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Multilateral Versus Regional Mutual Recognition*

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Abstract: In countries adopting the mutual recognition (MR) of goods, such as the European Union (EU) countries, any good meeting the standards of one country can be sold in other countries, even if it does not comply with the standards of those countries. Under the national treatment (NT), any good sold in a country must follow that country's standards. We develop a model in which the standards policy controls negative consumption externalities to examine whether countries form regional MR and whether regional MR benefits non-members and leads to multilateral MR. Stricter standards reduce externalities but increase firms' costs. We find that countries form regional MR when they cooperatively choose their standards, benefiting the members and non-members of regional MR. However, while multilateral MR benefits the members of regional MR, it may harm the non-members, suggesting that regional MR may act as a stumbling block for multilateral MR.

Keywords: Mutual recognition of goods; national treatment; standards; multilateralism; regionalism

JEL classification numbers: F12; F15; F18

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1. Introduction

Domestic regulations such as product standards often act as impediments to trade because of reductions in tariffs through past trade negotiations (Baldwin, 1970; Ederington and Ruta, 2016). Countries implement standards policies to ensure the health and safety of their consumers or to protect the environment by imposing minimum quality standards. As each country has its own policy goals, these standards differ between countries and can function as non-tariff barriers.[1]

There are two distinct principles regarding product standards: "national treatment" (NT) and "mutual recognition" (MR). Under the NT principle in the World Trade Organization (WTO) rules, to sell goods in one country, domestic and foreign firms must comply with the standards of that country. Therefore, all firms are subject to the same standards under NT.[2] By contrast, in countries adopting the MR principle, any good that meets the standards of one country can be sold in another country, even if it does not fully comply with the latter's standards. In other words, under the MR of goods, a country accepts goods that are lawfully sold in another country.[3]

Comparing MR with NT, MR seems to facilitate more trade because firms do not need to produce goods according to different standards under MR. However, in the real world, most WTO member countries adopt NT, whereas the MR of goods is enforced only in a limited number of countries, such as the European Union (EU) countries.[4] This raises the following important questions: Why is MR adopted in only a few countries (regional MR)? Does regional MR benefit or harm its non-members? Can countries form multilateral MR?

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[1] See "Standards and safety" on the web of the World Trade Organization (https://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm4_e.htm; last accessed on February 8, 2025).

[2] The principle of NT is that a member of the WTO must treat the imported products produced by another member's firms no less favorably than its domestic products with respect to all laws and regulations affecting sales. See the General Agreement on Tariffs and Trade (GATT) Article III.

[3] The principle of MR should not be confused with the "MR agreements" widely formed in the world. In MR agreements, MR applies to conformity assessment procedures but not to product standards.

[4] The EU countries enforce the MR of goods to complement the harmonization of product standards. See the web of the European Commission (EC) (https://single-market-economy.ec.europa.eu/single-market/goods/free-movement-sectors/mutual-recognition-goods_en; last accessed on February 8, 2025). Non-EU countries such as the U.S. and Korea agreed on the recognition of U.S. standards for auto parts under the U.S.–Korea Free Trade Agreement. See the web of the Office of the United States Trade Representative (USTR) (https://ustr.gov/about-us/policy-offices/press-office/fact-sheets/2018/september/fact-sheet-us-korea-free-trade; last accessed on February 8, 2025). In the Japan–EU Economic Partnership Agreement (EPA), the parties agreed to accelerate the approval of unapproved wine additives that are approved in the other's market. See the web of the United States Department of Agriculture (USDA) (https://fas.usda.gov/data/japan-wine-additive-approvals-under-eu-japan-economic-partnership-agreement; last accessed on February 8, 2025).

To answer these questions, we develop a tractable three-country oligopoly model in which each country implements a standards policy to mitigate the negative externalities caused by the consumption of traded goods. The standards are continuous, and stricter standards reduce negative consumption externalities but increase firms' production costs. The oligopoly is essential in this analysis. Without the rent-shifting motive, governments impose the same standards under NT and MR, rendering the two regimes identical. We consider a two-stage game: in Stage 1, each government endogenously sets its own standard, and in Stage 2, firms choose the quantities they supply to each country's market. The NT regime is examined as a benchmark. In our model, there are two distortions—negative consumption externalities and underproduction due to imperfect competition—whereas the government has only one policy instrument, the standards policy.[5] This results in a suboptimal equilibrium.

The main results are as follows. First, regional MR is formed when its members maximize their *joint* welfare but not when they maximize their *national* welfare. Under national welfare maximization, a member of the regional MR significantly lowers its standards to increase exports to another member for rent-shifting purposes (a race to the bottom), resulting in substantial negative consumption externalities for the members. Therefore, the members are worse off relative to NT, and regional MR harms a non-member if the degree of transboundary negative externalities is large. However, when the members cooperatively choose their standards, there is no race to the bottom. Thus, regional MR is formed and, surprisingly, benefits a non-member.

Second, we demonstrate that multilateral MR benefits the members of regional MR but harms the non-members if the marginal compliance cost of standards is high and the degree of transboundary negative externalities is not small. Intuitively, this is because it is too costly for non-members to raise their standards from the NT (lenient) to multilateral MR (stringent) standards. Therefore, non-members block the achievement of multilateral MR. Otherwise, multilateral MR is achieved because it benefits all countries more than regional MR.

Our theoretical results might be consistent with empirical observations. The EU can be classified as a successful regional MR because its members share common interests. Furthermore, the enlargement of the EU can be considered a successful multilateral MR, if we treat members of the regional MR as existing members of the EU and a non-member as a new member.

This study contributes to the literature on minimum quality standards and regional trade

[5] In reality, a large number of products makes it difficult to employ consumption taxes (or subsidies) on each product.

agreements (RTAs). The seminal paper by Fischer and Serra (2000) analyzed the role of standards in a two-country Cournot oligopoly model with consumption externalities. Several subsequent studies have examined standards (Sturm, 2006; Baltzer, 2011; Ishikawa and Okubo, 2011; Petropoulou, 2013; Takarada et al., 2020; Kawabata and Takarada, 2021; Macedoni and Weinberger, 2022, 2024). However, these studies focused exclusively on NT. Our study is closely related to Costinot (2008), who developed a two-country model with low and high standards, showing that standards are too lenient under MR because of a race to the bottom. Thus, NT can be relatively more welfare-enhancing than MR, despite countries choosing the most cooperative (Pareto-efficient) equilibrium.[6] Toulemonde (2013) explored how MR shifts the transaction costs of adapting to different norms (standards) from firms to consumers by considering disutility from consuming imported goods of unfamiliar norms.[7]

The novelty of our study lies in the fact that existing studies on standards do not investigate the impact of regional MR on non-members or the relationship between regionalism and multilateralism because they employ a two-country model.[8] Furthermore, countries can select their standards from a *continuous* range, which is critical for obtaining new results.

The remainder of this paper is organized as follows. Section 2 describes the model and considers NT as a benchmark. Section 3 analyzes regional MR, and Section 4 explores multilateral MR. Section 5 discusses extensions. Finally, Section 6 concludes.

2. The Model

2.1. Basic setting

The world economy comprises three symmetric countries: X, Y, and Z. In each country, one firm produces a homogeneous good, which is freely traded and sold in all three segmented markets.[9] The consumption of these products generates negative externalities, which may be transboundary. The basic setting of the model is based on Takarada et al. (2020).

Each country implements a standards policy to mitigate negative consumption externalities. Let

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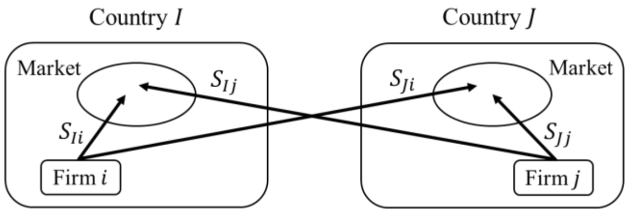
[6] Geng (2019) extended Costinot's model by incorporating heterogeneous preferences for externalities and demonstrated that NT tends to be better than MR.

[7] Using a Ricardian model and focusing on gains from trade, Parenti and Vannoorenberghe (2024) found that countries with strong comparative advantages in distinct externality-generating goods can pursue the cooperative setting of standards through mutual regulatory concessions.

[8] The only exceptions are Takarada et al. (2020) and Kawabata and Takarada (2021), who developed a tractable three-country model to consider the harmonization of standards under NT.

[9] Asymmetry in countries and the case of differentiated goods are discussed in Section 5.

s_{Ij} represent country I's minimum quality standard imposed on a firm in country J (firm j), where $I = X, Y, Z$ and $j = x, y, z$. We use uppercase and lowercase letters to denote countries and firms, respectively (e.g., country X's firm is denoted as firm x). Figure 1 depicts two types of standards policies, NT and MR, between countries I and J. Under NT, country I treats a domestic firm (firm i) and foreign firms (firm j) equivalently, such that $s_{Ii} = s_{Ij}$, and vice versa ($I, J = X, Y, Z$, $I \neq J$, $i, j = x, y, z$, $i \neq j$). In other words, in the NT regime, any good lawfully sold in one country must follow that country's standards. However, in countries adopting MR, any good complying with the standards of one country can be sold in another, even if the good does not fully meet the standards of the latter country. When countries I and J implement MR, country I's standard on firm j, s_{Ij} (country J's standard on firm i, s_{Ji}), is equivalent to the standard the firm must comply with at home, s_{Jj} (s_{Ii}), that is, $s_{Ij} = s_{Jj}$ ($s_{Ji} = s_{Ii}$).



NT: $s_{Ii} = s_{Ij}$, $s_{Jj} = s_{Ji}$ MR: $s_{Ij} = s_{Jj}$, $s_{Ji} = s_{Ii}$

Figure 1. Standards policy

Firms compete in a Cournot fashion in each of the national markets and incur unit production costs, denoted as $c(s_{Ij})$, to produce a good with standard s_{Ij}, where $c'(s_{Ij}) > 0$ and $c''(s_{Ij}) \geq 0$. As the negative effects of consumption are external to consumers, the level of standards does not influence consumers' demand for goods, as in Fischer and Serra (2000). Consequently, firms have no incentive to voluntarily raise their standards, thereby producing goods that exactly meet the minimum quality standards.

Firm j earns the following profit from sales in country I's market:

$$\pi_{Ij} = \left[p(Q_I) - c(s_{Ij})\right] q_{Ij}, \quad I = X, Y, Z, \quad j = x, y, z, \tag{1}$$

where q_{Ij} and Q_I denote firm j's supply to country I's market and the total supply in country I's market, respectively. $p(Q_I)$ represents the inverse demand function in country I.

Let $g(s_{Ij})$ be the negative externalities per unit of consumption at standard s_{Ij}, and assume that $g(s_{Ij}) \geq 0$, $g'(s_{Ij}) < 0$, and $g''(s_{Ij}) \geq 0$. The loss associated with negative consumption externalities in country I is expressed as follows:

$$L_I = l_{II}\left(s_{Ii}, s_{Ij}, s_{Ik}\right) + \delta l_{JI}\left(s_{Ji}, s_{Jj}, s_{Jk}\right) + \delta l_{KI}\left(s_{Ki}, s_{Kj}, s_{Kk}\right),$$

$$I, J, K = X, Y, Z, \quad I \neq J \neq K, \quad i, j, k = x, y, z, \quad i \neq j \neq k, \quad (2)$$

where $l_{II}(s_{Ii}, s_{Ij}, s_{Ik}) = g(s_{Ii})q_{Ii} + g(s_{Ij})q_{Ij} + g(s_{Ik})q_{Ik}$, $l_{JI}(s_{Ji}, s_{Jj}, s_{Jk}) = g(s_{Ji})q_{Ji} + g(s_{Jj})q_{Jj} + g(s_{Jk})q_{Jk}$, and $\delta \in [0, 1]$ represents the degree of transboundary negative externalities. In Equation (2), the first term, l_{II}, represents the damage caused by country I's own consumption, and the second and third terms, δl_{JI} and δl_{KI}, represent the damage from country J's and K's consumption, respectively, if $\delta > 0$. All else being equal, the higher the standards, the smaller the loss.

Country I's welfare is given by

$$W_I = CS_I + \sum_{J=X,Y,Z} \pi_{Ji} - L_I, \quad I = X, Y, Z, \quad i = x, y, z, \quad (3)$$

where $CS_I = \int_0^{Q_I} p(\omega) d\omega - p(Q_I)Q_I$ is country I's consumer surplus. This can be rewritten as

$$W_I = w_{II}(s_{Ii}, s_{Ij}, s_{Ik}) + \sum_{J \neq I} w_{JI}(s_{Ji}, s_{Jj}, s_{Jk}), \quad I, J = X, Y, Z, \quad i, j, k = x, y, z, \quad i \neq j \neq k, \quad (3')$$

where $w_{II}(s_{Ii}, s_{Ij}, s_{Ik}) = CS_I + \pi_{Ii} - l_{II}$ is the domestic component of country I's welfare and $w_{JI}(s_{Ji}, s_{Jj}, s_{Jk}) = \pi_{Ji} - \delta l_{JI}$ is the component of country I's welfare obtained from country J.

