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TARIFF COORDINATION IN FREE TRADE AGREEMENTS AND CUSTOMS UNIONS

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ABSTRACT

This paper explains why free trade agreements (FTAs) are more popular than customs unions (CUs), and it identifies the optimal rule in FTAs and CUs to achieve global tariff-free trade. Employing an equilibrium theory of trade agreements with tariff coordination, I demonstrate that two FTA members can keep their external tariff higher than separately decided external tariffs by keeping the status-quo. This "implicit" tariff coordination can benefit each member through trade diversion. In a CU, each member country must have a common, optimal external tariff, and it must incur costs because each country has its own opinion regarding what tariff to impose on each good. The coordination factor accounts for the popularity of the FTA. This paper also compares equilibrium results for both types of trade agreements and each rule. FTA with coordination is best to support global tariff-free trade. CUs cannot make a noticeable change when an FTA is also possible.

CHAPTER 1

INTRODUCTION

Countries in the World Trade Organization (WTO) have tried hard to lower tariffs imposed on one another and reach global, tariff-free trade. Several times the WTO has provided a negotiation forum to encourage multilateral trade liberalization. Following completion of the Uruguay Round, a new major round, the Doha Round, was started in 2001, but it was not successful. As multilateral talks slowed, each country turned its attention to preferential trade agreements (PTAs), which lower tariffs exclusively for PTA member countries. The two most common forms of PTAs are the free trade agreement (FTA) and the customs union (CU). In both, there are zero tariffs between members.[1] In the CU, only a common external tariff is imposed on goods from non-participating countries. In contrast, in an FTA, members can impose their own external tariffs, and each participant can select a different tariff.

Free trade agreements became more prevalent than CUs, especially after Doha Round became slower. In reports by the World Trade Organization as of April 2015, 221 PTAs are notified to the WTO after January 2000 and only 11 cases are CUs, but 206 cases are FTAs.[2] This is surprising given that CU countries impose common, optimal external tariffs to maximize the sum of their members' welfare, whereas FTA countries can impose optimal, external tariffs independently of one another. Some propose that this property helps CU members acquire more welfare than would be possible under an FTA, at least in the short-run.[3]

An issue of concern to countries undergoing economic integration is whether FTAs or

1. Each PTA may have some exceptions on some goods and keep positive tariffs on them. I don't consider exceptions in this paper.

2. http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx
Among 11 CUs, 4 cases are extensions of EU and 5 cases are overlapped CUs in Africa. Many proposed CUs are still not active. However, many countries including the United States, Canada, Republic of Korea, India, and Chile, are establishing only FTAs. Other trade agreements are partial scope agreements (PSAs).

3. See **(author?)** [21] or **(author?)** [5] for an early contribution on this topic. **(author?)** [23] have proved that a CU provides higher welfare to its members than an FTA in the short-run, based on oligopoly model.

CUs will help WTO countries reach global free trade. That is, will these arrangements be building blocks or stumbling blocks? Some argue that FTAs and CUs make overall tariffs lower, and more trade agreements will make all tariffs approach zero. However, when an FTA or CU improves the welfare of member countries or non-member countries, and that gain is higher than what can be achieved under global free trade, those countries will reject free trade. When an external tariff is high, then member countries can gain more by trading among themselves. An "exclusive economic bloc" is established when members do not accept non-members and reject free trade. When an external tariff is low, a non-member country can export more goods to member countries. "Free-riding" occurs when a non-member country declines free trade because it can gain more as a non-member of trade agreements.

This paper addresses two principal questions: why are FTAs more popular than CUs, and what is the optimal rule to achieve global tariff-free trade (evading free-riding and exclusive blocs)? By addressing these questions, this paper examines how member countries in trade agreements coordinate their actions. In a CU, all member countries must have a single, common, external tariff for each good, and coordination is mandatory. On the other hand, in an FTA, when each country establishes its external tariff, it does so with the goal of maximizing its own welfare. But each country can also coordinate "implicitly" by keeping the status-quo after establishing an FTA. When both countries keep their external tariffs at the same level as before making an FTA, they can improve the welfare for both countries. Because of the GATT/WTO Article XXIV, which mandates that FTA or CU members cannot raise external tariffs, on average, keeping the status quo satisfies this Article XXIV constraint and becomes a focal point of optimization.

