

Economic Integration and Rules of Origin under International Oligopoly*

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Abstract

Free trade areas (FTAs) have rules of origin (ROOs) to prevent tariff circumvention by firms of non-member countries. This paper points out that in imperfectly competitive markets, ROOs have another role which has been overlooked in the existing literature. We examine the effects of ROOs on profits, prices, tariff revenue, and welfare. Under some conditions, ROOs benefit the firm producing a good originating outside the FTA and hurt the firm producing a good originating within the FTA. Under some other conditions, ROOs generate a collusive effect. Our analysis also sheds light on the FTA versus customs union comparison.

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1 Introduction

Recently, many countries and regions have been attempting to make regional trade agreements (RTAs) in order to strengthen economic ties with specific trading partners.¹ The WTO defines three basic categories of regional trade agreements: customs union (CU), free trade area (FTA), and the interim agreement.² While all members of a CU set the common external tariffs, each member of an FTA independently chooses its own external tariffs. Thus, were it not for any regulation in an FTA in the absence of transport costs, imports from outside of the FTA would be made through the countries with the lowest tariffs. If such tariff circumvention arises, those member countries whose tariff rates are not the lowest obviously lose their tariff revenue. This may lead to a race to the bottom in setting tariffs.³ Moreover, the firms within those countries face keener competition, because the exporting costs of the rival firms located outside the FTA fall. Thus, it is claimed that to prevent such tariff circumvention, rules of origin (ROOs), which condition goods to be regarded as produced within the FTA, are indispensable to FTAs.⁴ In fact, to our knowledge, all of the prevailing FTAs establish such ROOs.

Although the importance of regional trade agreements has recently been growing, the studies on the *role* of ROOs are relatively limited. Furthermore, most of the existing studies focus on the aspect of content protection caused by ROOs.⁵ This is because typical ROOs are based on percentage of value added.⁶ In the studies conducted in

¹The WTO says on its website (<http://www.wto.org>), “The surge in RTAs has continued unabated since the early 1990s. Some 250 RTAs have been notified to the GATT/WTO up to December 2002, of which 130 were notified after January 1995. Over 170 RTAs are currently in force; an additional 70 are estimated to be operational although not yet notified.” The first agreement was the 1957 Treaty of Rome to form the European Economic Community (EEC). It went into effect in 1958.

²For example, MERCOSUR, which went into effect in 1995, is an interim agreement which seeks the establishment of a CU by 2006.

³See Richardson (1995).

⁴Strictly speaking, ROOs are divided into two categories: non-preferential and preferential origin rules. The former is used for statistical purposes, while the latter is used to judge whether advantageous tariff treatments should be provided. The preferential origin rules are divided into two more categories: rules on general preferential treatment for developing countries (i.e. ROOs for the Generalized System of Preferences (GSP)) and rules relating to regional trade agreements.

⁵See Krishna and Krueger (1995), Krueger (1999), Rosellón (2000), Rodriguez (2001), and Ju and Krishna (2002), among others.

⁶There are two other methods to determine the origin. These are based on changes in tariff heading and on technical definition, respectively. For details, see Falvey and Reed (1998). Note that some ROOs, such as those of NAFTA, combine both the method based on percentage of value added and that based on changes in tariff heading.

the context of content protection, when ROOs are employed or when ROOs become tighter, producers will respond so as to have their products classified as those originating in the FTA. Thus, Falvey and Reed (1998, 2002) indicate that the analyses of ROOs conducted in the context of content protection are essentially the same with those of content protection itself.

In this paper, we direct our attention to the final-good market rather than the intermediate-good market. This paper points out that in imperfectly competitive markets, ROOs have an important role which has been overlooked in the existing literature. The products which meet ROOs are freely traded within the FTA, while the products which do not satisfy ROOs are subject to tariffs when being traded among the member countries of the FTA. That is, the markets for a product originating within the FTA are completely integrated, whereas those for a product which does not meet ROOs are not. This obviously results in different pricing behavior among firms. The firms producing goods originating within the FTA are forced to set the uniform price due to arbitrage, while those producing goods originating outside the FTA can price-discriminate to some extent. Thus, market integration and segmentation in the final-good markets are key to our understanding of the role of ROOs.

We investigate the role of ROOs in a simple Bertrand duopoly model. One firm produces a final good within an FTA, while the other produces a final good outside the FTA. These two goods are imperfect substitutes to each other. We compare profits, prices, tariff revenue, and welfare with and without ROOs. While we have several possibilities, the following two cases are noteworthy.

In one case, ROOs benefit the firm producing a good originating outside the FTA and hurt the firm producing a good originating within the FTA. This presents a striking contrast to the studies that are concerned with content protection.⁷ In those studies, producers will have their products regarded as those originating in the FTA, while in our analysis, they may not have such an incentive.

In another case, both firms gain from ROOs at the expense of consumers. This implies that ROOs could lead to a hidden collusion. This collusion effect of ROOs is novel.⁸ In her analysis of the FTA, Krueger (1999) points out that ROOs result in an important

⁷Note that using a Cournot duopsony model, Richardson (1991) shows that a domestic content protection scheme may benefit the foreign final-good producer as well as the domestic intermediate-good producers and harm the domestic final-good producer.

⁸Note that using a model of successive Cournot oligopolies, Ishikawa (1999) shows that a domestic content protection scheme may benefit both domestic and foreign final-good producers.

protectionist bias inherent in FTAs which is not present in CUs. This protectionist bias stems from distortions in the intermediate-good markets. The present paper indicates an additional distortion in FTAs which arises in the final-good markets.

Using a three-country partial equilibrium model, Falvey and Reed (2002) examine the conditions under which the imposition of ROOs is welfare improving for an importer of the final good.⁹ However, their framework is perfect competition. Although the aspect of content protection has been analyzed in various market structures, to our knowledge, our study is the first attempt among those that examine the other aspects of ROOs under oligopoly.

Takechi and Kiyono (2003) compare two kinds of local content schemes in a two-country model under perfect competition. Their point is that the effects of local content scheme crucially depend on how the local content scheme segments the final-good markets. We should note that our point is the *coexistence* of completely and incompletely integrated (or segmented) markets for a differentiated final product in an FTA. Furthermore, since their analysis is that of content protection, both intermediate goods and foreign direct investment are indispensable. In contrast, neither intermediate goods nor FDI are crucial to make our point, so we do not explicitly deal with them in our analysis.

In their analysis of bundling products with non-tradable services, Horn and Shy (1996) also consider a case where the integrated and segmented markets coexist. Using a spatial duopoly model, they show that in equilibrium, one firm will bundle its product with local service while the other firm will not. As a result, the markets are segmented for the former good, and integrated for the latter. While this feature is similar to ours, the focus of their analysis is obviously different. Moreover, our benchmark is the case where both markets are integrated, whereas their benchmark is the case where both markets are segmented.

As Vousden (1990) points out in his textbook, an FTA which allows free arbitrage of all commodities among member countries is essentially equivalent to a CU. In our analysis, an FTA without ROOs can be regarded as a CU that sets the common tariff equal to the lowest member country tariff. Therefore, the comparison between the cases with and without ROOs can be reinterpreted as that between an FTA and a CU and our analysis provides an important viewpoint in the FTA versus CU comparison under oligopoly. There are a number of works that compare between the FTA and the CU in the light of their optimal external tariffs.¹⁰ It has been shown that both optimal tariff

⁹In their analysis, ROOs improve the terms of trade and hence could raise welfare.

¹⁰See Bagwell and Staiger (1999), Kose and Riezman (2000), and Freund (2000), for instance.

level and social welfare are generally higher in the CU than in the FTA. This is because the members of a CU set a common external external tariff so that they can internalize positive externality associated with an increase in partner's external tariff.¹¹ Our analysis suggests, however, that neither FTAs nor CUs are unambiguously preferable.

Many studies make use of oligopoly models to analyze RTAs.¹² However, some of those studies keep an assumption throughout the analyses that the markets are simply segmented. This may not be satisfactory, because economic integration is basically an attempt to make segmented national markets a single integrated market. Once economic integration is completed, it seems more plausible to assume an integrated market in the region. Although there exist studies which regard economic integration as a switch from segmented markets to an integrated market, most of those studies abstract from non-member countries.¹³ In contrast, we explicitly consider the non-member country whose market is segmented from the markets in an FTA or a CU.

The remainder of this paper is organized as follows: Section 2 presents the basic model, Section 3 compares FTAs with and without ROOs, and Section 4 provides some concluding remarks. All proofs of Lemmas and Propositions are delegated to the Appendices.

2 Model

We consider an FTA whose members are countries 1 and 2. There are two firms, firms I and O . Each firm produces one final good, which is an imperfect substitute for the good produced by its rival firm. While firm I produces good I within the FTA, firm O produces good O outside the FTA. The two firms supply their products to both countries 1 and 2 and compete in a Bertrand fashion. The member countries commit to zero tariffs on imports from the partner, but they set their own tariffs on imports from the non-members. The external tariff set by country i ($i = 1, 2$) is denoted by t_i , which is positive

¹¹Suppose that country 1 and country 2 form an FTA and each sets her external tariff against non-members. An increase in country 2's external tariff benefits producers in country 1 by raising the price and sales in country 2. Similarly, an increase in country 1's external tariff benefits producers in country 2. In the case of FTAs, each government does not take this positive externality into account when maximizing its welfare. In the case of CUs, on the other hand, countries internalize the externality, because they choose the common external tariff.

