

Agreements on product standards in a three-country model of international oligopoly

Akihiko Yanase ^a, Hiroshi Kurata ^b, and Yaqiong Lin ^c

^{a,c}Nagoya University

^bTohoku Gakuin University

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Abstract

This paper extends the comparative institutional analysis of agreements on product standards developed by Costinot (2008, *Journal of International Economics*) to a three-country world, in which there are two “member” countries of an agreement on standards and a “non-member” country. We examine the comparative performance of two principles; one is a “National Treatment” (NT) principle, and the other is a principle of “Mutual Recognition” (MR). We consider an international oligopoly in which the traded goods generate consumption externalities. We show that for low levels of externalities, the member countries prefer MR to NT, while they prefer NT to MR for high levels of externalities. Assuming the member countries conclude a standard agreement that yields higher benefits, the non-member country becomes better off only when the member countries choose NT. We also discuss whether the bilateral agreement on standards can be a “building block” or a “stumbling block” to a multilateral agreement by all three countries.

Keywords: International oligopoly; Consumption externalities; Product standards; National treatment; Mutual recognition.

JEL classifications: F12; F13; F15; F18

1. Introduction

Agreements on non-tariff barriers have become increasingly important in recent times. As a result of WTO negotiation and the growth of preferential trade agreements (PTAs), tariffs have become sufficiently low, reducing tariffs is not so effective. Non-tariff barriers, many previously treated as domestic regulations, often differ from country to country. As a result, such differences in non-tariff barriers tend to disadvantage foreign firms (Estevadeordal, Suominen, and Teh, 2009; Maskus, Otsuki, and Wilson, 2005). Therefore, recent PTAs tends to contain provisions on non-tariff barriers.¹

In this paper, we focus on product standards in the non-tariff barriers. Product standards are set to protect the health and safety of the public, and we have often witnessed the difference from country to country. The WTO has two agreements concerning standards: the agreements on technical barriers to trade (TBT) and sanitary and phytosanitary standards (SPS), to control the impact of country-specific product standards on trade. In addition, recent PTAs include provisions on the TBT and SPS Agreements. For example, Hofmann, Osnago, and Ruta (2017) point out that about 50% of the total PTA in 2015 in force includes the TBT and SPS agreements.²

Despite the growing importance of product standards, the economic benefits of product standards have not been understood. In particular, concerning agreements on product standards, Costinot (2008) develops the two-country model to compare the performances of two principles on product standards: national treatment (NT) and mutual recognition (MR). He focuses on the externalities of trading products and shows that the NT is preferred to the MR when the volume of trade with high externalities is large. However, analysis in the two-country model cannot focus on the effects of the agreements on

¹ We call agreements with the tariff and non-tariff measures "Deep Trade Agreement" (Matoos, Roche, and Ruta, 2020).

² The numbers of agreements including the SPS and TBT are 152 and 147, respectively, out of the total number of PTAs in 2015 is 279 (Hofmann, Osnago, and Ruta, 2017).

product standards to the overall economy, including non-member countries. Furthermore, we cannot consider whether the bilateral agreements can be "building block" or "stumbling block" to the multilateral agreements. On the other hand, Yanase and Kurata (2022) focus on the effects of the FTAs with agreements on product standards in a three-country model. They demonstrate that the more stringent product standards may or may not benefit the member countries while it is beneficial for the non-member country. Takarada et al. (2020) set up a three-country model and examine if the harmonization of product standards expands from regional to multinational. They show that regional harmonization is a "building block" when the negative externality is quite transboundary. Although these studies consider the three-country model to examine the economic effects of agreements on product standards, they focus only on the harmonization of product standards.

This paper extends Costinot's comparative analysis of the agreements to the three-country model. We consider two member countries and one non-member country and focus on a situation where the consumption of goods generates a negative externality. Product standard controls the externality: high standard reduces the negative externality more. As Costinot (2008), we compare the performances of the NT or the MR in the model. We also examine whether the member countries of the bilateral agreement prefer to conclude the multilateral agreement.

We demonstrate that the agreement on product standards can be preferable or not preferable for member and non-member countries, depending on the degree of the negative externality. In particular, for member countries, the MR is reasonable for the low degree of externality, while the NT is reasonable for the high degree of externality. For the non-member countries, both MR and NT is reasonable for the low degree of externalities, while only NT is reasonable for the high degree of externalities. Furthermore, we find some externalities where the agreement of product standards is beneficial for both member and non-member countries.

Our analysis is related to the literature on product standards. Fischer and Serra (2000), Sturn (2006), and Ishikawa and Okubo (2011) conduct their analysis in a two-country model. Takarada and Kawabata (2021) set up a three-country model to examine the effects of the harmonization of product standards. They do not focus on the MR. Our analysis is also related to the literature on the WTO principle (Krishna, 1998; Bagwell and Staiger, 2001; Orneras, 2005, 2007; Saggi and Yildiz, 2010; Limão and Saggi, 2013). These studies consider agreements to reduce the tariff and not consider agreements on product standards. Our study examines the effects of agreements on product standards in a three-country model and provides new insight into these research streams.

The remainder of the paper is as follows. In Section 2, we set up a basic model. Then, section 3 considers the bilateral agreement and policy game with the NT and the MR. We examine the welfare effect of the bilateral agreement on the member and non-member countries. In Section 4, we discuss the possibilities of extending the bilateral agreement to the multilateral agreement. Finally, in Section 5, we provide brief concluding remarks.

