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Determination and Harmonization of Product Standards in a Free Trade Agreement*

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Abstract

This study considers endogenous domestic standards on products to control negative consumption externalities in a three-country model of international oligopoly with a possible free trade agreement (FTA). We examine how the level of standards and welfare effects of FTA are affected and what is caused by harmonization of standards. We find that if asymmetries in preference or transboundary externalities are not too strong, an FTA makes the standards more stringent, and it may or may not make the FTA members better off, while the non-member countries better off. We also demonstrate that harmonization of standards between the FTA members makes the FTA more favorable.

Keywords: Optimal tariffs; Standards; Free trade agreements; International oligopoly; Harmonization

JEL classifications: F12; F13; F15; F18

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1 Introduction

Regional trade agreements (RTAs) have dramatically been increased in the last two decades. As of 8 January 2015, 604 notifications of RTAs (counting goods, services and accessions separately) had been received by the World Trade Organization (WTO), and among them 398 were in force.[1] This is more than twenty times from the corresponding number in 1990. Under these RTAs, tariffs on trade in manufacturing products have been considerably reduced between its member countries. In contrast, even under the RTAs, non-tariff barriers such as domestic regulations and technical regulations still exist among the RTA member countries. Instead of tariffs, non-tariff barriers can now be a cause of trade disputes.

Among non-tariff barriers, product standards, that is, domestic regulations to keep safety or environmental condition for the country, become emerging issues relating to trade agreements. Such product standards include vehicle emissions and safety standards, restrictions on pesticide residues on agricultural goods, regulations on food additives, and ensuring the safety of electrical products. If these product standards are mandatory, they will have direct impacts on international trade because the standards are generally different across the countries and only the products that meet standards are allowed to circulate in the market; consequently, such different standards may be obstacles for foreign exporters. Moreover, if regulations and standards are set arbitrarily, they could be used as an excuse for protectionism.[2]

In the recent trend, governments lower tariffs by contracting RTAs, while they take non-tariff barriers at the same time. Then, the levels of product standards must be affected by RTAs. In other words, product standards and the RTAs are strategically interacted. Although some studies focus on product standards quite recently, such strategic interactions between product standards and RTAs have been overlooked. Fisher and Serra (2000) point out the possibility of strategic use of standards under international oligopoly; they show that governments can exclude foreign firms by setting the lowest standard though

[1] See WTO website: http://www.wto.org/.

[2] In response to the concerns that standards might be a disguised form of protectionism, the WTO has established two specific agreements that govern standards: Agreement on Technical Barriers to Trade (TBT) and Agreement on the Application of Sanitary and Phytosanitary Measures (SPS).

it increases costs of domestic firms. Costinot (2008) compares performance between two different agreements on product standards; one is based on a national treatment principle applied in the WTO, and the other is based on a mutual recognition principle, which is being employed within the EU. More recently, Takarada, et al (2016) investigate regional and multilateral agreements on standards in a three-country oligopolistic trade model to shed light on how country-specific or region-specific regulations affect multilateralism. Notice that these studies focus on standards as non-tariff barriers by assuming no tariff-based protection. Furthermore, with such strategic interactions between product standards and RTAs, are RTAs reasonable for the member or nonmember countries? This question is not straightforward, and we believe that this question is quite important from the viewpoint of economic policy.

Additionally, we have often witnessed harmonization of standards in contracting RTAs.[3] For example, when the European Union (EU) forms an RTA with other countries, the agreement requests the partner country to harmonize its national standards and conformity assessment procedures with those of the EU (Stoler, 2011). What is the reason for harmonization of product standards in RTAs?

The purpose of this paper is two-fold. The first one is to clarify how product standards is determined in an RTA and whether the RTA with standards is preferable for member and nonmember countries. The second one is to explain the incentive to harmonize standards in contracting RTAs. Among several forms of RTAs, this paper focuses on free trade agreements (FTAs), where each member country chooses its external tariffs independently.[4] More specifically, we address the following questions: Do standards become more or less stringent under an FTA than in the absence of it? After a formation of the FTA, do member and nonmember countries better off? Do potential FTA members have an incentive to

[3]Harmonization is one of the approaches for removing impediments caused by differences between national standards. The approaches are (i) using the existing international standards set by international standard bodies such as the International Organization for Standardization (ISO), and (ii) mutual recognition (MR), where a country may recognize standards imposed by another country as equivalent to its own standards even if they differ. The EU has adopted the MR principle as well as harmonization.

[4]In view of the fact that most existing RTA arrangements take the form of FTAs and less than 10% can be considered to be fully fledged customs unions, Facchini et al. (2012) develop a political economy model of trade policy under imperfect competition to provide a positive explanation for the prevalence of FTAs.

harmonize their standards? In a simple theoretical framework, we provide clear answers to these questions. In contrast to the existing studies we have mentioned, we consider both tariffs and non-tariff barriers — standards. In this paper, therefore, we take account of the interactions between these "traditional" and "modern" forms of trade protection.

The structure of our model is based on those in the studies on welfare effects of RTAs or the possibilities for RTAs to achieve global free trade under international oligopoly (Yi, 1996, 2000; Krishna, 1998; Freund, 2000; Orneras, 2005a,b; Saggi, 2006). We consider a three-country model of international oligopoly and incorporate an endogenous determination of standards by national governments into the model. More specifically, we consider standards for controlling negative externalities by consumption of goods; in order to enter the importer country?fs market, foreign exporters must produce goods that meet the import?fs standard. Assuming that governments are benevolent, without any political incentives to set their respective standards, we consider endogenous determination of standards as well as (external) tariffs.[5]

Among several forms of RTAs, this paper focuses on free trade agreements (FTAs), where each member country chooses its external tariffs independently.[6] The structure of the model employed in this paper is based on those in the studies on welfare effects of RTAs or the possibilities for RTAs to be multilateral free trade under international oligopoly (Yi, 1996, 2000; Krishna, 1998; Freund, 2000; Orneras, 2005a, b; Saggi, 2006). We consider a three-country model of international oligopoly and incorporate an endogenous determination of standards by national governments into the model. More specifically, we consider

[5]Taxation on consumption can also be as a means to control the negative externalities. Gulati and Roy (2008) point out that it is often difficult to employ an emissions tax. For example, according to Fullerton and West (2002), the technology to apply a tax per unit of automobile emissions is currently unfeasible. It is not possible to measure each car's emissions in a reliable and cost-effective manner. Being unable to measure and regulate emissions effectively generally true for most consumption-generated pollutants, mainly because the technology to do so does not justify the costs. In the absence of an emissions tax, the government ' s next best alternative is to tax consumption instead. However, unlike an emission tax, the consumption tax does not encourage consumers to value goods with a higher environmental standard. Under a consumption tax, the market fails to deliver the optimal environmental standard, the government has to regulate both the standard and the consumption tax to achieve its first best.

[6]In view of the fact that most existing RTA arrangements take the form of FTAs and less than 10% can be considered to be fully fledged customs unions, Facchini et al. (2012) develop a political economy model of trade policy under imperfect competition to provide a positive explanation for the prevalence of FTAs.

standards for controlling negative externalities generated by consumption of goods;[7] in order to enter the importer country's market, foreign exporters must produce goods that meet the import's standard, and thus the standard can be a nontariff barrier. Assuming that governments are benevolent, without any political incentives to set their respective standards, we consider endogenous determination of standards as well as (external) tariffs.

Our main findings are as follows: Compared with the policy game in the absence of FTAs, an FTA makes the member countries to choose more stringent standards. Regarding the national welfare in each country, the FTA member countries may or may not be better off under the formation of an FTA, while the nonmember country becomes better off. By comparing the case in which FTA members independently determine their respective national standards with the case in which the FTA member countries harmonize their standards within the FTA, such harmonization of standards will lead the member countries to choose less stringent standards and make the formation of the FTA more favorable.

The rest of this paper is organized as follows. In section 2, we set up a three-country model of international oligopoly with standard imposed by the national government. In section 3, we derive the equilibrium of policy game in the absence of FTAs. In section 4, we derive the equilibrium of policy game under an FTA. When governments in the member countries determine their respective standards, they may act independently or jointly. In section 5, we examine how a formation of the FTA affects the standards chosen by the member countries and national welfare in member and nonmember countries. In section 6, we compare the outcomes under national standards with those under harmonization of standards within the FTA. We extend the basic model and discuss the robustness of the basic results; in section 7, we consider an asymmetry in externality parameters, and in section 8, we introduce transboundary externalities into the basic model. In section 9, we provide brief concluding remarks.

[7]We focus on product standards related to consumption externalities because the issue will not be an easy job when we discuss the optimal level of standards and harmonization of such standards. In the presence of externalities, national governments have an incentive to set their own respective standards so as to protect the residents from possible damages. In general, the resultant standards can differ between these countries, an anecdotal evidence reveals that countries dealt with the conflicts in different manners.

2 Model

We consider three countries, A, B, and C, each with one firm that produces a homogeneous product. Consumption of the product generates negative externalities, the level of which depends on a regulatory standard imposed by the national government. We suppose a world in which the standard should be nondiscriminatory; if the government sets a standard on the product produced by the home firm, the same standard should be applied to imported products. Let us denote the standard imposed in country i by s_i $(i = A, B, C)$, and the externalities per unit of consumption is thus given by $b_i(s_i)$, which is assumed to be decreasing in s_i. In the basic model, we assume that the externalities are purely local. This assumption will be relaxed in the later section. There is also another homogeneous good, which serves as the numeraire and is assumed to be freely traded and produced under perfect competition with constant returns to scale technology, and generate no externalities.

There is a continuum of homogeneous consumers of measure one. Each consumer in country i has the following quasi-linear preference:

$$U^i(Q_i, Y_i; s_i, \bar{Q}_i) = u_i(Q_i) + Y_i - b_i(s_i)\bar{Q}_i,$$

where Q_i and Y_i are his consumption of the externality-generating product and the numeraire, respectively, and $\bar{Q}_i$ is the aggregate consumption of the product. As explained above, $b_i(s_i)\bar{Q}_i$ denotes the negative externalities in this country.[8] Throughout the paper, we assume that $u_i(Q_i)$ is quadratic and hence the consumers' utility maximization derives the linear inverse demand function $P_i(Q_i) = \alpha_i - Q_i$, $\alpha_i > 0$, $i = A, B, C$.

The three firms compete in quantities in each of the national markets, which are assumed to be segmented. Throughout the paper we assume that these firms have identical technologies and each firm's unit production cost is a function of standard imposed in the country of consumption. Let us denote the unit production cost by $c(s_i)$, which is assumed to be increasing in s_i. That is, it is more expensive to produce at a higher standard.[9]

[8]For each consumer, $b_i(s_i)\bar{Q}_i$ is taken as given in the utility maximization problem, the first-order condition of which is thus given by $p_i = u_i'(Q_i)$

[9]For example, if the use of a certain food additive is legally prohibited in a country, the firms supplying food products in that country's market should avoid using that material in their production process.

This is because the firms are banned from selling goods that do not meet individual national standards, and thus the firms produce goods which exactly fulfill the requirements of standards in each country's market.

We also assume that the governments imposes tariffs on imports. Because the markets are segmented, we can consider the Cournot–Nash equilibrium in each market separately. Let us denote the output of the domestic firm by q_{ii} and the outputs of foreign exporters by q_{ij}, and q_{ik}, $i, j, k = A, B, C$, $i \neq j \neq k$, thus $Q_i = q_{ii} + q_{ij} + q_{ik}$. The foreign firms face a specific tariff when exporting to country i. Let us denote the tariff rates on imports that the national government in country i imposes by t_{ij} and t_{ik}, respectively. Assuming that the firms do not incur fixed costs, profits of the respective firms supplying to the market in country i are given by

$$\begin{aligned}
\pi_{ii} &= [P_i(Q_i) - c(s_i)]q_{ii} = [a_i(s_i) - Q_i]q_{ii}, \\
\pi_{ij} &= [P_i(Q_i) - c(s_i) - t_{ij}]q_{ij} = [a_i(s_i) - Q_i - t_{ij}]q_{ij}, \\
\pi_{ik} &= [P_i(Q_i) - c(s_i) - t_{ik}]q_{ik} = [a_i(s_i) - Q_i - t_{ik}]q_{ik},
\end{aligned}$$

where $a_i(s_i) \equiv \alpha_i - c(s_i)$. From the first-order conditions for profit maximization, Cournot–Nash equilibrium output of each firm is derived as follows:

$$q_{ii} = \frac{a_i(s_i) + t_{ij} + t_{ik}}{4}, \quad q_{ij} = \frac{a_i(s_i) - 3t_{ij} + t_{ik}}{4}, \quad q_{ik} = \frac{a_i(s_i) + t_{ij} - 3t_{ik}}{4}. \tag{1}$$

The total output sold in country i is therefore derived as

$$Q_i = \frac{3a_i(s_i) - t_{ij} - t_{ik}}{4}. \tag{2}$$

These equilibrium outputs are a function of policy variables imposed by the government in country i.

The total profit of the firm producing the externalities-generating product is the sum of profits from domestic and export sales: $\pi_i = \pi_{ii} + \pi_{ji} + \pi_{ki}$, $i, j, k = A, B, C$, $i \neq j \neq k$. National welfare in each country is defined as the sum of consumer surplus $CS_i = \int_0^{Q_i} P_i(x)dx - P_i(Q_i)Q_i$, total profit π_i, and tariff revenue $t_{ij}q_{ij} + t_{ik}q_{ik}$, minus the social cost from negative externalities $b_i(s_i)Q_i$. Given the linear demand function, it holds that

$CS_i = (Q_i)^2/2$ and $\pi_i = (q_{ii})^2 + (q_{ji})^2 + (q_{ki})^2$. In light of (1) and (2), national welfare is therefore given by

$$W_i = \frac{[3a_i(s_i) - t_{ij} - t_{ik}]^2}{32} + \frac{[a_i(s_i) + t_{ij} + t_{ik}]^2}{16} + \frac{[a_j(s_j) - 3t_{ji} + t_{jk}]^2}{16} + \frac{[a_k(s_k) - 3t_{ki} + t_{kj}]^2}{16} + t_{ij}\frac{a_i(s_i) - 3t_{ij} + t_{ik}}{4} + t_{ik}\frac{a_i(s_i) + t_{ij} - 3t_{ik}}{4} - b_i(s_i)\frac{3a_i(s_i) - t_{ij} - t_{ik}}{4}. \quad (3)$$

In the following analysis, we assume that there are two standards available, s_H and s_L, with $s_H > s_L$. If the government chooses a low standard, firms do not incur costs, i.e., $c(s_L) = 0$, but consumption generates negative externalities $b_i(s_L) = \beta_i > 0$. If the national government chooses a high standard, firms incur a unit cost $c(s_H) = \gamma > 0$, but negative externalities generated from consumption becomes smaller, i.e., $b_i(s_H) = \theta\beta_i$, $\theta < 1$. These simplifications of unit cost and externality functions enable us to compare the welfare levels under different regimes of policy games.