To obtain clear-cut results, we specify the functional forms as in Takarada et al. (2020): $c(s_{Ij}) = \gamma s_{Ij}$, $p(Q_I) = \alpha - Q_I$, and $g(s_{Ij}) = \beta - s_{Ij}$, where $\beta - s_{Ij} \geq 0$ for $\forall s_{Ij} \geq 0$. Here, γ measures the extent to which stricter standards increase a firm's unit production costs to comply with the standards. We can interpret γ as the marginal compliance cost of standards. $s_{Ij} = 0$ represents the most lenient standard, which generates the maximum negative externalities per unit of consumption, $g(0) = \beta$. By contrast, $s_{Ij} = \beta$ represents the most stringent standard, causing no negative externalities, $g(\beta) = 0$. Furthermore, we assume the following to ensure that the second-order conditions for welfare maximization and the positive sales conditions are satisfied in the subsequent analysis:[10]

Assumption 1. (i) $2\beta > \alpha > 3\beta/2$ *and* (ii) $1/2 < \gamma < (2 + \delta)/2$.

We consider a two-stage game. In Stage 1, each government endogenously sets its own standard. In Stage 2, firms choose the quantities they supply to each country's market. Using backward induction, we derive the subgame perfect Nash equilibrium of the game.

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[10] From Assumption 1 (i), demand size α is sufficiently large to ensure positive outputs, and β is large enough to generate negative externalities that must be controlled by standards. As for (ii), if $\gamma \leq 1/2$, countries impose the most stringent standards in both the NT and MR regimes regardless of the value of δ because it is not costly to remove negative externalities. This is excluded by assuming $\gamma > 1/2$. In addition, from $0 \leq \delta \leq 1$, the upper bound of γ is $3/2$.

2.2. National treatment: Benchmark

We examine the NT regime in which the three countries adopt the principle of NT. In this regime, firms selling in country I face the same standard, $s_I = s_{Ii} = s_{Ij} = s_{Ik}$ $(I = X, Y, Z,\ i, j, k = x, y, z,\ i \neq j \neq k)$, and countries set their respective standards independently. The profits earned by firms i and j in country I's market are $\pi_{Ii} = [p(Q_I) - c(s_I)]q_{Ii}$ and $\pi_{Ij} = [p(Q_I) - c(s_I)]q_{Ij}$, respectively $(i, j = x, y, z,\ i \neq j)$. The loss associated with negative consumption externalities in country I is $L_I = g(s_I)Q_I + \delta g(s_J)Q_J + \delta g(s_K)Q_K$ $(I, J, K = X, Y, Z,\ I \neq J \neq K)$.

In Stage 2, each firm chooses the quantities it will supply to country I's market to maximize its own profits, taking the rivals' output and standards as given. From the first-order condition for profit maximization, firm i's and j's sales in country I's market are given by:

$$q_{Ii} = q_{Ij} = \frac{\alpha - \gamma s_I}{4}, \quad I = X, Y, Z, \quad i, j = x, y, z, \quad i \neq j. \tag{4}$$

From Equation (4), we obtain the equilibrium total sales (consumption) in country I:

$$Q_I = \frac{3(\alpha - \gamma s_I)}{4}, \quad I = X, Y, Z. \tag{5}$$

In Stage 1, the government of country I determines its standard s_I $(= s_{Ii} = s_{Ij} = s_{Ik})$ to maximize its welfare, taking the other countries' standards as given.[11] Using Equations (3), (4), and (5), country I's first-order condition for welfare maximization is given by:

$$\frac{\partial W_I}{\partial s_I} = \frac{1}{16}[12\gamma\beta - (11\gamma - 12)\alpha - \gamma(24 - 11\gamma)s_I] = 0, \quad I = X, Y, Z. \tag{6}$$

Equation (6) depends only on s_I, indicating the *strategic independence* of countries' standards under NT.[12] This is because w_{II} depends only on country I's standards and w_{JI} depends only on country J's standards. Recalling that $0 \leq s_I \leq \beta$ and using Equation (6), we obtain country I's standard under NT (the superscript N denotes equilibrium values in the NT regime):

$$s_I^N = \begin{cases} \beta, & if \ \frac{1}{2} < \gamma \leq \frac{12}{11} \\ \frac{12\gamma\beta - (11\gamma - 12)\alpha}{\gamma(24 - 11\gamma)}, & if \ \frac{12}{11} < \gamma < \frac{3}{2} \end{cases}, \quad I = X, Y, Z. \tag{7}$$

We can show that the interior solution, $s_I^N = [12\gamma\beta - (11\gamma - 12)\alpha]/\gamma(24 - 11\gamma)$, satisfies $0 < s_I^N < \beta$ under Assumption 1 (i) and (ii) and increases with β; that is, the dirtier the products, the higher the NT standards. When the marginal compliance cost of standards, γ, is low $(1/2 < \gamma <$

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[11] Under the linear demand, country I's consumer surplus is given by $CS_I = (Q_I)^2/2$. Firm j's profits in country I's market are $\pi_{Ij} = (q_{Ij})^2$ from the first-order condition for profit maximization.

[12] The second-order condition is $\partial^2 W_I/\partial s_I^2 = -\gamma(24 - 11\gamma)/16 < 0$. This condition is satisfied under Assumption 1 (ii).

$12/11$), countries impose the highest standard (a corner solution), β, to eliminate all negative externalities because it is not costly to do so. However, when γ is high ($12/11 < \gamma < 3/2$), countries set the interior solution standards.

Substituting Equation (7) into Equations (4) and (5) yields the NT equilibrium sales in country I:

$$q_{Ii}^N = q_{Ij}^N = \begin{cases} \dfrac{\alpha - \gamma\beta}{4}, & if \ \dfrac{1}{2} < \gamma \leq \dfrac{12}{11} \\ \dfrac{3(\alpha - \gamma\beta)}{24 - 11\gamma}, & if \ \dfrac{12}{11} < \gamma < \dfrac{3}{2} \end{cases},$$

$$Q_I^N = \begin{cases} \dfrac{3(\alpha - \gamma\beta)}{4}, & if \ \dfrac{1}{2} < \gamma \leq \dfrac{12}{11} \\ \dfrac{9(\alpha - \gamma\beta)}{24 - 11\gamma}, & if \ \dfrac{12}{11} < \gamma < \dfrac{3}{2} \end{cases}, \quad I = X, Y, Z, \quad i, j = x, y, z, \quad i \neq j. \quad (8)$$

Q_I^N is decreasing in γ.

Using Equations (7) and (8) in Equation (3'), we obtain the NT welfare level of country I:

$$W_I^N = w_{II}(s_I^N, s_I^N, s_I^N) + w_{JI}(s_J^N, s_J^N, s_J^N) + w_{KI}(s_K^N, s_K^N, s_K^N), \quad I, J, K = X, Y, Z, \quad I \neq J \neq K, \quad (9)$$

where:

$$w_{II}(s_I^N, s_I^N, s_I^N) = \begin{cases} \dfrac{11(\alpha - \gamma\beta)^2}{32}, & if \ \dfrac{1}{2} < \gamma \leq \dfrac{12}{11} \\ \dfrac{9(\alpha - \gamma\beta)^2}{2\gamma(24 - 11\gamma)}, & if \ \dfrac{12}{11} < \gamma < \dfrac{3}{2} \end{cases},$$

$$w_{JI}(s_J^N, s_J^N, s_J^N) = w_{KI}(s_K^N, s_K^N, s_K^N) = \begin{cases} \dfrac{(\alpha - \gamma\beta)^2}{16}, & if \ \dfrac{1}{2} < \gamma \leq \dfrac{12}{11} \\ \dfrac{9[\gamma - \delta(11\gamma - 12)](\alpha - \gamma\beta)^2}{\gamma(24 - 11\gamma)^2}, & if \ \dfrac{12}{11} < \gamma < \dfrac{3}{2} \end{cases}.$$

w_{II} decreases with γ because it becomes more costly to produce goods when γ is large.

3. Regional Mutual Recognition

This section considers the regional MR between countries X and Y, without loss of generality. We regard country Z as a non-member country that remains subject to NT. Under regional MR, member J accepts goods that follow member I's standards, even if the goods do not comply with member J's standards ($I, J = X, Y, \ I \neq J$), that is, $s_I = s_{Ii} = s_{Ji}$ ($i = x, y$). However, firm z in non-member country Z selling in member I must comply with member I's standard, that is, $s_{Iz} = s_I$ ($I = X, Y$).

In Stage 1, each member of regional MR endogenously sets its standard for either (i) maximizing its own welfare or (ii) maximizing the sum of the members' welfare, and a non-member imposes its standard to maximize its own welfare. Stage 2 proceeds as in the basic setting.

Under regional MR, the profits of the three firms in member I are given by $\pi_{Ii} = [p(Q_I) - c(s_I)]q_{Ii}$, $\pi_{Ij} = [p(Q_I) - c(s_J)]q_{Ij}$, and $\pi_{Iz} = [p(Q_I) - c(s_I)]q_{Iz}$ ($I, J = X, Y$, $I \neq J$, $i, j = x, y$, $i \neq j$). The losses associated with negative consumption externalities in the member and non-member countries are $L_I = g(s_I)(q_{Ii} + q_{Iz}) + g(s_J)q_{Ij} + \delta[g(s_I)q_{Ji} + g(s_J)(q_{Jj} + q_{Jz})] + \delta g(s_Z)Q_Z$ and $L_Z = g(s_Z)Q_Z + \delta[g(s_I)(q_{Ii} + q_{Iz}) + g(s_J)q_{Ij}] + \delta[g(s_I)q_{Ji} + g(s_J)(q_{Jj} + q_{Jz})]$, respectively.

Solving profit maximization in Stage 2, we obtain firms' and total sales in member I's market:

$$q_{Ii} = q_{Iz} = \frac{\alpha - 2\gamma s_I + \gamma s_J}{4}, \quad q_{Ij} = \frac{\alpha + 2\gamma s_I - 3\gamma s_J}{4},$$

$$Q_I = \frac{3\alpha - 2\gamma s_I - \gamma s_J}{4}, \quad I, J = X, Y, \quad I \neq J, \quad i, j = x, y, \quad i \neq j. \tag{10}$$

3.1. National welfare maximization

In this subsection, we investigate the case of member and non-member countries of a regional MR imposing their standards to maximize their own welfare.

In Stage 1, subject to $s_I = s_{Ii} = s_{Ji} = s_{Iz}$, the government of member I sets its standard, s_I, to maximize its national welfare, taking the other countries' standards as given ($I, J = X, Y$, $I \neq J$, $i = x, y$). Similarly, the government of non-member Z sets its standard s_Z ($= s_{Zz} = s_{Zx} = s_{Zy}$) to maximize its national welfare. Non-member Z continues to impose standard s_Z^N as given by Equation (7) because it adopts the principle of NT, and strategic independence remains valid.

Recalling that $0 \leq s_I \leq \beta$ and applying the first-order condition for welfare maximization by member I, we derive member I's reaction function as follows:[13]

Case 1: $1/2 < \gamma \leq (2+\delta)/4$

$$s_I = \begin{cases} \dfrac{2\{\gamma(2+\delta)\beta - [4\gamma - (2+\delta)]\alpha\}}{\gamma(16 + 12\delta - 15\gamma)} + \dfrac{8(1+\delta) - 7\gamma}{16 + 12\delta - 15\gamma} s_J, & if \;\; 0 \leq s_J < s_1 \\ \beta, & if \;\; s_1 \leq s_J \leq \beta \end{cases},$$
$$I, J = X, Y, \quad I \neq J, \tag{11a}$$

where $s_1 = \{2[4\gamma - (2+\delta)]\alpha + \gamma[12 + 10\delta - 15\gamma]\beta\}/\gamma[8(1+\delta) - 7\gamma]$.

Case 2: $(2+\delta)/4 < \gamma < (2+\delta)\alpha/[4\alpha - (2+\delta)\beta]$

[13] The second-order condition is $\partial^2 W_I/\partial s_I^2 = -\gamma[4(4+3\delta) - 15\gamma]/8 < 0$. This condition holds under Assumption 1 (ii).

$$s_I = \frac{2\{\gamma(2+\delta)\beta - [4\gamma - (2+\delta)]\alpha\}}{\gamma(16+12\delta-15\gamma)} + \frac{8(1+\delta)-7\gamma}{16+12\delta-15\gamma} s_J. \tag{11b}$$

Case 3: $(2+\delta)\alpha/[4\alpha-(2+\delta)\beta] \leq \gamma < (2+\delta)/2$

$$s_I = \begin{cases} 0, & if\ 0 \leq s_J \leq s_2 \\ \frac{2\{\gamma(2+\delta)\beta - [4\gamma - (2+\delta)]\alpha\}}{\gamma(16+12\delta-15\gamma)} + \frac{8(1+\delta)-7\gamma}{16+12\delta-15\gamma} s_J, & if\ s_2 < s_J \leq \beta \end{cases}, \tag{11c}$$

where $s_2 = 2\{[4\gamma-(2+\delta)]\alpha - \gamma(2+\delta)\beta\}/\gamma[8(1+\delta)-7\gamma]$. In particular, when $\delta = 0$, only the latter two cases are applicable.

From Equations (11a) to (11c), member I's and J's standards are *strategically interdependent*.[14] This sharply contrasts with the case of NT. The coefficient of s_J is positive under Assumption 1 (ii), i.e., members' standards are *strategic complements*. This result is consistent with that of Costinot (2008).