¹²See Venables (1987), Long and Soubeyran(1997), Krishna (1998), and Freund (2000), among others.

¹³An exception is Mukunoki (2002) which uses a similar setting to ours and shows that the external tariff levels of an FTA determined under the Nash equilibrium are higher in the integrated-market case than in the segmented-market case.

and exogenously given. For simplicity, transport costs are assumed away.¹⁴ Moreover, we focus on the case where both firms always serve both countries.

Demand in each country is characterized by a represented consumer. The indirect utility function in country i ($i = 1, 2$) is given by

$$V_i [p_i^I, p_i^O] = \bar{V}_i - a_i (p_i^I + p_i^O) + \frac{(p_i^I)^2 + (p_i^O)^2}{2} - b_i (p_i^I p_i^O) + Y_i, \quad (1)$$

where p_i^I and p_i^O are, respectively, the prices charged by firm I and firm O in country i ; \bar{V}_i is a positive constant; and Y_i is the income in country i . Throughout the analysis, square brackets refer to functions. By using Roy's identity, the demand for each product in country i is given by

$$x_i^I [p_i^I, p_i^O] = a_i - p_i^I + b_i p_i^O, \quad (2)$$

$$x_i^O [p_i^O, p_i^I] = a_i - p_i^O + b_i p_i^I, \quad (3)$$

where a_i and $b_i \in (0, 1)$, respectively, represent the market size and substitutability of products in country i . As b_i approaches one, products become more similar. Note that both market size and substitutability of products may be different between countries. For ease of exposition, however, we impose the following restrictions: $\sum_{i=1,2} a_i \equiv a$ and $\sum_{i=1,2} b_i \equiv b$ (where both a and b are constant), that is, any difference is a mean-preserving spread.

We compare two types of FTA: (i) an FTA without ROOs and (ii) an FTA with ROOs.¹⁵ With ROOs, good O is subject to the tariffs when being traded between countries 1 and 2. Without ROOs, firm O can supply good O to both countries 1 and 2 through the country with the lower external tariff, because both goods I and O are freely traded between countries 1 and 2. That is, tariff circumvention occurs without ROOs. For simplicity, we abstract from the possibility of firm O 's production within the FTA.

A per-unit cost of producing differentiated goods is assumed to be identical across firms. It is constant and normalized to zero. The total profits of each firm are given by

$$\pi^I = \sum_{i=1,2} p_i^I x_i^I [p_i^I, p_i^O], \quad (4a)$$

$$\pi^O = \sum_{i=1,2} (p_i^O - \tau) x_i^O [p_i^O, p_i^I], \quad (4b)$$

¹⁴Even if there are transport costs, our point is still valid unless they are so high that the markets are always segmented.

¹⁵An FTA without ROOs could be interpreted as a CU. See section 4.

where $\tau = t_i$ with ROOs and $\tau = \min\{t_1, t_2\}$ without ROOs.

We assume that in the FTA, there are many competitive arbitragers who supply parallel imports or re-imports by purchasing in the low price market and selling in the high price market; and that there is no additional cost in such arbitrage activities. Since good I is freely traded in the FTA, any price differential of good I within the FTA leads to arbitrage activities. Consequently, firm I is forced to set the uniform price in the two markets. That is, the markets for good I are completely integrated. In the absence of ROOs, such complete market integration also occurs in the markets for good O . In the presence of ROOs, however, arbitrage activities must bear the external tariff when good O is traded between countries 1 and 2. That is, the markets for good O are incompletely integrated or even segmented and hence arbitrage activities cannot eliminate the price differential made by firm O . When the markets for good O are incompletely integrated, firm O sets the price differential such that all arbitrage activities are actually exhausted. When the markets for good O are segmented, firm O freely sets the prices among the markets.

2.1 Equilibrium without ROOs

As our benchmark case, we first derive the equilibrium in the absence of ROOs. Without loss of generality, we assume $t_1 \geq t_2$ and define $\Delta t \equiv t_1 - t_2 \geq 0$. Since markets are completely integrated for both goods I and O , each firm sets the same price across markets. We let $p^j (= p_1^j = p_2^j)$ denote the uniform price set by firm $j \in \{I, O\}$. Since firm O can export its product to country 1 via country 2, $\tau = \min\{t_1, t_2\} = t_2$.

Since each firm maximizes its profits by choosing its own price with given rival's price, the first-order conditions of profit maximization are:

$$\frac{\partial \pi^I}{\partial p^I} = \sum_{i=1,2} x_i^I [p^I, p^O] + p^I \sum_{i=1,2} \frac{\partial x_i^I [p^I, p^O]}{\partial p^I} = 0, \quad (5a)$$

$$\frac{\partial \pi^O}{\partial p^O} = \sum_{i=1,2} x_i^O [p^O, p^I] + (p^O - t_2) \sum_{i=1,2} \frac{\partial x_i^O [p^O, p^I]}{\partial p^O} = 0. \quad (5b)$$

Rearranging the above two equations yields the reaction functions:

$$p^I \equiv \tilde{R}^I [p^O] = \frac{a + bp^O}{4}, \quad (6a)$$

$$p^O \equiv \tilde{R}^O [p^I] = \frac{a + 2t_2 + bp^I}{4}. \quad (6b)$$

Recalling that both a and b are constant, we should note that any difference in demand does not affect each firm's choice. Intuitively, since each firm sets the same price across

countries, each firm regards two markets as a single market. Hence, the pricing strategy of each firm depends only on the total demand within the FTA, not on the spread of the demand between countries.

The equilibrium is depicted in Figure 1. $R^I R^I$ and $\tilde{R}^O \tilde{R}^O$ represent the reaction functions of firm I and firm O , respectively, and point \tilde{E} is the equilibrium which gives the following equilibrium prices:

$$\tilde{p}^I = \frac{a(4+b) + 2bt_2}{16 - b^2}, \quad (7a)$$

$$\tilde{p}^O = \frac{a(4+b) + 8t_2}{16 - b^2}. \quad (7b)$$

An increase in t_2 raises both \tilde{p}^I and \tilde{p}^O . However, the increase in \tilde{p}^O is less than the increase in t_2 and hence its producer price decreases.

[Figure 1 around here]

By substituting the first-order conditions into the profit functions, the equilibrium profits are, respectively, given by

$$\tilde{\pi}^I = 2(\tilde{p}^I)^2, \quad (8a)$$

$$\tilde{\pi}^O = 2(\tilde{p}^O - t_2)^2. \quad (8b)$$

Moreover, the equilibrium consumer surplus and tariff revenue are, respectively, given by

$$\tilde{S}_i = V_i[\tilde{p}^I, \tilde{p}^O] - Y_i, \quad i = 1, 2, \quad (9)$$

$$\tilde{R}_1 = 0, \quad \tilde{R}_2 = t_2 \sum_{i=1,2} \tilde{x}_i[\tilde{p}^I, \tilde{p}^O]. \quad (10)$$

2.2 Equilibrium with ROOs

We next obtain the equilibrium in the presence of ROOs. Since the markets remain completely integrated for good I , firm I still chooses the same price across internal markets. Firm O , on the other hand, can price-discriminate to some extent, because the arbitrage activities must incur the external tariff. Firm O sets the prices so that the arbitrage activities do not actually occur. That is, firm O maximizes its profits with arbitrage constraint. However, as long as both $\hat{p}_1^O \leq \hat{p}_2^O + t_1$ and $\hat{p}_2^O \leq \hat{p}_1^O + t_2$ (where \hat{p}_i^O is the price of good O in country i under segmented markets) hold, firm O is free from the constraint and hence can independently choose p_1^O and p_2^O . In the following analysis,

to make our point as simply as possible, we focus on this case (i.e. the case of segmented markets).¹⁶

The first-order conditions of profit maximization under segmented markets are:

$$\frac{\partial \pi^I}{\partial p^I} = \sum_{i=1,2} x_i^I[p^I, p_i^O] + p^I \sum_{i=1,2} \frac{\partial x_i^I[p^I, p_i^O]}{\partial p^I} = 0, \quad (11a)$$

$$\frac{\partial \pi^O}{\partial p_i^O} = x_i^O[p_i^O, p^I] + (p_i^O - t_i) \frac{\partial x_i^O[p_i^O, p^I]}{\partial p_i^O} = 0, \quad i = 1, 2. \quad (11b)$$

Rearranging the above three equations yields the following reaction functions:

$$p^I \equiv \widehat{R}^I [p_1^O, p_2^O] = \frac{a + \sum_{i=1,2} b_i p_i^O}{4}, \quad (12a)$$

$$p_i^O \equiv \widehat{R}_i^O [p^I] = \frac{a_i + t_i + b_i p^I}{2}, \quad i = 1, 2. \quad (12b)$$