2. The Model

2.1. The economic environment

There are three identical countries, A, B and C, with one firm per country, a, b and c, all producing a homogeneous good. There are two types of good, H and L, that the firms can produce, distinguished by production cost and the level of consumption pollution. For H type of good, firms' unit production cost is 0, but θ units of pollution are emitted per unit of consumption. For L type of good, unit production cost is c , and no consumption pollution is generated. Pollution damage occurs at the location of consumption.

There is a continuum of consumers of measure one. Each consumer can buy at most one unit of product. For consumers, both types of products are indifferent. Consumers are heterogeneous and

utility of type v consumer living in country J (J=A, B, C) is given by

$$u(v) = \begin{cases} v - p - \varphi^J & \text{if she buys the product} \\ -\varphi^J & \text{if she buys nothing,} \end{cases} \quad (1)$$

where v is uniformly distributed with support $[0,1]$, p is the price of the good, and φ^J is the pollution damage.

Since consumers of type $v \geq p$ will buy the good, the demand for the product in country J is

$$Q^J = \int_p^1 1 \cdot dv = 1 - p \quad (2)$$

From (2), the inverse demand in country J is

$$P(Q^J) = 1 - Q^J \quad (3)$$

Pollution damage in country J depends on the consumption in each country:

$$\varphi^J = \sum_{j=a,b,c} \theta_j^J q_j^J, \quad (4)$$

where q_j^J is firm j 's sales in country J and $\theta_j^J \in \{0, \theta\}$ is the pollution damage per unit of consumption of firm j 's product.

Firm j 's profit earned in country J's market ($j=a, b, c$ and $J=A, B, C$) is given by

$$\pi_j^J = [P^J(Q^J) - c_j^J] q_j^J = (1 - Q^J - c_j^J) q_j^J, \quad (5)$$

where $c_j^J \in \{0, c\}$ is the unit production cost of the good produced in firm j and consumed in country J and $Q^J = \sum_{i=a,b,c} q_i^J$ is the total consumption in country J. Tariffs or transport costs are not considered in this model.

Country J's government can regulate its market by setting standards $\sigma_j^J \in \{H, L\}$ for each firm j 's product. ($j= a, b, c$). Each firm can sell in country J's market if and only if its product's type satisfies the minimum quality standard. If $\sigma_j^J = H$, firm j can sell both H and L type, but firm will choose H type because the unit production cost is 0. If $\sigma_j^J = L$, firm j must produce and sell the production of L type.

The standards setting game with Cournot competition is represented by the following two stage

game:

Stage 1: Governments simultaneously choose their standards policy.

Stage 2: After observing the governments' standards, firms simultaneously decide which type of the good and what quantity to sell in each market.

We solve the game by backward induction to derive the subgame perfect Nash equilibrium.

2.2. Cournot-Nash equilibrium

In stage 2, given the standards policy in the respective countries, the firms play Cournot game in each country's market. In country J's market, firm j chooses q_j^J to maximize $\pi_j^J = (1 - q_j^J - \sum_{i \neq j} q_i^J - c_j^J)q_j^J$, taking $q_i^J, i \neq j$, as given. From the first-order conditions for profit maximization, the Cournot-equilibrium outputs can be obtained as $q_j^J = (1 - 3c_j^J + \sum_{i \neq j} c_i^J)/4$, $j, i = a, b, c$. The equilibrium sales and price in country J are then derived as $Q^J = (3 - \sum_{j=a,b,c} c_j^J)/4$ and $P(Q^J) = (1 + \sum_{j=a,b,c} c_j^J)/4$, respectively.

We regard the governments' objective function for the policy game in stage 1 as the social welfare in the respective countries, which is the sum of consumer surplus, which can be calculated as $CS^J = (Q^J)^2/2 - \varphi^J$, and the domestic firm's total profits from domestic sales and exports, which can be represented by $\pi_j = \sum_{J=A,B,C} \pi_j^J = \sum_{J=A,B,C} (q_j^J)^2$. In light of the Cournot-Nash equilibrium outputs, the equilibrium social welfare in country J is

$$SW^J = \frac{(3 - \sum_{j=a,b,c} c_j^J)^2}{32} - \sum_{j=a,b,c} \theta_j^J \frac{1 - 3c_j^J + \sum_{i \neq j} c_i^J}{4} + \sum_{I=A,B,C} \frac{(1 - 3c_j^I + \sum_{i \neq j} c_i^I)^2}{16}, \quad (6)$$

J=A, B, C.

Throughout this paper, we put the following assumption.

Assumption. $0 < c < 1/5$

2.3. Noncooperative policy equilibrium without agreements

As a benchmark for the subsequent analysis, we consider outcomes under which the governments noncooperatively determine their standards without making any agreements among countries. In the absence of agreements on standards, in stage 1, country J 's government chooses the standards for the products consumed in that country, $(\sigma_a^J, \sigma_b^J, \sigma_c^J)$, to maximize country J 's social welfare (6), taking the other countries' standards $(\sigma_a^I, \sigma_b^I, \sigma_c^I)$, $I \neq J$, as given. There are three regimes for governments to choose from:³

1. Full regulation (FR): $(\sigma_a^J, \sigma_b^J, \sigma_c^J) = (L, L, L)$
2. No regulation (NR): $(\sigma_a^J, \sigma_b^J, \sigma_c^J) = (H, H, H)$ for $J = A, B, C$;
3. Discrimination (D): $(\sigma_a^A, \sigma_b^A, \sigma_c^A) = (H, L, L)$, $(\sigma_a^B, \sigma_b^B, \sigma_c^B) = (L, H, L)$, and $(\sigma_a^C, \sigma_b^C, \sigma_c^C) = (L, L, H)$

Since export profits depend only on other countries' standards, country J chooses its standards in order to maximize the domestic welfare, which is the sum of the consumer surplus and the domestic firm's profit from domestic sales. Take country A as the example, the domestic welfare is:

$$CS^A + \pi_a^A = \frac{(3 - \sum_{j=a,b,c} c_j^A)^2}{32} - \sum_{j \in a,b,c} \theta_j^A \frac{1 - 3c_j^A + \sum_{i \neq j} c_i^A}{4} + \frac{(1 - 3c_j^A + \sum_{i \neq j} c_i^A)^2}{16} \quad (7)$$

By comparing domestic welfare under the respective strategies for standards policy, we obtain the following proposition.