From Equations (11a) to (11c), we obtain member I's standard under regional MR (the superscript M denotes equilibrium values in the regional MR regime under national welfare maximization):

$$s_I^M = \begin{cases} \beta, & if\ \frac{1}{2} < \gamma \leq \frac{2+\delta}{4} \\ \frac{\gamma(2+\delta)\beta - [4\gamma-(2+\delta)]\alpha}{2\gamma(2+\delta-2\gamma)}, & if\ \frac{2+\delta}{4} < \gamma < \frac{(2+\delta)\alpha}{4\alpha-(2+\delta)\beta} \\ 0, & if\ \frac{(2+\delta)\alpha}{4\alpha-(2+\delta)\beta} \leq \gamma < \frac{2+\delta}{2} \end{cases}, \quad I = X, Y. \tag{12}$$

Members set the most stringent standards ($s_I^M = \beta$) when γ is sufficiently small, but they enforce the most lenient standards ($s_I^M = 0$) when γ is sufficiently large. Otherwise, an intermediate standard, s_I^M ($0 < s_I^M < \beta$), is imposed. We can show that the interior solution s_I^M is smaller than s_I^N in Equation (7) under Assumption 1 (i) and (ii).

Lemma 1. *Assume national welfare maximization. If* $1/2 < \gamma \leq (2+\delta)/4$, $s_I^M = s_I^N = \beta$ $(I = X, Y)$. *However, if* $(2+\delta)/4 < \gamma < (2+\delta)/2$, $s_I^M < s_I^N$.

Intuitively, there are three effects. First, the member's government aims to reduce negative externalities by raising its standards. Second, setting lenient standards addresses underproduction. Third, because a member can supply goods with its standards to another member's market, the member seeks to increase exports to another member's market for rent-shifting by imposing lenient standards (a race to the bottom). When γ is small, following stringent standards is not costly; thus, the first effect dominates. However, when γ is large, adopting stringent standards becomes costly, and the latter two

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[14] Equations (11a) to (11c) show that member I's standard is independent of non-member Z's standard.

effects outweigh the first effect.

Substituting Equation (12) into Equation (10) yields the equilibrium sales in member I's market:

$$q_{Ii}^M = q_{Ij}^M = q_{Iz}^M = \begin{cases} \dfrac{\alpha - \gamma\beta}{4}, & if \ \dfrac{1}{2} < \gamma \le \dfrac{2+\delta}{4} \\ \dfrac{(2+\delta)(\alpha - \gamma\beta)}{8(2+\delta-2\gamma)}, & if \ \dfrac{2+\delta}{4} < \gamma < \dfrac{(2+\delta)\alpha}{4\alpha-(2+\delta)\beta} \\ \dfrac{\alpha}{4}, & if \ \dfrac{(2+\delta)\alpha}{4\alpha-(2+\delta)\beta} \le \gamma < \dfrac{2+\delta}{2} \end{cases},$$

$$Q_I^M = \begin{cases} \dfrac{3(\alpha - \gamma\beta)}{4}, & if \ \dfrac{1}{2} < \gamma \le \dfrac{2+\delta}{4} \\ \dfrac{3(2+\delta)(\alpha - \gamma\beta)}{8(2+\delta-2\gamma)}, & if \ \dfrac{2+\delta}{4} < \gamma < \dfrac{(2+\delta)\alpha}{4\alpha-(2+\delta)\beta} \\ \dfrac{3\alpha}{4}, & if \ \dfrac{(2+\delta)\alpha}{4\alpha-(2+\delta)\beta} \le \gamma < \dfrac{2+\delta}{2} \end{cases},$$

$$I = X, Y, \quad i, j = x, y, \quad i \ne j. \quad (13)$$

From Equations (8) and (13) and Lemma 1, $q_{Ii}^M = q_{Ij}^M = q_{Iz}^M = q_{Ii}^N = q_{Ij}^N = q_{Iz}^N$ and $Q_I^M = Q_I^N$ for $1/2 < \gamma \le (2+\delta)/4$ because standards are the same under NT and regional MR. For $(2+\delta)/4 < \gamma < (2+\delta)/2$, $q_{Ii}^M = q_{Ij}^M = q_{Iz}^M > q_{Ii}^N = q_{Ij}^N = q_{Iz}^N$ and $Q_I^M > Q_I^N$ because standards are lower under regional MR than under NT. Therefore, *regional MR increases the trade between members and a non-member's exports to members*. In non-member *Z*'s market, $q_{Zz}^M = q_{Zi}^M = q_{Zz}^N = q_{Zi}^N$ $(i = x, y)$.

Using Equations (7), (8), (12), and (13) in Equation (3'), we obtain the welfare levels of member and non-member countries under regional MR as shown in Equations (14) and (15), respectively:[15]

$$W_I^M = w_{II}(s_I^M, s_J^M, s_I^M) + w_{JI}(s_I^M, s_J^M, s_J^M) + w_{ZI}(s_Z^N, s_Z^N, s_Z^N), \quad I, J = X, Y, \quad I \ne J, \quad (14)$$

$$W_Z^M = w_{ZZ}(s_Z^N, s_Z^N, s_Z^N) + w_{XZ}(s_X^M, s_X^M, s_Y^M) + w_{YZ}(s_Y^M, s_X^M, s_Y^M), \quad (15)$$

where:

$$w_{II}(s_I^M, s_J^M, s_I^M)$$

$$= \begin{cases} \dfrac{11(\alpha - \gamma\beta)^2}{32}, & if \ \dfrac{1}{2} < \gamma \le \dfrac{2+\delta}{4} \\ \dfrac{(2+\delta)[2(24-37\gamma)+\delta(24+11\gamma)](\alpha-\gamma\beta)^2}{128\gamma(2+\delta-2\gamma)^2}, & if \ \dfrac{2+\delta}{4} < \gamma < \dfrac{(2+\delta)\alpha}{4\alpha-(2+\delta)\beta} \\ \dfrac{\alpha(11\alpha - 24\beta)}{32}, & if \ \dfrac{(2+\delta)\alpha}{4\alpha-(2+\delta)\beta} \le \gamma < \dfrac{2+\delta}{2} \end{cases},$$

$$w_{JI}(s_I^M, s_J^M, s_J^M) = w_{XZ}(s_X^M, s_X^M, s_Y^M) = w_{YZ}(s_Y^M, s_X^M, s_Y^M)$$

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[15] From Equation (3'), $W_Z = w_{ZZ}(s_{Zz}, s_{Zx}, s_{Zy}) + w_{XZ}(s_{Xz}, s_{Xx}, s_{Xy}) + w_{YZ}(s_{Yz}, s_{Yx}, s_{Yy})$.

$$
= \begin{cases} \dfrac{(\alpha-\gamma\beta)^2}{16}, & if\ \dfrac{1}{2} < \gamma \leq \dfrac{2+\delta}{4} \\ \dfrac{(2+\delta)[12\delta(2+\delta)-(47\delta-2)\gamma](\alpha-\gamma\beta)^2}{64\gamma(2+\delta-2\gamma)^2}, & if\ \dfrac{2+\delta}{4} < \gamma < \dfrac{(2+\delta)\alpha}{4\alpha-(2+\delta)\beta} \\ \dfrac{\alpha(\alpha-12\delta\beta)}{16}, & if\ \dfrac{(2+\delta)\alpha}{4\alpha-(2+\delta)\beta} \leq \gamma < \dfrac{2+\delta}{2} \end{cases} .
$$

As non-member Z adopts NT, $w_{ZI}(s_Z^N, s_Z^N, s_Z^N)$ and $w_{ZZ}(s_Z^N, s_Z^N, s_Z^N)$ are given by Equation (9).

We then establish the following proposition (see Appendix A for the proof).

Proposition 1. *Assume national welfare maximization.* (i) *When* $1/2 < \gamma \leq (2+\delta)/4$, *regional MR yields the same welfare as in NT for all countries.* (ii) *When* $(2+\delta)/4 < \gamma < \min\{(2+\delta)/2, 12/11\}$, *regional MR harms members. However, it benefits a non-member if* δ *is sufficiently small; otherwise, it harms a non-member.* (iii) *When* $12/11 \leq \gamma < (2+\delta)/2$, *all countries lose from regional MR.*

In terms of member countries, NT weakly dominates regional MR. Therefore, countries *never* have incentives to form regional MR under national welfare maximization.

The intuition behind this result is as follows. From Lemma 1, when the marginal compliance cost of standards, γ, is not low, members of regional MR set lenient standards (a race to the bottom). Consequently, large negative externalities arise due to increased consumption in members. Therefore, members always lose from forming regional MR, and it harms non-members unless the degree of cross-border externalities, δ, is small. When γ is sufficiently large, members impose more lenient standards, resulting in severe negative externalities and a subsequent deterioration of welfare in all countries.

Let us explain Proposition 1 using Figure 2. In Region I ($1/2 < \gamma \leq (2+\delta)/4$), where γ is sufficiently small, countries' standards are the same as those under NT, $s_I^M = s_I^N = \beta$ for $I = X, Y$ (Lemma 1) and $s_Z^N = \beta$. Thus, result (i) holds. In particular, when $\delta = 0$, Region I does not exist.

In Regions II–V ($(2+\delta)/4 < \gamma < (2+\delta)/2$), where γ is large, we obtain results (ii) and (iii). First, we explain member I's welfare by examining changes in the domestic component of its welfare, w_{II}, and the component of its welfare obtained from partner J, w_{JI} ($I, J = X, Y$, $I \neq J$). We do not need to consider the component of member I's welfare obtained from a non-member, w_{ZI}, because it remains the same as under NT. From Lemma 1, when $(2+\delta)/4 < \gamma < (2+\delta)/2$, a move from NT to regional MR reduces member I's standard, which increases firm i's local profits and member I's consumer surplus (a positive effect). However, it also exacerbates the negative externalities caused by domestic consumption (a negative effect). We can show that the negative effect outweighs the positive effect: $w_{II}(s_I^M, s_J^M, s_I^M) < w_{II}(s_I^N, s_I^N, s_I^N)$. Furthermore, the reduction in member I's standard increases the profits earned by firm i in partner J's market, π_{Ji}, but worsens member I's environmental quality due to the cross-border negative externalities caused by partner J's consumption, δl_{JI}. If δ is sufficiently small (i.e., near the vertical axis in Regions II and III), the positive effect of π_{Ji} outweighs the negative effect of δl_{Ji}: $w_{JI}(s_I^M, s_J^M, s_J^M) > w_{JI}(s_J^N, s_J^N, s_J^N)$. Otherwise, the negative effect dominates, leading to $w_{JI}(s_I^M, s_J^M, s_J^M) < w_{JI}(s_J^N, s_J^N, s_J^N)$. Although w_{JI} can increase, the decrease in w_{II} is dominant; thus, members are always worse off under regional MR than under NT.

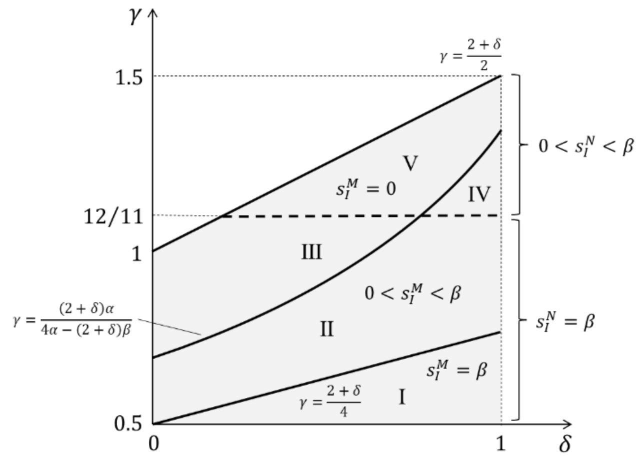

Figure 2. Regional MR under national welfare maximization

Notes: When $\delta = 0$, $\gamma = \alpha/(2\alpha - \beta)$, where $2/3 < \alpha/(2\alpha - \beta) < 3/4$ under Assumption 1 (i). When $\delta = 1$, $\gamma = 3\alpha/(4\alpha - 3\beta)$, where $6/5 < 3\alpha/(4\alpha - 3\beta) < 3/2$. $\gamma = 12/11$ when $\delta = 2(13\alpha - 12\beta)/(11\alpha + 12\beta)$, where $10/19 < 2(13\alpha - 12\beta)/(11\alpha + 12\beta) < 14/17$.

Second, we analyze the welfare of non-member *Z* in Regions II–V. The reduction in members' standards positively affects firm *z*'s export profits in members' markets (a positive effect), but it negatively impacts non-member *Z*'s environmental quality through the transboundary externalities caused by members' consumption (a negative effect). The positive effect is dominant only when δ is sufficiently small.

3.2. Joint welfare maximization

We explore the case where the members of regional MR impose their standards while considering another member. A non-member sets its standard to maximize its own welfare. The equilibrium for a non-member remains unchanged under NT because its standards policy is strategically independent.

In Stage 1, under the condition $s_I = s_{Ii} = s_{Ji} = s_{Iz}$, the government of member I sets its standard to maximize the joint welfare of the members, $W_X + W_Y$, taking the standards of other countries' as given ($I, J = X, Y,\ I \neq J,\ i = x, y$). Then, member I's reaction function is derived as follows:

Case 1: $1/2 < \gamma < \min\{12(1+\delta)/13, (2+\delta)/2\}$

$$s_I = \begin{cases} \dfrac{[12(1+\delta)-13\gamma]\alpha + 12\gamma(1+\delta)\beta}{\gamma[56(1+\delta)-41\gamma]} + \dfrac{4[8(1+\delta)-7\gamma]}{56(1+\delta)-41\gamma} s_J, & if\ 0 \le s_J < s_3 \\ \beta, & if\ s_3 \le s_J \le \beta \end{cases},$$

$$I = X, Y, \quad I \neq J, \quad (16a)$$

where $s_3 = \{-[12(1+\delta)-13\gamma]\alpha + \gamma[44(1+\delta)-41\gamma]\beta\}/4\gamma[8(1+\delta)-7\gamma]$.

