2)} \equiv q_3(\theta)$$

Note that $q_3(\theta)$ is non-positive for all θ belonging to $[0, 1]$, and $\pi^L(C, NC) > \pi^L(C, C)$ holds if $\gamma > q_3(\theta)$. Thus, we can immediately find that $\pi^L(C, NC) \geq \pi^L(C, C)$ for all $(\theta, \gamma) \in [0, 1] \times [0, \tau^{\max}]$. Therefore, $\pi^L(NC, NC) \geq \pi^L(C, NC) = \pi^L(NC, C) \geq \pi^L(C, C)$ holds for all $(\theta, \gamma) \in [0, 1] \times [0, \tau^{\max}]$. Q.E.D.

Proof of Proposition 3: First, we verify the shapes of $y(C,C)$ and $y(C,NC)$ for the content rate. Differentiating $y(C,C)$ and $y(C,NC)$ with respect to θ, we obtain

$$\frac{\partial y}{\partial \theta}(C,C)\begin{cases} \leq 0 & \text{if} \quad \theta \leq 1/2 \\ > 0 & \text{if} \quad \theta > 1/2 \end{cases} \quad \text{and} \quad \frac{\partial y}{\partial \theta}(C,NC)\begin{cases} \leq 0 & \text{if} \quad \theta \leq 2\sqrt{3}-3 \\ > 0 & \text{if} \quad \theta > 2\sqrt{3}-3 \end{cases}$$

Furthermore, we find $y(C,C)\big|_{\theta=1/2} = 0$, $y(C,NC)\big|_{\theta=2\sqrt{3}-3} = [3(a+\tau)(7-4\sqrt{3})]/[8b(9-5\sqrt{3})] > 0$. $y(C,C)\big|_{\theta=0} = y(C,C)\big|_{\theta=1} = a/(8b)$, $y(C,NC)\big|_{\theta=0} = y(C,NC)\big|_{\theta=1} = (a+\tau)/(8b)$, and

$$y(C,NC)\big|_{\theta=0} - y(C,NC)\big|_{\theta=2\sqrt{3}-3} = \frac{(7\sqrt{3}-12)(a+\tau)}{8(9-5\sqrt{3})b} > 0.$$

Thus, $y(C,C)$ and $y(C,NC)$ are U-shaped curve with respect to θ. Differentiating the equilibrium profit of firm L with respect to θ, we obtain the following equations.

$$\frac{\partial \pi^L}{\partial \theta}(C,C) = \frac{9a^2(-1+2\theta)^3}{4b(3-4\theta+4\theta^2)^3}, \tag{A.1}$$

$$\frac{\partial \pi^L}{\partial \theta}(C,NC) = \frac{\partial \pi^L}{\partial \theta}(NC,C) = \frac{(a+\tau)^2(-9+36\theta-54\theta^2+36\theta^3+7\theta^4)}{8b(3-2\theta+3\theta^2)^3}. \tag{A.2}$$

From equation (A.2), the real roots of equation $-9+36\theta-54\theta^2+36\theta^3+7\theta^4=0$ are $-(3+2\sqrt{3}\,) < 0$ and $-3+2\sqrt{3} > 0$. Thus, from equations (A.1) and (A.2), we obtain

$$\frac{\partial \pi^L}{\partial \theta}(C,C)\begin{cases} > 0 & \text{if} \quad \theta > 1/2 \\ \leq 0 & \text{if} \quad \theta \leq 1/2 \end{cases}$$

$$\frac{\partial \pi^L}{\partial \theta}(C,NC) = \frac{\partial \pi^L}{\partial \theta}(NC,C)\begin{cases} > 0 & \text{if} \quad \theta > -3+2\sqrt{3} \\ \leq 0 & \text{if} \quad \theta \leq -3+2\sqrt{3} \end{cases}.$$

Next, differentiating the equilibrium profit of exporters (firms F) with respect to θ, we obtain the following equations.