Proposition 1. *In the unconstrained noncooperative standards game without any international agreements, the equilibrium standards regime implies that:*

³ Strictly speaking, the discrimination regime should be interpreted as “negative discrimination” because the government discriminates against the foreign firms by setting more stringent standards. We may consider another type of discriminatory standards regime, namely, “positive discrimination”, which the government sets less stringent standards for foreign products than the domestic product; for country A , positive discrimination means $(\sigma_a^A, \sigma_b^A, \sigma_c^A) = (L, H, H)$. However, we can verify that under the assumption that $c < 1/5$, positive discrimination will never be an equilibrium outcome. Thus, throughout this paper, we regard the negative discrimination case as the discrimination regime.

No regulation for $0 \leq \theta < \underline{\theta}^U$;

Negative discrimination for $\underline{\theta}^U \leq \theta < \bar{\theta}^U$;

Full regulation for $\bar{\theta}^U \leq \theta$,

where $\underline{\theta}^U \equiv \frac{c(1-3c)}{4(1-c)}$ and $\bar{\theta}^U \equiv \frac{c(18+c)}{8(1+2c)}$.

(Proof) See the Appendix.

Intuitively, when the level of pollution is very small, no regulation could help country A gets biggest outcome. When the level of pollution gets bigger, country A has incentives to use discrimination strategy to reduce pollution emitted by the consumption of product produced in country B and C. Besides country A could also shift the profit from exporters to national producers. When the level of pollution is too big, country A must use full regulation to reduce the pollution.

3. Bilateral Agreements on Standards Policy

In this section, we consider a situation in which two of the three countries, namely countries A and B, sign an agreement that requires a commitment on rigid rule regarding their standards policy. We consider two rules for the standards agreements. One is “national treatment (NT)” and the other is “mutual recognition (MR)”. NT means that same standards should be applied to both domestic product and the product imported from the member country in the agreement. MR means that control over the standard on exported product is transferred from the importer to the exporter member country, meaning that the exporter country sets the standards, and the importer country has to accept it.

Although there is a bilateral agreement on standards policy, we assume that all countries choose standards noncooperatively. That is, member countries A and B, facing a constraint imposed by NT or MR, determine their respective standards to maximize their own welfare. Country C, which is an

outsider of the agreement, also determines its standards noncooperatively. Because country C's optimal standards are independent of the other countries' standards, Proposition 1 holds for country C even in the presence of bilateral agreements.

3.1. Policy game under NT

As in the unconstrained non-cooperative case, export profit only depends on the foreign standards under NT. Therefore, for country A and B, the government's problem in stage 1 is to decide on the standards policy to maximize the domestic welfare given by (7), subject to the constraint that the same standards should be applied to the domestic product and the product imported from the member country; that is, the constraint is $\sigma_a^J = \sigma_b^J \in \{H, L\}$, $J = A, B$.

The member countries A and B choose a strategy for standards policy from the following possible choices:

1. Full regulation (FR): $(\sigma_a^J, \sigma_b^J, \sigma_c^J) = (L, L, L)$;
2. No regulation (NR): $(\sigma_a^J, \sigma_b^J, \sigma_c^J) = (H, H, H)$;
3. Discrimination (D): $(\sigma_a^J, \sigma_b^J, \sigma_c^J) = (H, H, L)$

for $J = A, B$. Here, D means that the member countries discriminate against the nonmember country C regarding the choice of standards.

The equilibrium standards regime for the member countries under NT is represented by the following proposition.

Proposition 2. *Under a bilateral agreement of standards policy with NT, the member countries' equilibrium standards regime implies that:*

No regulation for $0 \leq \theta < \underline{\theta}$;

Discrimination for $\underline{\theta} \leq \theta < \bar{\theta}^N$;

Full regulation for $\bar{\theta}^N \leq \theta$,

where $\underline{\theta} \equiv \frac{c(2-3c)}{8(1-2c)}$ and $\bar{\theta}^N \equiv \frac{c(5-2c)}{4(1+c)}$.

(Proof) See the Appendix.

3.2. Policy game under MR

Under MR, each member country transfers the right to control importer to the other member (i.e., exporter) country. More specifically, country A controls $(\sigma_a^A, \sigma_a^B, \sigma_c^A)$ and country B controls $(\sigma_b^B, \sigma_b^A, \sigma_c^B)$. Each member country faces the constraint that the same policy should be applied to domestically consumed product and the product produced by the same firm and exported to another member country; that is, $\sigma_a^A = \sigma_a^B$ and $\sigma_b^A = \sigma_b^B$ must hold.