In our analysis, we consider the following order: in the first stage, each government determines tariffs and standards, and in the second stage the firms compete in the Cournot way. We derive the subgame perfect Nash equilibrium of this game by backward induction. Although we implicitly consider the situation in which the governments determine these policy instrument simultaneously, under our setting the same solutions are obtained even if the governments first determine the standards, and then chooses the optimal tariffs that maximizes national welfare taking the standard as given (see Appendix). We thus formulate the governments' behavior as if their policy games are played sequentially.

3 Policy Game without FTAs

In this section, we consider a policy game in the absence of FTAs as a benchmark. It is natural to assume that the determination of tariffs follows the principle of nondiscrimination, known as the most-favored-nation (MFN) clause. That is, the government in each country imposes a single nondiscriminatory tariff on its trading partners and all countries simultaneously choose their respective tariffs to maximize their own welfare. Substituting

$t_{ij} = t_{ik} = t_i$ into (3), the national welfare is rewritten as

$$W_i = \frac{[3a_i(s_i) - 2t_i]^2}{32} + \frac{[a_i(s_i) + 2t_i]^2}{16} + \frac{[a_j(s_j) - 2t_j]^2}{16} + \frac{[a_k(s_k) - 2t_k]^2}{16} + t_i\frac{a_i(s_i) - 2t_i}{2} - b_i(s_i)\frac{3a_i(s_i) - 2t_i}{4}. \tag{4}$$

Taking the tariffs in other countries t_j and t_k as given, the government in country i determines t_i so as to maximize welfare (4). From the first-order condition $\partial W_i/\partial t_i = 0$, the MFN tariff for a given standard is derived as

$$t_i = \frac{3a_i(s_i) + 4b_i(s_i)}{10} \equiv t_i^M(s_i). \tag{5}$$

Notice that because of the assumptions of segmented markets and a constant unit cost (for a given s_i), a country's MFN tariff does not depend on the other countries' tariffs. This also means that the MFN tariffs in the trading partners are $t_j^M(s_j)$ and $t_k^M(s_k)$. The stringency of standards affects the MFN tariff rate in the following manner:

$$t_i^M(s_H) = \frac{3(\alpha_i - \gamma) + 4\theta\beta_i}{10} < \frac{3\alpha_i + 4\beta_i}{10} = t_i^M(s_L). \tag{6}$$

Because more stringent standards lead a higher cost of compliance, which reduces outputs of both domestic and foreign firms and raises the price. In order to compensate for the resulting losses in consumer surplus and tariff revenue, the national government will reduce the tariffs on imports.

We turn to the determination of standards, which are made noncooperatively in this benchmark situation. In light of (5), the national welfare (4) can be rewritten as $W_i^M = w_i^M(s_i) + \pi_{ji}^M(s_j) + \pi_{ki}^M(s_k)$, where

$$w_i^M(s_i) \equiv \frac{[11a_i(s_i) - 10t_i^M(s_i)][a_i(s_i) + 2t_i^M(s_i)]}{32} - \frac{b(s_i)[3a_i(s_i) - 2t_i^M(s_i)]}{4} = \frac{4a_i(s_i)^2 - 6a_i(s_i)b_i(s_i) + b_i(s_i)^2}{10} \tag{7}$$

is the domestic surplus and

$$\pi_{hi}^M(s_h) \equiv \frac{[a_h(s_h) - 2t_h^M(s_h)]^2}{16} = \frac{[a_h(s_h) - 2b_h(s_h)]^2}{100}, \quad h = j, k \tag{8}$$

are the export profits. Taking the standards in other countries s_j and s_k as given, the government in country i determines $s_i \in \{s_L, s_H\}$ so as to maximize the national welfare W_i^M.

Since W_i^M is additively separable, the problem is equivalent to choose s_i that maximizes the domestic surplus (7).[10] A direct calculation yields that if

$$\Delta w_i^M \equiv w_i^M(s_H) - w_i^M(s_L) = \frac{-4\gamma(\alpha_i - \gamma) + 6\beta_i\gamma\theta + (1-\theta)\beta_i[6\alpha_i - (1+\theta)\beta_i]}{10} \tag{9}$$

is positive (negative), the government find it optimal to choose s_H (s_L). In order to exclude cases where governments set prohibitive tariffs, we restrict our attention to the parameter values that satisfy $\alpha_i > 2\theta\beta_i + \gamma$ and $\alpha_i > 2\beta_i$.[11] Given these parameter restrictions, Δw_i^M tends to be positive if β_i becomes larger whereas it tends to be negative if γ becomes larger. Because the property on the sign of Δw_i^M will be maintained for any $\theta < 1$, we henceforth assume that $\theta = 0$ without loss of generality. It therefore follows that $\Delta w_i^M > 0$ ($\Delta w_i^M < 0$) holds if and only if

$$\gamma < (>)\ \bar{\gamma}_i^M(\beta_i) \equiv \alpha_i - \sqrt{\alpha_i^2 - \frac{3}{2}\alpha_i\beta_i + \frac{\beta_i^2}{4}}.$$

It is easily verified that $\bar{\gamma}_i^M(\beta_i)$ is increasing and convex in β_i:

$$\frac{d\bar{\gamma}_i^M}{d\beta_i} = \frac{3\alpha_i - \beta_i}{4}\left(\alpha_i^2 - \frac{3}{2}\alpha_i\beta_i + \frac{\beta_i^2}{4}\right)^{-1/2} > 0, \quad \frac{d^2\bar{\gamma}_i^M}{d\beta_i^2} = \frac{5\alpha_i^2}{16}\left(\alpha_i^2 - \frac{3}{2}\alpha_i\beta_i + \frac{\beta_i^2}{4}\right)^{-3/2} > 0.$$

In addition, it holds that $\bar{\gamma}_i^M(\alpha_i/2) = (1 - \sqrt{5}/4)\alpha_i \approx 0.4410\alpha_i < \alpha_i$. Therefore, the government chooses a high standard if $\gamma < \bar{\gamma}_i^M(\beta_i)$, whereas it chooses a low standard if $\gamma > \bar{\gamma}_i^M(\beta_i)$.

Lemma 1. *Under the MFN, each government's dominant strategy for standards is to choose s_H if $0 < \gamma < \bar{\gamma}_i^M(\beta_i)$ and s_L if $\bar{\gamma}_i^M(\beta_i) < \gamma < \alpha_i$.*

The intuition behind Lemma 1 is straightforward. In tightening standards, national governments face a trade-off between a rise in the firms' unit cost γ and a mitigation of negative externalities β_i. If γ is relatively high compared with β_i, the former effect dominates the latter, and thus the governments will choose a less stringent standard. If β_i is relatively high, the government will make an opposite choice.

[10] That is, because of the additive-separability property of the welfare function indicates that a country's optimal standard is strategically independent of the other countries' standards.

[11] Substituting (5) into the export outputs, we obtain $q_{ij} = q_{ik} = [a_i(s_i) - 2b_i(s_i)]/10$, which becomes positive if $\alpha_i > 2\theta\beta_i + \gamma$ (in the case of high standard) and $\alpha_i > 2\beta_i$ (in the case of low standard).

4 Policy Games under an FTA

Let us now suppose that countries A and B form a free trade agreement (FTA), which reduces tariffs between these country to zero: $t_{AB} = t_{BA} = 0$. By definition of an FTA, the member countries set their respective external tariffs independently, and let us denote the external tariff rate by $t_{iC} = t_i$, $i = A, B$. Substituting these into (3), the national welfare of a member country is given by

$$W_i = \frac{[3a_i(s_i) - t_i]^2}{32} + \frac{[a_i(s_i) + t_i]^2}{16} + \frac{[a_j(s_j) + t_j]^2}{16} + \frac{[a_C(s_C) - 2t_C]^2}{16} + t_i\frac{a_i(s_i) - 3t_i}{4} - b_i(s_i)\frac{3a_i(s_i) - t_i}{4}, \quad i, j = A, B, j \neq i. \tag{10}$$

Because tariffs are eliminated within the FTA partners, total sales and the export to the FTA partner increase, which lead to increases in consumer surplus and export profit in the FTA partner's market. At the same time, the elimination of tariffs reduce the domestic profit and tariff revenue. In addition, the increase in the domestic consumption leads to larger negative externalities.

Taking the external tariff rate in the FTA partner t_j and the tariff rate in the non-member country t_C as given, the government in country i determines t_i so as to maximize welfare (10). The optimal external tariff for a given standard is derived as

$$t_i = \frac{3a_i(s_i) + 4b_i(s_i)}{21} \equiv t_i^F(s_i), \tag{11}$$

which is less than the optimal tariff level under the MFN, $t_i^M(s_i)$.

Lemma 2. *For a given level of standards, the optimal external tariff for member country i under an FTA is lower than the MFN tariff: $t_i^F(s_i) < t_i^M(s_i)$.*

Lemma 2 is a well-known tariff complementarity effect (Bagwell and Staiger, 1998). Intuitively, because of a change in competitive advantage in the member countries' markets, a formation of FTAs reduces imports from the nonmember country, which in turn reduces tariff revenue and consumer surplus, and in order to offset these negative effects the member countries encourage the import from the nonmember country by reducing external tariffs.

The government's behavior in the nonmember country is the same as that under MFN, and thus, for the firms in the FTA members, the export profit in the nonmember country is $\pi_{Ci}^M(s_C)$, $i = A, B$. Then, in light of (11), the member country's national welfare (10) can be rewritten as $W_i^F = w_i^F(s_i) + \pi_{ji}^F(s_j) + \pi_{Ci}^M(s_C)$, where

$$\begin{aligned} w_i^F(s_i) &\equiv \frac{11a_i(s_i)^2 + 6a_i(s_i)t_i^F(s_i) - 21t_i^F(s_i)^2}{32} - \frac{b_i(s_i)[3a_i(s_i) - t_i^F(s_i)]}{4} \\ &= \frac{15a_i(s_i)^2 - 30a_i(s_i)b_i(s_i) + b_i(s_i)^2}{42} \end{aligned} \tag{12}$$

is the domestic surplus and

$$\pi_{ji}^F(s_j) \equiv \frac{[a_j(s_j) + t_j^F(s_j)]^2}{16} = \frac{[6a_j(s_j) + b_j(s_j)]^2}{441} \tag{13}$$

is the export profit in the FTA partner's market.

In the following sections, we consider two scenarios regarding the determination of the FTA members' standards. One is a "national standards" regime, where the government in each member country independently determines the individual standard so as to maximize its own welfare. The other is a "harmonization" regime, where the governments in member countries harmonize their standards; they jointly determine a common standard in a cooperative manner.

5 National standards

5.1 Determination of standards

In the national-standards regime, taking the standards in other countries s_j and s_C as given, the government in country i determines $s_i \in \{s_L, s_H\}$ so as to maximize the national welfare W_i^F, or equivalently, the domestic surplus $w_i^F(s_i)$. From (11) and (12), it holds that $w_i^F(s_H) = 5(\alpha_i - \gamma)^2/14$ and $w_i^F(s_L) = (15\alpha_i^2 - 30\alpha_i\beta_i + \beta_i^2)/42$. Therefore, the government find it optimal to choose s_H (s_L) if

$$\Delta w_i^F \equiv w_i^F(s_H) - w_i^F(s_L) = \frac{-30\alpha_i\gamma + 15\gamma^2 + 30\alpha_i\beta_i - \beta_i^2}{42} \tag{14}$$

is positive (negative), or equivalently, if

$$\gamma < (>)\ \bar{\gamma}_i^F(\beta_i) \equiv \alpha_i - \sqrt{\alpha_i^2 - 2\alpha_i\beta_i + \frac{\beta_i^2}{15}}.$$

It is easily verified that $\bar{\gamma}_i^F(\beta_i)$ is increasing and convex in β_i. As in the policy game equilibrium in the absence of the FTAs, we can partition the set $\left\{(\beta_i, \gamma) \in \mathbb{R}_+^2 \mid \alpha_i > \gamma,\ \alpha_i > 2\beta_i\right\}$ into two regions, one in which the member countries choose s_H and the other in which they choose s_L.

Lemma 3. *Suppose that countries A and B form an FTA. If the governments in member countries choose their respective national standards, each government's dominant strategy is to choose* s_H *if* $0 < \gamma < \bar{\gamma}_i^F(\beta_i)$ *and* s_L *if* $\bar{\gamma}_i^F(\beta_i) < \gamma < \alpha_i$.

Comparing Lemmas 1 and 3, we see that a formation of the FTA changes the regions of optimal standards. More specifically, we obtain the following lemma.

Lemma 4. *It holds that* $\bar{\gamma}_i^M(\beta_i) < \bar{\gamma}_i^F(\beta_i)\ \forall \beta_i \in (0, \alpha_i/2)$.

(Proof) Comparing the slopes at the origin, we have $d\bar{\gamma}_i^M(0)/d\beta_i = 3/4 < 1 = d\bar{\gamma}_i^F(0)/d\beta_i$. In addition, it holds that $\bar{\gamma}_i^F(\alpha_i/2) = (1 - \sqrt{15}/30)\alpha_i \approx 0.8709\alpha_i > \bar{\gamma}_i^M(\alpha_i/2)$. Since both $\bar{\gamma}_i^M(\beta_i)$ and $\bar{\gamma}_i^F(\beta_i)$ are increasing and convex in β_i, the statement of the lemma holds. □

Lemma 4 implies that the FTA further partitions the region in (β_i, γ) space where the government in country i choose a low standard under the MFN into two subsets. In light of Lemmas 1 and 3, if $\bar{\gamma}_i^M(\beta_i) < \gamma < \bar{\gamma}_i^F(\beta_i)$, the member country i changes its behavior in such a way that it chooses a low standard under the MFN but it chooses a high standard after the formation of the FTA. This is illustrated in Figure 1. If (β_i, γ) is in region I, the member country i chooses s_L both under the MFN and FTA. If (β_i, γ) is in region II, the member country i chooses s_L under the MFN but they choose s_H under the FTA. If (β_i, γ) is in region III, the member country i chooses s_H both under the MFN and FTA. Because there exists a set of parameters (β_i, γ) in which each member country chooses a low standard under the MFN but chooses a high standard under an FTA and each member country does not change their standards before and after an FTA formation if (β_i, γ) is not an element of this set, we can establish the following proposition.