$$\frac{\partial \pi_j^F}{\partial \theta}(C,C) = \frac{a^2(7-64\theta+96\theta^2-64\theta^3+16\theta^4)}{8b(3-4\theta+4\theta^2)^3}, \tag{A.3}$$

$$\frac{\partial \pi_1^F}{\partial \theta}(C,NC) = \frac{\partial \pi_2^F}{\partial \theta}(NC,C) = \frac{(a+\tau)^2(-7-36\theta+54\theta^2-36\theta^3+9\theta^4)}{8b(3-2\theta+3\theta^2)^3}, \tag{A.4}$$

$$\frac{\partial \pi_1^F}{\partial \theta}(NC,C) = \frac{\partial \pi_2^F}{\partial \theta}(C,NC) = \frac{(a+\tau)(1-\theta^2)\,A}{4b(3-2\theta+3\theta^2)^3}, \tag{A.5}$$

where $A \equiv (7-2\theta+7\theta^2)a-(17-14\theta+17\theta^2)\tau$. From equation (A.3), the real roots of equation $7-64\theta+96\theta^2-64\theta^3+16\theta^4=0$ are $(1/2)(2-\sqrt{3}\,)<1$ and $(1/2)(2+\sqrt{3}\,)>1$. Thus, we obtain

$$\frac{\partial \pi_j^F}{\partial \theta}(C,C)\begin{cases} >0 & \text{if} \quad \theta<(1/2)(2-\sqrt{3}\,) \\ \leq 0 & \text{if} \quad \theta \geq (1/2)(2-\sqrt{3}\,) \end{cases}$$

From equation (A.4), the real roots of equation $-7-36\theta+54\theta^2-36\theta^3+9\theta^4=0$ are $(1/3)(3-2\sqrt{3})<0$ and $(1/3)(3+2\sqrt{3}\,)>1$. Since θ must belong to $[0,1]$, we obtain

$$\frac{\partial \pi_1^F}{\partial \theta}(C,NC) = \frac{\partial \pi_2^F}{\partial \theta}(NC,C)<0.$$

From equation (A.5), we obtain

$$(7-2\theta+7\theta^2)\,a-(17-14\theta+17\theta^2)\,\tau \geq 0 \Leftrightarrow \frac{7-2\theta+7\theta^2}{17-14\theta+17\theta^2} \geq \frac{\tau}{a}$$

Since $\tau^{\max} \equiv (7-2\theta+7\theta^2)/(17-14\theta+17\theta^2)$, we obtain

$$\frac{\partial \pi_1^F}{\partial \theta}(NC,C) = \frac{\partial \pi_2^F}{\partial \theta}(C,NC)>0.$$

Therefore, Proposition 3 holds. Q.E.D.

Welfare function: In equilibrium, the welfare of the local country is given by

$$W(NC,NC)=\frac{331a^2}{1152b}+\frac{91a\tau}{288b}-\frac{149\tau^2}{288b}, \tag{A.6}$$

$$W(C,C)=\frac{a^2(331-1032\theta+1896\theta^2-1696\theta^3+816\theta^4)}{128b(3-4\theta+4\theta^2)^2}, \tag{A.7}$$

$$W(C,NC)=\frac{\begin{bmatrix}(-725+11148\theta-1806\theta^2+1052\theta^3-645\theta^4)\,\tau^2\\+2(91-68\theta+274\theta^2-164\theta^3+171\theta^4)\,a\tau\\+(331-516\theta+946\theta^2-612\theta^3+411\theta^4)\,a^2\end{bmatrix}}{128b(3-2\theta+3\theta^2)^2}. \tag{A.8}$$

Proof of Proposition 4:

(i) Comparing (A.6) with (A.7), we obtain

$$W(NC,NC)=W(C,C)\ \Leftrightarrow\ \frac{\begin{bmatrix}91a\tau(3-4\theta+4\theta^2)^2-149\tau^2(3-4\theta+4\theta^2)^2\\-4a^2\theta(-84+239\theta-292\theta^2+128\theta^3)\end{bmatrix}}{288b(3-4\theta+4\theta^2)^2}=0.$$

This yields the following equations.

$$\gamma_1=\frac{91(3-4\theta+4\theta^2)^2+3\sqrt{-(3-4\theta+4\theta^2)^2B}}{298(3-4\theta+4\theta^2)^2},\quad \gamma_2=\frac{91(3-4\theta+4\theta^2)^2-3\sqrt{-(3-4\theta+4\theta^2)^2B}}{298(3-4\theta+4\theta^2)^2},$$

where $B\equiv-8281-168\theta+265504\theta^2-47904\theta^3+19184\theta^4$.