Unlike NT, each member country's standards policy affects the export profit earned in another member country as well as consumer surplus and domestic profit. Thus, considering country A's problem in stage 1 for example, its problem is represented as to maximize

$$CS^A + \pi_a^A + \pi_a^B = \frac{(3 - \sum_{j=a,b,c} c_j^A)^2}{32} - \sum_{j \in a,b,c} \theta_j^A \frac{1 - 3c_j^A + \sum_{i \neq j} c_i^A}{4} + \frac{(1 - 3c_a^A + \sum_{j \neq a} c_j^A)^2}{16} + \frac{(1 - 3c_a^B + \sum_{j \neq a} c_j^B)^2}{16} \quad (8)$$

subject to $\sigma_a^A = \sigma_a^B$. The problem for country B, which faces the constraint $\sigma_b^A = \sigma_b^B$, can be similarly defined. The member countries' possible strategies are as follows:

1. Full regulation (FR): $(\sigma_a^A, \sigma_a^B, \sigma_c^A) = (\sigma_b^B, \sigma_b^A, \sigma_c^B) = (L, L, L)$;
2. No regulation (NR): $(\sigma_a^A, \sigma_a^B, \sigma_c^A) = (\sigma_b^B, \sigma_b^A, \sigma_c^B) = (H, H, H)$;
3. Discrimination (D): $(\sigma_a^A, \sigma_a^B, \sigma_c^A) = (\sigma_b^B, \sigma_b^A, \sigma_c^B) = (H, H, L)$.

From (8), we observe that under MR, country A's optimal standards depend on country B's standards, and vice versa. This means that, unlike the previous policy regimes, we first need to derive each member country's best response strategies and then obtain the Nash equilibrium of the standards game. As we will see, both member countries' standards are strategic complements in the MR game.

This particular feature of MR creates room (in our setting with discrete policy choices) for multiple equilibria, as represented by the following proposition (see also Fig.1).

Proposition 3. *Under a bilateral agreement of standards policy with MR, the member countries' equilibrium standards regime implies that:*

No regulation for $0 \leq \theta < \underline{\theta}$;

Discrimination for $\underline{\theta} \leq \theta < \bar{\theta}^M$;

Discrimination or Full regulation for $\bar{\theta}^M \leq \theta < \theta'$;

Full regulation for $\theta' \leq \theta$,

where $\bar{\theta}^M \equiv \frac{(30+7c)c}{8(1+2c)}$ and $\theta' \equiv \frac{15(2-c)c}{8}$.

(Proof) See the Appendix.

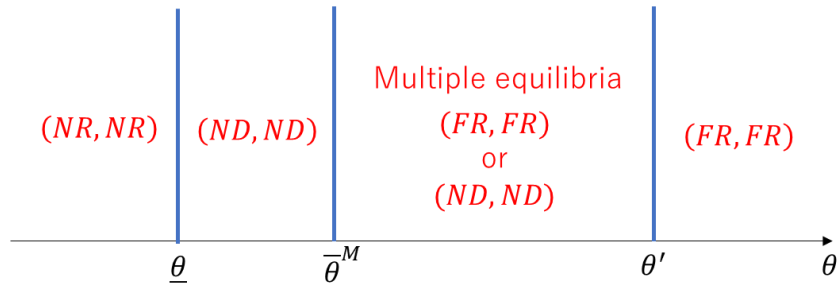


Fig.1: equilibrium standards of policy game under MR

In order to compare the outcomes under MR with those under NT, we need to make a refinement of equilibrium in the MR game. As in Costinot (2008), we restrict our attention to Pareto-efficient or “most cooperative” equilibrium; If one equilibrium is strictly preferred to any other by both countries, we assume that they can coordinate on this equilibrium.

Proposition 4. *In the most cooperative equilibrium under MR regime, the member countries will coordinate on Full regulation when $\theta \in [\bar{\theta}^M, \theta']$.*

(Proof) See the Appendix.

In light of Proposition 4, the equilibrium standards regime under MR characterized in Proposition 3 can be revised as follows: each member country chooses No regulation for $0 \leq \theta < \underline{\theta}$; Discrimination for $\underline{\theta} \leq \theta < \bar{\theta}^M$; and Full regulation for $\bar{\theta}^M \leq \theta$.

3.3. Summary of equilibrium standards under different policy regimes

To summarize the analysis so far, we obtain country A's equilibrium standards under different policy regimes, as illustrated in Fig.2.

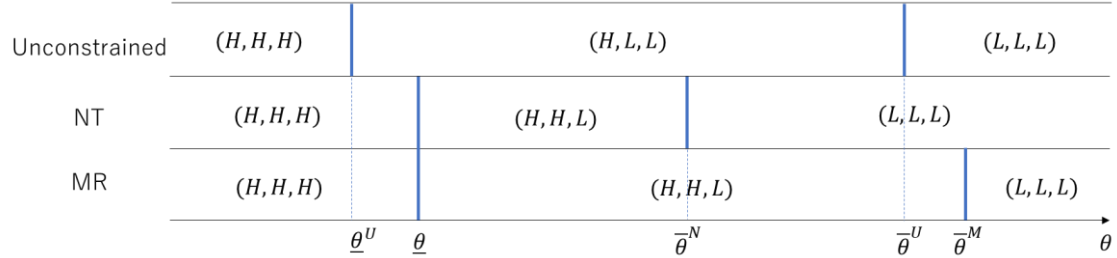


Fig.2: country A's equilibrium standards

The equilibrium strategies in country B, which concludes bilateral agreements with country A under NT and MR, are the same as those in country A, with $(\sigma_a^B, \sigma_b^B, \sigma_c^B) = (L, H, L)$ for $\underline{\theta}^U \leq \theta < \bar{\theta}^U$ in the unconstrained noncooperative (UN) equilibrium. Even when countries A and B conclude bilateral agreements on standards, country C's equilibrium strategies are the same as that of UN. From Fig.2, we can observe that the respective countries' equilibrium standards vary as the value of θ changes.