Case 2: $12(1+\delta)/13 < \gamma < (2+\delta)/2$ *and* $0 \le \delta < 2/11$

$$s_I = \frac{[12(1+\delta)-13\gamma]\alpha + 12\gamma(1+\delta)\beta}{\gamma[56(1+\delta)-41\gamma]} + \frac{4[8(1+\delta)-7\gamma]}{56(1+\delta)-41\gamma} s_J. \quad (16b)$$

From Equations (16a) and (16b), as the coefficient of s_J is positive under Assumption 1 (ii), the members' standards are *strategic complements*.

From Equations (16a) and (16b), we can derive member I's regional MR standard under joint welfare maximization (the superscript m represents equilibrium values in the regional MR regime under joint welfare maximization):

$$s_I^m = \begin{cases} \beta, & if\ \dfrac{1}{2} < \gamma < \min\left\{\dfrac{12(1+\delta)}{13}, \dfrac{2+\delta}{2}\right\} \\ \dfrac{12\gamma(1+\delta)\beta - [13\gamma - 12(1+\delta)]\alpha}{\gamma[24(1+\delta)-13\gamma]}, & if\ \dfrac{12(1+\delta)}{13} < \gamma < \dfrac{2+\delta}{2}\ and\ 0 \le \delta < \dfrac{2}{11} \end{cases},$$

$$I = X, Y. \quad (17)$$

Lemma 2. *Assume joint welfare maximization. If* $1/2 < \gamma \le \min\{12(1+\delta)/13, 12/11\}$, $s_I^m = s_I^N = \beta$ *(*$I = X, Y$*). If* $12(1+\delta)/13 < \gamma < (2+\delta)/2$ *and* $0 \le \delta < 2/11$, $s_I^m < s_I^N$. *If* $12/11 < \gamma < (2+\delta)/2$ *and* $2/11 < \delta \le 1$, $s_I^m > s_I^N$.

Unlike Lemma 1, the regional MR standard can exceed the NT standard. This implies that whether a member considers the welfare of other members is crucial in determining the level of standards.

The intuition is as follows. Under joint welfare maximization, a member of the regional MR considers the negative effect of lenient domestic standards on the other member. Therefore, members have no incentive to set lenient standards for rent-shifting purposes (no race to the bottom). There are two distortions to be solved: negative externalities and underproduction. When γ is small ($1/2 < \gamma \le \min\{12(1+\delta)/13, 12/11\}$), imposing the most stringent standards, β, is not costly. When γ is intermediate ($12(1+\delta)/13 < \gamma < (2+\delta)/2$), δ is small ($0 \le \delta < 2/11$). Under a small δ, we need not consider negative externalities; thus, the government imposes lenient standards to boost production. When γ is large $(12/11 < \gamma < (2+\delta)/2)$, δ is sufficiently large $(2/11 < \delta \le 1)$, thereby setting strict standards to mitigate negative externalities.

Substituting Equation (17) into Equation (10) yields the equilibrium sales in member I's market:

$$q_{Ii}^m = q_{Ij}^m = q_{Iz}^m = \begin{cases} \dfrac{\alpha - \gamma\beta}{4}, & if \ \dfrac{1}{2} < \gamma < \min\left\{\dfrac{12(1+\delta)}{13}, \dfrac{2+\delta}{2}\right\} \\ \dfrac{3(1+\delta)(\alpha-\gamma\beta)}{24(1+\delta)-13\gamma}, & if \ 0 \le \delta < \dfrac{2}{11} \ and \ \dfrac{12(1+\delta)}{13} < \gamma < \dfrac{2+\delta}{2} \end{cases},$$

$$Q_I^m = \begin{cases} \dfrac{3(\alpha - \gamma\beta)}{4}, & if \ \dfrac{1}{2} < \gamma < \min\left\{\dfrac{12(1+\delta)}{13}, \dfrac{2+\delta}{2}\right\} \\ \dfrac{9(1+\delta)(\alpha-\gamma\beta)}{24(1+\delta)-13\gamma}, & if \ 0 \le \delta < \dfrac{2}{11} \ and \ \dfrac{12(1+\delta)}{13} < \gamma < \dfrac{2+\delta}{2} \end{cases},$$

$$I = X, Y, \quad i, j = x, y, \quad i \ne j. \quad (18)$$

From Equations (8) and (18) and Lemma 2, $q_{Ii}^m = q_{Ij}^m = q_{Iz}^m = q_{Ii}^N = q_{Ij}^N = q_{Iz}^N$ and $Q_I^m = Q_I^N$ for $1/2 < \gamma \le \min\{12(1+\delta)/13, 12/11\}$; $q_{Ii}^m = q_{Ij}^m = q_{Iz}^m > q_{Ii}^N = q_{Ij}^N = q_{Iz}^N$ and $Q_I^m > Q_I^N$ for $12(1+\delta)/13 < \gamma < (2+\delta)/2$ and $0 \le \delta < 2/11$; $q_{Ii}^m = q_{Ij}^m = q_{Iz}^m < q_{Ii}^N = q_{Ij}^N = q_{Iz}^N$ and $Q_I^m < Q_I^N$ for $12/11 < \gamma < (2+\delta)/2$ and $2/11 < \delta \le 1$. Accordingly, regional MR *increases* the trade between members and a non-member's exports if δ is small but *decreases* both if δ is large.

Using Equations (7), (8), (17), and (18) in Equation (3'), we obtain the MR welfare levels of member and non-member countries as shown in Equations (19) and (20), respectively:

$$W_I^m = w_{II}(s_I^m, s_J^m, s_I^m) + w_{JI}(s_I^m, s_J^m, s_J^m) + w_{ZI}(s_Z^N, s_Z^N, s_Z^N), \quad I = X, Y, \quad I \ne J, \quad (19)$$

$$W_Z^m = w_{ZZ}(s_Z^N, s_Z^N, s_Z^N) + w_{XZ}(s_X^m, s_X^m, s_Y^m) + w_{YZ}(s_Y^m, s_X^m, s_Y^m), \quad (20)$$

where:

$$w_{II}(s_I^m, s_J^m, s_I^m) = \begin{cases} \dfrac{11(\alpha-\gamma\beta)^2}{32}, & if \ \dfrac{1}{2} < \gamma < \min\left\{\dfrac{12(1+\delta)}{13}, \dfrac{2+\delta}{2}\right\} \\ \dfrac{9(1+\delta)[24(1+\delta)-(15-11\delta)\gamma](\alpha-\gamma\beta)^2}{2\gamma[24(1+\delta)-13\gamma]^2}, & if \ \dfrac{12(1+\delta)}{13} < \gamma < \dfrac{2+\delta}{2} \ and \ 0 \le \delta < \dfrac{2}{11} \end{cases},$$

$$w_{JI}(s_I^m, s_J^m, s_J^m) = w_{XZ}(s_X^m, s_X^m, s_Y^m) = w_{YZ}(s_Y^m, s_X^m, s_Y^m) = \begin{cases} \dfrac{(\alpha-\gamma\beta)^2}{16}, & if \ \dfrac{1}{2} < \gamma < \min\left\{\dfrac{12(1+\delta)}{13}, \dfrac{2+\delta}{2}\right\} \\ \dfrac{9(1+\delta)[12\delta(1+\delta)-(12\delta-1)\gamma](\alpha-\gamma\beta)^2}{\gamma[24(1+\delta)-13\gamma]^2}, & if \ \dfrac{12(1+\delta)}{13} < \gamma < \dfrac{2+\delta}{2} \ and \ 0 \le \delta < \dfrac{2}{11} \end{cases}.$$

We then establish the following proposition (see Appendix B for the proof).

Proposition 2. *Assume joint welfare maximization.* (i) *When* $1/2 < \gamma \leq \min\{12(1+\delta)/13\,, 12/11\}$, *regional MR yields the same welfare as in NT for all countries.* (ii) *When* $12(1+\delta)/13 < \gamma < (2+\delta)/2$ *and* $0 \leq \delta < 2/11$ *or when* $12/11 < \gamma < (2+\delta)/2$ *and* $2/11 < \delta \leq 1$, *regional MR benefits all countries relative to NT.*

We emphasize that *countries always have incentives to form regional MR*. Intuitively, when members take into account each other's welfare when setting their standards, there is no race to the bottom, and regional MR standards are set to solve distortions such as negative externalities and underproduction. Consequently, a non-member and the members benefit from regional MR.

Let us explain this result using Figure 3. In Region A ($1/2 < \gamma \leq \min\{12(1+\delta)/13\,, 12/11\}$), where γ is small, we obtain result (i) in Proposition 2, which follows directly from Lemma 2.

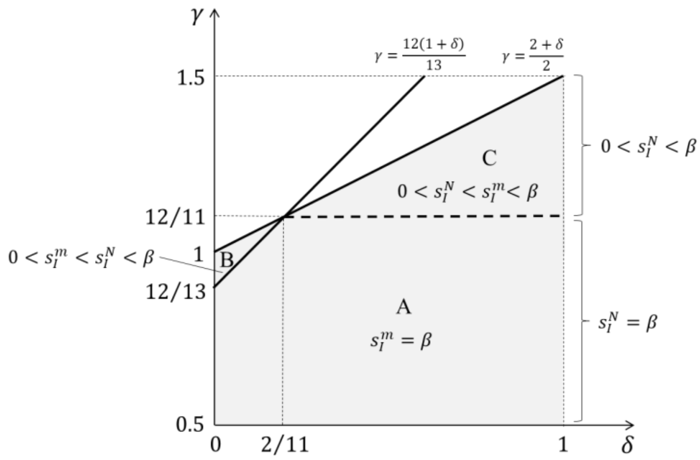

Figure 3. Regional MR under joint welfare maximization

In Region B ($12(1+\delta)/13 < \gamma < (2+\delta)/2$ and $0 \leq \delta < 2/11$), where γ is not large and δ is small, we obtain result (ii). In this region, a regime change from NT to regional MR reduces member I's standard (Lemma 2). This negatively affects $w_{II,}$ as explained in Section 3.1, but positively affects w_{JI} because δ is small. The latter positive effect outweighs the former negative effect; thus, the regime change enhances the welfare of the members. Regarding non-member *Z*, the reduction in members' standards increases w_{IZ} $(I = X, Y)$ when δ is small; hence, regional MR benefits non-member *Z*.

In Region C ($12/11 < \gamma < (2+\delta)/2$ and $2/11 < \delta \leq 1$), where γ and δ are large, we obtain result (ii). In this region, a move to regional MR *increases* member I's standard (Lemma 2). This negatively affects w_{II} because the reductions in firm I's local profits and member I's consumer surplus dominate the mitigation of negative externalities from domestic consumption. However, the increase in member I's standard positively affects w_{JI} because under a large δ, the mitigation of transboundary negative externalities caused by partner J's consumption outweighs the reduction in firm I's export profits earned in partner J's market. The latter positive effect is dominant; thus, members are better off under regional MR. As for non-member Z, the increase in members' standards increases w_{IZ} ($I = X, Y$) because under a large δ, the mitigation of cross-border negative externalities caused by members' consumption outweighs the decrease in firm Z's export profits earned in the members' markets. Hence, regional MR benefits non-member Z.

The result sharply differs from that of Costinot (2008) due to a difference in the range of choices regarding standards. Costinot (2008) assumed the existence of only "low" and "high" standards products and demonstrated that countries can be *worse off* by forming MR, although they select the most cooperative subgame perfect Nash equilibrium. Under MR, countries seek to benefit from expanded exports by setting low standards (rent-shifting), which are excessively lenient. By contrast, in our model, countries choose standards from a *continuous* range, thereby avoiding excessively lenient standards.

Our result might be consistent with empirical observation. The EU, whose members are economically integrated and cooperate on policy issues, adopts the principle of MR. However, other RTAs, whose members may find it difficult to share common interests, implement the principle of NT.

4. Multilateral Mutual Recognition

We now examine whether regional MR facilitates or hinders the achievement of multilateral MR among three countries. Countries that form multilateral MR are assumed to consider each other's welfare when setting their standards. Here, we focus on regional MR under joint welfare maximization.

Under multilateral MR, each country exports goods to other countries with its domestic standards. The profits of three firms in country I are $\pi_{Ii} = [p(Q_I) - c(s_I)]q_{Ii}$, $\pi_{Ij} = [p(Q_I) - c(s_J)]q_{Ij}$, and $\pi_{Ik} = [p(Q_I) - c(s_K)]q_{Ik}$ ($I, J, K = X, Y, Z$, $I \neq J \neq K$, $i, j, k = x, y, z$, $i \neq j \neq k$). The loss associated with negative consumption externalities in country I is $L_I = g(s_I)q_{Ii} + g(s_J)q_{Ij} + g(s_K)q_{Ik} + \delta[g(s_I)q_{Ji} + g(s_J)q_{Jj} + g(s_K)q_{Jk}] + \delta[g(s_I)q_{Ki} + g(s_J)q_{Kj} + g(s_K)q_{Kk}]$.