Proposition 1. *In comparison with the MFN, an FTA makes the member countries to choose more stringent standards.*

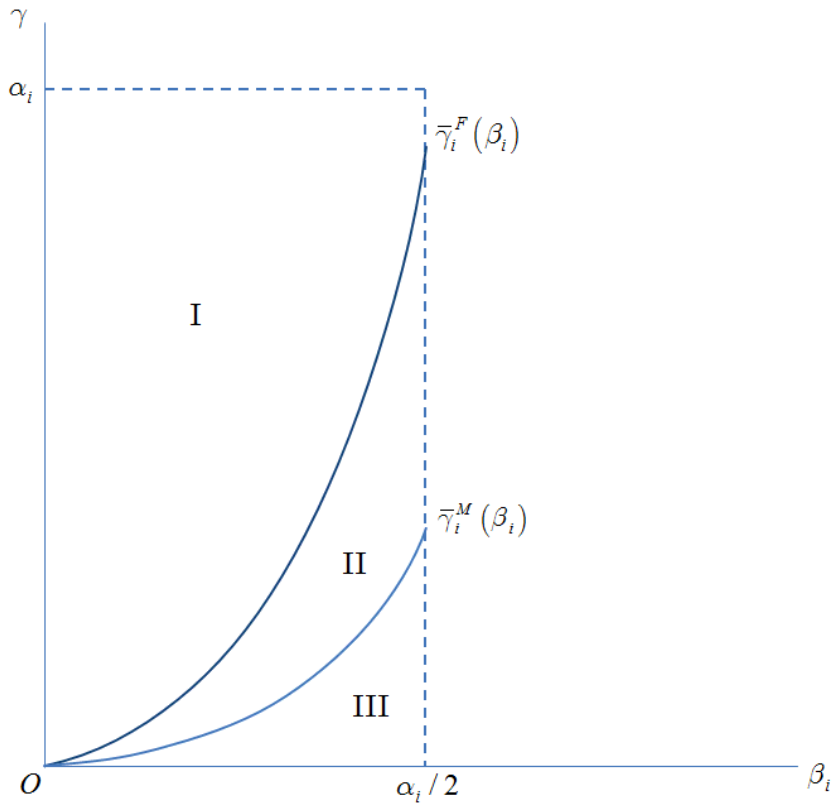

Figure 1: Comparison of optimal standards before and after an FTA

The intuition behind Proposition 1 is as follows. Eliminating tariffs between FTA partners increases consumption and production in the member countries, but at the same time, the member countries suffer from reduced tariff revenue. However, because of the tariff complementarity effect demonstrated in Lemma 2, the import from the nonmember country increases, which mitigates the reduction of tariff revenue. Therefore, the positive effect of the FTA dominates the negative one, and the member country will not be worse off even though it raises the unit costs of firms supplying to the market by adopting more stringent standards. Moreover, the increase in consumption will cause expansion of negative externalities, and thus the member country should actually adopt more stringent standards.

5.2 Welfare effects of an FTA with national standards

We are now in a position to examine whether or not an FTA makes each country better off. In light of Proposition 1 and Figure 1, there are nine possibilities regarding the combination

of the member countries' optimal standards under MFN and FTA, as shown by Table 1. Therefore, we make comparisons of each country's national welfare in the respective regions.

	(s_i, s_j) under MFN	(s_i, s_j) under FTA
(i)	(s_L, s_L)	(s_L, s_L)
(ii)	(s_L, s_L)	(s_H, s_L)
(iii)	(s_L, s_L)	(s_L, s_H)
(iv)	(s_L, s_L)	(s_H, s_H)
(v)	(s_H, s_L)	(s_H, s_L)
(vi)	(s_H, s_L)	(s_H, s_H)
(vii)	(s_L, s_H)	(s_L, s_H)
(viii)	(s_L, s_H)	(s_H, s_H)
(ix)	(s_H, s_H)	(s_H, s_H)

Table 1: Possible combinations of the member countries' optimal standards

Member countries We begin with the member countries. Member country i's national welfare is given by $W_i^M = w_i^M(s_i) + \pi_{ji}^M(s_j) + \pi_{Ci}^M(s_C)$ under the MFN and $W_i^F = w_i^F(s_i) + \pi_{ji}^F(s_j) + \pi_{Ci}^M(s_C)$ under the FTA, $i, j = A, B$, $j \neq i$.[12] Then, from (7), (8), (12), and (13), we have

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_i) + \pi_{ji}^M(s_j) - [w_i^F(s_i) + \pi_{ji}^F(s_j)] \\ &= \frac{4a_i(s_i)^2 - 6a_i(s_i)b_i(s_i) + b_i(s_i)^2}{10} + \frac{[a_h(s_h) - 2b_h(s_h)]^2}{100} \\ &\quad - \frac{15a_i(s_i)^2 - 30a_i(s_i)b_i(s_i) + b_i(s_i)^2}{42} - \frac{[6a_j(s_j) + b_j(s_j)]^2}{441}. \end{aligned} \tag{15}$$

In the Appendix, we present the calculation results for cases from (i) to (ix) in Table 1, from which it is difficult to judge whether each member country gains or loses from forming an FTA. In the following analysis, we focus on some specific cases.

Let us first consider the case in which the member countries share common preference parameters; i.e., $\alpha_A = \alpha_B = \alpha$ and $\beta_A = \beta_B = \beta$.[13] In this case of symmetric member countries, only cases (i), (iv), and (ix) in Table 1 are possible. In case (i) in Table 1, (15)

[12]The nonmember country always chooses the MFN tariff and does not change the standard before and after the formation of FTA.

[13]In this symmetric countries case, we omit the subscript indicating the country index in the functions γ^M and γ^F.

can be rewritten as

$$W_i^M - W_i^F = -\frac{(423\alpha - 1256\beta)(3\alpha + 4\beta)}{44100}. \tag{16}$$

Then, $W_i^M > W_i^F$ ($W_i^M < W_i^F$) if and only if $\beta > (<)\ 423\alpha/1256 \approx 0.3368\alpha$.[14] In case (iv) in Table 1, (15) can be rewritten as

$$W_i^M - W_i^F = \frac{-141\alpha^2 - 3136\alpha\beta + 686\beta^2 + 4300\alpha\gamma - 2150\gamma^2}{4900}. \tag{17}$$

Given the parameter restrictions $\alpha > \gamma$ and $\alpha > 2\beta$, it can be verified that $W_i^M > W_i^F$ ($W_i^M < W_i^F$) holds if and only if

$$\gamma > (<)\ \tilde{\gamma}(\beta) \equiv \alpha - \frac{7}{5}\sqrt{\frac{41}{86}\alpha^2 - \frac{32}{43}\alpha\beta + \frac{7}{43}\beta^2}.$$

It also holds that $\tilde{\gamma}(0) \approx 0.0333\alpha$ and $\tilde{\gamma}(\alpha/2) \approx 0.4663\alpha \in \left(\bar{\gamma}^M(\alpha/2), \bar{\gamma}^F(\alpha/2)\right)$. Finally, in case (ix) in Table 1, (15) can be rewritten as

$$W_i^M - W_i^F = -\frac{141(\alpha - \gamma)^2}{4900} < 0. \tag{18}$$

Therefore, the FTA achieves higher welfare than MFN for the member countries. To sum up, we have the following lemma (see also Figure 2).

Lemma 5. *Suppose that $\alpha_A = \alpha_B = \alpha$ and $\beta_A = \beta_B = \beta$. For the FTA member countries $i = A, B$, the national welfare under the FTA and the national standards compared with the MFN is as follows.*
(i) If $\bar{\gamma}^F(\beta) < \gamma < \alpha$, $W_i^M > W_i^F$ ($W_i^M < W_i^F$) for $\beta > (<)\ 423\alpha/1256$.
(ii) If $\tilde{\gamma}(\beta) < \gamma < \bar{\gamma}^F(\beta)$, $W_i^M > W_i^F$.
(iii) If $0 < \gamma < \tilde{\gamma}(\beta)$, $W_i^M < W_i^F$.

Lemma 5 can be interpreted as follows. In case (i), the member countries choose s_L both under the MFN and FTA. Because of the elimination of tariffs within the FTA and the tariff complementarity effect, output and consumption become larger under the FTA. Therefore, the member countries gains from the formation of the FTA unless the negative externalities per unit of consumption indicated by the parameter β are large enough. In

[14] It holds that $\bar{\gamma}^F(423\alpha/1256) \approx 0.4221\alpha < \bar{\gamma}^M(\alpha/2)$.

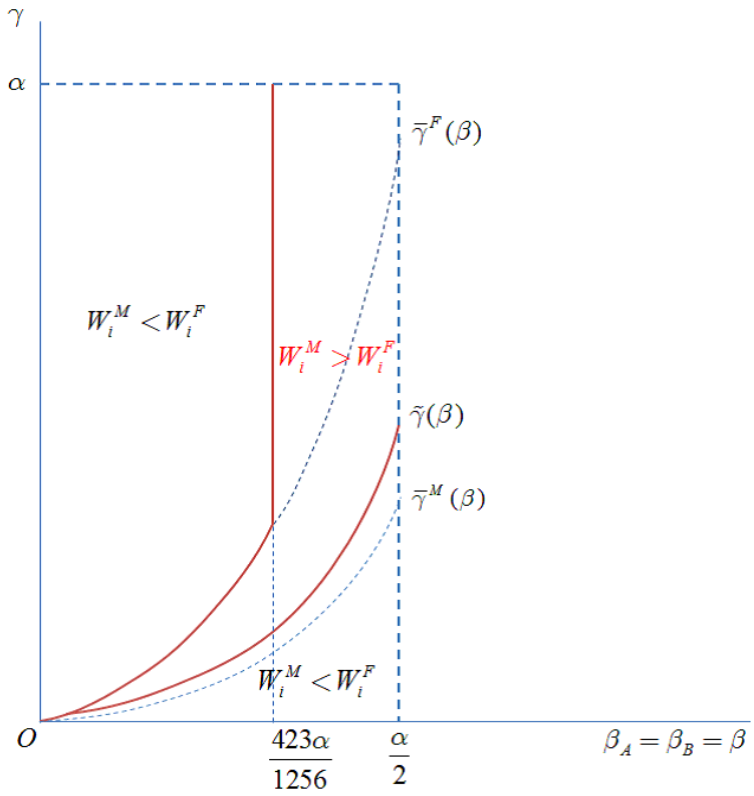

Figure 2: Comparison of the FTA members' welfare in the symmetric case

case (ix), the member countries choose s_H both under MFN and the FTA. In this case, the negative externalities are internalized by the imposition of a high standard, and thus the FTA unambiguously achieves higher welfare to the member countries. In case (iv), where the member countries choose s_L under MFN but they choose s_H under the FTA, the member countries face the firms' higher compliance costs but the negative externalities will be reduced under the FTA. If γ is relatively high, the high compliance costs harm the member countries, but if β is high, the escape from the negative externalities benefits the member countries.

We now relax the assumption that the member countries are completely symmetric by considering the case where the member countries have different perceptions toward consumption externalities (i.e., β_A and β_B can differ). We focus on one specific case in which the member countries continue to share a common demand size, i.e., $\alpha_A = \alpha_B = \alpha$, and γ is equal to $\bar{\gamma}^M(\alpha/2)$. In this case, the standards chosen under the MFN regime are $s_A^M = s_B^M = s_L$, and the standard chosen by country i $(i = A, B)$ under the FTA with

national standard is

$$s_i^F = \begin{cases} s_L & \text{if } 0 \le \beta_i \le \beta_* \\ s_H & \text{if } \beta_* \le \beta_i \le \alpha/2, \end{cases}$$

where β_* satisfies $\bar{\gamma}^F(\beta_*) = \bar{\gamma}^M(\alpha/2)$.[15] That is, there are four cases, i.e., from (i) to (ix) in Table 1, and the equilibrium configurations of the member countries' standards are illustrated in Figure 3.

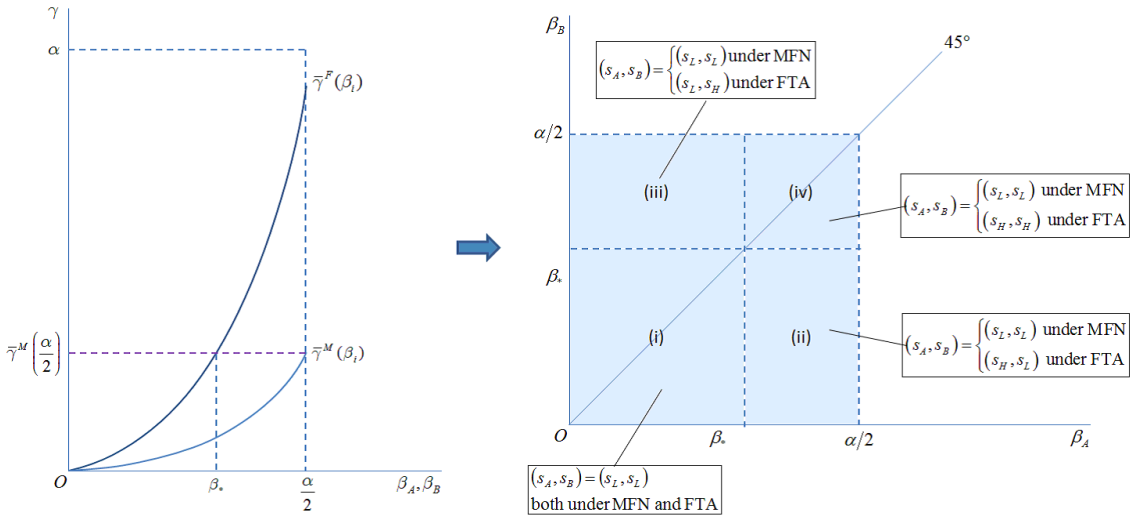

Figure 3: Equilibrium configurations of the member countries' standards when β_i's differ

The possibility that the member countries may choose different standards implies that the welfare effects of an FTA formation will be more complicated.