This paper applies tariff coordination elements to the trade liberalization with a three-country oligopoly goods market. To begin, this paper finds implicit coordination is possible by endogenous decisions of members in an FTA when they can choose between two external tariff policies: a separate, optimal tariff decision, and implicit coordination that keeps external tariffs following the status-quo. Next, this paper shows that each country prefers

to make their first trade agreement with each other when they can choose between an FTA and a CU. Then, coordination elements make an FTA more profitable than a CU. Making a CU becomes costly as cost or demand size asymmetry increases. Countries choose an FTA over a CU under implicit tariff coordination, and this explains the popularity of the FTA. In contrast, CU is much popular without considering implicit coordination in the FTA. Also, this paper tests the role of the GATT/WTO Article XXIV and finds that this regulation on external tariffs can be more costly to countries forming a CU and makes countries more favorable to an FTA.

Next, I analyze different equilibrium results made by endogenous decisions of players under four regimes: (1) when only an FTA is possible, (2) when only a CU is possible, (3) when both are possible, and (4) when all preferential trade agreements are banned. When both FTAs and CUs are banned, countries can make a trade agreement and agree to a tariff decrease, but it must be applied to all countries under the most-favored-nation (MFN) rule. Then, this paper compares how large parameter ranges achieve global, tariff-free trade and evade "free-riding" or "exclusive economic blocs" for each regime. An FTA without coordination can result in free-riding, but an FTA with implicit coordination can prevent it with a higher external tariff. Additionally, FTAs are better at preventing exclusive blocs than CUs are because FTAs are more flexible. As a result, when an FTA is possible, countries achieve the goal of global free trade better than any other regime does. Also, even when a CU is possible, it will have a negligible effect if making an FTA is possible as an alternative. This is because an FTA becomes more favorable than a CU.

Previous studies have found that FTA members tend to lower external tariffs after establishing an FTA. This is called a "tariff complementarity" **(author?)** [2] note that an FTA encourages member countries to import less from countries outside the FTA, which lowers the incentive to manipulate the terms-of-trade of non-members.[4] Hence, keeping the

4. In addition to **(author?)** [2], others, including **(author?)** [21] and **(author?)** [7], have explained this effect through various mechanisms.

status-quo means keeping high, external tariffs when tariff complementarity exists.

However, **(author?)** [14] and **(author?)** [9] approached the problem empirically, and showed conflicting results on the existence of tariff complementarity. Developing countries have a tendency to lower their external tariff after making trade agreements, but developed countries do not. Additionally, the existence of tariff complementarity can increase the incidence of free-riding. When FTA members lower external tariffs enough, this outcome benefits non-member countries through import increase. In contrast, a non-member country will not lower its tariff because its optimal tariff condition does not change. Then, a non-member country will not accept free trade when the export increase imposed on it by the trade agreement is greater than the welfare gain that would be acquired if free trade were accepted.

This problem is solved when member countries coordinate implicitly to keep their external tariffs high. They can keep the status-quo by setting their tariffs at a level before making an FTA. Status-quo tariffs are tariffs in states that do not have trade agreements, which is called the trade war state. In contrast to an FTA without coordination, when FTA member countries coordinate implicitly, trade between members increases, but imports from non-member countries decline. This trade diversion always produces a loss for an outside country because the diversion decreases its exports to members. This policy makes non-members view global, free trade favorably, and it increases the acceptance of additional FTAs. I assume the existence of tariff complementarity in optimal tariff decisions but show that maintaining a high, external tariff by implicit coordination can produce better results than lowering the external tariff when both countries in the FTA coordinate.