We find that $\gamma_2<0$ for all θ. Thus, we can ommit γ_2. Here, γ_1 implies that $W(NC,NC)>W(C,C)$ holds if $\gamma<\gamma_1$ and $W(NC,NC)<W(C,C)$ holds if $\gamma>\gamma_1$. However, we find that $\gamma_1>\tau^{\max}$ holds for all θ belonging to $[0,1]$. Thus, $W(NC,NC)>W(C,C)$ always holds.

(ii) Comparing (A.7) with (A.8), we obtain

$$W(C,C)=W(C,NC)$$

$$\Leftrightarrow\ \frac{\begin{bmatrix}-\,2a\tau(3-4\theta+4\theta^2)^2\left(819-1572\theta+1538\theta^2-708\theta^3+99\theta^4\right)\\-\,\tau^2(3-4\theta+4\theta^2)^2\left(1161-3180\theta+3142\theta^2-2316\theta^3+441\theta^4\right)\\+\,a^2\begin{pmatrix}26811-125388\theta+357786\theta^2-652500\theta^3+877067\theta^4\\-841192\theta^5+595976\theta^6-273120\theta^7+77616\theta^8\end{pmatrix}\end{bmatrix}}{1152b(3-2\theta+3\theta^2)^2(3-4\theta+4\theta^2)^2}=0.$$

Solving the above equation with respect to τ, we obtain

$$\gamma_3 = -\frac{\left(3-4\theta+4\theta^2\right)^2 D - 6\left(9-18\theta+29\theta^2-20\theta^3+12\theta^4\right)\sqrt{E}}{\left(3-4\theta+4\theta^2\right)^2\left(1161-3180\theta+3142\theta^2-2316\theta^3+441\theta^4\right)},$$

$$\gamma_4 = -\frac{\left(3-4\theta+4\theta^2\right)^2 D + 6\left(9-18\theta+29\theta^2-20\theta^3+12\theta^4\right)\sqrt{E}}{\left(3-4\theta+4\theta^2\right)^2\left(1161-3180\theta+3142\theta^2-2316\theta^3+441\theta^4\right)},$$

where $D \equiv 819-1572\theta+1538\theta^2-708\theta^3+99\theta^4$ and $E \equiv 114705-680724\theta+1996874\theta^2-3698236\theta^3+4594521\theta^4-3950392\theta^5+2254340\theta^6-792944\theta^7+106128\theta^8$.

We can find that $\gamma_4 < 0$ for all θ belonging to $[0,1]$. Thus, we can ommit γ_4. On the other hand, $\gamma_3 > 0.7 (> \tau^{\max})$ always holds and γ_3 is a strictly increasing with respect to θ for all θ. The contour γ_3 implies that $W(C,C) > W(C,NC)$ holds if $\gamma < \gamma_3$. Thus, $W(C,C) > W(C,NC) (= W(NC,C))$ always holds. From step (i) and (ii), Proposition 4 holds. Q.E.D.

Proof of Proposition 6: Differentiating (A.7) and (A.8) with respect to θ, we obtain

$$\frac{\partial W}{\partial\theta}(C,C) = \frac{a^2(-14+61\theta-90\theta^2+44\theta^3+8\theta^4)}{4b(3-4\theta+4\theta^2)^3}, \tag{A.9}$$

$$\frac{\partial W}{\partial\theta}(C,NC) = \frac{\partial W}{\partial\theta}(NC,C) = \frac{\begin{bmatrix}(17+5\theta-27\theta^2+31\theta^3-18\theta^4)\,\tau^2 \\ +2(5+13\theta-27\theta^2+23\theta^3-6\theta^4)\,a\tau \\ +(-7+21\theta-27\theta^2+15\theta^3+6\theta^4)\,a^2\end{bmatrix}}{4b(3-2\theta+3\theta^2)^3}. \tag{A.10}$$

From equation (A.9), the real roots of equation $-14+61\theta-90\theta^2+44\theta^3+8\theta^4=0$ are

$$-\left[2+\frac{9}{2}\left(\frac{3}{16-\sqrt{13}}\right)^{1/3}+\frac{3^{2/3}(16-\sqrt{13}\,)^{1/3}}{2}\right] < 0; \qquad \frac{1}{2}.$$

Thus, we obtain

$$\frac{\partial W}{\partial\theta}(C,C)\begin{cases} \leq 0 & \text{if} \quad \theta \leq 1/2 \\ > 0 & \text{if} \quad \theta > 1/2. \end{cases}$$