Case (i): $(s_A, s_B) = (s_L, s_L)$ both under MFN and FTA From (15), the difference in member country i's welfare between MFN and FTA is

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_L) + \pi_{ji}^M(s_L) - [w_i^F(s_L) + \pi_{ji}^F(s_L)] \\ &= \frac{(3\alpha + 4\beta_i)^2}{210} - \frac{13(3\alpha + 4\beta_j)(81\alpha - 32\beta_j)}{44100}, \end{aligned} \tag{19}$$

which is positive (negative) if

$$\beta_i > (<) \frac{1}{4}\left\{\sqrt{\frac{13(81\alpha - 32\beta_j)(3\alpha + 4\beta_j)}{210}} - 3\alpha\right\} \equiv \bar{\beta}(\beta_j).$$

It is verified that $\bar{\beta}' > 0$, $\bar{\beta}'' < 0$, and $\bar{\beta}(0) < \bar{\beta}(\beta_*) < \beta_*$. That is, for a given value of β_j, country i's welfare is smaller (larger) under the FTA than under the MFN if β_i is

[15] Since $\bar{\gamma}^M(\alpha/2) = \alpha(1 - \sqrt{5}/4)$, β_* is explicitly solved as $\beta_* = \alpha(60 - \sqrt{3435})/4 \approx 0.3478\alpha$.

higher (lower) than a critical value. It follows that both member countries will be better off from the FTA formation if these countries' externality parameters are not sufficiently large and not so different. However, if the externality parameters are considerably different, only the country with a lower externality parameter will be better off. The intuition is similar to the case of symmetric countries; since the member countries do not change their standards before and after the formation of an FTA, the optimal external tariffs of the FTA member countries become lower than the MFN tariffs, as demonstrated in Lemma 2. In addition to this tariff complementarity effect and the elimination of mutual tariffs of FTA members lead to an increase in consumption and export in the member countries. The increase in consumption, however, has a negative effect on member country i's welfare if β_i is sufficiently large.

Case (ii): $(s_A, s_B) = (s_L, s_L)$ under MFN and $(s_A, s_B) = (s_H, s_L)$ under FTA The difference in member country A's welfare between MFN and FTA is derived as

$$\begin{aligned} W_A^M - W_A^F &= w_A^M(s_L) + \pi_{BA}^M(s_L) - [w_A^F(s_H) + \pi_{BA}^F(s_L)] \\ &= \frac{323\alpha^2 - 672\alpha\beta_A + 112\beta_A^2}{1120} - \frac{13(3\alpha + 4\beta_B)(81\alpha - 32\beta_B)}{44100}, \end{aligned}$$

which is positive (negative) if

$$\beta_A < (>) 3\alpha - \frac{\sqrt{241047\alpha^2 + 23712\alpha\beta_B - 13312\beta_B^2}}{84\sqrt{5}} \equiv \hat{\beta}(\beta_B).$$

It is verified that $\hat{\beta}' < 0$, $\hat{\beta}'' > 0$, and $\beta_* < \hat{\beta}(\beta_*) < \hat{\beta}(0) < \alpha/2$. Therefore, for a given value of β_B, country A's welfare is larger (smaller) under the FTA than under the MFN if β_A is higher (lower) than a critical value. Intuitively, because country A chooses more stringent standard under the FTA than under MFN, its tariff complementarity effect is strong.[16] This means that the FTA formation increases country A's domestic consumption to a larger extent, which increases its consumer surplus. At the same time, the large reduction in the optimal external tariff reduces the profit from domestic sales and the tariff revenue. However, since the more stringent standard is chosen under the FTA, negative consumption externalities reduce (becomes zero in the present setting), and the benefit

[16]From Lemma 2 and (11), it holds that $t_i^M(s_L) > t_i^F(s_L) = (3\alpha + 4\beta_i)/21 > (\alpha - \gamma)/7 = t_i^F(s_H)$.

from the reduction in the negative externalities becomes larger if β_A is larger. Therefore, for larger values of β_A, country A tends to be better off by the FTA formation.

The difference in member country B's welfare between MFN and FTA is derived as

$$\begin{aligned} W_B^M - W_B^F &= w_B^M(s_L) + \pi_{AB}^M(s_L) - [w_B^F(s_L) + \pi_{AB}^F(s_H)] \\ &= \frac{51\alpha^2 + 336\alpha\beta_B + 224\beta_B^2}{1120} + \frac{(\alpha - 2\beta_A)^2}{100}, \end{aligned}$$

which is unambiguously positive. That is, country B loses from the FTA formation. Intuitively, since Country B does not change its standard, the FTA formation generates the tariff complementarity effect, which increases the domestic consumption but reduces the domestic output. Thus, there is an increase in consumer surplus, but the country also suffers from more negative externalities. In addition, the firm profit from domestic sales and tariff revenue decrease. These negative welfare effects dominate the increase in consumer surplus, and therefore, country B becomes worse off by forming an FTA.

To sum up, in this case, only the country that changes its standard to a more stringent one under the FTA can, if any, gain from the FTA formation.

Case (iii): $(s_A, s_B) = (s_L, s_L)$ under MFN and $(s_A, s_B) = (s_L, s_H)$ under FTA This case is the same as case (ii) with A and B being interchanged. That is, country A unambiguously loses from the FTA formation ($W_A^M > W_A^F$), and country B becomes better off (worse off) from the FTA formation if $\beta_B > \hat{\beta}(\beta_A)$ ($\beta_B < \hat{\beta}(\beta_A)$).

Case (iv): $(s_A, s_B) = (s_L, s_L)$ under MFN and $(s_A, s_B) = (s_H, s_H)$ under FTA From (15), the difference in member country i's welfare between MFN and FTA is

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_L) + \pi_{ji}^M(s_L) - [w_i^F(s_H) + \pi_{ji}^F(s_H)] \\ &= \frac{4\alpha^2 - 6\alpha\beta_i + \beta_i^2}{10} + \frac{(\alpha - 2\beta_j)^2}{100} - \frac{215}{1568}\alpha^2, \end{aligned}$$

which is positive (negative) if

$$\beta_i < (>) 3\alpha - \frac{\sqrt{24583\alpha^2 + 1568\alpha\beta_j - 1568\beta_j^2}}{28\sqrt{5}} \equiv \tilde{\beta}(\beta_B).$$

It is verified that $\tilde{\beta}' < 0$, $\tilde{\beta}'' > 0$, and $\beta_* < \tilde{\beta}(\alpha/2) < \tilde{\beta}(\beta_*) < \alpha/2$. This means that for a given value of β_j, country i's welfare is larger (smaller) under the FTA than under the MFN if β_i is higher (lower) than a critical value, and if β_A and β_B are sufficiently large and close to each other, both countries will gain from the FTA formation. The intuition is basically similar to that of country A in case (ii). That is, since both member countries choose more stringent standard under the FTA than under MFN, they reduce their external tariffs to a larger extent. As a result, both countries enjoy higher consumption and therefore higher consumer surplus, but the profit from domestic sales and the tariff revenue under the FTA are small than those under the MFN. However, the member countries suffer less from negative consumption externalities under the FTA than under the MFN because they set more stringent standards, and country i's benefit from the reduction in the negative externalities becomes larger if β_i is larger. Therefore, for larger values of β_i, the positive welfare effects of the FTA formation in country i will dominate the negative effects. If both β_A and β_B are sufficiently large, both member countries tend to be better off by the FTA formation.

From the analysis of welfare comparison in each case, we obtain the welfare effects of an FTA, as illustrated in Figure 4. This figure shows that, depending on each member country's externality parameter, it is possible that both member countries' welfare will increase under the FTA compared with the MFN, that both member countries' welfare will decrease, or that one member country gains and the other member country loses. In particular, if the member countries' externality parameters are sufficiently close to each other and if these parameters take sufficiently small or sufficiently large value, both members will gain from an FTA conclusion. However, if the externality parameters take medium values, both member countries will lose from the FTA formation. These results are consistent with the symmetric case demonstrated in Lemma 5. In addition, if the externality parameters considerably differ between the members, the welfare effects of the FTA become asymmetric.

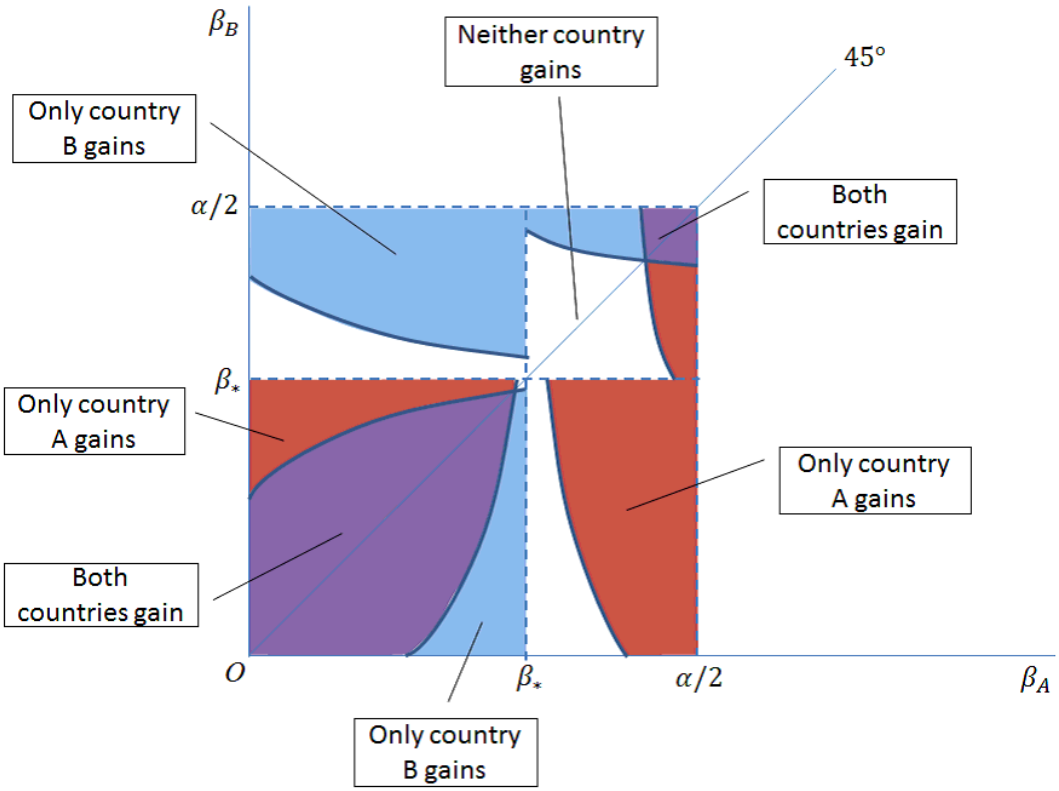

Figure 4: Welfare effects of an FTA for member countries in an asymmetric countries case

Nonmember country In the nonmember country, the national government always chooses the MFN tariff and does not change the standard before and after the formation of FTA. Therefore, comparisons of the nonmember's welfare are equivalent to those of its export profits: $W_C^M - W_C^F = \sum_{i=A,B}[\pi_{iC}^M(s_i) - \pi_{iC}^F(s_i)]$, where

$$\pi_{iC}^F(s_i) = \frac{[a_i(s_i) - 3t_i^F(s_i)]^2}{16} = \frac{[a_i(s_i) - b_i(s_i)]^2}{49}, \quad i = A, B$$

is the export profit in each member country's market.

If the pair of parameters (β_i, γ) for each member country is in either region I or region III in Figure 1, $W_C^M < W_C^F$ holds because $\pi_{iC}^M(s_L) - \pi_{iC}^F(s_L) = -(17\alpha_i - 24\beta_i)(3\alpha_i + 4\beta_i)/4900 < 0$ and $\pi_{iC}^M(s_H) - \pi_{iC}^F(s_H) = -51(\alpha_i - \gamma)^2/4900 < 0$. If (β_i, γ) is in region II, where member country i chooses s_L under the MFN and s_H under the FTA, it holds that

$$\pi_{iC}^M(s_L) - \pi_{iC}^F(s_H) = -\frac{(17\alpha_i - 14\beta_i - 10\gamma)(3\alpha_i + 14\beta_i - 10\gamma)}{4900}.$$

Since $\alpha_i > 2\beta_i$, it holds that $17\alpha_i - 14\beta_i - 10\gamma > 10(\alpha_i - \gamma) > 0$. Therefore, the sign of the above expression is positive (negative) if and only if $\gamma > (<)\ (3\alpha_i + 14\beta_i)/10$ holds. Region

II is contained in the set $\left\{(\beta_i, \gamma) \in \mathbb{R}^2_+ \mid \gamma < (3\alpha_i + 14\beta_i)/10,\ \alpha_i > 2\beta_i\right\}$. Therefore, in region II it holds that $\pi^M_{iC}(s_L) < \pi^F_{iC}(s_H)$, which means that $W^M_C < W^F_C$ holds as well. To sum up, we have the following proposition.

Proposition 2. *In comparison with the MFN, the nonmember country of the FTA unambiguously becomes better off under the formation of an FTA.*

Intuitively, Proposition 2 can be interpreted as follows. When (β_i, γ) is in region I or region III in Figure 1 for both member countries, the nonmember's welfare improvement stems from the tariff complementarity effect shown in Lemma 2. Because the members adopt the same standards under the FTA as under the MFN, the nonmember country will face a lower tariff rate under the FTA than under the MFN, which increases its exports to the member countries and hence export profits of the domestic firm. If (β_i, γ) is in region II, member countries i will tighten up their standards under the FTA, which raises the unit production cost of the firm in the nonmember country. At the same time, as we have shown in (6) and similar result holds for the comparison of $t^F_i(s_H)$ and $t^F_i(s_L)$, a more stringent standard lowers the optimal (external) tariff. Therefore, in region II, the tariff rate that the nonmember country faces under the FTA becomes lower than the MFN tariff in two channels: one is the tariff complementarity effect and the other is a more stringent standards chosen by the FTA member. Because the unit cost is at a "moderate" level in region II, the reduction in the tariff offsets the increase in the unit cost, and thus the nonmember country can increase its export under the FTA.

6 Harmonization of standards

We now consider the second scenario regarding the determination of standards, namely "harmonization". Suppose that the FTA member countries harmonize their standards in addition to eliminate tariffs between them. More specifically, the member countries A and B determine a common standard $s_A = s_B = s \in \{s_L, s_H\}$, taking the standards in the nonmember country s_C as given, in a cooperative manner. As a cooperative solution, we consider a Nash bargaining solution, in which the member countries jointly determine the

common standard s so as to maximize the Nash product $\left[W_A(s) - \bar{W}_A\right]\left[W_B(s) - \bar{W}_B\right]$ subject to the constraints $W_A(s) \geq \bar{W}_A$ and $W_B(s) \geq \bar{W}_B$, where $W_i(s)$ is country i's welfare under harmonization of standards and $\bar{W}_i$ is country i's welfare when negotiations break down. We assume that in the case of disagreement, the member countries choose their respective national standards, denoted by s_A^F and s_B^F, keeping the FTA. Because the nonmember country C chooses the tariffs and standards under the MFN regime, it holds that $W_i(s) = \omega_i(s) + \pi_{Ci}^M(s_C)$ and $\bar{W}_i = \tilde{\omega}_i(s_A^F, s_B^F) + \pi_{Ci}^M(s_C^M)$, where $\omega_i(s) \equiv w_i^F(s) + \pi_{ji}^F(s)$ and $\tilde{\omega}_i(s_A^F, s_B^F) \equiv w_i^F(s_i^F) + \pi_{ji}^F(s_j^F)$, $i, j = A, B$. Therefore, the Nash bargaining problem can be rewritten as follows:

$$\max_s \ \left[\omega_A(s) - \tilde{\omega}_A(s_A^F, s_B^F)\right]\left[\omega_B(s) - \tilde{\omega}_B(s_A^F, s_B^F)\right] \quad \text{s.t. } \omega_i(s) \geq \tilde{\omega}_i(s_A^F, s_B^F) \text{ for } i = A, B. \tag{20}$$

6.1 Symmetric member countries

We begin with the case where the member countries share identical preference parameters. The solution to the problem (20) is characterized by the following lemma.