We define $\bar{p}^O \equiv (b_1 p_1^O + b_2 p_2^O) / b$ as the weighted average of the prices of good O where the weights are each country's relative substitutability. Using \bar{p}^O , we can rewrite firm I 's reaction function and define the weighted average of firm O 's reaction functions as follows:

$$p^I = \widehat{R}^I [\bar{p}^O] = \frac{a + b \bar{p}^O}{4}, \quad (13)$$

$$\begin{aligned} \bar{p}^O &= \widehat{R}^O [p^I] \equiv \frac{1}{b} \sum_{i=1,2} b_i \widehat{R}_i^O [p^I] \\ &= \frac{\sum_{i=1,2} (a_i + t_i) b_i + (\sum_{i=1,2} b_i^2) p^I}{2b}. \end{aligned} \quad (14)$$

This arrangement makes the strategic interaction as if the firms compete by setting p^I and \bar{p}^O . Once the equilibrium level of p^I is determined, the equilibrium level of p_i^O ($i = 1, 2$) can be obtained from equation (12b). The equilibrium with ROOs is shown in Figure 2. $R^I R^I$ represents firm I 's reaction function. $\widehat{R}_i^O \widehat{R}_i^O$ ($i = 1, 2$) is firm O 's reaction function in country i , and $\widehat{R}^O \widehat{R}^O$ shows the weighted average of firm O 's reaction curves. The intersection between $R^I R^I$ and $\widehat{R}^O \widehat{R}^O$, point \widehat{E} , determines the equilibrium prices:

$$\widehat{p}^I = \frac{2a + \sum_{i=1,2} (a_i + t_i) b_i}{\Gamma}, \quad (15a)$$

$$\widehat{p}_i^O = \frac{2ab_i + (8 - b_j^2) (a_i + t_i) + b_i b_j (a_j + t_j)}{2\Gamma}, \quad (15b)$$

where $i, j = 1, 2$ ($j \neq i$) and $\Gamma \equiv 8 - \sum_{i=1,2} b_i^2 > 0$.

¹⁶The condition for segmented markets is derived in the appendix. Even if the markets are not segmented, our point is still valid.

[Figure 2 around here]

For ease of exposition, we restrict our attention to the case with $\widehat{p}_1^O \geq \widehat{p}_2^O$. This is the case if $\widehat{p}_1^O \geq \widehat{p}_2^O$ holds with $\Delta t = 0$, because an increase in Δt raises $(\widehat{p}_1^O - \widehat{p}_2^O)$.¹⁷ This sufficient condition can be rewritten as

$$\Omega \equiv (16 - b^2) \Delta a + \{a(4 + b) + 2bt_2\} \Delta b \geq 0, \quad (16)$$

where $\Delta a \equiv a_1 - a_2$ and $\Delta b \equiv b_1 - b_2$. This condition is assumed in the following analysis. The size of Ω represents the extent of the price discrimination.

The equilibrium profits, consumer surplus, and tariff revenue are, respectively, given by

$$\widehat{\pi}^I = 2 (\widehat{p}^I)^2, \quad (17a)$$

$$\widehat{\pi}^O = \sum_{i=1,2} (\widehat{p}_i^O - t_i)^2, \quad (17b)$$

$$\widehat{S}_i = V_i [\widehat{p}^I, \widehat{p}_i^O] - Y_i, \quad i = 1, 2, \quad (18)$$

$$\widehat{R}_i = t_i \widehat{x}_i^O [\widehat{p}_i^O, \widehat{p}^I], \quad i = 1, 2. \quad (19)$$

3 Comparison

Now we compare the two equilibria: the equilibria with and without ROOs. We should note that ROOs have two effects. On one hand, ROOs do not allow firm O to circumvent the higher tariff. That is, firm O cannot export its product to country 1 via country 2 which sets the lower tariff. Thus, firm O faces the higher tariff to serve country 1. We call this effect as the *anti-tariff-circumvention effect*. On the other hand, ROOs allow firm O to take the pricing-market behavior, because arbitrage activities cannot eliminate the price differential made by firm O . We call this effect as the *price-discrimination effect*.

3.1 Prices

First of all, we compare the prices with and without ROOs. To this end, we first consider both anti-tariff-circumvention and price-discrimination effects when p^I is fixed at \widetilde{p}^I .

¹⁷If $\widehat{p}_1^O \leq \widehat{p}_2^O$ holds when $t_1 = t_2$, the ranking in price can be reversed as the difference in the external tariffs increases. This makes the analysis complicated without changing the results qualitatively.

These effects are illustrated in Figure 3. In the figure, $F_i F_i$ shows the locus of the first-order condition (12b) with $p^I = \tilde{p}^I$ and $t_i = \min\{t_1, t_2\} (= t_2)$ ($i = 1, 2$). $F'_1 F'_1$ shows (12b) with $p^I = \tilde{p}^I$ and $i = 1$. If the two markets are segmented with $p^I = \tilde{p}^I$ and $t_i = \min\{t_1, t_2\}$, the equilibrium is given by \widehat{E}' . Similarly, if the two markets are segmented with $p^I = \tilde{p}^I$, the equilibrium is given by \widehat{E}'' . The equilibrium without ROOs is given by \tilde{E} which is located on the 45 degree line, OZ .¹⁸ In the figure, the shift from \tilde{E} to \widehat{E}' and that from \widehat{E}' to \widehat{E}'' , respectively, show the price-discrimination effect and the anti-tariff-circumvention effect when p^I is fixed at \tilde{p}^I . It should be noted that the anti-tariff-circumvention effect disappears with $\Delta t = 0$, while the price-discrimination effect vanishes with $\Delta a = \Delta b = 0$.¹⁹ Moreover, it follows from (15a) that as long as $\Delta b = 0$, the price-discrimination effect does not affect p^I even with $\Delta a \neq 0$.

[Figure 3 around here]

It follows from (12b) that the anti-tariff-circumvention effect with $p^I = \tilde{p}^I$ increases p_1^O by $\Delta t/2$, which implies that the producer price (i.e. $p_1^O - t_1$) falls. The price-discrimination effect with $p^I = \tilde{p}^I$, on the other hand, raises p_1^O and lowers p_2^O . Since the prices of products are strategic complements, the anti-tariff-circumvention effect raises the uniform price charged by firm I . However, the price-discrimination effect has an ambiguous effect on p^I . If the substitutability of products is higher in country 1 (i.e. $\Delta b > 0$), for firm I , the variation of p_1^O is more important than that of p_2^O . In this case, the price-discrimination effect also raises p^I . If it is higher in country 2 (i.e. $\Delta b < 0$), on the other hand, the effect decreases p^I . The overall effect depends on the magnitude of the two effects, and it is summarized in the following lemma.

Lemma 1 *When $\Delta b \geq 0$, $\widehat{p}^I \geq \tilde{p}^I$ holds. When $\Delta b < 0$, $\widehat{p}^I < \tilde{p}^I$ if $-\Omega\Delta b / (16 - b^2) (b + \Delta b) > \Delta t$ and $\widehat{p}^I \geq \tilde{p}^I$ otherwise.*

When $\Delta b > 0$, both anti-tariff-circumvention and price-discriminations effects work in the same direction to raise p^I . When $\Delta b < 0$, the anti-tariff-circumvention effect increases p^I but the price-discrimination effect decreases p^I . The latter effect is likely to dominate the former if Δt is low so that the anti-tariff-circumvention effect is small and

¹⁸ \tilde{E} is given by a point where an iso-profit contour, which surrounds the segmented-market equilibrium obtained by replacing $t_i = t_j$ with t_2 in (15a) and (15b), is tangent to the $p_1^O = p_2^O$ plain.

¹⁹ $F_1 F_1$ coincides with $F'_1 F'_1$ when $\Delta t = 0$. $F_2 F_2$ goes through \tilde{E} with $\Delta b = 0$. $F_1 F_1$ and $F_2 F_2$ intersect at \tilde{E} with $\Delta a = \Delta b = 0$.

Ω is high so that the price-discrimination effect is large. Since Ω is positively related to Δa , a large difference in the market sizes with $\Delta b < 0$ is likely to decrease p^I .

As for p_i^O , we have the following lemma.

Lemma 2 $\hat{p}_1^O \geq \tilde{p}^O \geq \hat{p}_2^O$ when $(8 - bb_1)\Omega / (2b_1b_2) > \Delta t$; and $\hat{p}_1^O > \hat{p}_2^O \geq \tilde{p}^O$ otherwise.

If $\Delta t = 0$, only the price-discrimination effect exists. Thus, the price dispersion between countries 1 and 2 results in $\hat{p}_1^O \geq \tilde{p}^O \geq \hat{p}_2^O$. An increase in Δt expands the price dispersion. At the same time, however, firm I makes p^I higher, because the increase in Δt leads to relatively high protection under ROOs. The increase in p^I in turn increases both p_1^O and p_2^O . Thus, both \hat{p}_1^O and \hat{p}_2^O exceed \tilde{p}^O if Δt is sufficiently large. It should be noted that there is a case where ROOs increase all the prices.