From the denominator of equation (A.10), we solve the inequality $(17+5\theta-27\theta^2+31\theta^3-18\theta^4)\,\tau^2+2(5+13\theta-27\theta^2+23\theta^3-6\theta^4)\,a\tau+(-7+21\theta-27\theta^2+15\theta^3+6\theta^4)\,a^2 \geq 0$ with respect to τ, and obtain

$\tau \leq -a$ or $a \times g(\theta) \leq \tau$. Thus, we obtain

$$\frac{\partial W}{\partial \theta}(C, NC) \begin{cases} \leq 0 & \text{if} \quad \gamma \leq g(\theta) \\ > 0 & \text{if} \quad \gamma > g(\theta), \end{cases}$$

where

$$g(\theta) \equiv \frac{-7 + 21\theta - 27\theta^2 + 15\theta^3 + 6\theta^4}{-17 - 5\theta + 27\theta^2 - 31\theta^3 + 18\theta^4}.$$

Therefore, Proposition 6 holds. Q.E.D.

	NC	C
NC	$\pi_1^F(NC, NC), \;\; \pi_2^F(NC, NC)$	$\pi_1^F(NC, C), \;\; \pi_2^F(NC, C)$
C	$\pi_1^F(C, NC), \;\; \pi_2^F(C, NC)$	$\pi_1^F(C, C), \;\; \pi_2^F(C, C)$