Additionally, this paper supports the assertion in **(author?)** [11] and **(author?)** [15] that only developing countries with high, external tariffs experience a strong tariff complementarity effect. Implicit coordination is possible only when the welfare gained from lowering external tariff is not high. Otherwise, implicit coordination in an FTA becomes impossible

and then each FTA shows tariff complementarity in my model. [5]

Implicit tariff coordination in this paper can be thought of as similar to "the rule of reciprocity" from the GATT/WTO. Each government will not lower its tariff unilaterally without evaluating the possibility of mutual tariff reductions. This produces a result similar to that of the rule of reciprocity in which each government seeks a balance of concessions. However, I do not examine the bargaining process, nor do I assume correct reciprocal tariff moves in negotiations. In this paper, the rule of reciprocity is only "partially" applied to trade agreement relationship members and non-members. This use differs from **(author?)** [3], who looks at the rule of reciprocity as leaving world prices unchanged. Instead, implicit tariff coordination, in keeping with the status-quo, can be thought of as one "focal point" in the strategic choices of each country.

In a CU, external tariff coordination between all members is mandatory; all members must have a single, common external tariff for each good, and members are assumed to maximize their sum of welfare with one common external tariff. If each member country has a different demand or production cost, they will want a different external tariff. As these differences increase, participating countries also want different external tariffs, and the cost of achieving a common external tariff increases.

In this study, I assume that international transfer is impossible. Then, each FTA or CU can make non-members lose their welfare, which is harmful in the short-run, but this loss of welfare is helpful for the world to reach global, tariff-free trade in the long-run; it can prevent free-riding and make non-members try to jointly reduce tariff levels by establishing another trade agreement. In this sense, this paper supports domino theory or contagion of trade agreements and recent steep increases of FTA. **(author?)** [22] approaches this problem similarly. Trade agreements can create trade diversion or a loss to non-member countries, and it makes global, free trade more accessible. This is also empirically shown in **(author?)**

5. Tariff complementarity effects decrease with tariff coordination. **(author?)** [13] demonstrate that due to mandatory, external tariff coordination, trade diversion and common, optimal external tariffs are higher in CUs than in FTAs. In contrast to my approach, they do not examine implicit coordination in FTAs.

[4]. [6] [7]

Several other studies such as **(author?)** [1] and **(author?)** [10] have employed a political economic approach to answer what is the optimal ruling on FTA or CU, or popularity of FTAs, respectively. Note that I approach this question without considering political-economic elements or specific bargaining processes. As a result, the outcomes of this paper can be integrated with other papers based on political economy, and explain popularity of FTA. In this paper, GATT/WTO Article XXIV regulation on external tariffs also plays an important role. Other works such as **(author?)** [19] examine how Article XXIV affects their decisions and works as a constraint, but they do not consider FTA as an alternative and consider only CU.[8] Under Article XXIV, member countries adopt a more favorable attitude towards FTAs than to CUs. In conclusion, it helps to explain why CUs are less observed but does not have a critical effect on the equilibrium stability of global, free trade.

This paper is based on a relatively simple three-country oligopoly model. That is, in each of my scenarios, there are three participating countries. My model contains both free-riding and exclusive economic bloc possibilities. I analyze the endogenous decision of all three countries regarding external tariff policies under an FTA, a CU, and a type of trade agreement distinguished by multilateralism. **(author?)** [20], **(author?)** [25] and **(author?)** [24] also assume a three-country oligopoly trade liberalization game without an international transfer, but in contrast to my paper, these papers do not consider the implicit coordination possibility and cannot support popularity of FTAs.

My paper is structured as follows: In Section 2, which presents my model, I explain

6. However, this paper uses only three countries and has only limited implications on domino theory. I leave this issue to future research.

7. If trade agreements are more advantageous to non-members, some 'marginal,' non-member country becomes unfavorable to free trade; those who receive a small gain from accepting free trade choose to be a free-rider. If observed tariff complementarity is high, the non-member country gains more and this problem appears, and then contagion cannot be explained. To solve this problem, other papers have analyzed specific external tariffs that make non-members indifferent to define Pareto-improving PTAs. See **(author?)** [18] for recent developments in the literature.