Lemma 6. *Suppose that countries A and B form an FTA and harmonize their standards. Assuming that $\alpha_A = \alpha_B = \alpha$ and $\beta_A = \beta_B = \beta$, it is optimal for both member countries to choose s_H if $0 < \gamma < \bar{\bar{\gamma}}^F(\beta)$ and s_L if $\bar{\bar{\gamma}}^F(\beta) < \gamma < \alpha$, where $\bar{\bar{\gamma}}^F(\beta) \equiv \alpha - \sqrt{\alpha^2 - \frac{202}{129}\alpha\beta + \frac{23}{387}\beta^2}$.*

(Proof) Since the countries are assumed to be symmetric, either $(s_A^F, s_B^F) = (s_L, s_L)$ or $(s_A^F, s_B^F) = (s_H, s_H)$ holds under national standards. Suppose that $(s_A^F, s_B^F) = (s_L, s_L)$. In light of (11), (12), and (13), it follows that the member countries jointly choose $s = s_H$ if

$$\omega_i(s_H) - \omega_i(s_L) = \frac{387\gamma^2 - 774\alpha\gamma + 606\alpha\beta - 23\beta^2}{882} \tag{21}$$

is positive for $i = A, B$.[17] By straightforward calculation, it can be verified that $\omega(s_H) > \omega(s_L)$ holds if and only if $387\gamma^2 - 774\alpha\gamma + 606\alpha\beta - 23\beta^2 > 0$, or equivalently, given the

[17]The conditions for $s = s_L$ to be chosen are $\omega_A(s_H) \geq \tilde{\omega}_A(s_L, s_L)$, $\omega_B(s_H) \geq \tilde{\omega}_B(s_L, s_L)$, and $[\omega_A(s_H) - \tilde{\omega}_A(s_L, s_L)][\omega_B(s_H) - \tilde{\omega}_B(s_L, s_L)] > [\omega_A(s_L) - \tilde{\omega}_A(s_L, s_L)][\omega_B(s_L) - \tilde{\omega}_B(s_L, s_L)]$. Since $\omega_i(s_L) - \tilde{\omega}_i(s_L, s_L) = 0$ for $i = A, B$, the above three conditions hold if the sign of (21) is positive.

parameter restrictions, $\gamma < \bar{\bar{\gamma}}^F(\beta)$. Conversely, if $\gamma > \bar{\bar{\gamma}}^F(\beta)$, it follows that the member countries jointly choose $s = s_L$. In the case where $(s_A^F, s_B^F) = (s_H, s_H)$, the same results are obtained. □

Since $d\bar{\bar{\gamma}}^F(0)/d\beta = 101\alpha/129 \approx 0.7829\alpha$ and $\bar{\bar{\gamma}}^F(\alpha/2) = (1-\sqrt{359}/6\sqrt{43})\alpha \approx 0.5184\alpha$, it follows that $\bar{\gamma}^M(\beta) < \bar{\bar{\gamma}}^F(\beta) < \bar{\gamma}^F(\beta)$ for all $\beta \in (\alpha/2)$. This implies that, in light of Lemmas 3 and 6, region II in Figure 1 is further partitioned into two subregions: one in which s_H is chosen by member countries both under national standards and harmonization (when $\bar{\gamma}^M(\beta) < \gamma < \bar{\bar{\gamma}}^F(\beta)$), and the other in which s_H is chosen under the national standards but s_L is chosen under harmonization (when $\bar{\bar{\gamma}}^F(\beta) < \gamma < \bar{\gamma}^F(\beta)$). See also Figure 5.

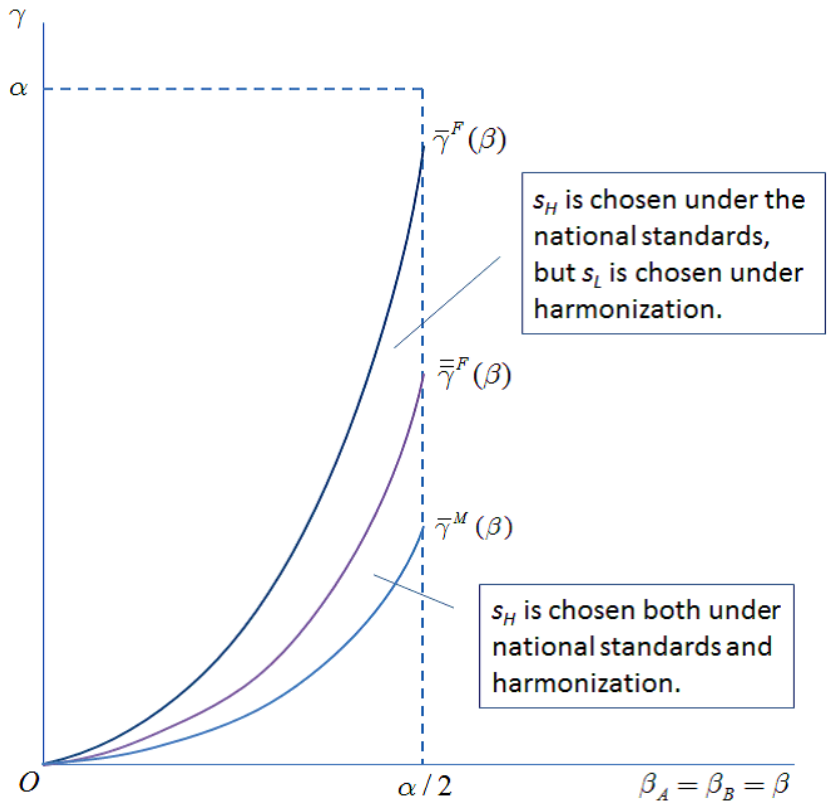

Figure 5: Harmonization of standards under the FTA in the symmetric case

Proposition 3. *The FTA member countries have an incentive to choose less stringent standards when they harmonize their standards than when they choose their respective national standards.*

Intuitively, Proposition 3 can be interpreted as follows. If the FTA member countries determine their respective standards independently, their objective is to maximize the domestic surplus $w_i^F(s_i)$. By contrast, if the member countries harmonize their standards, they can take into account the export profit in the FTA partner's market $\pi_{ij}^F(s)$ as well as the domestic surplus $w_i^F(s)$ because the FTA partner chooses the same standard ($s_i = s_j = s$). Because an increase in the standard reduces the export profit in the FTA partner's market, compared to the national standards, each member country should adopt less stringent standards under harmonization.[18]

Let us conclude this subsection by analyzing the welfare effects of the FTA with harmonization of standards. For the nonmember country, it is verified that Proposition 2 remains valid; the nonmember country unambiguously gains from a formation of FTAs. For the member countries, because $\bar{\gamma}^M(\alpha/2) < \tilde{\gamma}(\alpha/2) < \bar{\bar{\gamma}}^F(\alpha/2)$ holds, we obtain the following lemma.

Lemma 7. *For the FTA member countries $i = A, B$, the national welfare under the FTA and harmonization of standards compared with the MFN is as follows.*
(i) If $\bar{\bar{\gamma}}^F(\beta) < \gamma < \alpha$, $W_i^M > W_i^F$ ($W_i^M < W_i^F$) for $\beta > (<)\ 423\alpha/1256$.
(ii) If $\tilde{\gamma}(\beta) < \gamma < \bar{\bar{\gamma}}^F(\beta)$, $W_i^M > W_i^F$.
(iii) If $0 < \gamma < \tilde{\gamma}(\beta)$, $W_i^M < W_i^F$.

From Lemmas 5 and 7, we find that if β and γ are of moderate size, the member countries' welfare under the FTA becomes higher than the MFN level when they jointly determine the standards even though the opposite holds when they determine their respective standards independently, as illustrated by the shaded area in Figure 6. In other regions, such a reversal of welfare ranking between the MFN and the FTA does not occur. The reversal of the welfare ranking implies that harmonization of standards within an FTA makes the formation of the FTA more favorable.

Proposition 4. *Suppose that the member countries have identical preferences as well as technologies. Then, regional harmonization of standards increases the gains from an FTA*

[18]Notice that similar intuition and result hold under more general economic environment, as demonstrated by Takarada et al. (2016) assuming free trade in goods.

formation in the sense that there exists a set of parameters (β, γ) *in which, for* $i = A, B$, $W_i^M > W_i^F$ *holds when the member countries seek their national standards but* $W_i^M < W_i^F$ *holds under harmonization of standards.*

Proposition 4 has the following implications. The FTA member countries prefer harmonizing their standards in addition to remove tariffs between them. This can explain the recent regional and preferential economic agreements being the form of harmonized domestic regulations as well as tariff reductions. Notice that the less stringent standards are chosen by the members at the expense of increasing the gains from FTA.

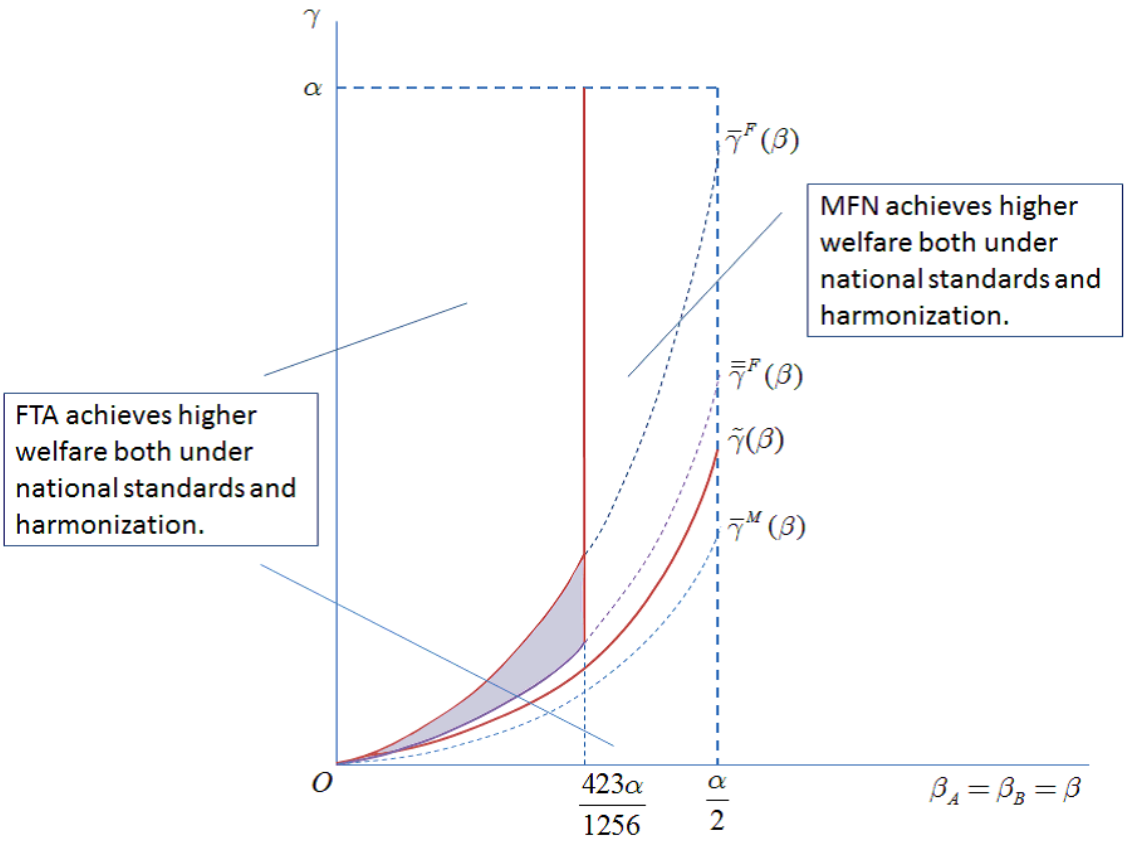

Figure 6: Comparison of the welfare effects of FTA between national standards and harmonization in the symmetric case

6.2 Asymmetric member countries

We next consider a situation in which preferences can differ across member countries and discuss how our findings under the assumption of symmetric countries can be affected.

As in the previous section, we focus on the case where $\alpha_A = \alpha_B = \alpha$ and γ is equal to $\bar{\gamma}^M(\alpha/2)$. As noted in the previous section, there are four cases, i.e., from (i) to (ix) in Table 1, and the equilibrium configurations of the member countries' national standards are illustrated in Figure 3.

Case (i): $(s_A^F, s_B^F) = (s_L, s_L)$ under national standards In this case, if $\omega_i(s_H) > \tilde{\omega}_i(s_L, s_L) = \omega_i(s_L)$ for $i = A, B$, $s = s_H$ is the Nash bargaining solution. Otherwise, $s_A = s_B = s_L$ is the equilibrium outcome.[19] Comparing $\omega_i(s_H)$ and $\omega_i(s_L)$, we have

$$\begin{aligned}\omega_i(s_H) - \omega_i(s_L) &= w_i^F(s_H) + \pi_{ji}^F(s_H) - w_i^F(s_L) - \pi_{ji}^F(s_L) \\ &= \frac{-336\beta_i^2 + 10080\alpha\beta_i - (4257\alpha^2 + 384\alpha\beta_j + 32\beta_j^2)}{14112}.\end{aligned}$$

Suppose that the sign of the above equation is positive, which is possible if

$$\beta_i < 15\alpha - \frac{\sqrt{71343\alpha^2 - 384\alpha\beta_j - 32\beta_j^2}}{4\sqrt{21}}. \tag{22}$$

It is easily verified that the right-hand side of (22) is increasing in β_j. In addition, $\beta_i = (420 - \sqrt{166467})\alpha/28 \approx 0.4284\alpha$ if $\beta_j = 0$ and $\beta_i = (60 - \sqrt{2453 + 16\sqrt{3435}})\alpha/4 \approx 0.4424\alpha$ if $\beta_j = \beta_*$. Both of these values for β_i are strictly greater than β_*, and thus contradicts $(\beta_A, \beta_B) \in [0, \beta_*] \times [0, \beta_*]$. Therefore, it must hold that $\omega_i(s_H) < \omega_i(s_L)$ for $i = A, B$, and thus, we have the Nash bargaining solution $s = s_L$.

