

# Effect of Bilateral FTA on Cost-Reducing R&D Activity in a Developing Country

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## Abstract

This paper examines how a bilateral FTA between developed countries affects a cost-reducing R&D activity in a developing country in a three-country model. Our main conclusions are as follows: (i) the formation of FTA between developed countries may encourage or discourage the cost-reducing R&D investment in the developing country, (ii) it always benefits both member countries of the FTA, and (iii) it may harm the developing country even when it encourages the R&D investment although it tends to increase welfare of the developing country.

## 1 Introduction

Recently, contrary to sluggish multilateral negotiations for free trade in GATT/WTO, a formation/negotiation of Preferential Trade Agreements (PTAs) has been increased dramatically. Fiorentino et al. (2009) points out that a majority of the recently established PTAs are bilateral agreements and most of the recent PTAs are free trade agreements (FTAs).

Previous studies have examined some aspects of PTAs. One strand of related literature conducts a static analysis of PTAs and investigates the endogenous formation of bilateral FTAs (e.g., Freund 2000; Endoh 2006). Another strand conducts a dynamic time-pass analysis, as called by Bhagwati (2008), and considers whether the formation of PTAs serves as a building block or a stumbling block for multilateral free trade (e.g., Krishna 1998; Yi 1996, 2000; Ornelas 2005a, 2005b; Mukunoki and Tachi 2006; Saggi and Yildiz 2011; Nomura et al. 2013).

Although these previous papers present interesting results, they assume production

technologies of firms as given. Only few attempts, to our knowledge, have so far been made at the relationship between the formation of FTA and firms' cost-reducing R&D activities. Choi (1995) and Hwang, Kou, and Mai (1997) examine the effect of tariff policy on the technology choice under the discriminatory tariff regime and the Most favored Nation (MFN) clause in the Brander-Spencer model<sup>1)</sup>. Noting that the difficulty of implementation of the discriminatory tariff among WTO member countries, Nomura (2012) examines the effect of formation of FTA on firms' technology choice in a three-country model where each country has a domestic market and a local firm. However, Nomura (2012) assumes that countries as well as firms are *ex ante* identical. In this paper, we investigate how the formation of bilateral FTA between developed countries affects the cost-reducing R&D activity in the developing country and welfare of each country. Main conclusions are as follows: (i) the formation of FTA between developed countries may encourage or discourage the cost-reducing R&D investment in the developing country, (ii) it always benefits both member countries of FTA between developed countries, and (iii) it may harm the developing country even when it encourages the R&D investment although it tends to increase welfare of the developing country.

Rest of the paper is organized as follows: Section 2 formulates the model. Section 3 analyses the effect of the formation of bilateral FTA between developed countries on the cost-reducing activity in the developing country as well as welfare. Last section concludes the paper.

## 2 The model

Consider a world economy with three countries, denoted by country 1, 2, and 3. Each country has a local firm and a domestic market. These countries are symmetric with respect to market size. Firms produce a homogenous good and supply it to both home and foreign markets. Demand function of market  $i$  is given by

$$p^i = 1 - Q^i, \quad i = 1, 2, 3, \quad (1)$$

where  $p^i$  is a price in market  $i$ ,  $Q^i = q_i^i + q_j^i + q_k^i$  ( $i, j, k = 1, 2, 3$  and  $i \neq j \neq k$ ) is the total quantities supplied to market  $i$ , and  $q_i^j$  is the quantities supplied by firm  $i$  to market  $j$ . We assume that markets are segmented and that no transportation costs exist among markets.

Each firm can decrease its marginal production cost by undertaking the cost-reducing

R&D investment before producing. Cost function of firm  $i$  is described by

$$C_i = c_i(q_i^i + q_i^j + q_i^k) - f_i, \quad (2)$$

where  $c_i$  ( $f_i$ ) is marginal cost (R&D expenditure) of firm  $i$ . Based on Mills and Smith (1996), two technologies are available: the *new technology* with zero marginal costs and high R&D expenditure ( $f > 0$ ) and the *old technology* with high production costs ( $c > 0$ ) and zero R&D expenditure for simplicity. We assume  $c < \frac{1}{7}$  for non-negative condition for output. We also assume that firms 1 and 2 have already adopted the new technology but firm 3 has not adopted. In this sense, countries 1 and 2 are called *developed countries* and country 3 is called a *developing country*.