Table 1 summarizes the equilibrium standards $(\sigma_a^A, \sigma_b^A, \sigma_c^A; \sigma_a^B, \sigma_b^B, \sigma_c^B; \sigma_a^C, \sigma_b^C, \sigma_c^C)$ under

respective regimes.

	UN	NT	MR
$0 \leq \theta < \underline{\theta}^U$	(H,H,H; H,H,H; H,H,H)	(H,H,H; H,H,H; H,H,H)	(H,H,H; H,H,H; H,H,H)
$\underline{\theta}^U \leq \theta < \underline{\theta}$	(H,L,L; L,H,L; L,L,H)	(H,H,H; H,H,H; L,L,H)	(H,H,H; H,H,H; L,L,H)
$\underline{\theta} \leq \theta < \bar{\theta}^N$	(H,L,L; L,H,L; L,L,H)	(H,H,L; H,H,L; L,L,H)	(H,H,L; H,H,L; L,L,H)
$\bar{\theta}^N \leq \theta < \bar{\theta}^U$	(H,L,L; L,H,L; L,L,H)	(L,L,L; L,L,L; L,L,H)	(H,H,L; H,H,L; L,L,H)
$\bar{\theta}^U \leq \theta < \bar{\theta}^M$	(L,L,L; L,L,L; L,L,L)	(L,L,L; L,L,L; L,L,L)	(H,H,L; H,H,L; L,L,L)
$\bar{\theta}^M \leq \theta$	(L,L,L; L,L,L; L,L,L)	(L,L,L; L,L,L; L,L,L)	(L,L,L; L,L,L; L,L,L)

Table 1: Summary of the equilibrium standards $(\sigma_a^A, \sigma_b^A, \sigma_c^A; \sigma_a^B, \sigma_b^B, \sigma_c^B; \sigma_a^C, \sigma_b^C, \sigma_c^C)$

3.4. the welfare implications of NT and MR for member and nonmember countries

In this subsection, having characterized the equilibrium outcome under NT and MR, we compare

their performance by analyzing member and nonmember countries' social welfare $SW^J = CS^J + \pi_j$,

J=A, B, C, and j=a, b, c.

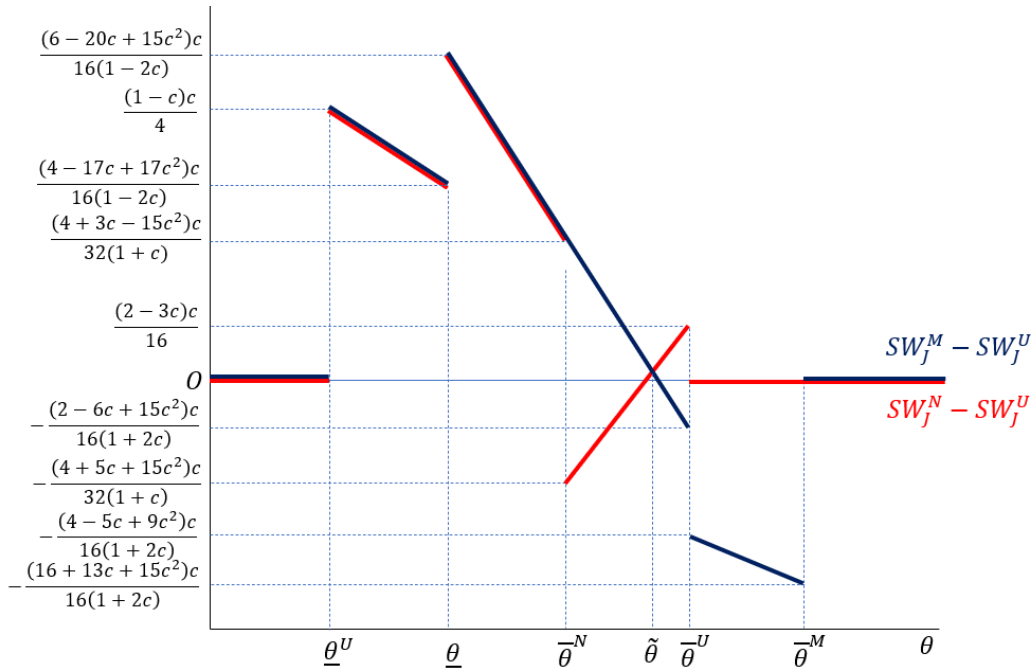


Fig.3. welfare comparison of member countries.

The blue line in Fig.3 represents $SW_j^M - SW_j^U$, where SW_j^M and SW_j^U denote country J's

welfare under MR and UN, respectively, for $J=A,B$. First, we consider the performance of MR. Compared to the benchmark of UN, when θ is extremely small, member countries impose negative regulation and the outcomes under MR and UN are same. When $\underline{\theta}^U \leq \theta < \underline{\theta}$, where θ is a little larger than before, under UN, country began to discriminate to reduce pollution and shift profit from exporters to national producers. While because under MR, the control of standard over B's product has been transferred to B's government. A and B impose same standard policy towards each other and the discrimination policy towards C. However, compared with UN, the distortion of the market power under MR is smaller. Also, under MR, country A could prompt the exporting to B. So, the outcome of MR increases. For very large level of pollution, $\bar{\theta}^M \leq \theta$, member countries imposed a positive regulation and outcomes become equivalent. As for the immediate range, when $\tilde{\theta} \leq \theta < \bar{\theta}^M$, country A and B should impose the positive standard, while governments still have the incentive to shift more profits from C to themselves and prompt the exportation to each other. Consequently, the level of pollution which they started to impose the regulation is too high. This is a "Race to the Bottom", similarly with Costinot (2008).