Table 1: The payoff matrix of the exporters

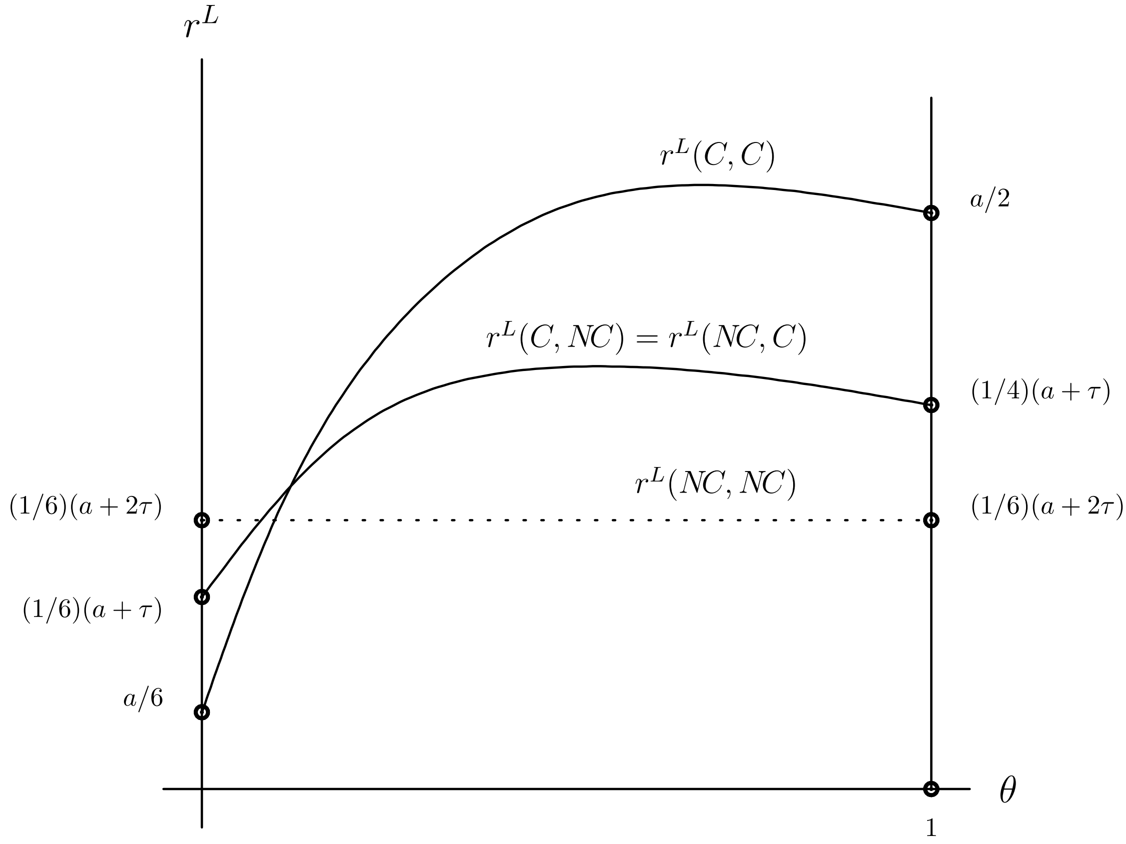

Figure 1: Local intermediate good price in each regime

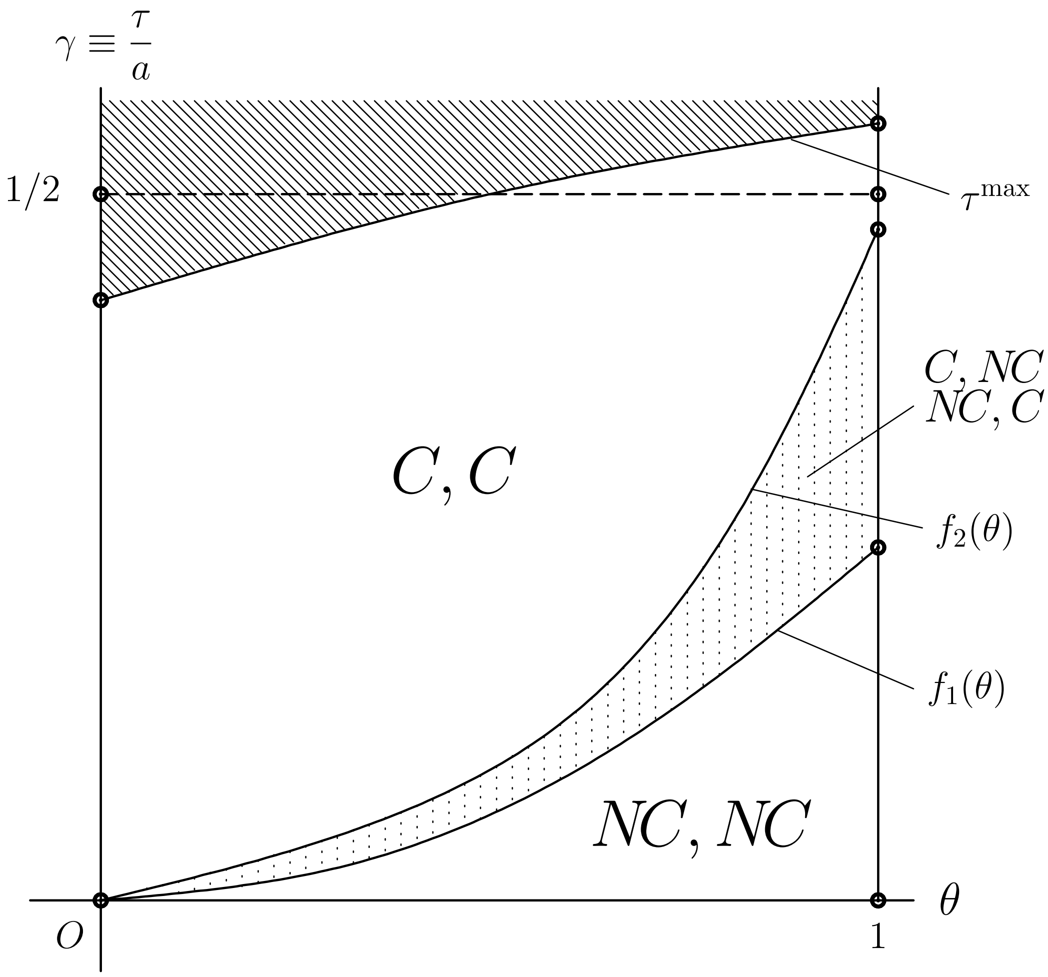

Figure 2: Equilibrium regimes in θ-γ plane.

Note that $\tau^{\max} \equiv \dfrac{7 - 2\theta + 7\theta^2}{17 - 14\theta + 17\theta^2}$,

$$f_1(\theta) \equiv \frac{4\theta(1+3\theta)}{51 - 38\theta + 39\theta^2}, \quad f_2(\theta) \equiv \frac{4\theta(1 + 2\theta - \theta^2 + 4\theta^3)}{(3 - 4\theta + 4\theta^2)(17 - 14\theta + 17\theta^2)}.$$