8. That paper assumes that CU offers higher welfare than FTA, and so FTA cannot be an alternative.

market equilibrium and the optimal tariff choice of each country that is, how, for a given trade agreement, each country decides its optimal tariffs. In Section 3, I analyze how two countries reach endogenous decisions about the type of trade agreements used. Section 4 analyzes trade agreement negotiations and equilibrium results within the trade liberalization game. Section 5 describes equilibrium results with exogenous demand or productivity differences. Here I establish a parameter range for differences, and indicate where global, tariff-free trade is achieved in each regime. Section 6 applies my setup to a real example with three countries: China, Japan, and the United States. I present my conclusions in Section 7.

CHAPTER 2

MODEL

This paper applies tariff coordination elements to an adapted version of the three-country partial equilibrium 'competing exporters' framework developed by **(author?)** [2] and **(author?)** [25]. The model is simple, and it contains a tariff complementarity element because in each market, there is always more than one firm. In this setup, each country wants to shift the profits of foreign firms in its domestic market to tariff revenues and domestic firm profits. Each country uses tariffs to maximize its total welfare, and the "profit-shifting" incentive and the "manipulating terms-of-trade" incentive appear.

My model progresses through three stages. Prior to stage 1, the social planner decides the rule of trade agreement among participating countries. There are four rules: (1) both the FTA and the CU are possible, (2) only an FTA is possible, (3) only a CU is possible, and (4) both possibilities are banned. In stage 1, countries can undertake the trade agreements permitted under the rules devised by the social planner and establish an FTA or a CU, but an agreement is made only if the two countries agree to that. Each country wants to maximize its welfare as total surplus, which consists of consumer surplus, tariff revenue, and firm profits on domestic and foreign markets.

In my model, there are 3 countries, 1, 2, and 3, and these countries become players in a trade liberalization game. I denote $\{12\}$ as one trade agreement between country 1 and 2. Four types of game results are possible: (1) no agreement is made($\{\Phi\}$), (2) one agreement is made($\{12\}, \{13\}, \{23\}$), (3) two agreements are made($\{12-13\}, \{12-23\}, \{13-23\}$), and (4) three agreements are made and global tariff-free trade is achieved ($\{G\}$). In the third state, when two countries establish an FTA, one can arrange two separate FTAs with outside countries, and states such as $\{12-13\}$ become possible. Country 1 becomes a 'hub' of two FTAs $\{12\}$ and $\{13\}$, and FTA countries 2 and 3 become the spokes. I denote this state $\{1-hub\}$.

Under a CU, the two member countries must agree to impose a common, external tariff

on one another. For example, assume that trade agreements {12} and {13} are made as a CU. To follow a CU {12}, countries 1 and 2 should choose a common, external tariff levied on product from country 3, but country 1 cannot set a positive tariff on country 3 because country 1 has made a CU with 3. Hence, country 1 must choose one of two countries when countries 2 and 3 decide not to establish a trade agreement with one another. This is not a problem for an FTA because tariffs are selected on the basis of separate decisions, but under a CU, this would be impossible. As a result, each member of FTA can make another FTA with outside countries, but extension of CU to non-members requires agreement of all member countries.[1] In this respect, the FTA is flexible and the CU is not. This non-flexibility of CU has a significant impact on the establishment of free trade equilibrium. [2]

At stage 2, each country decides its tariff for the trade agreements established during stage 1. Each country wants to maximize its national total welfare with a constraint that depends on the result of stage 1. For example, in stage 1, when two of three countries establish an FTA or a CU, they will have a zero internal tariff and they must decide, in coordination with trade agreements, what external tariff to impose on non-member countries. Additionally, the Article XXIV regulation may bind tariff decisions in a CU.

Finally, in stage 3, each firm decides its optimal production under given tariff and demand conditions. This qualifies as a Cournot equilibrium, produced by firm production decisions. In stage 2, each country determines its tariff based on its expectations about firm decisions in stage 3. Likewise, in stage 1, the strategy of each country rests on the expectation about

1. Countries cannot be a member of two CUs. However there are some overlapping cases of a CU and FTA. For example, all EU members do not have a separate FTA with outside countries. In contrast, some CU member countries (especially Colombia and some Latin American countries, and countries with Russian areas) also have FTA with some other countries, but this can be thought of as the part of the process making FTA with all CU members. Turkey has a CU with EU, and all FTA with Turkey is also extended to EU countries (not all FTA of EU is extended to Turkey.) In this sense, my assumptions about FTA and CU are acceptable, and some FTA agreements include an article that mandates that each member country cannot extend FTAs with the other countries. This paper does not examine those cases.