3.2 Comparison with $\Delta b = 0$

We now examine the effects of ROOs on each component of welfare. In this subsection, we consider the case with $\Delta b = 0$ (i.e. the case where both markets have the same substitutability). In this case, $\Delta a \geq 0$ is necessary for the condition (16) to hold.

To begin with, we compare the equilibrium profits with and without ROOs. It follows from equations (8a) and (17a) that:

$$\Delta\pi^I \equiv \hat{\pi}^I - \tilde{\pi}^I = 2 \left\{ (\hat{p}^I)^2 - (\tilde{p}^I)^2 \right\}, \quad (20)$$

$$\Delta\pi^O \equiv \hat{\pi}^O - \tilde{\pi}^O = \sum_{i=1,2} (\hat{p}_i^O - t_i)^2 - 2(\tilde{p}^O - t_2)^2. \quad (21)$$

We thus have the following proposition.

Proposition 1 *Suppose $\Delta b = 0$. If $\Delta t > 0$, firm I 's profits are larger with ROOs than without them. When $\Delta t = 0$, firm I 's profits are the same. If $\Delta a > 0$ and Δt is not too large, firm O 's profits are larger with ROOs than without them. Otherwise, firm O 's profits are larger without ROOs.*

The proposition is illustrated in Figure 4.²⁰ As for firm I , its profits rise as the equilibrium level of p^I rises. From Lemma 1, the price-discrimination effect does not affect p^I with $\Delta b = 0$ and hence the anti-tariff-circumvention effect caused by $\Delta t > 0$ is the sole effect. Since p^I rises as Δt increases, $\Delta\pi^I$ also rises as t_1 (or, Δt) increases. Moreover, $\Delta\pi^I = 0$ holds when $\Delta t = 0$.

²⁰In Figures 4-7, an increase in Δt means an increase in t_1 keeping t_2 fixed.

As for firm O 's profits, the anti-tariff-circumvention effect is harmful to firm O . On the other hand, the price-discrimination effect generated by the market-size difference ($\Delta a > 0$) is beneficial to firm O . If the external tariffs are identical (i.e. $\Delta t = 0$), the anti-tariff-circumvention effect does not exist and hence ROOs certainly benefit firm O . As the external-tariff differential increases, the anti-tariff-circumvention effect becomes larger. When Δt exceeds the critical level Ψ , the anti-tariff-circumvention effect dominates the price-discrimination effect so that firm O is made worse off with ROOs. If the market sizes are the same (i.e. $\Delta a = 0$), the price-discrimination effect does not exist and firm O loses from ROOs because of the anti-tariff-circumvention effect.

If both $\Delta a > 0$ and $\Delta t < \Psi$ hold, then both firms gain from ROOs. This implies that ROOs could generate a hidden collusion among the final-good producers. As is seen below, this collusive effect is detrimental to consumers as a whole.

[Figure 4 around here]

We next compare consumer surplus with and without ROOs. From equations (9) and (18), the change in consumer surplus caused by ROOs is given by

$$\Delta S_i \equiv \widehat{S}_i - \widetilde{S}_i, \quad i = 1, 2. \quad (22)$$

We let $\Delta S \equiv \Delta S_1 + \Delta S_2$ denote the change in the total consumer surplus in the FTA. If $\Delta S < 0$, the introduction of ROOs makes consumers as a whole worse off.

Suppose $\Delta t = 0$. By virtue of Lemmas 1 and 2, if $\Delta a > 0$, the introduction of ROOs leads to only the price-discrimination effect which makes the price of good O higher in country 1 but lower in country 2. This benefits consumers in country 2 but hurts consumers in country 1. The price of good I and the total supply of good I in the FTA remain unchanged when $\Delta b = \Delta t = 0$.²¹ As t_1 rises from $t_1 = t_2$ and hence Δt rises from $\Delta t = 0$, all prices increase so that consumer surplus in each country falls. The overall effect is stated in the following proposition.

Proposition 2 *Suppose $\Delta b = 0$. ROOs decrease the overall consumer surplus in the FTA if $\Delta a > 0$ and/or $\Delta t > 0$. It remains unchanged if $\Delta a = \Delta t = 0$.*

The anti-tariff-circumvention effect definitely harms consumers. The price-discrimination effect is also detrimental. This is because the price dispersion from the uniform level of

²¹When $\Delta a = \Delta b = \Delta t = 0$, ROOs do not affect the prices at all.

p^O is symmetric, but the market sizes are asymmetric (i.e. the market size of country 1 where p^O rises is larger than that of the country 2 where p^O falls). The changes in the total consumer surplus are drawn in Figure 5. In the figure, the curve drawn with $\Delta a = 0$ shows the case where only the anti-tariff-circumvention effect exists, while the curve drawn with $\Delta a > 0$ shows the case with both anti-tariff-circumvention and price-discrimination effects.

Proposition 2 states the change in the overall consumer surplus. Thus, some consumers may actually gain from ROOs. However, it should be emphasized that there is a case where all consumers lose from ROOs.

[Figure 5 around here]

Next we examine how ROOs affect the equilibrium amount of tariff revenue. From equations (10) and (19), the change in tariff revenue is given by

$$\Delta R_i \equiv \widehat{R}_i - \widetilde{R}_i, \quad (i = 1, 2). \quad (23)$$

We let $\Delta R \equiv \Delta R_1 + \Delta R_2$ denote the change in the total tariff revenue of the FTA. $\Delta R_1 > 0$ obviously holds, because there is no tariff revenue without ROOs but there is some with ROOs. $\Delta R_2 < 0$ holds since the supply of good O to country 1 is no longer made via country 2.

Proposition 3 *Suppose $\Delta b = 0$. ROOs increase the total tariff revenue in the FTA only if t_2 is not very high and $0 < \Delta t < \Phi$ (where Φ is the cut-off value) holds.*

Since the tariff revenue is concave with respect to the tariff level, an increase in the tariff level decreases the tariff revenue when the tariff level is high enough. Noting $t_1 \geq t_2$, the high level of t_2 implies that t_1 is also high. Thus, ROOs decrease the total tariff revenue if the tariff level without ROOs (i.e. t_2) is high enough. If t_2 is not too high, on the other hand, ΔR becomes inverse-U-shaped with respect to Δt so that ROOs increase the total tariff revenue if Δt is not too large (i.e., $0 < \Delta t < \Phi$). The results are depicted in Figure 6.

[Figure 6 around here]

With respect to the change in the overall welfare of the FTA, $\Delta W \equiv \Delta S + \Delta R + \Delta \pi^I$, the following proposition can be established.

Proposition 4 *If t_2 or Δa is large enough, ROOs deteriorate the total welfare of the FTA. If neither t_2 nor Δa is large, ROOs raise the total welfare only if $\underline{\mu} < \Delta t < \bar{\mu}$ (where $\underline{\mu}$ and $\bar{\mu}$ are the cut-off values) holds.*

As has been analyzed, ROOs lower the tariff revenue when t_2 is high enough. In this case, the negative effects of ROOs on the tariff revenue and consumer surplus always dominate the positive effect on π^I , and hence ROOs always lower the sum of FTA members' welfare. When t_2 is not too high, ROOs may raise the tariff revenue. Nonetheless, if Δa is large enough, the negative effect on consumer surplus always dominates the possible positive effect on tariff revenue as well as the producer's gain, so that $\Delta W < 0$. It should be noted that as Δa becomes large, the degree of price discrimination by firm O becomes large. When both t_2 and Δa are small, consumers' loss is moderate and the positive effect on tariff revenue may dominate the loss. Noting that the value of Δt that maximizes ΔR is positive in this case, $\Delta W > 0$ holds if Δt falls into some range (i.e. $\Delta t \in (\underline{\mu}, \bar{\mu})$). Figure 7 shows the results.

[Figure 7 around here]

3.3 Comparison with $\Delta b \neq 0$

To this point, we have concentrated on the case with $\Delta b = 0$. As long as $\Delta b = 0$, firm I always benefits from ROOs. In this subsection, investigating the profits with $\Delta b \neq 0$, we show that firm I could lose from ROOs.

From Lemma 1, the price-discrimination effect does not affect the equilibrium level of p^I when $\Delta b = 0$. However, any difference between b_1 and b_2 leads to the price-discrimination effect which changes p^I . In this case, ROOs may decrease the profits of firm I . In fact, by virtue of equation (20) and Lemma 1, we can obtain the following proposition.

Proposition 5 *ROOs decrease the profits of firm I only if $\Delta b < 0$. The profits of firm I are likely to fall when Δt is small and Δa is large.*

The case with $\Delta b > 0$ is depicted in Figure 8. Since both anti-tariff-circumvention and price-discrimination effects raise \bar{p}^O , $\hat{R}^O \hat{R}^O$ is located above $\tilde{R}^O \tilde{R}^O$. We can verify that the slope of $\hat{R}^O \hat{R}^O$ is (weakly) greater than that of $\tilde{R}^O \tilde{R}^O$.²² Thus, we have $\hat{p}^I \geq \tilde{p}^I$ (where the equality holds with $\Delta a = \Delta t = 0$).