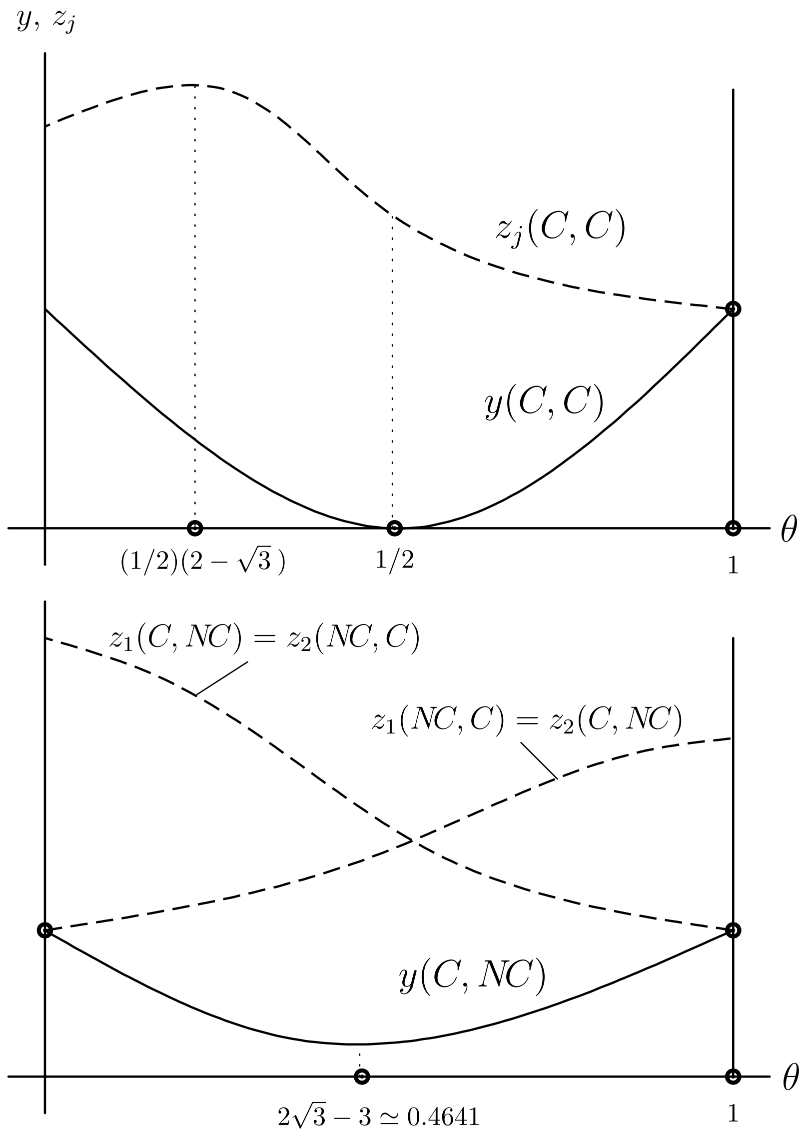

Figure 3: Outputs in (C, C) and (C, NC) (or (NC, C)).