Solving for profit maximization in Stage 2, we obtain firms' and total sales in country I's market:

$$q_{Ii} = \frac{\alpha - 3\gamma s_I + \gamma s_J + \gamma s_K}{4}, \quad q_{Ij} = \frac{\alpha + \gamma s_I - 3\gamma s_J + \gamma s_K}{4}, \quad Q_I = \frac{3\alpha - \gamma s_I - \gamma s_J - \gamma s_K}{4},$$

$$I, J, K = X, Y, Z, \quad I \neq J \neq K, \quad i, j, k = x, y, z, \quad i \neq j \neq k \quad (21)$$

In Stage 1, subject to $s_I = s_{Ii} = s_{Ji} = s_{Ki}$, the government of country I sets its standard to maximize the aggregate welfare of the three countries, $W_X + W_Y + W_Z$, while taking the other countries' standards as given. Then, we obtain country I's standard under multilateral MR (the superscript mm denotes equilibrium values under multilateral MR):[16]

$$s_I^{mm} = \begin{cases} \beta, & if \ \frac{1}{2} < \gamma < \min\left\{\frac{4(1+2\delta)}{5}, \frac{2+\delta}{2}\right\} \\ \frac{4\gamma(1+2\delta)\beta - [5\gamma - 4(1+2\delta)]\alpha}{\gamma[8(1+2\delta) - 5\gamma]}, & if \ \frac{4(1+2\delta)}{5} < \gamma < \frac{2+\delta}{2} \ and \ 0 \leq \delta < \frac{2}{11} \end{cases},$$

$$I = X, Y, Z. \quad (22)$$

Lemma 3. *If* $1/2 < \gamma < \min\{4(1+2\delta)/5, (2+\delta)/2\}$, $s_I^{mm} = s_I^m = \beta$ ($I = X, Y$). *If* $4(1+2\delta)/5 < \gamma < (2+\delta)/2$ *and* $0 \leq \delta < 2/11$, $s_I^{mm} < s_I^m$.

From Lemmas 2 and 3, we find that the multilateral MR standards are the lowest, $s_I^{mm} < s_I^m \leq s_I^N = \beta$, if $4(1+2\delta)/5 < \gamma < (2+\delta)/2$ and $0 \leq \delta < 2/11$. Otherwise, the multilateral MR standards are the same as the regional MR standards under joint welfare maximization (the most stringent standards), $s_I^{mm} = s_I^m = \beta \geq s_I^N$. Intuitively, when δ is small, countries prefer to increase consumer surplus by expanding production through lenient standards.

Substituting Equation (22) into Equation (21) yields the equilibrium sales in country I's market:

$$q_{Ii}^{mm} = q_{Ij}^{mm} = q_{Ik}^{mm} = \begin{cases} \frac{\alpha - \gamma\beta}{4}, & if \ \frac{1}{2} < \gamma < \min\left\{\frac{4(1+2\delta)}{5}, \frac{2+\delta}{2}\right\} \\ \frac{(1+2\delta)(\alpha - \gamma\beta)}{8(1+2\delta) - 5\gamma}, & if \ \frac{4(1+2\delta)}{5} < \gamma < \frac{2+\delta}{2} \ and \ 0 \leq \delta < \frac{2}{11} \end{cases},$$

$$Q_I^{mm} = \begin{cases} \frac{3(\alpha - \gamma\beta)}{4}, & if \ \frac{1}{2} < \gamma < \min\left\{\frac{4(1+2\delta)}{5}, \frac{2+\delta}{2}\right\} \\ \frac{3(1+2\delta)(\alpha - \gamma\beta)}{8(1+2\delta) - 5\gamma}, & if \ \frac{4(1+2\delta)}{5} < \gamma < \frac{2+\delta}{2} \ and \ 0 \leq \delta < \frac{2}{11} \end{cases},$$

$$I, J, K = X, Y, Z, \quad I \neq J \neq K, \quad i, j, k = x, y, z, \quad i \neq j \neq k. \quad (23)$$

From Equations (18) and (23), we can show that $q_{Ii}^{mm} = q_{Ij}^{mm} = q_{Ik}^{mm} = q_{Ii}^m = q_{Ij}^m = q_{Ik}^m$ and $Q_I^{mm} = Q_I^m$ for $1/2 < \gamma \leq \min\{4(1+2\delta)/5, (2+\delta)/2\}$; $q_{Ii}^{mm} = q_{Ij}^{mm} = q_{Ik}^{mm} > q_{Ii}^m = q_{Ij}^m = q_{Ik}^m$ and $Q_I^{mm} > Q_I^m$ for $4(1+2\delta)/5 < \gamma < (2+\delta)/2$ and $0 \leq \delta < 2/11$. Accordingly,

[16] The second-order condition is $\partial^2(W_I + W_J + W_K)/\partial s_I^2 = -3\gamma[24(1+2\delta) - 23\gamma]/16 < 0$. This condition is satisfied under Assumption 1 (ii).

multilateral MR increases the volume of world trade.

Using Equations (22) and (23) in Equation (3'), we obtain welfare under multilateral MR:

$$W_I^{mm} = w_{II}(s_I^{mm}, s_J^{mm}, s_K^{mm}) + w_{JI}(s_I^{mm}, s_J^{mm}, s_K^{mm}) + w_{KI}(s_I^{mm}, s_J^{mm}, s_K^{mm}),$$
$$I, J, K = X, Y, Z, \quad I \neq J \neq K, \quad (24)$$

where:

$$w_{II}(s_I^{mm}, s_J^{mm}, s_K^{mm})$$
$$= \begin{cases} \dfrac{11(\alpha-\gamma\beta)^2}{32}, & if \ \dfrac{1}{2} < \gamma < \min\left\{\dfrac{4(1+2\delta)}{5}, \dfrac{2+\delta}{2}\right\} \\ \dfrac{(1+2\delta)[24(1+2\delta)-(19-22\delta)\gamma](\alpha-\gamma\beta)^2}{2\gamma[8(1+2\delta)-5\gamma]^2}, & if \ \dfrac{4(1+2\delta)}{5} < \gamma < \dfrac{2+\delta}{2} \ and \ 0 \le \delta < \dfrac{2}{11} \end{cases},$$

$$w_{JI}(s_I^{mm}, s_J^{mm}, s_K^{mm}) = w_{KI}(s_I^{mm}, s_J^{mm}, s_K^{mm})$$
$$= \begin{cases} \dfrac{(\alpha-\gamma\beta)^2}{16}, & if \ \dfrac{1}{2} < \gamma < \min\left\{\dfrac{4(1+2\delta)}{5}, \dfrac{2+\delta}{2}\right\} \\ \dfrac{(1+2\delta)[12\delta(1+2\delta)-(13\delta-1)\gamma](\alpha-\gamma\beta)^2}{\gamma[8(1+2\delta)-5\gamma]^2}, & if \ \dfrac{4(1+2\delta)}{5} < \gamma < \dfrac{2+\delta}{2} \ and \ 0 \le \delta < \dfrac{2}{11} \end{cases},$$

Then, we establish the following main proposition (see Appendix C for the proof).

Proposition 3. *Assume that countries care about each other's welfare.* (i) *When* $1/2 < \gamma \le \min\{4(1+2\delta)/5, 12/11\}$, *multilateral MR yields the same welfare as in regional MR under joint welfare maximization for all countries.* (ii) *When* $4(1+2\delta)/5 < \gamma < (2+\delta)/2$ *and* $0 \le \delta < 2/11$, *multilateral MR benefits all countries relative to regional MR.* (iii) *When* $12/11 < \gamma < (2+\delta)/2$ *and* $2/11 < \delta \le 1$, *multilateral MR benefits members of regional MR but harms a non-member.*

Multilateral MR always benefits members of regional MR but may harm non-members. Intuitively, this is because non-members need to raise their standards from a low level (NT) to a high level (multilateral MR), which is too costly for them.

Let us explain this result using Figure 4. In Region A-1 ($1/2 < \gamma \le \min\{4(1+2\delta)/5, 12/11\}$), where γ is small, we obtain result (i) in Proposition 3, which follows directly from Lemma 3.

In Regions A-2 and B ($4(1+2\delta)/5 < \gamma < (2+\delta)/2$ and $0 \le \delta < 2/11$), where γ and δ are small, we get result (ii). In these regions, the regime change to multilateral MR lowers the standards of all countries (Lemma 3). This negatively affects w_{II} ($I = X, Y, Z$) because of increased negative externalities but positively affects w_{JI} $(I, J = X, Y, Z,\ I \neq J)$ because δ is small. The latter effect outweighs the former; therefore, the regime change increases the welfare of all countries.

In Region C $(12/11 < \gamma < (2+\delta)/2)$ and $2/11 < \delta \leq 1)$, where γ and δ are large, we obtain result (iii). In this region, the regime change to multilateral MR does not alter members' standards (Lemma 3). This has no effect on w_{II} $(I = X, Y)$, w_{JI} $(I, J = X, Y,\ I \neq J)$, and w_{IZ} $(I = X, Y)$. On the other hand, the regime change increases a non-member's standards up to the multilateral MR standards. This positively affects w_{ZI} $(I = X, Y)$ because the mitigation of cross-border negative externalities from a non-member outweighs the reduction in members' export profits under a large δ. Thus, members are better off under multilateral MR than under regional MR. However, for a non-member, the increase in its standards negatively affects w_{ZZ} because the negative effect caused by the reduction in local profits and consumer surplus dominates the positive effect caused by mitigating negative externalities. Consequently, a non-member is *worse off* under multilateral MR.

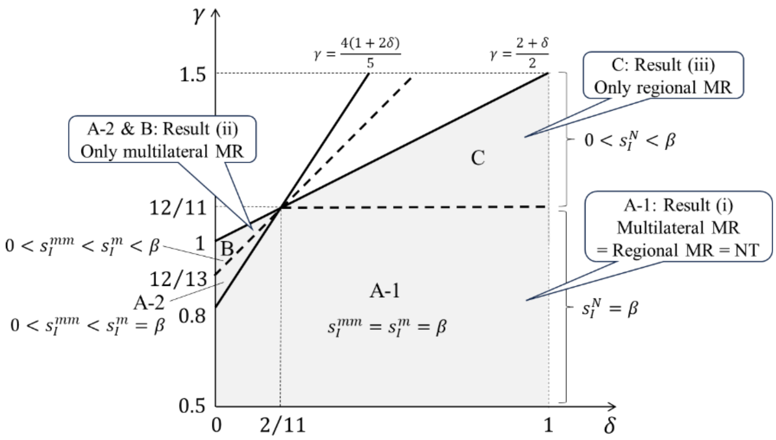

Figure 4. Multilateral MR

Corollary 1. *In Regions A-2, B, and C in Figure 4, regional MR is formed. In Regions A-2 and B, only multilateral MR is realized. However, in Region C, only regional MR is attained.*

From Propositions 2 and 3, in Regions A-2 and B, only multilateral MR is realized because it is the best regime for all countries. However, in Region C, only regional MR is attained because multilateral MR is blocked by non-members. Regional MR serves as a *stumbling block* for multilateral MR. In Region A-1, NT, regional MR, and multilateral MR are indifferent, implying that multilateral MR will be achieved.

This result is similar to that of Takarada et al. (2020), although their analysis focused on harmonizing standards. Takarada et al. (2020) demonstrated that only multilateral harmonization of standards is achieved if negative consumption externalities are local or slightly transboundary; otherwise, only regional harmonization of standards is realized because non-members block multilateral harmonization. In our model of MR, not only the degree of transboundary negative externalities but also the marginal compliance cost of standards is crucial determinants of the outcomes.

Our theoretical result is supported by empirical observations. Consider the members of a regional MR as existing members of the EU and a non-member as a potential new member. The enlargement of the EU can be classified as a successful multilateral MR. Furthermore, the EU does not apply MR to all goods and has exceptions in cases where public safety, health, or environmental concerns arise, implying that such exceptions correspond to large values of γ and δ.[17]

5. Discussion

5.1. Asymmetry in the awareness of externalities

In this subsection, we examine the case where only country Z is not so much aware of the negative consumption externalities. The welfare of country Z is then expressed as:

$$W_Z = CS_Z + \sum_{J=X,Y,Z} \pi_{Jz} - \theta L_Z, \tag{25}$$

where θ $(0 < \theta < 1)$ represents the degree of the awareness of externalities in country Z. We focus on regional MR under joint welfare maximization. As it is difficult to analytically characterize the equilibrium, we use numerical simulations.

We find that in Region B in Figure 4, *only regional MR is attained* when θ is small (see the online appendix). This finding contrasts with Proposition 3, and is consistent with that of Geng (2019). In the other regions of Figure 4, the main result remains valid.

The reason is straightforward. To form a multilateral MR, members X and Y need to reduce their standards significantly because non-member Z prefers more lenient standards due to its low θ. If the reduction in members' standards results in large negative externalities, the members are worse off than in the regional MR case. In contrast, non-member Z must increase its standards to meet multilateral MR standards. If this increase imposes substantial costs on the non-member, adopting multilateral MR harms

[17] See the web of the European Commission for the MR of goods (https://single-market-economy.ec.europa.eu/single-market/goods/free-movement-sectors/mutual-recognition-goods_en; last accessed on February 8, 2025) and harmonized standards (https://single-market-economy.ec.europa.eu/single-market/european-standards/harmonised-standards_en; last accessed on February 8, 2025).

the non-member. Therefore, multilateral MR is blocked by either members or a non-member.