²²Compared to the market integration case, firm O , which can price-discriminate, reacts to the change in p^I more in the country with higher b_i than in the other country. The definition of \bar{p}^O places the

[Figure 8 around here]

On the other hand, the case with $\Delta b < 0$ is presented in Figure 9. In this case, the price-discrimination effect is detrimental to firm I so that an increase in Δa shifts $\widehat{R}^O \widehat{R}^O$ downward. An increase in Δt shifts the curve upward as in the case with $\Delta b > 0$. Thus, when $\Delta b < 0$ and Δt is small relative to Δa , the negative price-discrimination effect dominates the anti-tariff-circumvention effect and hence ROOs harm firm I .

[Figure 9 around here]

Next we consider the profits of firm O . Since the increase (resp. decrease) in p^I raises (resp. lowers) both \widehat{p}_1^O and \widehat{p}_2^O , $\Delta\pi^O$ is more likely to be positive (resp. negative) with $\Delta b > 0$ (resp. with $\Delta b < 0$).

The effects of ROOs on the profits of both firms with $\Delta b \neq 0$ are calculated by using a numerical example with $a = 5$, $b = 0.5$, $t_2 = 1$ (see Table 1).²³ The results suggest that it is ambiguous whether ROOs benefit or hurt the firms. In fact, there are four possible equilibria: (i) ROOs benefit firm I but hurt firm O , (ii) ROOs benefit both firms, (iii) ROOs hurt firm I but benefit firm O , and (iv) ROOs hurt both firms.

[Table 1 around here]

We should note that while ROOs never increase the overall consumer surplus when $\Delta b = 0$, they could increase it when $\Delta b < 0$. This is because ROOs could lower p^I with $\Delta b < 0$. Whenever p^I falls, firm I loses.

4 Conclusion

In this paper, we have explored the effects of ROOs in the framework of international oligopoly. In particular, we have pointed out an effect of ROOs which has been ignored in the existing literature. That is, ROOs lead to incomplete market integration (including market segmentation) for the firm located outside the FTA. Thus, ROOs generate two effects: the anti-tariff-circumvention and price-discrimination effects. The anti-tariff-circumvention effect is beneficial to the producer located in the FTA but is harmful to the producer located outside the FTA. On the other hand, the price-discrimination

larger weight on p_i^O with higher b_i , so that the overall substitutability is always greater in the market segmentation case if $\Delta b \neq 0$.

²³ All cases satisfy $\Omega \geq 0$, the conditions for market segmentation, and the positive sales constraint.

effect benefits the producer located outside the FTA. There is a case where the price-discrimination effect is harmful to the producer located in the FTA. Therefore, the net effect of ROOs on profits is ambiguous and depends on the magnitude of these two effects.

For the producer located outside the FTA, the net effect of ROOs depends on the difference in the external tariffs and that in the market sizes. If the difference in the external tariffs is large, the anti-tariff-circumvention effect is large. If the difference in the market sizes is large, the price-discrimination effect is large. Thus, if the difference in the external tariffs is not so large relative to that in the market sizes, ROOs benefit the producer located outside the FTA.

For the producer located in the FTA, the net effect of ROOs depends on the difference in the substitutability of products as well as that in the external tariffs. If the difference in the substitutability of products is not so large relative to that in the external tariffs, ROOs could be harmful to the producer located in the FTA.

In particular, the following two cases are noteworthy. In one case, ROOs benefit the firm located outside the FTA and hurts the firm located inside the FTA. Thus, although ROOs let the firm located outside the FTA face the higher tariff, they do not necessarily protect the firm in the FTA. In another case, both producers gain from ROOs at the expense of consumers. In this case, thus, ROOs become a device to generate a collusive effect.

Our benchmark case is an FTA without ROOs. One may wonder if there exists any FTA that has no ROOs. However, our benchmark is certainly useful to make our point very clear. Moreover, our benchmark can be regarded as a CU which sets the common tariff equal to the lowest external tariff among the members. In this case, our analysis can be reinterpreted as the comparison between an FTA and a CU. Our analysis suggests that it is not possible to determine one arrangement is always superior to the other from the viewpoint of welfare. However, we have pointed out an important role of ROOs under oligopoly, which is potentially an essential factor in the FTA versus CU comparison.

We have specifically used a Bertrand model for our analysis. The point of our analysis is a trade-off between the anti-tariff-circumvention and price-discrimination effects. As long as goods are differentiated, these effects also arise in a Cournot model. Therefore, our main results would still be valid in a Cournot model with differentiated goods.²⁴

We have abstracted from intermediate goods in our analysis. As far as the intermediate-good industry is subject to perfect competition with constant-returns-to-scale technolo-

²⁴See also Mukunoki (2002).

gies, our analysis needs no modification. Since firms in the intermediate-good industry always obtain zero profit, they neither gain nor lose from ROOs. If it is subject to imperfect competition, on the other hand, the results crucially depend on the market structure, particularly the vertical link between intermediate-good firms and final-good firms. This extension is left for future research.

Appendix

The condition for market segmentation

Arbitrage activities are blocked and hence the markets for good O are segmented if $t_1 - (\widehat{p}_1^O - \widehat{p}_2^O) > 0$. From equation (15b), we can verify that the left-hand side of the inequality is increasing in Δt . Substituting $\Delta t = 0$ into the inequality yields

$$t_2 > \frac{\Omega}{4\Gamma}.$$

If this inequality holds, the markets for good O are always segmented.

Proof of Lemma 1

From equations (7a) and (15a), we have

$$\widehat{p}^I - \widetilde{p}^I = \frac{\Omega\Delta b + (16 - b^2)(b + \Delta b)\Delta t}{2(16 - b^2)\Gamma}.$$

If $\Delta b \geq 0$, the numerator is always positive. If $\Delta b < 0$, the sign of the numerator depends on the levels of Δt and Ω :

$$\widehat{p}^I \begin{matrix} \leq \\ \geq \end{matrix} \widetilde{p}^I \iff \frac{\Omega\Delta b}{(16 - b^2)(b + \Delta b)} \begin{matrix} \geq \\ < \end{matrix} \Delta t.$$

Hence, we obtain Lemma 1. Q.E.D.

Proof of Lemma 2

From equation (7b) and (15b), we have

$$\begin{aligned} \widehat{p}_1^O - \widetilde{p}^O &= \frac{2(8 - bb_2)\Omega + (16 - b^2)(32 - 4b_2^2)\Delta t}{8\Gamma(16 - b^2)}, \\ \widehat{p}_2^O - \widetilde{p}^O &= -\frac{(8 - bb_1)\Omega - 2b_1b_2\Delta t}{4\Gamma(16 - b^2)}. \end{aligned}$$

It follows from these equations that $\widehat{p}_1^O \geq \widetilde{p}^O$ (with equality if $\Omega = \Delta t = 0$) and

$$\widehat{p}_2^O \begin{matrix} \leq \\ \geq \end{matrix} \widetilde{p}^O \iff \frac{(8 - bb_1)\Omega}{2b_1b_2} \begin{matrix} \geq \\ < \end{matrix} \Delta t.$$

Thus, we obtain Lemma 2. Q.E.D.

Proof of Proposition 1

From Lemma 1, we have $\widehat{p}^I \geq \widetilde{p}^I$ (where equality holds with $\Delta t = 0$) and hence $\Delta\pi^I \geq 0$ (where equality holds with $\Delta t = 0$). With respect to $\Delta\pi^O$, we first check the assumption of the positive sales of firm O under $\Delta b = 0$. Without ROOs, $x_2^O[\widetilde{p}_2^O, \widetilde{p}^I]$ is the smallest and it is positive if

$$\frac{4a(4+b) - (16-b^2)\Delta a}{4(8-b^2)} \equiv \bar{t}_2 > t_2,$$

that is, if t_2 is not too large. With ROOs, $x_2^O[\widehat{p}_2^O, \widehat{p}^I]$ is also positive under $\bar{t}_2 > t_2$. Alternatively, $x_1^O[\widehat{p}_1^O, \widehat{p}^I]$ is positive if

$$\frac{4a(4+b) + (16-b^2)\Delta a - 4(8-b^2)t_2}{(32-3b^2)} \equiv \lambda > \Delta t.$$

Using equations (7b), (8b), (15b), and (17b), the difference in firm O 's profits with $\Delta b = 0$ is given by

$$\Delta\pi^O = \frac{(\Delta a)^2}{8} - A\Delta t + B(\Delta t)^2,$$

where

$$A \equiv \frac{8(8-b^2)\{(4+b)a - (8-b^2)t_2\} + (16-b^2)^2\Delta a}{4(16-b^2)^2} > \frac{32-3b^2}{4(16-b^2)}\Delta a \geq 0,$$

$$B \equiv \frac{(512-96b^2+5b^4)}{8(16-b^2)^2} > 0.$$

The first inequality of A is due to $\bar{t}_2 > t_2$. If $\Delta\pi^O > 0$, firm O 's profits are higher with ROOs and vice versa. Note that $\Delta\pi^O$ is U-shaped in Δt with a non-negative intercept. We can verify that

$$\begin{aligned} \Delta\pi^O|_{\Delta t=0} &= \frac{(\Delta a)^2}{8} \geq 0, \\ \Delta\pi^O|_{\Delta t=\lambda} &= -\frac{\left[(8-b^2)(16-b^2)^2\{4a(4+b) - (8-b^2)\Delta a - 4(8-b^2)t_2\}\Delta a + 2(512-128b^2+7b^4)((4+b)a - (8-b^2)t_2)^2 \right]}{(32-3b^2)^2(16-b^2)^2} \\ &< -\frac{\left[8(8-b^2)(16-b^2)^2(\Delta a)^2 + 2(512-128b^2+7b^4)\{(4+b)a - (8-b^2)t_2\}^2 \right]}{(32-3b^2)^2(16-b^2)^2} \quad (\because \bar{t}_2 > t_2) \\ &< 0. \end{aligned}$$

Accordingly, there exists an unique value of $\Delta t = \Psi \geq 0$ which satisfies $\Delta\pi^O > 0$ if $\Delta t < \Psi$, $\Delta\pi^O = 0$ if $\Delta t = \Psi$, and $\Delta\pi^O < 0$ if $\Delta t > \Psi$. Note that $\Psi = 0$ if and only if $\Delta a = 0$. Q.E.D.