Case (ii): $(s_A^F, s_B^F) = (s_H, s_L)$ under national standards In this case, $s = s_L$ is chosen as a Nash bargaining solution if $\omega_A(s_L) \geq \tilde{\omega}_A(s_H, s_L)$, $\omega_B(s_L) \geq \tilde{\omega}_B(s_H, s_L)$, and $[\omega_A(s_L) - \tilde{\omega}_A(s_H, s_L)][\omega_B(s_L) - \tilde{\omega}_B(s_H, s_L)] > [\omega_A(s_H) - \tilde{\omega}_A(s_H, s_L)][\omega_B(s_H) - \tilde{\omega}_B(s_H, s_L)]$. However,

$$\omega_A(s_L) - \tilde{\omega}_A(s_H, s_L) = w_A^F(s_L) - w_A^F(s_H) = \frac{165\alpha^2 - 480\alpha\beta_A + 16\beta_A^2}{672}$$

is equal to 0 if $\beta_A = \beta_*$ and negative for $\beta_A \in (\beta_*, \alpha/2)$. This means that country A has no incentive to join in the bargaining. By contrast, country B has an incentive to participate

[19] If $\omega_i(s_L) > \tilde{\omega}_i(s_H, s_H) = \omega_i(s_H)$ for $i = A, B$, $s = s_L$ is the Nash bargaining solution. If $\omega_i(s_H) < \omega_i(s_L)$ but $\omega_j(s_H) > \omega_j(s_L)$, $i \neq j$, the member countries fail to reach an agreement. In this case, these countries implement national standards, which are $s_A^F = s_L$ and $s_B^F = s_L$.

in the bargaining since

$$\omega_B(s_L) - \tilde{\omega}_B(s_H, s_L) = \pi^F_{AB}(s_L) - \pi^F_{AB}(s_H) = \frac{99\alpha^2 + 48\alpha\beta_A + 4\beta_A^2}{1764} > 0.$$

Suppose, then, country B makes an international transfer to compensate country A's welfare loss. Now the question is whether $[\omega_A(s_L) - \tilde{\omega}_A(s_H, s_L)][\omega_B(s_L) - \tilde{\omega}_B(s_H, s_L)] > [\omega_A(s_H) - \tilde{\omega}_A(s_H, s_L)][\omega_B(s_H) - \tilde{\omega}_B(s_H, s_L)]$ holds, or equivalently, whether $[w^F_A(s_L) - w^F_A(s_H)][\pi^F_{AB}(s_L) - \pi^F_{AB}(s_H)] - [\pi^F_{BA}(s_H) - \pi^F_{BA}(s_L)][w^F_B(s_H) - w^F_B(s_L)]$ is positive. A straightforward calculation yields

$$\begin{aligned}&[w^F_A(s_L) - w^F_A(s_H)][\pi^F_{AB}(s_L) - \pi^F_{AB}(s_H)] - [\pi^F_{BA}(s_H) - \pi^F_{BA}(s_L)][w^F_B(s_H) - w^F_B(s_L)] \\ &= \frac{\alpha(\beta_A - \beta_B)(-660\alpha^2 + 32\beta_A\beta_B + 11\alpha(\beta_A + \beta_B)}{14112},\end{aligned}$$

which unambiguously negative since we are considering the case of $\beta_A > \beta_B$ and it holds that $-660\alpha^2 + 32\beta_A\beta_B + 11\alpha(\beta_A + \beta_B) < 0$. Therefore, even though the transfer from country B to country A is made, $s = s_L$ cannot be a Nash bargaining solution.

We next consider the possibility that $s = s_H$ is chosen as a bargaining solution, which occurs if $\omega_A(s_H) \geq \tilde{\omega}_A(s_H, s_L)$, $\omega_B(s_H) \geq \tilde{\omega}_B(s_H, s_L)$, and $[\omega_A(s_H) - \tilde{\omega}_A(s_H, s_L)][\omega_B(s_H) - \tilde{\omega}_B(s_H, s_L)] > [\omega_A(s_L) - \tilde{\omega}_A(s_H, s_L)][\omega_B(s_L) - \tilde{\omega}_B(s_H, s_L)]$. However, since

$$\omega_A(s_H) - \tilde{\omega}_A(s_H, s_L) = \pi^F_{BA}(s_H) - \pi^F_{BA}(s_L) = -\frac{99\alpha^2 + 48\alpha\beta_A + 4\beta_A^2}{1764} < 0$$

and

$$\omega_B(s_H) - \tilde{\omega}_B(s_H, s_L) = w^F_B(s_H) - w^F_B(s_L) = -\frac{165\alpha^2 - 480\alpha\beta_B + 16\beta_B^2}{672}$$

is nonpositive if $\beta_B \leq \beta_*$, both countries have no incentive to join in the bargaining.

To sum up, the bargaining for harmonization breaks down in this case.

Case (iii): $(s^F_A, s^F_B) = (s_L, s_H)$ under national standards This case is the same as case (ii) with A and B being interchanged. That is, the member countries fail to achieve the harmonization of standards.

Case (iv): $(s^F_A, s^F_B) = (s_H, s_H)$ under national standards In this case, if $\omega_i(s_L) > \tilde{\omega}_i(s_H, s_H) = \omega_i(s_H)$ for $i = A, B$, $s = s_L$ is the Nash bargaining solution. Otherwise,

$s_A = s_B = s_H$ is the equilibrium outcome.[20] As demonstrated in the analysis of case (i), $\omega_i(s_H) > \omega_i(s_L)$ holds if the parameters satisfy (22). The right-hand side of this inequality is shown to be increasing and convex, and it holds that $\beta_i = (60 - \sqrt{2453 + 16\sqrt{3435}})\alpha/4 \approx 0.4424\alpha > \beta_*$ if $\beta_j = \beta_*$ and $\beta_i = (60 - \sqrt{71143/21})\alpha/4 \approx 0.4489\alpha \in (\beta_*, \alpha/2)$ if $\beta_j = \alpha/2$. Therefore, if (β_A, β_B) is in the area northeast of $\omega_A(s_H) = \omega_A(s_L)$ curves and $\omega_B(s_H) = \omega_B(s_L)$ in Figure 7, the member countries harmonize their standards and choose $s = s_H$. By contrast, if (β_A, β_B) is in the area southwest of these curves, they jointly choose $s = s_L$. In other areas, the member countries fail to achieve harmonization of standards, and thus, individually choose s_H.

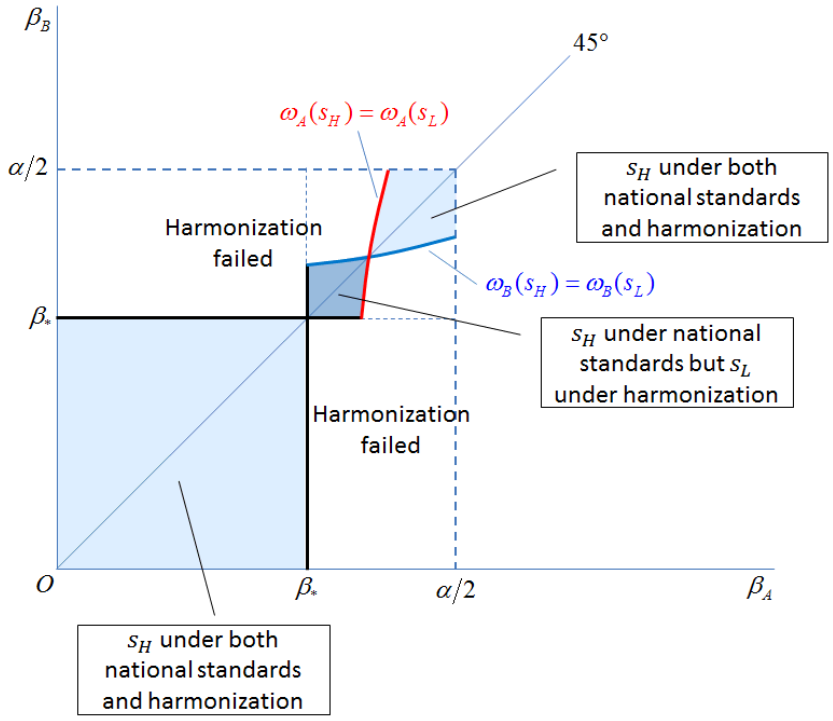

Figure 7: Harmonization of standards under an FTA in an asymmetric countries case

To sum up the above discussion, we obtain the outcome of negotiation over harmonization of standards, as illustrated in Figure 7. The member countries will agree on harmonizing their standards only if the pair of parameters (β_A, β_B) is in the shaded area; if there is a considerable asymmetry in the externality parameter, the member countries

[20] If $\omega_i(s_H) > \omega_i(s_L)$ for $i = A, B$, $s = s_H$ is the Nash bargaining solution. If the signs of $\omega_A(s_H) - \omega_A(s_L)$ and $\omega_B(s_H) - \omega_B(s_L)$ differ, the member countries fail to reach an agreement and thus, these countries implement national standards, i.e., $s_A^F = s_B^F = s_H$.

fail to achieve harmonization. In addition, if β_A and β_B are of intermediate values (dark-shaded area in Figure 7), the member countries will choose $s = s_L$ under harmonization even though they individually choose s_H under national standards. That is, we can confirm that Proposition 3 remains valid in the presence of an asymmetry considered here.

We conclude this subsection by discussing whether harmonization of standards increases the gains from an FTA formation. We are interested in the case where the member countries will choose less stringent standards when they harmonize their standards than when they choose their respective national standards, i.e., the dark-shaded area in Figure 7. In this case, under national standards, $W_i^M > W_i^F$ holds for both member countries $i = A, B$, as shown in Figure 4. However, under harmonization, the comparison of W_i^M and W_i^F follows (19), and it was shown that $W_i^M > W_i^F$ if $\beta_i > \bar{\beta}(\beta_j)$ and vice versa. It can be verified that $\bar{\beta}(\alpha/2) = (\sqrt{887250} - 630)\alpha/840 \approx 0.3714\alpha > \beta_*$, which means that the curve $\beta_i = \bar{\beta}(\beta_j)$ goes through the dark-shaded area, as illustrated in Figure 8. It follows that if $\beta_i \in (\beta_*, \bar{\beta}(\beta_j))$, $W_i^M < W_i^F$ and $W_j^M > W_j^F$ hold for $i, j = A, B$, $j \neq i$. That is, one of the member countries can gain from an FTA formation when these countries harmonize their standards even though they both lose from the FTA formation in the absence of harmonization.[21]

7 Transboundary Externalities

In this section, we extend our basic model by incorporating transboundary consumption externalities. A typical example of standards related to transboundary externalities is the regulation to limit automotive exhaust emissions. For analytical tractability, we focus on the situation in which all countries are symmetric in terms of preferences as well as technologies.

Let us denote the degree of transboundary externalities by $\delta \in [0, 1]$. Then, the representative consumer's utility function is rewritten as $U(Q_i, Y_i; s_i, \bar{Q}_i) = u(Q_i) + Y_i - b(s_i)\bar{Q}_i -$

[21] In this example, only one country can gain from an FTA formation under harmonization. This is because we set $\gamma = \bar{\gamma}^M(\alpha/2)$. If we assume a case where γ is sufficiently lower than $\bar{\gamma}^M(\alpha/2)$, Figure 6 infers that there can be the case where harmonization of standards facilitates an improvement in member countries' welfare under an FTA.

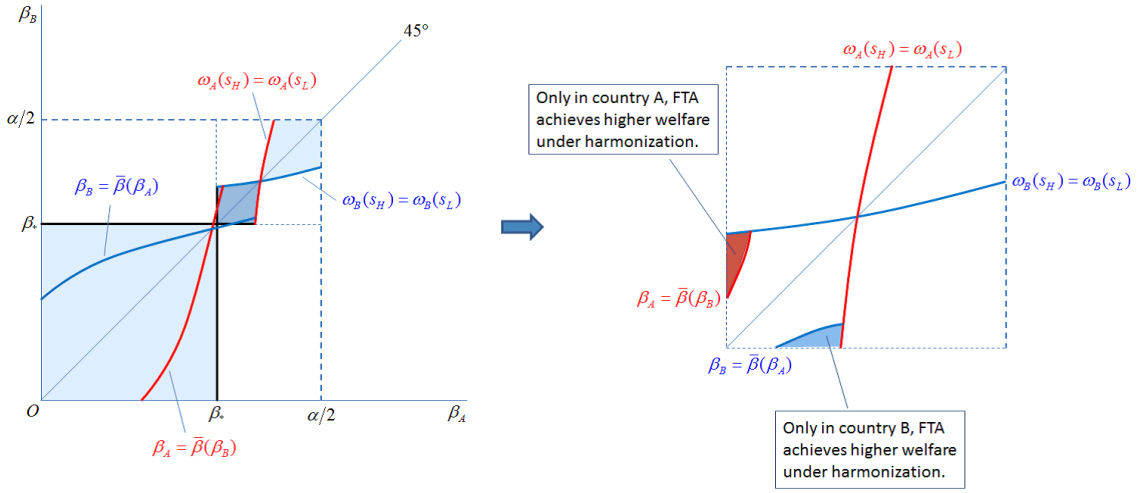

Figure 8: Welfare effects of an FTA with harmonization of standards in an asymmetric countries case

$\sum_{j\neq i}\delta b(s_j)\bar{Q}_j$,[22] and hence the national welfare (3) is rewritten as

$$\begin{aligned} W_i = {} & \frac{[3a(s_i)-t_{ij}-t_{ik}]^2}{32}+\frac{[a(s_i)+t_{ij}+t_{ik}]^2}{16}+\frac{[a(s_j)-3t_{ji}+t_{jk}]^2}{16}+\frac{[a(s_k)-3t_{ki}+t_{kj}]^2}{16} \\ & + t_{ij}\frac{a(s_i)-3t_{ij}+t_{ik}}{4}+t_{ik}\frac{a(s_i)+t_{ij}-3t_{ik}}{4}-b(s_i)\frac{3a(s_i)-t_{ij}-t_{ik}}{4} \\ & - \delta\left[b(s_j)\frac{3a(s_j)-t_{ji}-t_{jk}}{4}+b(s_k)\frac{3a(s_k)-t_{ki}-t_{kj}}{4}\right]. \end{aligned} \tag{23}$$

The above expression implies that the presence of transboundary externalities does not affect the first-order conditions for optimal unilateral tariffs. Therefore, the optimal tariff formulas, i.e., (5) under the MFN and (11) under an FTA, are still valid when transboundary externalities exist.