Each government  $i$  can impose a specific tariff  $t_i^j$  on imports from country  $j$  in order to maximize its welfare. Note that government  $i$  imposes a uniform tariff  $t_i^j = t_i^k = t_i^{MFN}$  under MFN clause when there is no FTA. If an FTA is formed, then governments of member countries eliminate the internal tariff and impose the external tariff against only non-member country. Profits of firm  $i$  is given by

$$\pi_i = p^i q_i^i + (p^j - t_j^i) q_i^j + (p^k - t_k^i) q_i^k - C_i. \quad (3)$$

Welfare of country  $i$  is the sum of consumer surplus, producer surplus, and tariff revenue, and described as follows:

$$W_i = \frac{(1-p^i)Q^i}{2} + \pi_i + t_i^j q_j^i + t_i^k q_k^i \quad (4)$$

We construct a following three-stage game. In the first stage, the firm in the developing country (firm 3) decides whether it undertakes the cost-reducing R&D investment or not. In the second stage, each government sets import tariff so as to maximize its national welfare simultaneously and independently, given the technology chosen by firm 3. Note that, when an FTA formed, governments of member countries impose only external tariff. In the third stage, all firms compete *à la* Cournot in all markets given the technology and the tariff level. We solve this game by the backward induction.

### 3 Analysis

#### 3.1 No FTA

In this subsection, we confirm the outcome where no FTA is formed. In the third stage, given the technologies and tariff level, firms compete *à la* Cournot. From (1), (2), and (3), the equilibrium output and profit of each firm are as follows<sup>2)</sup>:

$$q_1^1 + q_1^2 + q_1^3 = \frac{1}{4}(1+c+2t_1^{MFN}) + \frac{1}{4}(1+c-2t_2^{MFN}) + \frac{1}{4}(1+c-2t_3^{MFN}), \quad (5)$$

$$q_2^1 + q_2^2 + q_2^3 = \frac{1}{4}(1+c-2t_1^{MFN}) + \frac{1}{4}(1+c+2t_2^{MFN}) + \frac{1}{4}(1+c-2t_3^{MFN}),$$

$$q_3^1 + q_3^2 + q_3^3 = \frac{1}{4}(1-3c-2t_1^{MFN}) + \frac{1}{4}(1-3c-2t_2^{MFN}) + \frac{1}{4}(1-3c+2t_3^{MFN}),$$

$$\pi_1 = \frac{1}{16}(1+c+2t_1^{MFN})^2 + \frac{1}{16}(1+c-2t_2^{MFN})^2 + \frac{1}{16}(1+c-2t_3^{MFN}), \quad (6)$$

$$\pi_2 = \frac{1}{16}(1+c-2t_1^{MFN})^2 + \frac{1}{16}(1+c+2t_2^{MFN})^2 + \frac{1}{16}(1+c-2t_3^{MFN}),$$

$$\pi_3 = \frac{1}{16}(1-3c-2t_1^{MFN})^2 + \frac{1}{16}(1-3c-2t_2^{MFN})^2 + \frac{1}{16}(1-3c+2t_3^{MFN}) - f.$$

In the second stage, each government sets import tariff so as to maximize its welfare. From (4), (5), and (6), we obtain the optimal tariff level as follows:

$$t_i^{MFN} = \frac{3-c}{10}, \quad i = 1, 2, 3. \quad (7)$$

From (7), the optimal tariff level under MFN is the same in all countries and the cost-reducing R&D investment by firm 3 decreases the tariff level in all countries. Substituting (7) into (6), we obtain the profit of each firm, given firm 3's technology, as follows:

$$\pi_i = \frac{1}{50}(9+14c+11c^2), \quad i = 1, 2, \quad (8)$$

$$\pi_3 = \frac{1}{50}(9-46c+81c^2) - f.$$

In the first stage, firm 3 decides whether it undertakes the cost-reducing R&D investment. Firm 3 invests when the profit with the high technology is greater than that with the old technology. Therefore, we obtain the following result:

Lemma 1 *Suppose that there is no FTA. If  $f < \frac{(46-81c)c}{50} \equiv F^{MFN}$ , then firm 3 undertakes the cost-reducing R&D investment.*

### 3.2 North-North FTA

In this subsection, we consider how the formation of North-North FTA (FTA between developed countries) affects the decision of R&D investment by firm 3 in the developing country. Suppose that countries 1 and 2 form an FTA. Then member countries eliminate internal tariff ( $t_1^2 = t_2^1 = 0$ ) and set external tariff  $t_i^{ext}$  ( $i = 1, 2$ ) against only non-member country 3. On the other hand, the government of non-member country 3 does not change the tariff level against both member countries, that is,  $t_3^{MFN} = \frac{3-c}{10}$ . From (1) through (4), the external tariff level under North-North FTA is

$$t_1^{ext} = t_2^{ext} = \frac{1-3c}{7}. \quad (9)$$

From (7) and (9), the formation of FTA decreases the tariff level, which is called the *tariff complementarity effect*<sup>3</sup>. From (1), (2), (3), and (9), we obtain the profit of each firm under North-North FTA given firm 3's technology as follows:

$$\begin{aligned} \pi_i^{FTA} &= \frac{849 + 1094c + 641c^2}{4900}, \quad i = 1, 2, \\ \pi_3^{FTA} &= \frac{246 - 1084c + 1234c^2}{1225} - f. \end{aligned} \quad (10)$$