Proof of Proposition 2

When $\Delta b = 0$, we have

$$\begin{aligned} \frac{\partial(\Delta S)}{\partial(\Delta t)} &= -\frac{16a(4+b)^2 + (16-b^2)^2 \Delta a - (512 - 80b^2 + b^4) \Delta t - 32(16-3b^2)t_2}{8(16-b^2)^2} \\ &< -\frac{\{2a(32+16b+b^2) + b^3 \Delta a + 2b^3 t_2\} b}{4(32-3b^2)(16-b^2)} \quad (\because \lambda > \Delta t) \\ &< 0. \end{aligned}$$

Besides that,

$$\Delta S|_{\Delta t=0} = -\frac{3(\Delta a)^2}{16} < 0.$$

Hence, ΔS is decreasing in Δt and is negative when $\Delta t = 0$. Q.E.D.

Proof of Proposition 3

When $\Delta b = 0$, the following holds:

$$\Delta R|_{\Delta t=0} = 0.$$

In addition,

$$\begin{aligned} \frac{\partial(\Delta R)}{\partial(\Delta t)} &\stackrel{\geq}{\leq} 0 \iff \frac{4a(4+b) + (16-b^2) \Delta a - 8(8-b^2)t_2}{2(32-3b^2)} \equiv T \stackrel{\geq}{\leq} \Delta t, \\ \frac{\partial^2(\Delta R)}{\{\partial(\Delta t)\}^2} &= -\frac{(32-3b^2)}{2(16-b^2)} < 0. \end{aligned}$$

Hence, ΔR is concave in Δt ; and $\Delta R = 0$ holds with $\Delta t = 0$. It is maximized at $\Delta t = T$. If t_2 is large enough, $T < 0$ so that an increase in Δt always decreases ΔR . If t_2 is not very large, $T > 0$ and we have

$$\begin{aligned} \Delta R|_{\Delta t=T} &= \frac{\{4a(4+b) + (16-b^2) \Delta a - 8(8-b^2)t_2\}^2}{16(32-3b^2)(16-b^2)} \geq 0, \\ \Delta R|_{\Delta t=\lambda} &= -\frac{(8-b^2) \{4a(4+b) + (16-b^2) \Delta a - 8(8-b^2)t_2\} t_2}{(16-b^2)(32-3b^2)} \\ &= -\frac{2(8-b^2) T t_2}{(16-b^2)} < 0. \end{aligned}$$

Since ΔR is concave in Δt , there exists an unique value of Δt , $\Phi (\geq 0)$, which satisfies $\Delta R > 0$ if $\Delta t < \Phi$, $\Delta R = 0$ if $\Delta t = \Phi$, and $\Delta R < 0$ if $\Delta t > \Phi$. Q.E.D.

Proof of Proposition 4

When $\Delta b = 0$, we have

$$\begin{aligned}
\Delta W|_{\Delta t=0} &= \Delta S|_{\Delta t=0} = -\frac{3(\Delta a)^2}{16} < 0. \\
\Delta W|_{\Delta t=\lambda} &= -\frac{\left[(16-b^2) \left[\begin{aligned} &(224-43b^2+2b^4)(\Delta a)^2 \\ &+ \{a(64-10b^2-b^3) + 2t_2(64-18b^2+b^4)\} \Delta a \end{aligned} \right] \right.}{(32-3b^2)^2(16-b^2)} \\
&\quad \left. + \{a(4+b) - (8-b^2)t_2\} \left\{ \begin{aligned} &a(128-32b-20b^2+b^3) \\ &+ (768-216b^2+13b^4)t_2 \end{aligned} \right\} \right] \\
&< -\frac{\left[\begin{aligned} &(224-43b^2+2b^4)(\Delta a)^2 \\ &+ \{a(384-32b-60b^2-3b^3) + (1280-360b^2+21b^4)t_2\} \Delta a \end{aligned} \right]}{4(32-3b^2)^2} \quad (\because \bar{t}_2 > t_2) \\
&< 0.
\end{aligned}$$

The following suggest that ΔW is an inverse U-shaped function of Δt which takes the maximum value at $\Delta t = \max\{0, \Theta\}$.

$$\begin{aligned}
\frac{\partial(\Delta W)}{\partial(\Delta t)} &\begin{matrix} \geq \\ < \end{matrix} 0 \iff \frac{8a(2+b) + (16-b^2)\Delta a - 16(6-b^2)t_2}{96-11b^2} \equiv \Theta \begin{matrix} \geq \\ < \end{matrix} \Delta t, \\
\frac{\partial^2(\Delta W)}{\{\partial(\Delta t)\}^2} &= -\frac{96-11b^2}{8(16-b^2)} < 0.
\end{aligned}$$

When t_2 is sufficiently high, $\Theta < 0$. In this case, ΔW is maximized at $\Delta t = 0$ and the maximum value is negative from the above. Alternatively, when t_2 is not so high that $\Theta > 0$, ΔW is maximized at $\Delta t = \Theta$. The maximum value is

$$\Delta W|_{\Delta t=\Theta} = \frac{4\{a(2+b) - 2(6-b^2)t_2\}^2}{(16-b^2)(96-11b^2)} + C\Delta a - D(\Delta a)^2,$$

where

$$\begin{aligned}
C &\equiv (16-b^2)(a(2+b) - 2(6-b^2)t_2), \\
D &\equiv 272 - 49b^2 + 2b^4 > 0.
\end{aligned}$$

Note that $\Delta W|_{\Delta t=\Theta} > 0$ when $\Delta a = 0$. If t_2 is large enough, $C < 0$ so that an increase in Δa decreases $\Delta W|_{\Delta t=\Theta}$. If t_2 is not so large, $C > 0$ and hence $\Delta W|_{\Delta t=\Theta}$ is an inverse U-shaped function as to Δa . Hence, if Δa is large enough, $\Delta W|_{\Delta t=\Theta} < 0$ so that ΔW is always negative. If Δa is not so large, $\Delta W|_{\Delta t=\Theta} > 0$. In the latter case, there exist two positive, cut-off values denoted by $(\underline{\mu}, \bar{\mu})$. $\Delta W < 0$ if $\Delta t < \underline{\mu}$ or $\bar{\mu} < \Delta t$, $\Delta W = 0$ if $\Delta t = \underline{\mu}$ or $\bar{\mu} = \Delta t$, and $\Delta W > 0$ if $\underline{\mu} < \Delta t < \bar{\mu}$. Q.E.D.

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Tables and Figures

Table 1 : Numerical Example

($a = 5, b = 0.5, t_2 = 1$)

$\hat{\pi}^k - \tilde{\pi}^k$ $k \in \{I, O\}$	$\Delta a = 1$					
	$\Delta b = 0$		$\Delta b = 0.25$		$\Delta b = -0.25$	
	Firm <i>I</i>	Firm <i>O</i>	Firm <i>I</i>	Firm <i>O</i>	Firm <i>I</i>	Firm <i>O</i>
$\Delta t = 0$	0.000	0.125	0.132	0.248	-0.059	0.045
$\Delta t = 0.5$	0.095	-0.399	0.277	-0.320	-0.012	-0.436
$\Delta t = 1.0$	0.191	-0.801	0.426	-0.768	0.036	-0.792
$\Delta t = 1.5$	0.289	-1.079	0.576	-1.096	0.083	-1.024
$\Delta t = 2.0$	0.387	-1.234	0.729	-1.302	0.132	-1.131
	$\lambda = 2.40$		$\lambda = 2.61$		$\lambda = 2.19$	