7.1 MFN

In the presence of transboundary externalities, the national welfare under the MFN can now be rewritten as $W_i^M = w_i^M(s_i)+\eta_{ji}^M(s_j)+\eta_{ki}^M(s_k)$, where the domestic surplus $w_i^M(s_i)$ is defined by (7) and

$$\begin{aligned} \eta_{li}^M(s_l) &\equiv \pi_{li}^M(s_l)-\delta b(s_l)Q_l \\ &= \frac{[a(s_l)-2t^M(s_l)]^2}{16}-\delta b(s_l)\frac{3a(s_l)-2t^M(s_l)}{4}, \quad l=j,k \end{aligned} \tag{24}$$

[22]Because of the symmetry assumption, we omit the subscripts in the subutility function u and the per-unit externality function b.

is the net export profits deducted the costs of transboundary externalities.

Notice that because the optimal standards depend on the comparison between $w_i^M(s_H)$ and $w_i^M(s_L)$, the replacement of $\pi_{li}^M(s_l)$ by $\eta_{li}^M(s_l)$ due to the presence of transboundary externalities does not affect the condition under which whether s_H or s_L is chosen. In other words, Lemma 1 is still valid.

7.2 FTA with national standards

After the formation of an FTA between countries A and B, each member country's national welfare can be rewritten as $W_i^F = w_i^F(s_i) + \eta_{ji}^F(s_j) + \eta_{Ci}^M(s_C)$, $i = A, B$, where the domestic surplus $w_i^F(s_i)$ is the same as (12) and

$$\begin{aligned} \eta_{ji}^F(s_j) &\equiv \pi_{ji}^F(s_j) - \delta b(s_j) Q_j \\ &= \frac{[a(s_j) + t^F(s_j)]^2}{16} - \delta b(s_j) \frac{3a(s_j) - t^F(s_j)}{4} \end{aligned} \tag{25}$$

is the export profits net of transboundary externality costs associated with the FTA member country.

Again, the presence of transboundary externalities does not affect the optimal choice of standards characterized in Lemma 3. Therefore, Lemma 4 also holds, and so does Proposition 1. That is, in comparison with the MFN, an FTA makes the member countries to choose more stringent standards.

The welfare effects of the FTA compared with the MFN are obtained by a comparison between W_i^M and W_i^F, as implemented in section 5. Given the components of national welfare explained above, the welfare effects can be dependent on the degree of transboundary externalities, δ, as well as the other parameters β and γ.

Let us begin with the welfare comparison in the member countries. As in the case without transboundary externalities, there are three possibilities, i.e., the case where the member countries choose s_L both under the MFN and FTA (region I in Figure 1), the case where the member countries choose s_L under the MFN but they choose s_H under the FTA (region II), and the case where the member countries choose s_H both under the MFN and FTA (region III), depending on the values of β and γ. In region I, the difference between

W_i^M and W_i^F is

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_L) + \eta_{ji}^M(s_L) - [w_i^F(s_L) + \eta_{ji}^F(s_L)] \\ &= -\frac{(3\alpha + 4\beta)[423\alpha - 8(157 + 210\delta)]}{44100}, \end{aligned}$$

from which it holds that $W_i^M > W_i^F$ ($W_i^M < W_i^F$) if and only if $\beta > (<)$ $423\alpha/[8(157 + 210\delta)]$. The cutoff value for β becomes smaller if δ becomes higher, implying that the transboundary externalities make the formation of an FTA less beneficial for the member countries when these countries choose a low standard both under the MFN and FTA.

In region II, the difference between W_i^M and W_i^F is

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_L) + \eta_{ji}^M(s_L) - [w_i^F(s_H) + \eta_{ji}^F(s_H)] \\ &= \frac{-2150\gamma^2 + 4300\alpha\gamma - 141\alpha^2 - 196(16 + 15\delta)\alpha\beta + 98(7 + 10\delta)\beta^2}{4900}, \end{aligned}$$

which becomes positive (negative) if and only if

$$\gamma > (<)\ \tilde{\gamma}(\beta, \delta) \equiv \alpha - \frac{7}{5}\sqrt{\frac{41}{86}\alpha^2 - \frac{32 + 30\delta}{43}\alpha\beta + \frac{7 + 10\delta}{43}\beta^2}.$$

Note that $\tilde{\gamma}(\beta, \delta)$ is increasing in δ:

$$\frac{\partial\tilde{\gamma}(\beta, \delta)}{\partial\delta} = \frac{7\beta(3\alpha - \beta)}{43\sqrt{\frac{41}{86}\alpha^2 - \frac{32+30\delta}{43}\alpha\beta + \frac{7+10\delta}{43}\beta^2}} > 0.$$

In other words, an increase in the degree of transboundary externalities make the formation of an FTA more beneficial for the member countries in the case where the member countries choose more stringent standard under the FTA than under the MFN. Finally, in region III, all countries choose s_H both under the MFN and FTA and the analysis in the absence of transboundary externalities remains valid since $b(s_H) = 0$ in the present model.

While transboundary externalities narrow the region in which $W_i^M < W_i^F$ holds for the member countries when these countries choose the low standard both under the MFN and FTA, the region with $W_i^M < W_i^F$ expands when the member countries choose more stringent standard under the FTA than under the MFN. Intuitively, these findings can be interpreted as follows. A formation of an FTA increases consumption in member countries, and so does the consumption externalities for a given standard. In the presence of

transboundary externalities, the social costs of externalities become higher if the member countries choose the same standard both under the MFN and FTA. Because of this, transboundary externalities will have a pressure to reduce welfare under the FTA in region I. In region II, however, the member countries choose more stringent standards under the FTA than the MFN equilibrium, and in this particular model, $b(s_H) = 0$ and hence the social costs of externalities disappear completely under the FTA. Therefore, the advantage of the FTA in terms of the social costs of externalities increases as δ becomes higher.

Let us proceed to the nonmember country's welfare. Comparisons of the nonmember's welfare are now equivalent to those of its export profits net of the social costs of transboundary externalities since $W_C^M - W_C^F = 2[\eta_{iC}^M(s_i) - \eta_{iC}^F(s_i)]$, $i = A, B$, where

$$\eta_{iC}^F(s_i) = \frac{[a(s_i) - 3t^F(s_i)]^2}{16} - \delta b(s_i)\frac{3a(s_i) - t^F(s_i)}{4}.$$

If member countries choose s_L both before and after the formation of the FTA (i.e., region I in Figure 1), it holds that

$$\eta_{iC}^M(s_L) - \eta_{iC}^F(s_L) = -\frac{(3\alpha + 4\beta)[51\alpha - 8(9 + 70\delta)\beta]}{14700}.$$

As shown in section 5, given the condition $\alpha > 2\beta$, the sign of the above equation is unambiguously negative if $\delta = 0$. However, even if the condition $\alpha > 2\beta$ is satisfied, the sign of the above equation can be positive when $\delta > (51\alpha - 72\beta)/560\beta$. The intuition behind this result is similar to the narrowing of the region in which $W_i^M < W_i^F$ holds in region I for the member countries: since an FTA increases consumption in member countries, the consumption externalities in these countries become larger, and if the degree of transboundary externalities is sufficiently high, the social costs of transboundary externalities may outweigh the benefit of the FTA which the nonmember country can earn.

In the case where the member countries choose s_L under the MFN and s_H under the FTA (i.e., region II), it follows that

$$\eta_{iC}^M(s_L) - \eta_{iC}^F(s_H) = -\frac{(17\alpha - 14\beta - 10\gamma)(3\alpha + 14\beta - 10\gamma) + 980\delta\beta(3\alpha - \beta)}{4900},$$

the sign of which is, in view of the discussion in section 5, unambiguously negative for any $\delta \in [0, 1]$. Therefore, as in the case of no transboundary externalities, the nonmember

country becomes better off under the FTA. Finally, if the member countries choose s_H both under the MFN and FTA, $\pi_{iC}^M(s_H) - \pi_{iC}^F(s_H) = -51(\alpha-\gamma)^2/4900 < 0$ holds, as in the case of no transboundary externalities, because $b(s_H) = 0$.

Proposition 5. *In comparison with the MFN, the nonmember country of the FTA may be worse off under the formation of an FTA if $\bar{\gamma}^F(\beta) < \gamma < \alpha$ and if the degree of transboundary externalities is sufficiently high.*

7.3 FTA with harmonization of standards

As examined in section 6, the FTA member countries jointly determine a common standard $s_A = s_B = s$ by means of a Nash bargaining. In the presence of transboundary externalities, the problem is equivalent to

$$\max_s \left[\hat{\omega}_A(s) - \tilde{\hat{\omega}}_A(s_A^F, s_B^F)\right]\left[\hat{\omega}_B(s) - \tilde{\hat{\omega}}_B(s_A^F, s_B^F)\right] \quad \text{s.t. } \hat{\omega}_i(s) \geq \tilde{\hat{\omega}}_i(s_A^F, s_B^F) \text{ for } i = A, B, \tag{26}$$

where $\hat{\omega}_i(s) \equiv w_i^F(s) + \eta_{ji}^F(s)$ and $\tilde{\hat{\omega}}_i(s_A^F, s_B^F) \equiv w_i^F(s_i^F) + \eta_{ji}^F(s_j^F)$, $i.j = A, B$. It is verified that

$$\begin{aligned}\hat{\omega}_i(s_H) - \hat{\omega}_i(s_L) &= \omega_i(s_H) - \omega_i(s_L) + \frac{\delta b(s_L)[3a(s_L) - t^F(s_L)]}{4} \\ &= \frac{387\gamma^2 - 774\alpha\gamma + (606 + 630\delta)\alpha\beta - (23 + 42\delta)\beta^2}{882}, \quad i = A, B, \end{aligned} \tag{27}$$

where $\omega_i(s) = w_i^F(s) + \pi_{ji}^F(s)$ as is defined in section 6. Therefore, as in the proof of Lemma 6, it can be verified that there exists a cutoff value for γ given by

$$\bar{\bar{\gamma}}^F(\beta, \delta) \equiv \alpha - \sqrt{\alpha^2 - \frac{202 + 210\delta}{129}\alpha\beta + \frac{23 + 42\delta}{387}\beta^2}$$

and that if γ is higher than this value, the member countries jointly choose s_L, while the member countries choose s_H if γ is lower than the cutoff value. It is easily verified that this cutoff value is increasing in δ. This implies that, as expected, the existence of transboundary externalities motivates the FTA member countries to choose more stringent standards if they harmonize their standards.

Compared with the cutoff value in the case of national standards under the FTA, it follows that

$$\begin{aligned}
&\bar{\gamma}^F(\beta) - \bar{\bar{\gamma}}^F(\beta,\delta) \\
&= \sqrt{\alpha^2 - \frac{202+210\delta}{129}\alpha\beta + \frac{23+42\delta}{387}\beta^2} - \sqrt{\alpha^2 - 2\alpha\beta + \frac{\beta^2}{15}} \\
&> 0\ (<0) \quad \Leftrightarrow \quad 15\alpha(4-15\delta) - \beta(1-15\delta) > 0\ (<0).
\end{aligned}$$

Therefore, in contrast to the case without transboundary externalities, $\bar{\bar{\gamma}}^F(\beta,\delta)$ can be larger than $\bar{\gamma}^F(\beta)$ if the degree of transboundary externalities satisfies[23]

$$\frac{60\alpha-\beta}{15(15\alpha-\beta)} < \delta < \frac{387\alpha^2 - 606\alpha\beta + 23\beta^2}{42(15\alpha-\beta)\beta}.$$

That is, for sufficiently high values of δ, there can exist a set of parameters (β,γ) in which the member countries choose s_H under harmonization but choose s_L under the national standards, or in other words, Proposition 3 may not hold. The possibility that $\bar{\bar{\gamma}}^F(\beta,\delta)$ can be larger than $\bar{\gamma}^F(\beta)$ implies that the ranking of welfare gains from an FTA between national standards and harmonization, illustrated in Figure 6, can be reversed; if $\bar{\bar{\gamma}}^F(\beta,\delta) > \bar{\gamma}^F(\beta)$, there exists a set of parameters (β,γ) in which, for $i = A, B$, $W_i^M < W_i^F$ holds under national standards but $W_i^M > W_i^F$ holds under harmonization.

Proposition 6. *If the degree of transboundary externalities is sufficiently high, regional harmonization of standards may induce the FTA member countries to choose more stringent standards than those under national standards and may reduce the gains from an FTA formation.*

8 Concluding Remarks

In this paper, we have considered both product standard and FTA to show how these new and traditional policy tools are strategically interacted. Constructing a three-country model of international oligopoly with endogenous determination of tariffs and standards on products that cause negative consumption externalities in the presence of possible FTA, we

[23]The left-hand side of this inequality comes from $15\alpha(4-15\delta) - \beta(1-15\delta) < 0$. The right-hand side comes from the constraint that $\bar{\bar{\gamma}}^F(\beta,\delta)$ should be a real number for given parameter values. Notice that if $\beta < \alpha/2$, it holds that $0 < (60\alpha-\beta)/[15(15\alpha-\beta)] < 1$.

examine the level of standards and welfare levels of FTA member/nonmember countries. Furthermore, we clarify the effect of harmonization of standards on these two items.

The main results that we obtained are as follows: (i) Compared with the MFN, and FTA makes the member countries to choose more stringent standards; (ii) Compared with the MFN, the FTA member countries may or may not be better off under the formation of an FTA, while the nonmember country becomes better off; and (iii) Harmonization of standards within an FTA will lead the member countries to choose less stringent standards than national standards case and make the formation of the FTA more favorable. We verified the robustness of the results. As long as the asymmetries in preferences or transboundary externalities are not so large, these results hold. These results will have implications for the recent movement towards regionalism that takes harmonization of domestic policies into consideration as well as liberalizing trade in goods.

Throughout this paper we focused on FTAs as a form of preferential trade agreement, and have not considered the case of a customs union (CU), where member countries set a common external tariff, harmonizing their external trade policy. Our next task is to examine the effects of CU with endogenous determination of standards. Of another interest is the analysis of dynamic time-path problem that considers whether regional standards are stumbling blocks or building blocks toward multilateral harmonization. There are also a number of possible extensions of the basic model such as difference in technologies among countries, generalization of demand functions, introduction of quality improving R&D, and sequential determination of trade and domestic policies.

Appendix

A.1 Simultaneous determination of tariffs and standards

In this Appendix, we show that when the governments simultaneously determine their tariffs and standards, the optimal policy mix is the same as that under the sequential policy choice.