5.2. Regional MR in "same bed, different dreams"

This subsection considers another asymmetric case in which country *X* maximizes its own welfare, whereas country *Y* maximizes the joint welfare of countries *X* and *Y* when setting their regional MR standards. Country *Z,* a non-member, sets its standards according to the principle of NT, as in the basic setting. We employ numerical simulations because the analysis is complicated.

We find that member *X*'s standard is likely to be lower than the NT standards (a race to the bottom), and member *Y*'s standard may be lower or higher than the NT standards. Consequently, regional MR benefits member *X* but harms member *Y*; hence, regional MR is not achieved (see the online appendix). This outcome reconfirms Proposition 1, and the reasoning is straightforward.

5.3. Fixed costs

We discuss two types of fixed costs: (i) a firm incurs fixed costs when changing its standards (e.g., fixed costs for redesigning products to meet new standards), and (ii) a firm faces fixed costs when producing goods under different standards (e.g., fixed costs for establishing separate production lines). We assume that only firm *z* in country *Z* incurs these fixed costs, as firm *z* possesses relatively inferior technology compared with other firms. Here, we focus on regional MR under joint welfare maximization.

Depending on the type of fixed costs, the results can differ significantly. In type (i), after forming regional MR, the standards in countries *X* and *Y* change, requiring country *Z* to incur fixed costs to supply their markets. Country *Z* experiences losses under regional MR if these fixed costs are substantial. Furthermore, a shift to multilateral MR can negatively impact country *Z* as adapting to the multilateral MR standards also results in fixed costs. Consequently, country *Z* is likely to oppose multilateral MR.

In type (ii), under regional MR, country *Z* incurs fixed costs because it must produce products with different standards—its own standards and those of the member countries. However, under multilateral MR, country *Z* can supply products following its own standards across all markets, thereby avoiding fixed costs. Thus, country *Z* is unlikely to block multilateral MR.

5.4. Differentiated goods

Finally, let us discuss the case of differentiated goods. When goods are sufficiently differentiated between countries, a country's rent-shifting motive is weak because lowering its standards does not significantly shift demand toward its exports. Therefore, regional MR standards do not decrease substantially. This means that the loss associated with negative externalities is relatively small; thus, countries may form regional MR even if they seek to maximize their own welfare. A non-member may also benefit from regional MR if transboundary negative externalities are small.

6. Concluding Remarks

This study examined the MR of goods when countries implement standards policies to control negative externalities caused by the consumption of traded goods. The novelty of our analysis is to use a three-country model with a continuous range of standards to clarify whether countries form regional MR and whether such regional MR benefits or harms non-members countries, potentially leading to multilateral MR.

The main findings are as follows. First, countries form regional MR when they cooperatively choose their standards, and regional MR successfully addresses distortions (i.e., negative externalities and underproduction), benefiting all countries. However, regional MR is not established when countries focus on maximizing their individual welfare. Second, multilateral MR benefits members of regional MR but may harm non-members, depending on the marginal compliance cost of standards and the degree of transboundary negative externalities. Consequently, non-members may block the realization of multilateral MR. An important policy implication is that countries should cooperate in setting MR standards to enjoy more gains from trade and correct market distortions.

For future research, incorporating heterogeneity in firms and differences in countries' market sizes could enrich the present analysis. It would also be valuable to consider the role of deep RTAs to address the MR of goods and elimination of tariffs.

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Appendix A: Proof of Proposition 1

The welfare changes between NT and regional MR are:

$$W_I^M - W_I^N = \left[w_{II}(s_I^M, s_J^M, s_I^M) - w_{II}(s_I^N, s_I^N, s_I^N)\right] + \left[w_{JI}(s_I^M, s_J^M, s_J^M) - w_{JI}(s_J^N, s_J^N, s_J^N)\right],$$
$$I, J = X, Y, \quad I \neq J, \quad \text{(A1)}$$

$$W_Z^M - W_Z^N = [w_{XZ}(s_X^M, s_X^M, s_Y^M) - w_{XZ}(s_X^N, s_X^N, s_X^N)] + [w_{YZ}(s_Y^M, s_X^M, s_Y^M) - w_{YZ}(s_Y^N, s_Y^N, s_Y^N)]. \quad \text{(A2)}$$

Result (i) in Region I of Figure 2 is straightforward.

Comparing Equation (9) with Equations (14) and (15), we obtain the following.

Region II: $(2+\delta)/4 < \gamma < \min\{(2+\delta)\alpha/[4\alpha-(2+\delta)\beta], 12/11\}$

$$w_{II}(s_I^M, s_J^M, s_I^M) - w_{II}(s_I^N, s_I^N, s_I^N) = -\frac{(4\gamma-2-\delta)(\alpha-\gamma\beta)^2}{128\gamma(2+\delta-2\gamma)^2}[44\gamma^2 - 33(2+\delta)\gamma + 24(2+\delta)]$$
$$< 0, \quad \text{(A3)}$$

because $4\gamma - 2 - \delta > 0$ and $44\gamma^2 - 33(2+\delta)\gamma + 24(2+\delta) > 0$ when in Region II.

$$w_{JI}(s_I^M, s_J^M, s_J^M) - w_{JI}(s_J^N, s_J^N, s_J^N) = w_{XZ}(s_X^M, s_X^M, s_Y^M) - w_{XZ}(s_X^N, s_X^N, s_X^N)$$
$$= w_{YZ}(s_Y^M, s_X^M, s_Y^M) - w_{YZ}(s_Y^N, s_Y^N, s_Y^N)$$

$$= -\frac{(4\gamma - 2 - \delta)(\alpha - \gamma\beta)^2}{64\gamma(2 + \delta - 2\gamma)^2}[12\delta^2 + 3(8 - \gamma)\delta - 2\gamma(3 - 2\gamma)]. \quad \text{(A4)}$$

$12\delta^2 + 3(8 - \gamma)\delta - 2\gamma(3 - 2\gamma) < 0$ if $0 \le \delta < A$, where $A \equiv (\gamma/8) - 1 + \sqrt{3}\sqrt{192 + 48\gamma - 61\gamma^2}/24$ is the solution of the quadratic equation of δ. $12\delta^2 + 3(8 - \gamma)\delta - 2\gamma(3 - 2\gamma) > 0$ if $A < \delta \le 1$.

Using Equations (A1), (A3), and (A4), we obtain:

$$W_I^M - W_I^N = -\frac{(4\gamma - 2 - \delta)[52\gamma^2 - 39(2 + \delta)\gamma + 24(2 + \delta)(1 + \delta)](\alpha - \gamma\beta)^2}{128\gamma(2 + \delta - 2\gamma)^2} < 0, \quad \text{(A5)}$$

because $52\gamma^2 - 39(2 + \delta)\gamma + 24(2 + \delta)(1 + \delta) > 0$ for $\forall\gamma > 0$ under $0 \le \delta \le 1$.

From Equations (A2) and (A4), $W_Z^M - W_Z^N > 0$ if $0 \le \delta < A$ but $W_Z^M - W_Z^N < 0$ if $A < \delta \le 1$.

Region III: $(2 + \delta)\alpha/[4\alpha - (2 + \delta)\beta] < \gamma < \min\{(2 + \delta)/2, 12/11\}$

$$w_{II}(s_I^M, s_J^M, s_I^M) - w_{II}(s_I^N, s_I^N, s_I^N) = -\frac{\beta}{32}[2(12 - 11\gamma)\alpha + 11\gamma^2\beta] < 0, \quad \text{(A6)}$$

because $2(12 - 11\gamma)\alpha + 11\gamma^2\beta > 0$ from $\gamma < 12/11$ in Region III.

$$w_{JI}(s_I^M, s_J^M, s_J^M) - w_{JI}(s_J^N, s_J^N, s_J^N) = w_{XZ}(s_X^M, s_X^M, s_Y^M) - w_{XZ}(s_X^N, s_X^N, s_X^N)$$

$$= w_{YZ}(s_Y^M, s_X^M, s_Y^M) - w_{YZ}(s_Y^N, s_Y^N, s_Y^N) = \frac{\beta}{16}[\gamma(2\alpha - \gamma\beta) - 12\delta\alpha], \quad \text{(A7)}$$

where $\gamma(2\alpha - \gamma\beta) - 12\alpha\delta > 0$ if $0 \le \delta < \gamma(2\alpha - \gamma\beta)/12\alpha$ but $\gamma(2\alpha - \gamma\beta) - 12\alpha\delta < 0$ if $\gamma(2\alpha - \gamma\beta)/12\alpha < \delta \le 1$.

Using Equations (A1), (A6), and (A7), we derive:

$$W_I^M - W_I^N = -\frac{\beta}{32}[24(1 + \delta)\alpha + 13\beta\gamma^2 - 26\alpha\gamma] < 0, \quad \text{(A8)}$$

because $24(1 + \delta)\alpha + 13\beta\gamma^2 - 26\alpha\gamma > 0$ from Assumption 1 (i) and $\gamma < 12/11$.

From Equations (A2) and (A7), $W_Z^M - W_Z^N > 0$ if $0 \le \delta < \gamma(2\alpha - \gamma\beta)/12\alpha$ but $W_Z^M - W_Z^N < 0$ if $\gamma(2\alpha - \gamma\beta)/12\alpha < \delta \le 1$.

Region IV: $12/11 < \gamma < (2 + \delta)\alpha/[4\alpha - (2 + \delta)\beta]$

$$w_{II}(s_I^M, s_J^M, s_I^M) - w_{II}(s_I^N, s_I^N, s_I^N) = -\frac{\gamma(26 - 11\delta)^2(\alpha - \gamma\beta)^2}{128(24 - 11\gamma)(2 + \delta - 2\gamma)^2} < 0, \quad \text{(A9)}$$

$$w_{JI}(s_I^M, s_J^M, s_J^M) - w_{JI}(s_J^N, s_J^N, s_J^N) = w_{XZ}(s_X^M, s_X^M, s_Y^M) - w_{XZ}(s_X^N, s_X^N, s_X^N)$$

$$= w_{YZ}(s_Y^M, s_X^M, s_Y^M) - w_{YZ}(s_Y^N, s_Y^N, s_Y^N)$$

$$= -\frac{\gamma(26 - 11\delta)(\alpha - \gamma\beta)^2}{64(24 - 11\gamma)^2(2 + \delta - 2\gamma)^2}[132\delta^2 + 11(72 - 47\gamma)\delta - 2(48 - 35\gamma)] < 0, \quad \text{(A10)}$$

because $132\delta^2 + 11(72 - 47\gamma)\delta - 2(48 - 35\gamma) > 0$ from $12/11 < \gamma < 3/2$ and $10/19 < \delta \le 1$ under Assumption 1 (i).

From Equations (A1), (A2), (A9), and (A10), $W_I^M - W_I^N < 0$ and $W_Z^M - W_Z^N < 0$.

Region V: $\max\{11/12, (2 + \delta)\alpha/[4\alpha - (2 + \delta)\beta]\} < \gamma < (2 + \delta)/2$

$$w_{II}(s_I^M, s_J^M, s_I^M) - w_{II}(s_I^N, s_I^N, s_I^N) = -\frac{[12\gamma\beta - (11\gamma - 12)\alpha]^2}{32\gamma(24 - 11\gamma)} < 0, \quad \text{(A11)}$$

$$w_{JI}(s_I^M, s_J^M, s_J^M) - w_{JI}(s_J^N, s_J^N, s_J^N) = w_{XZ}(s_X^M, s_X^M, s_Y^M) - w_{XZ}(s_X^N, s_X^N, s_X^N)$$
$$= w_{YZ}(s_Y^M, s_X^M, s_Y^M) - w_{YZ}(s_Y^N, s_Y^N, s_Y^N)$$
$$= -\frac{[12\gamma\beta - (11\gamma - 12)\alpha]}{16\gamma(24 - 11\gamma)^2}\{[144\delta - \gamma(36 - 11\gamma)]\alpha + 12\gamma\beta[\gamma - (11\gamma - 12)\delta]\}$$
$$< 0, \quad \text{(A12)}$$

because $12\gamma\beta - (11\gamma - 12)\alpha > 0$ and $[144\delta - \gamma(36 - 11\gamma)]\alpha + 12\gamma\beta[\gamma - (11\gamma - 12)\delta] > 0$ from Assumption 1 (i) and the range of parameters γ and δ in Region V.

From Equations (A1), (A2), (A11), and (A12), $W_I^M - W_I^N < 0$ and $W_Z^M - W_Z^N < 0$.

Appendix B: Proof of Proposition 2

Result (i) in Region A of Figure 3 is straightforward.

Comparing Equation (9) with Equations (19) and (20), we obtain the following.