Figure 1 : Equilibrium without ROO

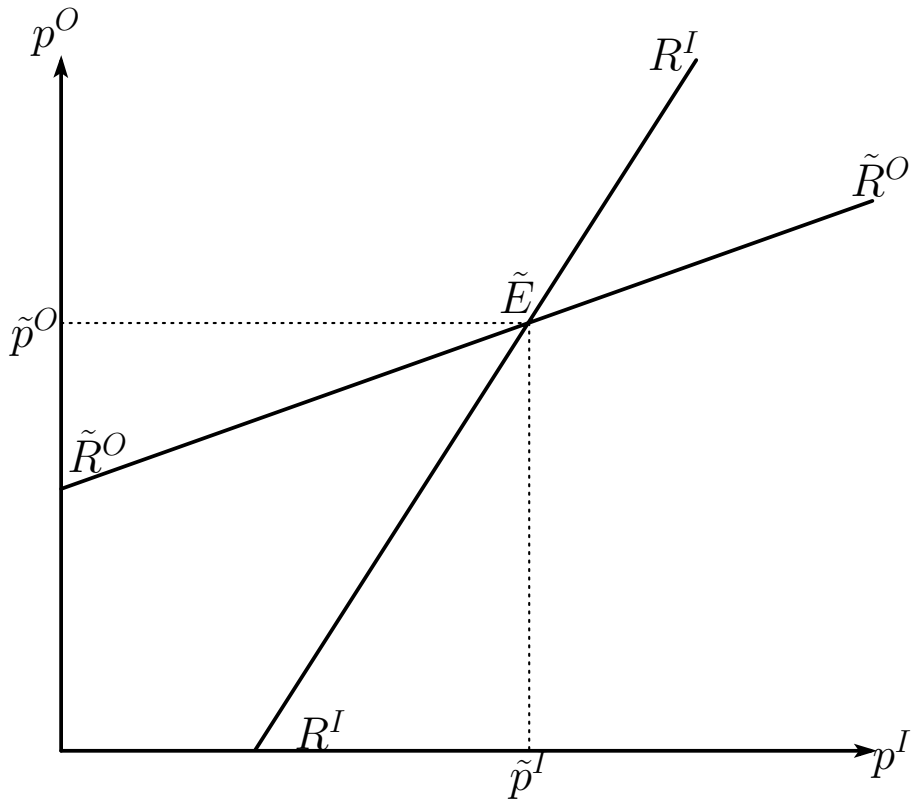


Figure 2 : Equilibrium with ROO

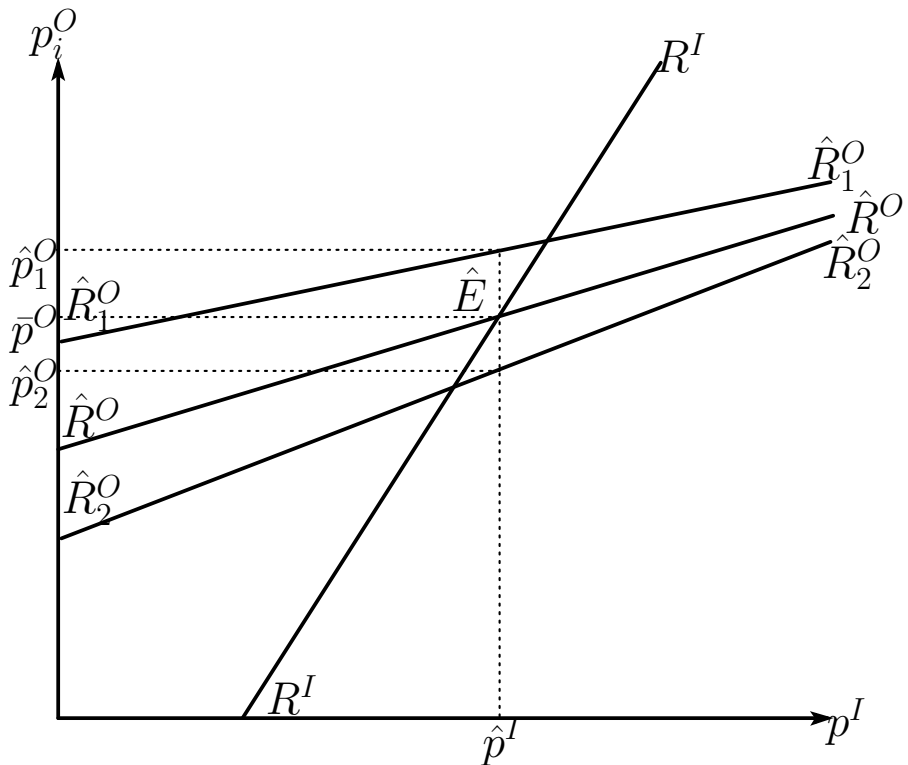


Figure 3 : Price-discrimination and anti-tariff-circumvention effects
 when $p^I = \tilde{p}^I$

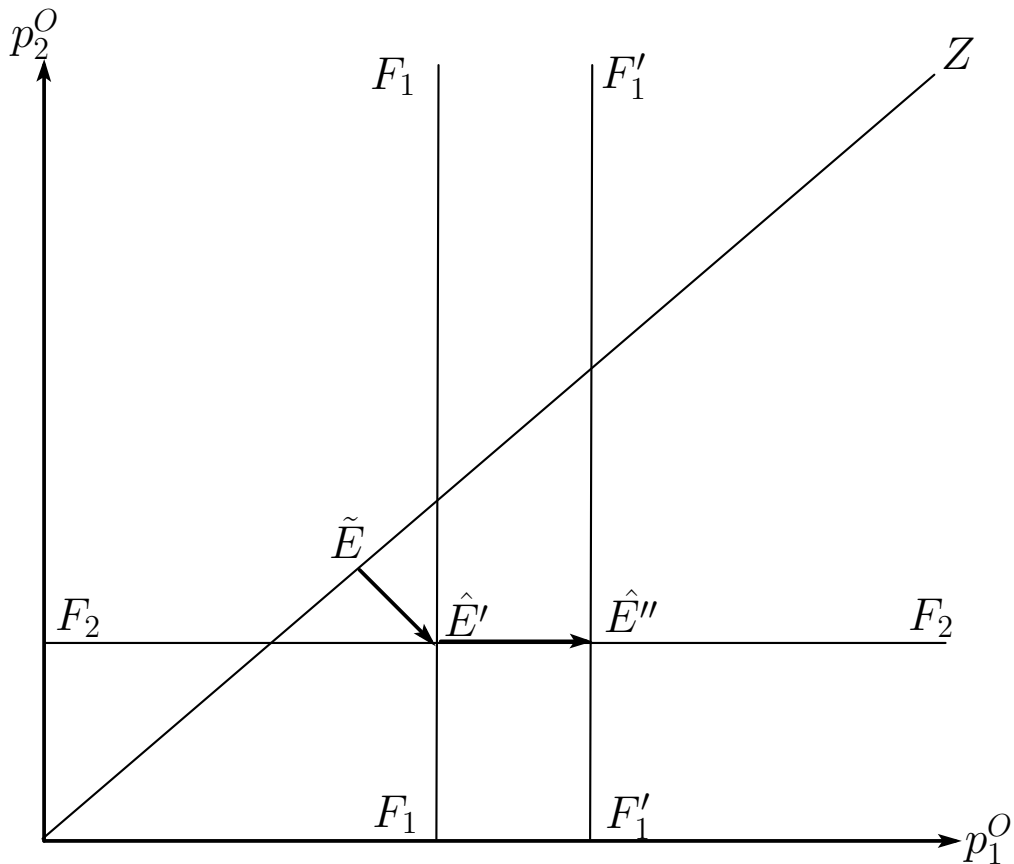


Figure 4 : Comparison of profits ($\Delta b = 0$)

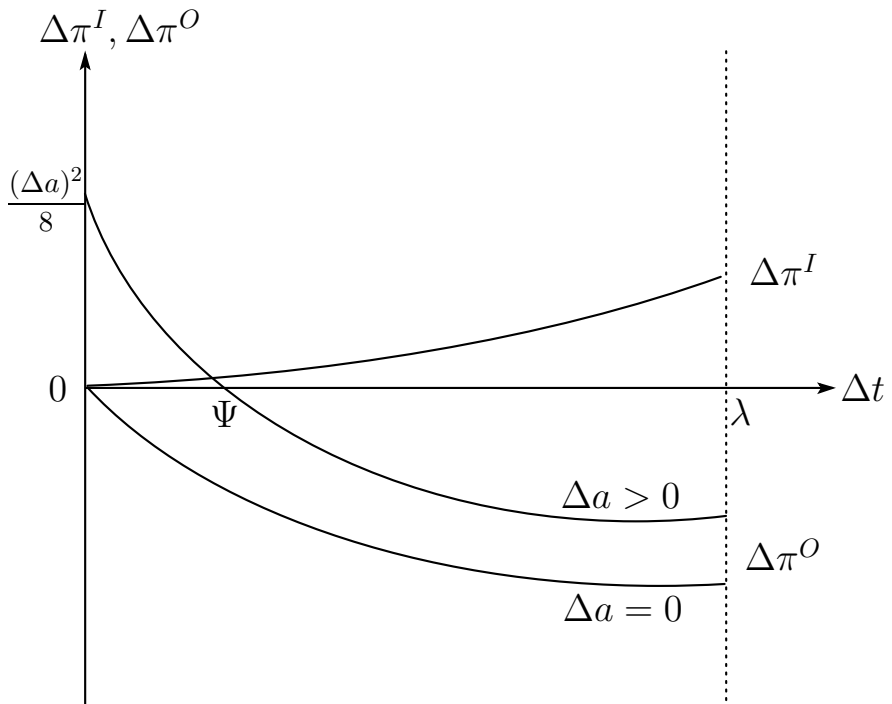


Figure 5 : Comparison of consumer surplus ($\Delta b = 0$)