Let us consider the policy game under MFN. The government in country i chooses t_i and s_i so as to maximize (4). If $s_i = s_H$, (4) is rewritten as

$$W_i = \frac{[3(\alpha_i - \gamma) - 2t_i]^2}{32} + \frac{(\alpha_i - \gamma + 2t_i)^2}{16} + t_i \frac{\alpha_i - \gamma - 2t_i}{2} - \theta\beta_i \frac{3(\alpha_i - \gamma) - 2t_i}{4} + \Pi_{-i}$$
$$\equiv W_i^H, \tag{A.1}$$

whereas it is rewritten as

$$W_i = \frac{(3\alpha_i - 2t_i)^2}{32} + \frac{(\alpha_i + 2t_i)^2}{16} + t_i \frac{\alpha_i - 2t_i}{2} - \beta \frac{3\alpha_i - 2t_i}{4} + \Pi_{-i} \equiv W_i^L \tag{A.2}$$

if $s_i = s_L$, where $\Pi_{-i} \equiv \{[a_j(s_j) - 2t_j]^2 + [a_k(s_k) - 2t_k]^2\}/16$. A direct comparison between (A.1) and (A.2) reveals that it is optimal for country i to choose s_H (s_L) if and only if

$$t_i < (>) \frac{24\beta_i[\alpha_i(1-\theta) + \theta\gamma] - 11\gamma(2\alpha_i - \gamma)}{4[4(1-\theta)\beta_i + 3\gamma]} \equiv \hat{t}_i. \tag{A.3}$$

From (A.1) and (A.2), the local maxima of W_i^H and W_i^L are attained at $t_i = [3(\alpha_i - \gamma) + 4\theta\beta_i]/10$ and $t_i = (3\alpha_i + 4\beta_i)/10$, respectively. In light of (A.1), (A.2), (A.3), and the inequality that $[3(\alpha_i - \gamma) + 4\theta\beta_i]/10 < (3\alpha_i + 4\beta_i)/10$, the relationship between W_i and t_i is derived as

$$W_i = \begin{cases} W_i^H & \text{if } t_i \leq \hat{t}_i, \\ W_i^L & \text{if } t_i \geq \hat{t}_i. \end{cases} \tag{A.4}$$

Depending on the parameter values, there are three possibilities: (i) $[3(\alpha_i - \gamma) + 4\theta\beta_i]/10 < \hat{t}_i < (3\alpha_i + 4\beta_i)/10$, (ii) $\hat{t}_i < [3(\alpha_i - \gamma) + 4\theta\beta_i]/10 < (3\alpha_i + 4\beta_i)/10$, and (iii) $[3(\alpha_i - \gamma) + 4\theta\beta_i]/10 < (3\alpha_i + 4\beta_i)/10 < \hat{t}_i$. See also Figure A.1.[24]

[24]Notice that $\hat{t}_i$ is uniquely determined.

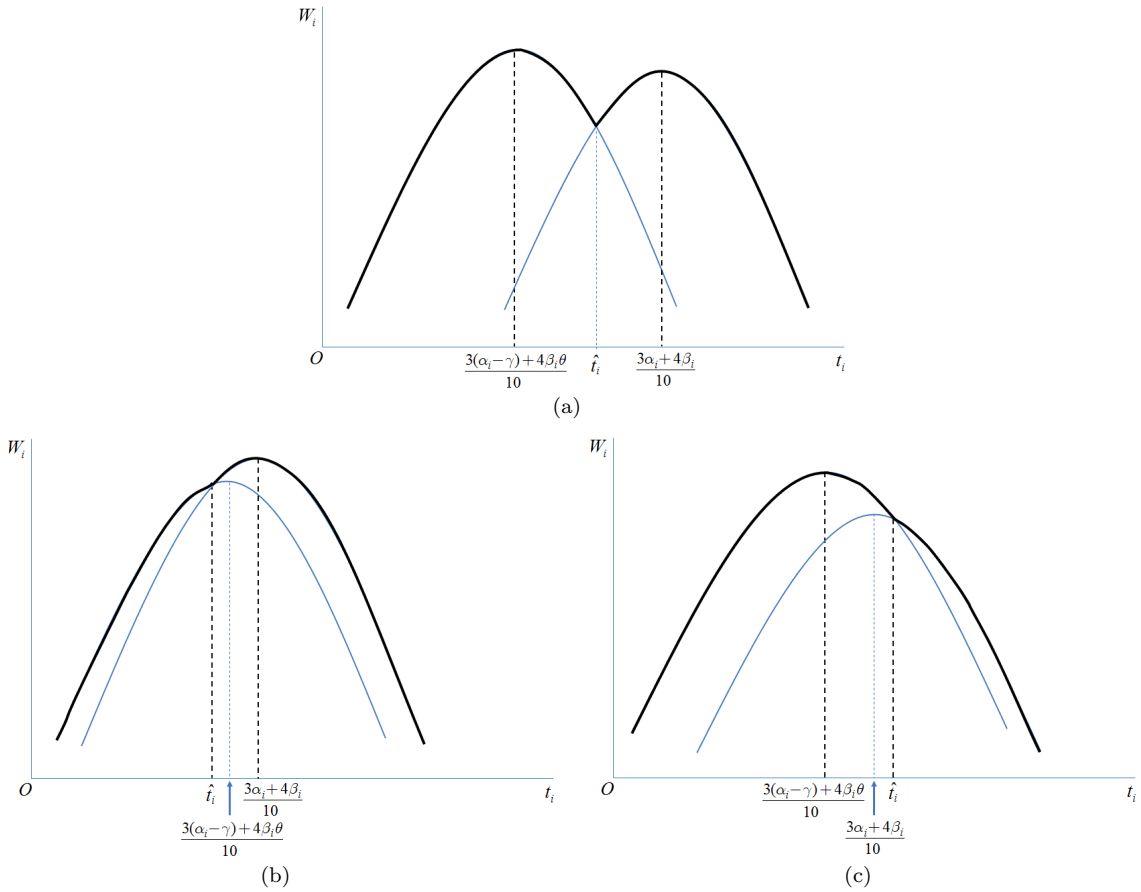

Figure A.1: Relationship between t_i and W_i

Let us begin with case (i) where $[3(\alpha_i-\gamma)+4\theta\beta_i]/10 < \hat{t}_i < (3\alpha_i+4\beta_i)/10$ holds. In this case, the relation between t_i and W_i can typically be illustrated as a curve with twin peaks, as illustrated in Figure A.1 (a). From (A.1), (A.2), and (A.4), the local maxima are attained at $(t_i, s_i) = \left(\frac{3(\alpha_i-\gamma)+4\theta\beta_i}{10}, s_H\right)$ and $(t_i, s_i) = \left(\frac{3\alpha_i+4\beta_i}{10}, s_L\right)$. Substituting these optimal pairs of (t_i, s_i) into (A.4), it follows that

$$\max W_i = \begin{cases} \dfrac{4(\alpha_i-\gamma)^2 - 6\beta_i\theta(\gamma-\alpha_i) + \beta_i^2\theta^2}{10} + \Pi_{-i} & \text{if } (t_i, s_i) = \left(\dfrac{3(\alpha_i-\gamma)+4\theta\beta_i}{10}, s_H\right), \\ \dfrac{4\alpha_i^2 - 6\alpha_i\beta_i + \beta_i^2}{10} + \Pi_{-i} & \text{if } (t_i, s_i) = \left(\dfrac{3\alpha_i+4\beta_i}{10}, s_L\right). \end{cases} \tag{A.5}$$

Assuming that $\theta = 0$ without loss of generality, it is clear from (A.5) and Figure A.1 (a) that if $-8\alpha_i\gamma + 4\gamma^2 + 6\alpha_i\beta_i - \beta_i^2$ is positive (negative), s_H (s_L) achieves the maximum level of W_i. This means that the optimal policy mix, which is the dominant strategy, for each country under MFN is $(t_i, s_i) = \left(\frac{3(\alpha_i-\gamma)}{10}, s_H\right)$ if $\gamma < \alpha_i - \sqrt{\alpha_i^2 - \frac{3}{2}\alpha_i\beta_i + \frac{\beta_i^2}{4}}$ and

$(t_i, s_i) = \left(\frac{3\alpha_i+4\beta_i}{10}, s_L\right)$ if $\gamma > \alpha_i - \sqrt{\alpha_i^2 - \frac{3}{2}\alpha_i\beta_i + \frac{\beta_i^2}{4}}$. However, the condition whether γ is higher or lower than $\alpha_i - \sqrt{\alpha_i^2 - \frac{3}{2}\alpha_i\beta_i + \frac{\beta_i^2}{4}}$ is equivalent to the condition imposed in Lemma 1.

Let us consider case (ii) where $\hat{t}_i < 3(\alpha_i - \gamma)/10 < (3\alpha_i + 4\beta_i)/10$ holds. In this case, Figure A.1 (b) reveals that W_i is maximized at $(t_i, s_i) = \left(\frac{3\alpha_i+4\beta_i}{10}, s_L\right)$. Finally, in case (iii) where $3(\alpha_i - \gamma)/10 < (3\alpha_i + 4\beta_i)/10 < \hat{t}_i$ holds, it is clear from Figure A.1 (c) that W_i is maximized at $(t_i, s_i) = \left(\frac{3(\alpha_i-\gamma)}{10}, s_H\right)$.

To sum up, we can conclude that the timing of the determination of the two policy instrument, tariffs and standards, does not matter. The above-mentioned equivalence between the simultaneous determination of policy instruments and sequential determination of these policies also holds in the policy games under an FTA between countries A and B.

A.2 Welfare effects of an FTA for member countries

In this Appendix, we present the calculation results of (15) for cases from (i) to (ix) in Table 1.

Case (i): (s_L, s_L) under MFN and (s_L, s_L) under FTA In this case, (15) is rewritten as

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_L) + \pi_{ji}^M(s_L) - [w_i^F(s_L) + \pi_{ji}^F(s_L)] \\ &= \frac{(3\alpha_i + 4\beta_i)^2}{210} - \frac{13(3\alpha_j + 4\beta_j)(81\alpha_j - 32\beta_j)}{44100}. \end{aligned} \tag{A.6}$$

If $\alpha_i = \alpha_j = \alpha$ and $\beta_i = \beta_j = \beta$, the above equation can be simplified to (16).

Case (ii): (s_L, s_L) under MFN and (s_H, s_L) under FTA In this case, (15) is rewritten as

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_L) + \pi_{ji}^M(s_L) - [w_i^F(s_H) + \pi_{ji}^F(s_L)] \\ &= \frac{3\alpha_i^2 - 42\alpha_i\beta_i + 7\beta_i^2 + 50\alpha_i\gamma - 25\gamma^2}{70} - \frac{13(3\alpha_j + 4\beta_j)(81\alpha_j - 32\beta_j)}{44100}. \end{aligned} \tag{A.7}$$

Case (iii): (s_L, s_L) **under MFN and** (s_L, s_H) **under FTA** In this case, (15) is rewritten as

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_L) + \pi_{ji}^M(s_L) - [w_i^F(s_L) + \pi_{ji}^F(s_H)] \\ &= \frac{(3\alpha_i + 4\beta_i)^2}{210} - \frac{(27\alpha_j - 14\beta_j - 20\gamma)(13\alpha_j + 14\beta_j - 20\gamma)}{4900}. \end{aligned} \tag{A.8}$$

Case (iv): (s_L, s_L) **under MFN and** (s_H, s_H) **under FTA** In this case, (15) is rewritten as

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_L) + \pi_{ji}^M(s_L) - [w_i^F(s_H) + \pi_{ji}^F(s_H)] \\ &= \frac{3\alpha_i^2 - 42\alpha_i\beta_i + 7\beta_i^2 + 50\alpha_i\gamma - 25\gamma^2}{70} - \frac{(27\alpha_j - 14\beta_j - 20\gamma)(13\alpha_j + 14\beta_j - 20\gamma)}{4900}. \end{aligned} \tag{A.9}$$

If $\alpha_i = \alpha_j = \alpha$ and $\beta_i = \beta_j = \beta$, the above equation can be simplified to (17).

Case (v): (s_H, s_L) **under MFN and** (s_H, s_L) **under FTA** In this case, (15) is rewritten as

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_H) + \pi_{ji}^M(s_L) - [w_i^F(s_H) + \pi_{ji}^F(s_L)] \\ &= \frac{3(\alpha_i - \gamma)^2}{70} - \frac{13(3\alpha_j + 4\beta_j)(81\alpha_j - 32\beta_j)}{44100}. \end{aligned} \tag{A.10}$$

Case (vi): (s_H, s_L) **under MFN and** (s_H, s_H) **under FTA** In this case, (15) is rewritten as

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_H) + \pi_{ji}^M(s_L) - [w_i^F(s_H) + \pi_{ji}^F(s_H)] \\ &= \frac{3(\alpha_i - \gamma)^2}{70} - \frac{(27\alpha_j - 14\beta_j - 20\gamma)(13\alpha_j + 14\beta_j - 20\gamma)}{4900}. \end{aligned} \tag{A.11}$$

Case (vii): (s_L, s_H) **under MFN and** (s_L, s_H) **under FTA** In this case, (15) is rewritten as

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_L) + \pi_{ji}^M(s_L) - [w_i^F(s_L) + \pi_{ji}^F(s_H)] \\ &= \frac{(3\alpha_i + 4\beta_i)^2}{210} - \frac{351(\alpha_j - \gamma)^2}{4900}. \end{aligned} \tag{A.12}$$

Case (viii): (s_L, s_H) **under MFN and** (s_H, s_H) **under FTA** In this case, (15) is rewritten as

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_L) + \pi_{ji}^M(s_H) - [w_i^F(s_H) + \pi_{ji}^F(s_H)] \\ &= \frac{3\alpha_i^2 - 42\alpha_i\beta_i + 7\beta_i^2 + 50\alpha_i\gamma - 25\gamma^2}{70} - \frac{351(\alpha_j - \gamma)^2}{4900}. \end{aligned} \tag{A.13}$$

Case (ix): (s_H, s_H) **under MFN and** (s_H, s_H) **under FTA** In this case, (15) is rewritten as

$$\begin{aligned} W_i^M - W_i^F &= w_i^M(s_L) + \pi_{ji}^M(s_H) - [w_i^F(s_H) + \pi_{ji}^F(s_H)] \\ &= \frac{3(\alpha_i - \gamma)^2}{70} - \frac{351(\alpha_j - \gamma)^2}{4900}. \end{aligned} \tag{A.14}$$

If $\alpha_i = \alpha_j = \alpha$ and $\beta_i = \beta_j = \beta$, the above equation can be simplified to (18).

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