Region B: $0 \le \delta < 2/11$ *and* $12(1+\delta)/13 < \gamma < (2+\delta)/2$

$$w_{II}(s_I^m, s_J^m, s_I^m) - w_{II}(s_I^N, s_I^N, s_I^N)$$
$$= -\frac{[13\gamma - 12(1+\delta)](\alpha - \gamma\beta)^2}{32\gamma[24(1+\delta) - 13\gamma]^2}[143\gamma^2 - 396(1+\delta)\gamma + 288(1+\delta)] < 0,$$
$$I, J = X, Y, \quad I \ne J, \quad \text{(B1)}$$

because $13\gamma - 12(1+\delta) > 0$ and $143\gamma^2 - 396(1+\delta)\gamma + 288(1+\delta) > 0$ in Region B.

$$w_{JI}(s_I^m, s_J^m, s_J^m) - w_{JI}(s_J^N, s_J^N, s_J^N) = w_{XZ}(s_X^m, s_X^m, s_Y^m) - w_{XZ}(s_X^N, s_X^N, s_X^N)$$
$$= w_{YZ}(s_Y^m, s_X^m, s_Y^m) - w_{YZ}(s_Y^N, s_Y^N, s_Y^N)$$
$$= \frac{[13\gamma - 12(1+\delta)](\alpha - \gamma\beta)^2}{16\gamma[24(1+\delta) - 13\gamma]^2}[36(1+\delta)\gamma - 13\gamma^2 - 144\delta(1+\delta)] > 0, \quad \text{(B2)}$$

because $36(1+\delta)\gamma - 13\gamma^2 - 144\delta(1+\delta) > 0$ in Region B.

Using Equations (A1), (B1), and (B2), we get:

$$W_I^m - W_I^N = \frac{[13\gamma - 12(1+\delta)]^2(\alpha - \gamma\beta)^2}{32\gamma[24(1+\delta) - 13\gamma]} > 0. \quad \text{(B3)}$$

From Equations (A2) and (B2), $W_Z^m - W_Z^N > 0$.

Region C: $2/11 < \delta \le 1$ *and* $12/11 < \gamma < (2+\delta)/2$

$$w_{II}(s_I^m, s_J^m, s_I^m) - w_{II}(s_I^N, s_I^N, s_I^N) = -\frac{(11\gamma - 12)^2(\alpha - \gamma\beta)^2}{32\gamma(24 - 11\gamma)} < 0, \quad \text{(B4)}$$

$$w_{JI}(s_I^m, s_J^m, s_J^m) - w_{JI}(s_J^N, s_J^N, s_J^N) = w_{XZ}(s_X^m, s_X^m, s_Y^m) - w_{XZ}(s_X^N, s_X^N, s_X^N)$$
$$= w_{YZ}(s_Y^m, s_X^m, s_Y^m) - w_{YZ}(s_Y^N, s_Y^N, s_Y^N)$$
$$= \frac{(11\gamma - 12)(\alpha - \gamma\beta)^2}{16\gamma(24 - 11\gamma)^2}(144\delta - 36\gamma + 11\gamma^2) > 0, \quad \text{(B5)}$$

because $11\gamma - 12 > 0$ and $144\delta - 36\gamma + 11\gamma^2 > 0$ in Region C.

Using Equations (A1), (B4), and (B5), we obtain

$$W_I^m - W_I^N = \frac{(11\gamma - 12)(\alpha - \gamma\beta)^2}{32\gamma(24 - 11\gamma)^2}[143\gamma^2 - 468\gamma + 288(1 + \delta)] > 0, \quad \text{(B6)}$$

because $143\gamma^2 - 468\gamma + 288(1 + \delta) > 0$ in Region C.

From Equations (A2) and (B5), $W_Z^m - W_Z^N > 0$.

Appendix C: Proof of Proposition 3

Result (i) in Region A-1 of Figure 4 is straightforward.

Comparing Equations (19) and (20) with Equation (24), we obtain:

$$\begin{aligned} W_I^{mm} - W_I^m = {} & \left[w_{II}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) - w_{II}\left(s_I^m, s_J^m, s_I^m\right)\right] \\ & + \left[w_{JI}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) - w_{JI}\left(s_I^m, s_J^m, s_J^m\right)\right] \\ & + \left[w_{ZI}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) - w_{ZI}(s_Z^N, s_Z^N, s_Z^N)\right], \quad I, J = X, Y, \quad I \neq J, \end{aligned} \quad \text{(C1)}$$

$$\begin{aligned} W_Z^{mm} - W_Z^m = {} & [w_{ZZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) - w_{ZZ}(s_Z^N, s_Z^N, s_Z^N)] \\ & + [w_{XZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) - w_{XZ}(s_X^m, s_X^m, s_Y^m)] \\ & + [w_{YZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) - w_{YZ}(s_Y^m, s_X^m, s_Y^m)], \end{aligned} \quad \text{(C2)}$$

Region A-2: $0 \leq \delta < 2/11$ *and* $4(1 + 2\delta)/5 < \gamma \leq 12(1 + \delta)/13$

In this region, $s_X^{mm} = s_Y^{mm} = s_Z^{mm} < s_X^m = s_Y^m = s_Z^N = \beta$. We derive the following:

$$\begin{aligned} & w_{II}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) - w_{II}\left(s_I^m, s_J^m, s_I^m\right) = w_{ZZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) - w_{ZZ}(s_Z^N, s_X^N, s_Y^N) \\ & = -\frac{[5\gamma - 4(1 + 2\delta)](\alpha - \gamma\beta)^2}{32\gamma[8(1 + 2\delta) - 5\gamma]^2}[55\gamma^2 - 132(1 + 2\delta)\gamma + 96(1 + 2\delta)] < 0, \\ & \qquad I, J = X, Y, \quad I \neq J, \end{aligned} \quad \text{(C3)}$$

because $5\gamma - 4(1 + 2\delta) > 0$ and $55\gamma^2 - 132(1 + 2\delta)\gamma + 96(1 + 2\delta) > 0$ from the range of parameters γ and δ in Region A-2.

$$\begin{aligned} & w_{JI}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) - w_{JI}\left(s_I^m, s_J^m, s_J^m\right) = w_{ZI}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) - w_{ZI}(s_Z^N, s_Z^N, s_Z^N) \\ & = w_{XZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) - w_{XZ}(s_X^m, s_X^m, s_Y^m) \\ & = w_{YZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) - w_{YZ}(s_Y^m, s_X^m, s_Y^m) \\ & = \frac{[5\gamma - 4(1 + 2\delta)](\alpha - \gamma\beta)^2}{16\gamma[8(1 + 2\delta) - 5\gamma]^2}[12(1 + 2\delta)\gamma - 5\gamma^2 - 48\delta(1 + 2\delta)] > 0, \end{aligned} \quad \text{(C4)}$$

because $12(1 + 2\delta)\gamma - 5\gamma^2 - 48(1 + 2\delta) > 0$ from the range of parameters γ and δ in Region A-2.

Using Equations (C1), (C2), (C3), and (C4), we obtain:

$$W_I^{mm} - W_I^m = W_Z^{mm} - W_Z^m = \frac{3[5\gamma - 4(1 + 2\delta)]^2(\alpha - \gamma\beta)^2}{32\gamma[8(1 + 2\delta) - 5\gamma]} > 0. \quad \text{(C5)}$$

Region B: $0 \leq \delta < 2/11$ *and* $12(1 + \delta)/13 < \gamma < (2 + \delta)/2$

In this region, $s_X^{mm} = s_Y^{mm} = s_Z^{mm} < s_X^m = s_Y^m < s_Z^N = \beta$.

Using Equations (9), (19), (20), and (24), we get:

$$w_{II}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) - w_{II}\left(s_I^m, s_J^m, s_I^m\right) = -\frac{\gamma(2-11\delta)^2[24(3+4\delta)-41\gamma](\alpha-\gamma\beta)^2}{2[8(1+2\delta)-5\gamma]^2[24(1+\delta)-13\gamma]^2} < 0, \quad \text{(C6)}$$

because $24(3+4\delta)-41\gamma > 0$ from $\gamma < 12/11$ in Region B.

$$w_{JI}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) - w_{JI}\left(s_I^m, s_J^m, s_J^m\right) = w_{XZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) - w_{XZ}(s_X^m, s_X^m, s_Y^m)$$

$$= w_{YZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) - w_{YZ}(s_Y^m, s_X^m, s_Y^m)$$

$$= \frac{2\gamma(2-11\delta)^2[6(2+3\delta)-7\gamma](\alpha-\gamma\beta)^2}{[8(1+2\delta)-5\gamma]^2[24(1+\delta)-13\gamma]^2} > 0, \quad \text{(C7)}$$

because $6(2+3\delta)-7\gamma > 0$ from $\gamma < 12/11$.

$$w_{ZI}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) - w_{ZI}(s_Z^N, s_Z^N, s_Z^N)$$

$$= \frac{[5\gamma-4(1+2\delta)](\alpha-\gamma\beta)^2}{16\gamma[8(1+2\delta)-5\gamma]^2}[12\gamma(1+2\delta)-5\gamma^2-48\delta(1+2\delta)] > 0, \quad \text{(C8)}$$

because $5\gamma-4(1+2\delta) > 0$ and $12\gamma(1+2\delta)-5\gamma^2-48\delta(1+2\delta) > 0$ in Region B.

Using Equations (C1), (C6), (C7), and (C8), we obtain:

$$W_I^{mm} - W_I^m = \frac{(\alpha-\gamma\beta)^2 F(\gamma,\delta)}{16\gamma[8(1+2\delta)-5\gamma][24(1+\delta)-13\gamma]} > 0, \quad \text{(C9)}$$

because $F(\gamma,\delta) = 576\delta(1+\delta)(1+2\delta) - 24(6+46\delta+53\delta^2)\gamma + 8(28+41\delta)\gamma^2 - 65\gamma^3 > 0$ in Region B.

From Equations (C2), (C3), and (C7), we get:

$$W_Z^{mm} - W_Z^m = \frac{(\alpha-\gamma\beta)^2 G(\gamma,\delta)}{32\gamma[8(1+2\delta)-5\gamma][24(1+\delta)-13\gamma]^2} > 0, \quad \text{(C10)}$$

because $G(\gamma,\delta) = 27648(1+2\delta)(1+\delta)^2 - 2304(1+\delta)(37+83\delta+33\delta^2)\gamma + 48(2033 + 4768\delta + 2904\delta^2)\gamma^2 - 1144(43+56\delta)\gamma^3 + 9295\gamma^4 > 0$ in Region B.

Region C: $2/11 < \delta \leq 1$ *and* $12/11 < \gamma < (2+\delta)/2$

In this region, $s_Z^N < s_X^m = s_Y^m = s_X^{mm} = s_Y^{mm} = s_Z^{mm} = \beta$. Thus, we obtain:

$$w_{II}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) - w_{II}\left(s_I^m, s_J^m, s_I^m\right) = w_{JI}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) - w_{JI}\left(s_I^m, s_J^m, s_J^m\right)$$

$$= w_{XZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) - w_{XZ}(s_X^m, s_X^m, s_Y^m)$$

$$= w_{YZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) - w_{YZ}(s_Y^m, s_X^m, s_Y^m) = 0. \quad \text{(C11)}$$

$$W_I^{mm} - W_I^m = w_{ZI}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) - w_{ZI}(s_Z^N, s_Z^N, s_Z^N)$$

$$= \frac{(11\gamma-12)(\alpha-\gamma\beta)^2}{16\gamma(24-11\gamma)^2}[144\delta-(36-11\gamma)\gamma] > 0, \quad \text{(C12)}$$

because $11\gamma-12 > 0$ and $144\delta-(36-11\gamma)\gamma > 0$ in Region C.

In country *Z*, we obtain:

$$W_Z^{mm} - W_Z^m = w_{ZZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) - w_{ZZ}(s_Z^N, s_X^N, s_Y^N) = -\frac{(11\gamma-12)^2(\alpha-\gamma\beta)^2}{32\gamma(24-11\gamma)} < 0. \quad \text{(C13)}$$

Online Appendix

Section 5.1

(a) $\alpha = 1$, $\beta = 0.6$, $\gamma = 0.95$, and $\delta = 0$.

In this case, we are in Region B of Figure 4, and the lower bound for θ is 0.73125 from the second-order condition for joint welfare maximization under multilateral MR.

Country I's and Z's standards in the NT regime are given by:

$$s_I^N = 0.6, \qquad I = X, Y,$$

$$s_Z^N = \begin{cases} \dfrac{4(1884\theta - 1045)}{19(480\theta - 209)}, & if \quad 0.73125 < \theta < 0.87083 \\ 0.6, & if \quad 0.87083 \leq \theta < 1 \end{cases}.$$

If $0.73125 < \theta < 0.87083$, the NT welfare levels of countries I and Z are:

$$W_I^N = w_{II}(s_I^N, s_I^N, s_I^N) + w_{JI}\left(s_J^N, s_J^N, s_J^N\right) + w_{ZI}(s_Z^N, s_Z^N, s_Z^N)$$

$$= 0.063559 + 0.011556 + \frac{16641\theta^2}{25(480\theta - 209)^2}, \quad I, J = X, Y, \quad I \neq J,$$

$$W_Z^N = w_{ZZ}(s_Z^N, s_Z^N, s_Z^N) + w_{XZ}(s_X^N, s_X^N, s_X^N) + w_{YZ}(s_Y^N, s_Y^N, s_Y^N)$$

$$= \frac{16641\theta^2}{950(480\theta - 209)} + 0.011556 + 0.011556.$$

If $0.87083 \leq \theta < 1$, the NT welfare levels of the three countries are:

$$W_I^N = 0.063559 + 0.011556 + 0.011556 = 0.086672, \quad I = X, Y, Z.$$

Member I's regional MR standard under joint welfare maximization is given by:

$$s_I^m = 0.5864, \quad I = X, Y.$$

If $0.73125 < \theta < 0.87083$, the welfare levels of member and non-member countries under regional MR are:

$$W_I^m = w_{II}\left(s_I^m, s_J^m, s_I^m\right) + w_{JI}\left(s_I^m, s_J^m, s_J^m\right) + w_{ZI}(s_Z^N, s_Z^N, s_Z^N)$$

$$= 0.062919 + 0.012261 + \frac{16641\theta^2}{25(480\theta - 209)^2}, \quad I, J = X, Y, \quad I \neq J,$$

$$W_Z^m = w_{ZZ}(s_Z^N, s_Z^N, s_Z^N) + w_{XZ}(s_X^m, s_X^m, s_Y^m) + w_{YZ}(s_Y^m, s_X^m, s_Y^m)$$

$$= \frac{16641\theta^2}{950(480\theta - 209)} + 0.012261 + 0.012261.$$

If $0.87083 \leq \theta < 1$, the welfare levels under regional MR are:

$$W_I^m = 0.062919 + 0.012261 + 0.011556 = 0.086736, \quad I, J = X, Y,$$

$$W_Z^m = 0.063559 + 0.012261 + 0.012261 = 0.088081.$$

From the above equations, $W_I^m > W_I^N$ $(I = X, Y)$ and $W_Z^m > W_Z^N$.