With similar calculations to the case with no FTA, we have

Lemma 2 *Suppose that North-North FTA is formed. Firm 3 in the developing country invests if*

$$f < \frac{2(542 + 617c)c}{1225} \equiv F^{FTA}.$$

From Lemmas 1 and 2, we establish the following:

Proposition 1 *North-North FTA encourages the cost-reducing R&D investment in the developing country if  $F^{FTA} > f > F^{MFN}$  while it discourages if  $F^{MFN} > f > F^{FTA}$ .*

Figure 1 summarizes these results.

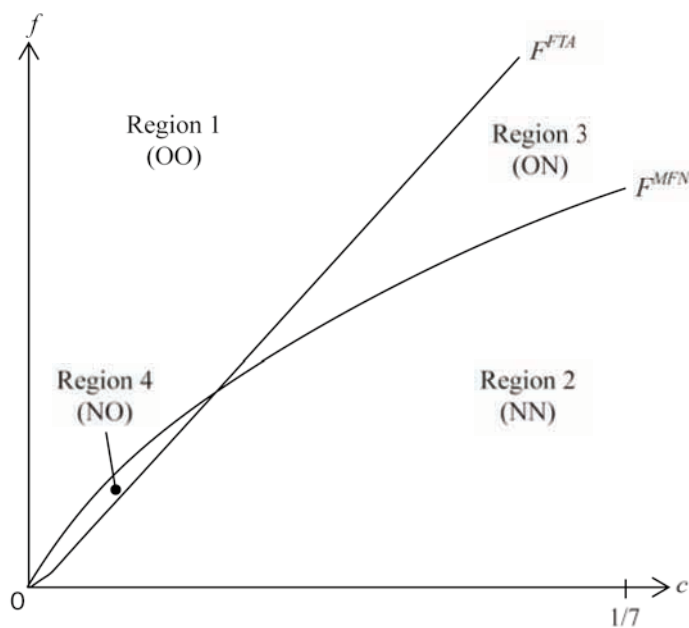


Figure 1: Effect of FTA on R&D Investment

Note that ON in Figure 1 represents the situation where firm 3 uses the old technology (O) under MFN while it uses the new technology (N) under North-North FTA. Figure 1 shows that the formation of North-North FTA induces the cost-reducing R&D investment by firm 3 in the developing country in Region 3 while it disturbs the adoption of the new technology by firm 3 in Region 4. In addition, the formation of the FTA does not change technology choice of firm 3 in the developing country both in Regions 1 and 2.

Let us consider the intuition behind Proposition 1. The formation of North-North FTA enlarges the difference in effective marginal costs between two technologies in both member countries' markets because the tariff elimination effect dominates the tariff complementarity effect while it has no direct effect on the tariff level in the developing country. In addition, in Region 3, the cost difference between two technologies are relatively large, which means the effect of R&D investment is large. Therefore, the North-North FTA strengthens the incentive for firm 3 to undertake the R&D investment in Region 3 because the adoption of the new technology enables firm 3 to earn more profits in both members' markets when  $f$  is not so high. In contrast, when the effect of R&D investment is small as in Region 4, the adoption of the new technology does not enable firm 3 to earn much profit in those markets

as compared with the R&D expenditure  $f$  because the cost difference between two technologies are small. That is why the formation of North-North FTA encourages the R&D investment in Region 3 while it discourages in Region 4.

### 3.3 Welfare

Now, let us examine how the formation of North-North FTA affects welfare of each country. From (1) through (4), (7), and (9), we derive the resulting welfare without and with the North-North FTA as shown in Tables 1 and 2.

| firm 3's technology | $W^i$                   | $W^3$                     |
|---------------------|-------------------------|---------------------------|
| old technology      | $\frac{21+c+14c^2}{50}$ | $\frac{21-44c+79c^2}{50}$ |
| new technology      | $\frac{21}{50}$         | $\frac{21}{50} - f$       |

Table 1: Welfare without an FTA

| firm 3's technology | $W^i$                          | $W^3$                         |
|---------------------|--------------------------------|-------------------------------|
| old technology      | $\frac{2199-6c+1591c^2}{4900}$ | $\frac{3(36-69c+79c^2)}{245}$ |
| new technology      | $\frac{2199}{4900}$            | $\frac{108}{245} - f$         |

Table 2: Welfare with North-North FTA

From Tables (1) and (2), we obtain the following results.