The red line in Fig.3 represents $SW_J^N - SW_J^U$, where SW_J^N denotes country J's welfare under NT for $J=A,B$. Then we analyze the performance of NT. Similarly with MR, when θ is extremely small and large, the outcome of NT and UN are equivalent. When $\underline{\theta} \leq \theta < \bar{\theta}^N$, Country A could only impose discrimination standards on C and the outcome of NT increase. Also, country A couldn't prompt the exporting to B and C. So, when θ starts getting larger, $\bar{\theta}^N \leq \theta < \tilde{\theta}$ country A over evaluate the negative externality and start to impose the regulation when the level of pollution is too low. This patten is called "Green Protectionism". Comparing the member countries' performance under MR and UN, we obtain the following proposition.

Proposition 5. Let us define $\tilde{\theta} \equiv \frac{(7-2c)c}{4(1+c)}$. Then, for member countries $J = A, B$

$MR \sim NT$ for $\theta < \bar{\theta}^N$ and $\theta > \bar{\theta}^M$;

$MR > NT$ for $\bar{\theta}^N \leq \theta < \tilde{\theta}$;

$NT > MR$ for $\tilde{\theta} \leq \theta < \bar{\theta}^M$.

We next analyze the performance of country C, the nonmember country of bilateral agreements of standards, in different policy regimes, as illustrated in Fig.4.

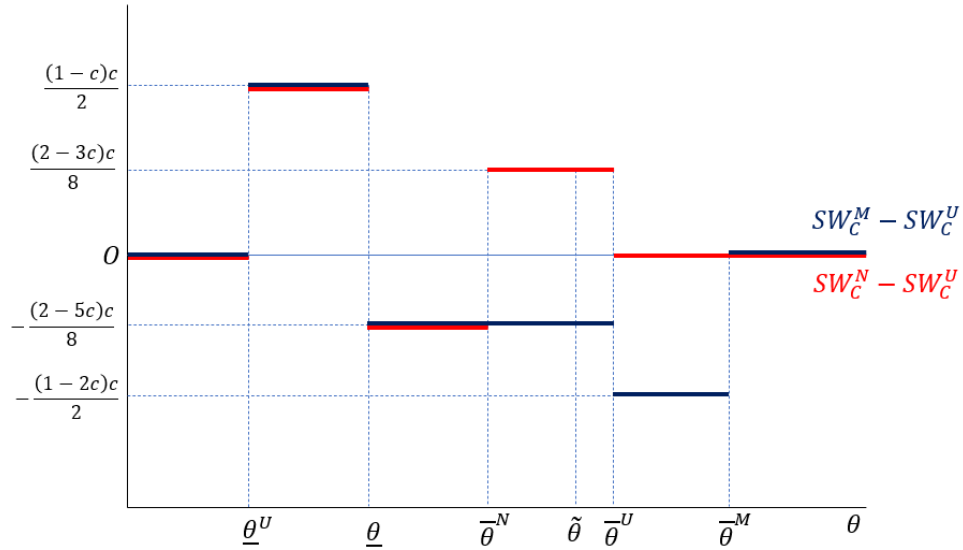


Fig.4. welfare comparison nonmember countries.

First, we see the nonmember countries' performance of MR. When the level of pollution is too small or too large, the strategies under MR and UN are same, so the outcomes are equivalent. When $\underline{\theta}^U \leq \theta < \underline{\theta}$, country C under UN uses discrimination strategy and shift profit from A and B while A and B are still imposing no regulation. So, the outcome under MR increases. When $\underline{\theta} \leq \theta < \bar{\theta}^N$, country A and B both impose discrimination standards on C, and the outcome under MR is lower than it under UN.

For the outcome of NT, the analysis is similar with MR. But the range $\bar{\theta}^N \leq \theta < \bar{\theta}^U$ is different. Because under NT, country A and B set Full regulation at a low pollution level, $\bar{\theta}^N$. When $\bar{\theta}^N \leq \theta < \bar{\theta}^U$, country C imposes discrimination policy, and C could shift profit from A and B. Thus, outcome increases. Compare the performance under MR and NT, we obtain the following proposition.

Proposition 6. *For nonmember country C,*

NT is beneficial for $\underline{\theta}^U \leq \theta < \underline{\theta}$ and $\bar{\theta}^N \leq \theta < \bar{\theta}^U$, but harmful for $\underline{\theta} \leq \theta < \bar{\theta}^N$.

MR is beneficial for $\underline{\theta}^U \leq \theta < \underline{\theta}$, but harmful for $\underline{\theta} \leq \theta < \bar{\theta}^M$.

Summarizing the welfare comparisons of member and nonmember countries, we obtain the following proposition.

Proposition 7.

Suppose that the member countries conclude a standards agreement that yields higher benefits. Then,

(i) the regional agreement on standards policy benefits both member and nonmember countries for

$\underline{\theta}^U \leq \theta < \underline{\theta}$ and $\tilde{\theta} \leq \theta < \bar{\theta}^U$; (ii) the regional agreement benefits only the member countries for

$\underline{\theta} \leq \theta < \tilde{\theta}$

4. Multilateral Agreements on Standards Policy

In this section, we consider the case in which country C join the agreements. Thus, country A, B and C's standard policies are under the restriction of agreements. Similarly with section 2, we consider two types of agreements, NT and MR.

4.1. Multilateral agreements on standards policy: NT

For all the countries, the government's problem in stage 1 is still to decide on the standards policy to maximize the domestic welfare given by (7), subject to the constraint, $\sigma_a^J = \sigma_b^J = \sigma_c^J, J = A, B, C$.