Member I's multilateral MR standard is given by:

$$s_I^{mm} = \frac{4(628\theta - 169)}{95(32\theta + 7)}, \quad I = X, Y, Z.$$

The welfare levels of countries I and Z under multilateral MR are as follows:

$$W_I^{mm} = w_{II}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) + w_{JI}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right) + w_{ZI}\left(s_I^{mm}, s_J^{mm}, s_Z^{mm}\right)$$

$$= \frac{1849(\theta + 2)(689\theta - 332)}{23750(32\theta + 7)^2} + \frac{1849(\theta + 2)^2}{625(32\theta + 7)^2} + \frac{1849(\theta + 2)^2}{625(32\theta + 7)^2}, \quad I, J = X, Y, \ I \neq J,$$

$$W_Z^{mm} = w_{ZZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) + w_{XZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) + w_{YZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm})$$

$$= \frac{1849(\theta + 2)(480\theta^2 - 541\theta + 418)}{23750(32\theta + 7)^2} + \frac{1849(\theta + 2)^2}{625(32\theta + 7)^2} + \frac{1849(\theta + 2)^2}{625(32\theta + 7)^2}.$$

By comparing the welfare under regional and multilateral MR, as for non-member Z, $W_Z^{mm} > W_Z^m$. If $0.73125 < \theta < 0.80884$, $W_I^{mm} < W_I^m$ $(I = X, Y)$; if $0.80884 < \theta < 1$, $W_I^{mm} > W_I^m$. This result sharply contrasts with Proposition 3 (ii).

The intuition behind this result is as follows. The regime change from regional to multilateral MR reduces the domestic component w_{II} of country I's welfare, which is a negative effect $(I = X, Y)$. Simultaneously, it increases the components obtained from countries J and Z, w_{JI} and w_{ZI}, which is a positive effect $(I, J = X, Y, \ I \neq J)$. If $0.73125 < \theta < 0.80884$, the regime change substantially lowers the standards of countries X and Y because the countries are concerned with country Z when setting their multilateral MR standards. This significant lowering of standards strengthens the negative effect, thereby causing a reduction in the welfare of members X and Y.

Consequently, we establish the following. If $0.73125 < \theta < 0.80884$, *only regional MR is realized* because multilateral MR is blocked by members X and Y.

(b) $\alpha = 1,\ \beta = 0.6,\ \gamma = 1.07$, and $\delta = 0.15$.

We are still in Region B, and the lower bound for θ is 0.49042 from country Z's second-order condition for welfare maximization under NT.

Country I's and Z's NT standards are given by:

$$s_I^N = 0.6, \qquad I = X, Y,$$

$$s_Z^N = \begin{cases} 0, & if \quad 0.49042 < \theta \le 0.59734 \\ \dfrac{20(9852\theta - 5885)}{107(2400\theta - 1177)}, & if \quad 0.59734 < \theta < 0.98083 \\ 0.6, & if \quad 0.98083 \le \theta < 1 \end{cases}.$$

If $0.49042 < \theta \le 0.59734$, the NT welfare levels of countries I and Z are:

$$W_I^N = w_{II}(s_I^N, s_I^N, s_I^N) + w_{JI}(s_J^N, s_J^N, s_J^N) + w_{ZI}(s_Z^N, s_Z^N, s_Z^N)$$

$$= 0.044056 + 0.0080103 - 0.005 = 0.047067, \quad I, J = X, Y, \quad I \ne J,$$

$$W_Z^N = w_{ZZ}(s_Z^N, s_Z^N, s_Z^N) + w_{XZ}(s_X^N, s_X^N, s_X^N) + w_{YZ}(s_Y^N, s_Y^N, s_Y^N)$$

$$= \frac{55 - 72\theta}{160} + 0.0080103 + 0.0080103.$$

If $0.59734 < \theta < 0.98083$, the NT welfare levels are:

$$W_I^N = 0.044056 + 0.0080103 + \frac{288369\theta(5740\theta - 3531)}{53500(2400\theta - 1177)^2}, \qquad I = X, Y,$$

$$W_Z^N = \frac{288369\theta^2}{5350(2400\theta - 1177)} + 0.0080103 + 0.0080103.$$

If $0.98083 \le \theta < 1$, the NT welfare levels are:

$$W_I^N = 0.044056 + 0.0080103 + 0.0080103 = 0.060077, \qquad I = X, Y, Z.$$

Member I's regional MR standard under joint welfare maximization is given by:

$$s_I^m = 0.59731, \quad I = X, Y.$$

If $0.49042 < \theta \le 0.59734$, the welfare levels of member and non-member countries under regional MR are:

$$W_I^m = w_{II}(s_I^m, s_J^m, s_I^m) + w_{JI}(s_I^m, s_J^m, s_J^m) + w_{ZI}(s_Z^N, s_Z^N, s_Z^N)$$

$$= 0.04404 + 0.008033 - 0.05 = 0.04707, \quad I, J = X, Y, \quad I \ne J,$$

$$W_Z^m = w_{ZZ}(s_Z^N, s_Z^N, s_Z^N) + w_{XZ}(s_X^m, s_X^m, s_Y^m) + w_{YZ}(s_Y^m, s_X^m, s_Y^m)$$

$$= \frac{55 - 72\theta}{160} + \frac{6632487(2461 - 33\theta)}{2005352270000} + \frac{6632487(2461 - 33\theta)}{2005352270000}.$$

If $0.59734 < \theta < 0.98083$, the welfare levels under regional MR are:

$$W_I^m = 0.04404 + 0.008033 + \frac{288369\theta(5740\theta - 3531)}{53500(2400\theta - 1177)^2}, \quad I = X, Y,$$

$$W_Z^m = \frac{288369\theta^2}{5350(2400\theta - 1177)} + \frac{6632487(2461 - 33\theta)}{2005352270000} + \frac{6632487(2461 - 33\theta)}{2005352270000}.$$

If $0.98083 \leq \theta < 1$, the welfare levels under regional MR are:

$$W_I^m = 0.04404 + 0.008033 + 0.0080103 = 0.06008, \quad I = X, Y,$$

$$W_Z^m = 0.044056 + \frac{6632487(2461 - 33\theta)}{2005352270000} + \frac{6632487(2461 - 33\theta)}{2005352270000}.$$

By comparing the welfare levels under NT and regional MR, $W_I^m > W_I^N$ $(I = X, Y)$ and $W_Z^m > W_Z^N$.

Member I's multilateral MR standard under joint welfare maximization is given by:

$$s_I^{mm} = \frac{4(21346\theta + 2567)}{535(208\theta + 95)}, \quad I = X, Y, Z.$$

The welfare levels of countries I and Z under multilateral MR are:

$$W_I^{mm} = w_{II}(s_I^{mm}, s_J^{mm}, s_Z^{mm}) + w_{JI}(s_I^{mm}, s_J^{mm}, s_Z^{mm}) + w_{ZI}(s_I^{mm}, s_J^{mm}, s_Z^{mm})$$

$$= \frac{416533(\theta + 2)(46501\theta - 3298)}{13375000(208\theta + 95)^2} + \frac{416533(\theta + 2)(7462\theta + 479)}{13375000(208\theta + 95)^2}$$

$$+ \frac{416533(\theta + 2)(7462\theta + 479)}{13375000(208\theta + 95)^2}, \quad I, J = X, Y, \ I \neq J,$$

$$W_Z^{mm} = w_{ZZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) + w_{XZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm}) + w_{YZ}(s_Z^{mm}, s_X^{mm}, s_Y^{mm})$$

$$= \frac{416533(\theta + 2)(31200\theta^2 - 18599\theta + 30602)}{13375000(44\theta + 13)^2} + \frac{416533(\theta + 2)(4680\theta^2 - 2303\theta + 5564)}{13375000(208\theta + 95)^2}$$

$$+ \frac{416533(\theta + 2)(4680\theta^2 - 2303\theta + 5564)}{13375000(208\theta + 95)^2}.$$

By comparing the welfare under regional and multilateral MR, if $0.6872 < \theta < 0.96623$, $W_I^{mm} < W_I^m$ $(I = X, Y)$; if $0.49042 < \theta < 0.6872$ or if $0.96623 < \theta < 1$, $W_I^{mm} > W_I^m$. If $0.49042 < \theta < 0.78641$, $W_Z^{mm} < W_Z^m$; if $0.78641 < \theta < 1$, $W_Z^{mm} > W_Z^m$. This result sharply contrasts with Proposition 3 (ii).

The reason why $W_I^{mm} < W_I^m$ for $0.6872 < \theta < 0.96623$ can be explained in the same way as in the previous case. In particular, the reason for $W_I^{mm} > W_I^m$ under $0.49042 < \theta < 0.6872$ is as follows. If $0.49042 < \theta < 0.6872$, the regime change from regional to multilateral MR substantially increases the component of country I's welfare obtained from country Z, w_{ZI} $(I = X, Y)$. This is because the regime change significantly raises country Z's standard and substantially reduces the cross-border negative externality from country Z. Thus, multilateral MR makes country I better off relative to regional MR.

The reason for $W_Z^{mm} < W_Z^m$ under $0.49042 < \theta < 0.78641$ is as follows. The regime change from regional to multilateral MR decreases the domestic component w_{ZZ} of country Z's welfare (a negative effect). Simultaneously, it increases the components obtained from countries X and Y, w_{XZ} and w_{YZ} (a positive effect). If $0.49042 < \theta < 0.78641$, the regime change significantly raises country Z's standard because country Z's NT standard is sufficiently low. This significant increase in standards intensifies the negative effect, resulting in a reduction in country Z's welfare.

In sum, we establish the following. If $0.49042 < \theta < 0.96623$, *only regional MR is attained* because multilateral MR is blocked by members X and Y or by non-member Z.

Section 5.2

Assume that $\alpha = 1$ and $\beta = 0.6$. The results of the numerical simulations are shown in the following tables ($I = X, Y, Z$). The superscript *MR* denotes the regional MR when country *Y* maximizes the joint welfare of countries *X* and *Y* but country *X* maximizes its own welfare. The reason why W_Y^{MR} and W_Z^N can be negative is as follows. When $\delta = 0$, regional MR causes a surge in the imports of goods from country X with extremely low standards, which increases local negative externalities in country Y. If they are sufficiently large, its welfare can be negative. When $\delta = 1$, transboundary negative externalities from country X are sufficiently large, which harms the other countries.

(a) $\gamma = 0.95$, $\delta = 0$

NT

s_I^N	W_I^N
0.6	0.086672

Regional MR

s_X^{MR}	s_Y^{MR}	W_X^{MR}	W_Y^{MR}	W_Z^N
0	0.40068	0.13186	–0.11499	0.18626

(b) $\gamma = 0.8, \quad \delta = 0$

NT

s_I^N	W_I^N
0.6	0.12675

Regional MR

s_X^{MR}	s_Y^{MR}	W_X^{MR}	W_Y^{MR}	W_Z^N
0.11697	0.44495	0.13203	–0.025026	0.18744

(c) $\gamma = 1.4, \quad \delta = 1$

NT

s_I^N	W_I^N
0.55482	0.00066754

Regional MR

s_X^{MR}	s_Y^{MR}	W_X^{MR}	W_Y^{MR}	W_Z^N
0.47595	0.55579	0.004743	–0.032131	–0.024599

(d) $\gamma = 1.2, \quad \delta = 1$

NT

s_I^N	W_I^N
0.57407	0.027222

Regional MR

s_X^{MR}	s_Y^{MR}	W_X^{MR}	W_Y^{MR}	W_Z^N
0.50464	0.58505	0.03423	–0.005439	0.0055097

(e) $\gamma = 1, \ \delta = 1$

NT

s_I^N	W_I^N
0.6	0.075

Regional MR

s_X^{MR}	s_Y^{MR}	W_X^{MR}	W_Y^{MR}	W_Z^N
0.53846	0.6	0.078077	0.046598	0.054172

In Cases (a) to (e), member X's standard is lower than the NT standard. By contrast, member Y's standard is lower than the NT standard in Cases (a) and (b), higher in Cases (c) and (d), and the same as the NT standard in Case (e).

In Cases (a) to (e), regional MR benefits member X relative to the NT regime but harms member Y. Thus, regional MR is not realized.