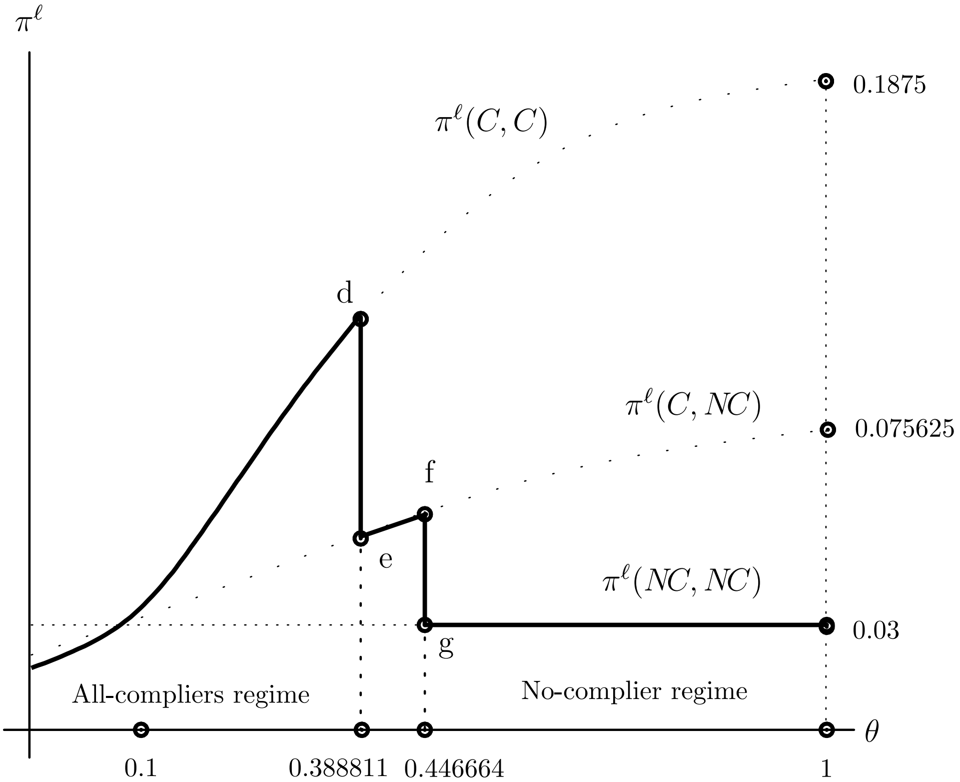

Figure 4: The profit of local intermediate-good producer in each regime

Note that the difference between points 'd' and 'e' is 0.0418547, but the difference between points 'f' and 'g' is 0.0285062, where $\tau = 1/10$ and $a = b = 1$.

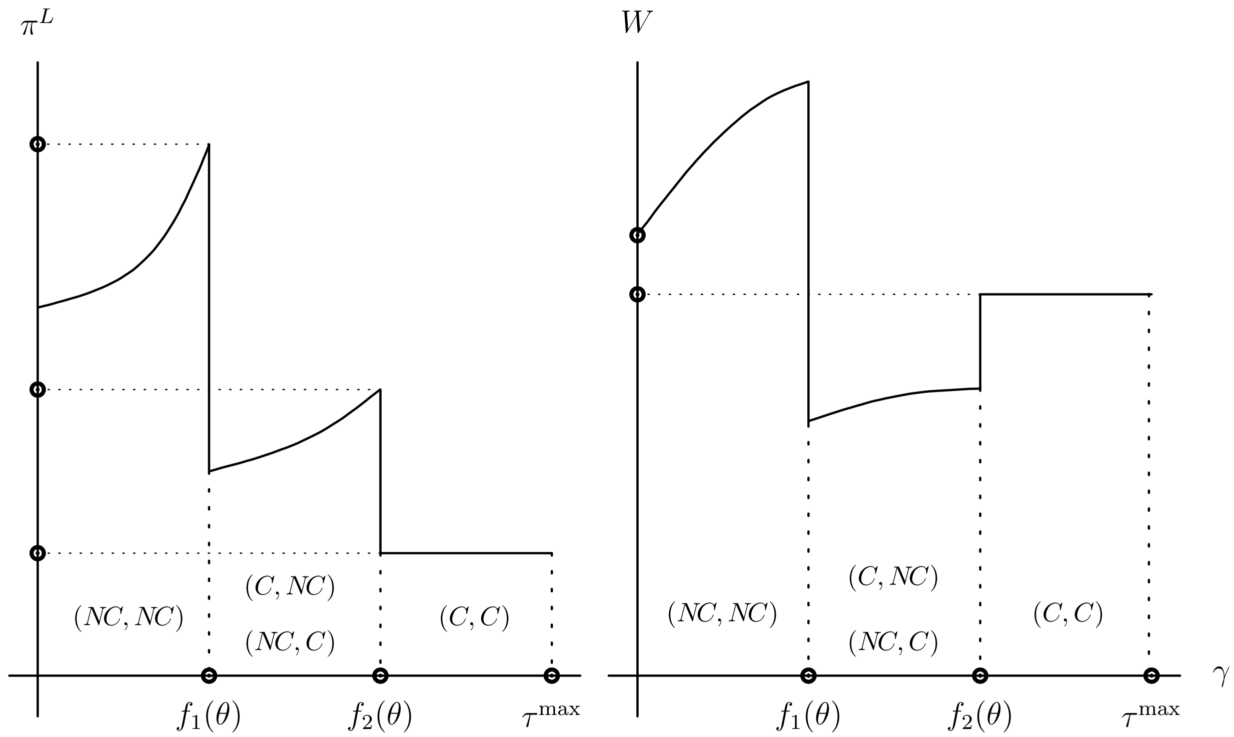

Figure 5: The profit of firm L and the social welfare of the importing country ($1 \geq \theta > 0$)