The government in each country has two possible choices; one is Full regulation (FR), which means $(\sigma_a^J, \sigma_b^J, \sigma_c^J) = (L, L, L)$, and the other is No regulation (NR), which means $(\sigma_a^J, \sigma_b^J, \sigma_c^J) = (H, H, H)$.

The equilibrium standards regime under NT is represented by the following proposition.

Proposition 8. *Under a multilateral agreement of standards based on national treatment, the equilibrium standards regime implies*

*No regulation for $0 \leq \theta < \theta^{*N}$;*

*Full regulation for $\theta^{*N} \leq \theta$,*

where $\theta^{*N} = \frac{11}{24}c(2 - c)$.

(Proof) See the Appendix.

We are interested in whether bilateral agreements can be a building block to multilateral agreements; that is, starting from a situation under a bilateral agreement, whether the countries have an incentive to conclude a multilateral agreement. We begin with a comparison of member countries' welfare under the NT-based bilateral agreement, denoted by SW_J^N , with that under the multilateral agreement, denoted by SW^{NM} , $J = A, B$. In light of Fig.3, the member countries are indifferent to the unconstrained noncooperative equilibrium and the bilateral agreements for $0 \leq \theta < \underline{\theta}^U$ and $\theta \geq \bar{\theta}^M$. Therefore, in what follows, we focus on the case of $\underline{\theta}^U \leq \theta < \bar{\theta}^M$. The results are shown in Fig.5.

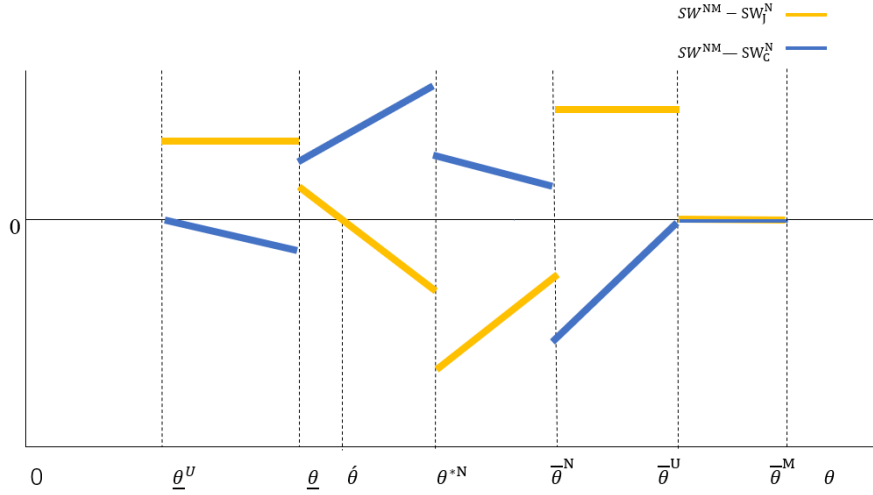


Fig. 5. The welfare comparison between bilateral and multilateral agreement under NT

Based on Fig. 5, We obtain the following Proposition:

Proposition 9. *Under NT, compare member countries' welfare in bilateral agreement and multilateral agreement,*

$$SW^{NM} = SW_j^N \text{ for } \bar{\theta}^U \leq \theta < \bar{\theta}^M;$$

$$SW^{NM} > SW_j^N \text{ for } \underline{\theta}^U < \theta < \hat{\theta} \text{ and } \bar{\theta}^N < \theta < \bar{\theta}^U;$$

$$SW^{NM} < SW_j^N \text{ for } \hat{\theta} \leq \theta < \bar{\theta}^N,$$

where $\hat{\theta} = \frac{13c^2 - 6c}{8(2c - 1)}$.

(Proof) See the Appendix.

For the nonmember country C, comparing its welfare under the NT-based bilateral agreement, denoted by SW_c^N , with that under the multilateral agreement SW^{NM} , we obtain the following proposition.

Proposition 10. *Under NT, compare nonmember country' welfare in bilateral agreement and multilateral agreement,*

$$SW^{NM} = SW_C^N \text{ for } \bar{\theta}^U \leq \theta < \bar{\theta}^M;$$

$$SW^{NM} < SW_C^N \text{ for } \underline{\theta}^U \leq \theta < \underline{\theta} \text{ and } \bar{\theta}^N < \theta < \bar{\theta}^U;$$

$$SW^{NM} > SW_C^N \text{ for } \underline{\theta} \leq \theta < \bar{\theta}^N.$$

(Proof) See the Appendix.

By comparison of welfare, we find that only when the welfare of member countries and nonmember country's increases under Multilateral agreements, a Bilateral agreement of NT could lead to a Multilateral agreement under NT. Summarizing the above analysis, we could find that for all the countries $J = A, B, C$ under NT policy regimes - A Bilateral agreement of NT could lead to a Multilateral agreement for $\underline{\theta} \leq \theta < \hat{\theta}$.

4.2. Multilateral agreements on standards policy: MR

After country C joins agreements, because all the countries are symmetric, we could take country A as example to make analysis. The economic problem in stage 1 is

$$\begin{aligned} SW^A &= CS^A + \sum_{J=A,B,C} \pi_a^J \\ &= \frac{(3 - \sum_{j=a,b,c} c_j^A)^2}{32} - \sum_{j \in a,b,c} \theta_j^A \frac{1 - 3c_j^A + \sum_{i \neq j} c_i^A}{4} + \sum_{J=A,B,C} \frac{(1 - 3c_a^J + \sum_{i \neq a} c_i^J)^2}{16} \end{aligned} \quad (9)$$

subject to $\sigma_a^A = \sigma_a^B = \sigma_a^C$. Country A's government has now two possible choices; one is Full regulation (FR), which means $(\sigma_a^A, \sigma_a^B, \sigma_a^C) = (L, L, L)$, and the other is No regulation (NR), which means $(\sigma_a^A, \sigma_a^B, \sigma_a^C) = (H, H, H)$. The governments' problems in countries B and C can be analogously presented.