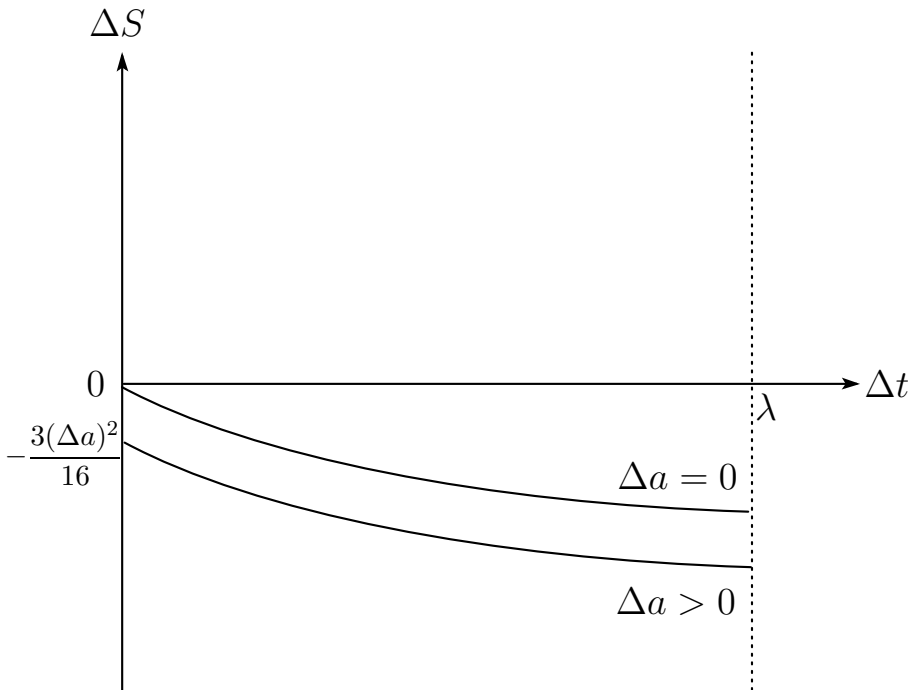


Figure 6 : Comparison of tariff revenues ($\Delta b = 0$)

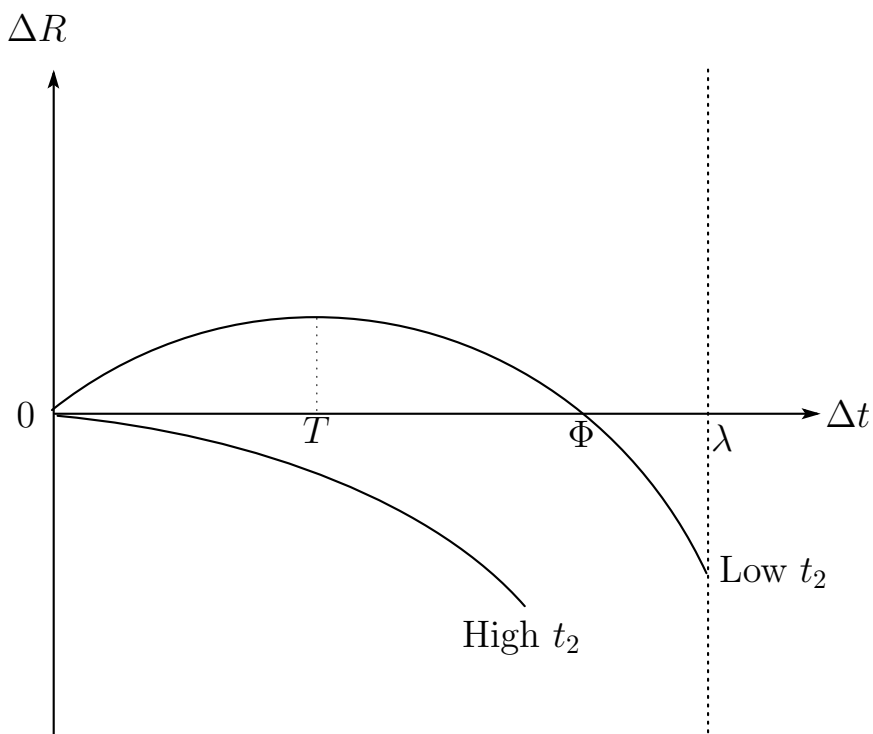


Figure 7 : Comparison of total welfare ($\Delta b = 0$)

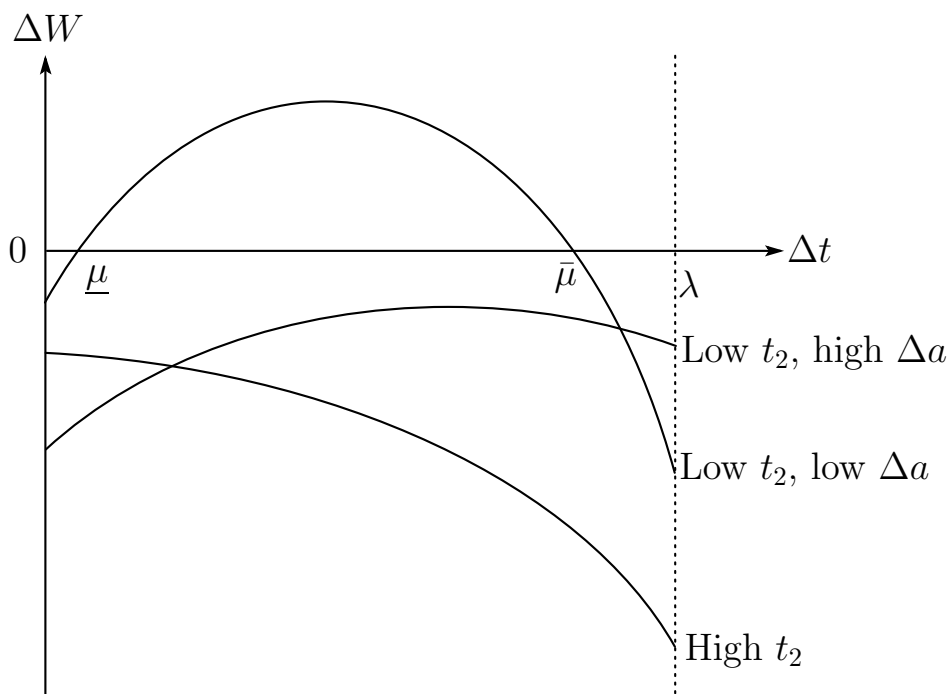


Figure 8 : Comparison of firm I's profits ($\Delta b > 0$)

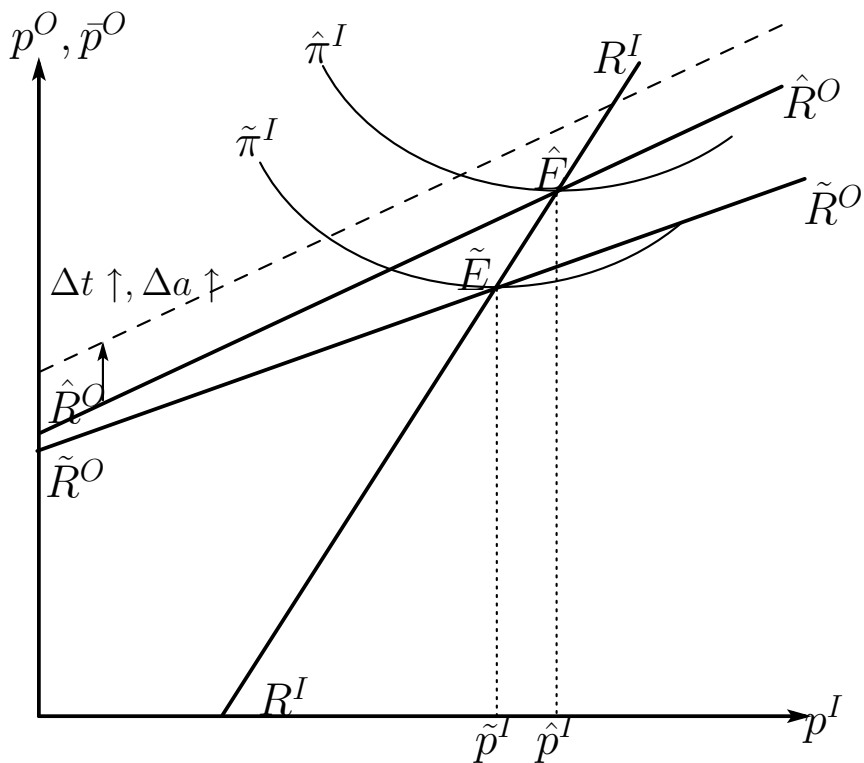


Figure 9 : Comparison of firm I's profits ($\Delta b < 0$)