Proposition 2 (i) *The formation of North-North FTA always increases welfare of developed countries.* (ii) *It decreases welfare of developing country although the FTA encourages the R&D investment in the developing country if  $c > \frac{-2+5\sqrt{1437}}{2113} \equiv \hat{c}$  and  $F^{FTA} > f > \frac{51+2156c-3871c^2}{2450} \equiv \hat{F}$ . Otherwise, it increases welfare of the developing country.*

Proposition 2 states that North-North FTA may harm the developing country even when it encourages the R&D investment in the developing country, although it tends to increase welfare of both developed and developing countries.

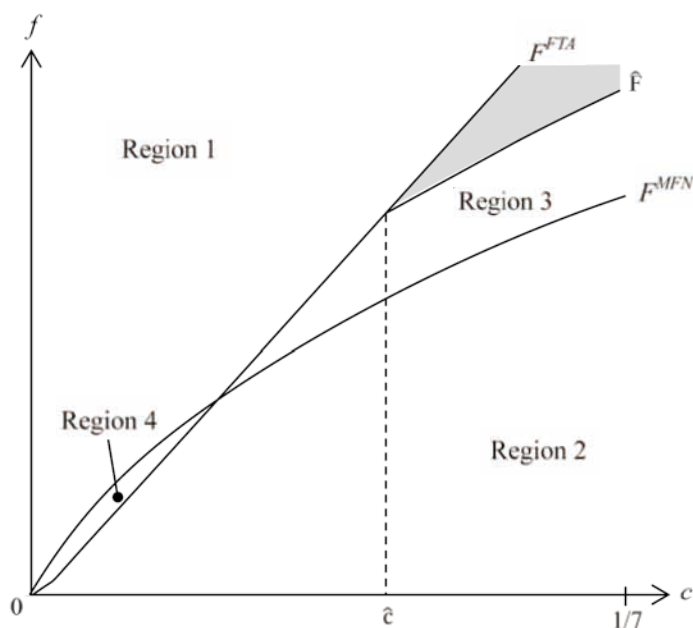


Figure 2: Effect of FTA on Welfare

Let us consider the intuition behind Proposition 2. Suppose that the formation of North-North FTA does not change technology choice of firm 3. In this case, the formation of North-North FTA enables firm 3 to earn more profits in both members' markets through the tariff complementarity effect and it does not change the outcome in the developing country. As a result, welfare of the developing country increases. Thus, North-North FTA increases welfare of the developing country when it does not change firm 3's technology choice.

In Region 3, however, North-North FTA encourages the R&D activity in the developing country. The adoption of the new technology brings more profits to firm 3 in both developed countries' markets. On the other hand, it increases the tariff level in the developing country as shown in (7). A reduction of marginal cost of firm 3 increases total quantities supplied to the developing country's market while it decreases the imports from two developed countries. Thus, when North-North FTA encourages the R&D investment, it increases consumer surplus but decreases tariff revenue in the developing country. The decrease in tariff revenue always dominates the increase in consumer surplus. The larger the effect of R&D investment, the larger is this welfare reduction effect. We should note that firm 3 does not care about the changes in consumer surplus as well as tariff revenue. Thus, when the



increase in profits of firm 3 by adopting the new technology is not so large, the reduction of tariff revenue dominates the increase in producer surplus and consumer surplus. In shaded region in Figure 2, the increase in profits of firm 3 by adopting the new technology is not so large because the R&D expenditure ( $f$ ) is relatively high, and the reduction of tariff revenue is large because the effect of R&D investment ( $c$ ) is high. Therefore, the formation of North-North FTA may harm the developing country when it encourages the cost-reducing R&D investment in the developing country.

In Region 4, North-North FTA discourages the R&D investment. Thus, effects on consumer surplus and tariff revenue by the formation of FTA turn over as compared to the effects in Region 3. Therefore, it increases welfare of the developing country.

#### 4 Concluding Remarks

This paper has investigated how the formation of North-North FTA affects the cost-reducing R&D activity in the developing country and welfare. Main findings are as follows: (i) the formation of North-North FTA may encourage or discourage the cost-reducing R&D investment in the developing country, (ii) it always benefits both member countries of North-North FTA, and (iii) it may harm the developing country even when it encourages the R&D investment although it tends to increase welfare of the developing country.

Future studies can extend this paper into several directions. In this paper, we did not consider North-South FTA, which is a potential extension of the model. It would be interesting to introduce a multiple number of firms and/or countries.

#### NOTE

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- 1) Liao (2008) introduces the spillover effect into their model.
- 2) Detailed calculations of the results in this paper are available from the author upon request.
- 3) See Bagwell and Staiger (1999) for detail.

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