As with the MR policy regimes of bilateral agreement, multiple equilibria can exist as well. We consider the "most cooperative" equilibrium of multilateral agreement. The results are represented as

the following proposition.

Proposition 11. *Under a multilateral agreement of standards based on MR, the “most cooperative” equilibrium standards regime implies*

*No regulation for $0 \leq \theta < \theta^{*M}$;*

*Full regulation for $\theta^{*M} \leq \theta$,*

where $\theta^{*M} = \frac{c(42+13c)}{8(1+2c)}$.

(Proof) See the Appendix.

Let us denote country J 's welfare under the MR-based multilateral agreement by SW_J^M , and compare its welfare under the bilateral agreement SW^{MM} , $J=A,B,C$. The results are shown in Fig.6.

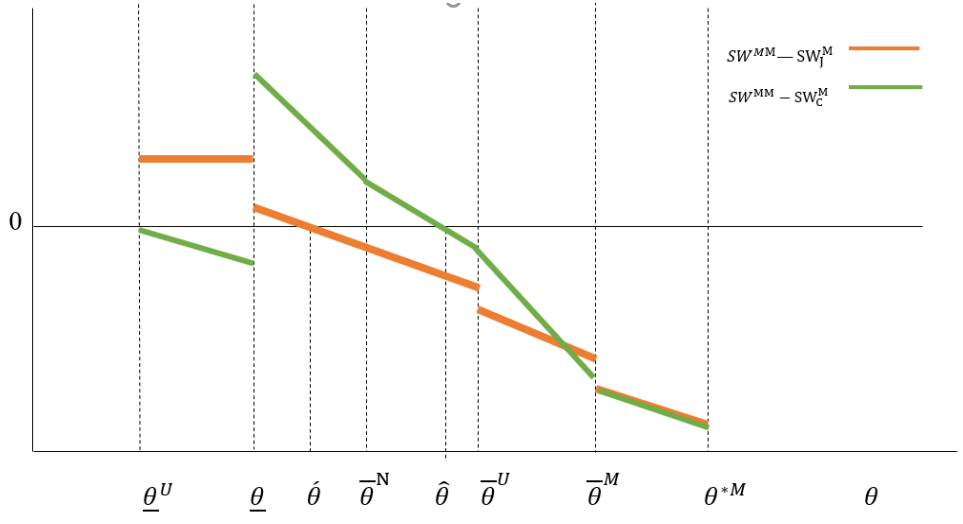


Fig. 6. The welfare comparison between bilateral and multilateral agreement under MR

We begin with the discussion of member countries A and B. Because $\theta^{*M} > \bar{\theta}^M$, here we consider the case of $\underline{\theta}^U \leq \theta < \theta^{*M}$. The following results hold for $J=A,B$. And we obtain the Proposition 12.

Proposition 12. *Under MR, compare member countries' welfare in bilateral agreement and multilateral agreement,*

$$SW^{MM} < SW_J^M \text{ for } \hat{\theta} < \theta < \theta^{*M};$$

$$SW^{MM} > SW_J^M \text{ for } \underline{\theta}^U \leq \theta < \hat{\theta}.$$

(Proof) See the Appendix.

For the nonmember country C, SW_C^M denotes the welfare under Bilateral agreements and SW^{MM} denotes the welfare under Multilateral agreements. We obtain the following Proposition.

Proposition 13. *Under MR, compare nonmember country' welfare in bilateral agreement and multilateral agreement*

$$SW^{MM} < SW_J^M \text{ for } \underline{\theta}^U \leq \theta < \underline{\theta} \text{ and } \hat{\theta} < \theta < \theta^{*M};$$

$$SW^{MM} < SW_J^M \text{ for } \underline{\theta} \leq \theta < \hat{\theta},$$

$$\hat{\theta} = \frac{12c^2 - 7c}{4(c-1)}.$$

(Proof) See the Appendix.

By the above analysis, we know that when the welfare of member countries and nonmember country's increase under Multilateral agreements, a Bilateral agreement of MR could lead to a Multilateral agreement. Then we could obtain that for all the countries J =A, B, C under MR or NT policy regimes - A Bilateral agreement could lead to a Multilateral agreement for $\underline{\theta} \leq \theta < \hat{\theta}$.

By summarizing the above analysis, we could obtain the following the Proposition:

Proposition 14. *A Bilateral agreement could lead to a Multilateral agreement for $\underline{\theta} \leq \theta < \hat{\theta}$.*

5. Concluding remarks

In Bilateral agreements, there is the range for the level of externality, where the regional agreements could be beneficial for not only member countries but nonmember countries. Inside the agreement, the outcome characterized by higher levels of externalities is larger under NT. And when the level of pollution is lower, the outcome under MR will be larger. As for nonmember country,

When the level of pollution is relatively low, all the member countries form the regional agreement and nonmember countries have the incentive to join the multilateral agreement. When the level of pollution increases, the outcome for member countries and nonmember country will be higher in the bilateral agreement under MR, it's better to keep the regional agreement. Under NT, when the level of pollution increases, only member countries could get more benefits from multilateral agreements while nonmember country doesn't have the incentive to join the agreement.

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