2. This flexibility issue is considered in some previous literature such as **(author?)** [26], which offers a similar conclusion to this papers by suggesting that trade agreements need to be open. **(author?)** [26] shows unanimous regionalism works as a stumbling block, and open regionalism is needed to reach free trade. However, open regionalism in this paper does not have a counterpart in reality. **(author?)** [16] also emphasized this flexibility issue.

what decisions will be made from decisions in stages 2 and 3. Next, I explain the model, starting with stage 3 and moving backwards to stage 1. I first examine demand, production, and market equilibrium in the context of stage 3, and then the optimal tariff decisions of each country in stage 2. Stage 1 decisions and game equilibrium are discussed in Section 4.

2.1 Market Equilibrium

2.1.1 Demand and Production

People in these countries have the same preference for 3 non-numeraire goods, A, B, and C, and numeraire ψ. Their utility function is additively separable for each good consumption:

$$U_i = \alpha_{iA}x_{iA} - \frac{1}{2}x_{iA}^2 + \alpha_{iB}x_{iB} - \frac{1}{2}x_{iB}^2 + \alpha_{iC}x_{iC} - \frac{1}{2}x_{iC}^2 + \psi_i \tag{2.1}$$

for each country i=1, 2, and 3. Consequently, demand from each country for each good becomes linear, and I normalize the price of numeraire $p_\psi = 1$. Each demand is given by $d(p_{iX}) = \alpha_{iX} - p_{iX}$ in each country i=1, 2, and 3, where $X = A$, B, and C. The full derivation of demand is explained in Appendix A.1. The slope of linear demand is fixed to 1. α_{iX} is the intercept of linear demand and represents market size for good X in country i.

Each country can produce numeraire good ψ and only two non-numeraire goods. Country 1 produces goods B and C but cannot produce good A. Country 2 produces good A and C, and country 3 produces only goods A and B. Each country has one domestic firm that produces the non-numeraire good and numerous firms that produce numeraire good ψ. The market for numeraire goods is perfectly competitive. Firms produce goods using only labor, and there is no capital. The production function is linear, and each unit that produces good X needs c_{jX} units of labor for the firm in country j. Similarly, each unit that produces a numeraire good needs one unit of labor. In this economy, there are six types of cost levels for production of non-numeraire goods: $\{c_{jX}\}^{X=A,B,C}_{j=1,2,3,jX\neq 1A,2B,3C}$ When a wage is w, the

profit for the firm producing good A in country j is $\pi_{jA} = p_{jA}q_{jA} - q_{jA}c_{jA}w_j$, but the wage is $w_j = p_\psi = 1$ because the numeraire goods market is competitive. Thus, profit for production of the numeraire good becomes zero.

I assume that when three countries begin trade, each country exports two goods that it produces, and imports three goods. Country 1 exports goods B and C to country 2 and 3. Country 1 imports goods A and C from country 2 and goods A and B from country 3. When optimal production is zero, each firm can choose zero production, but I constrain the parameter range that makes all production positive. Although trade flows can imbalance trade, numeraire goods are freely traded. This arrangement produces a trade balance and keeps the wages of each country fixed to 1. Numeraire goods are produced in sufficient quantities to ensure that trade balances are maintained. Each market reaches equilibrium through these trades of goods.

Also, each country levies a tariff on each import. I denote τ_{ijX} as the tariff that country i levies on good X imported from country j. The firm in country j that produces good X gets the profit

$$\pi_{ijX} = p_{iX}q_{ijX} - q_{ijX}(c_{jX} + \tau_{ijX}) \tag{2.2}$$

when it sells amount q_{ijX} in country i. Each firm identifies production goals that maximize its profit. There are no differences in quality between goods produced in different countries, but production cost c_{jX} can differ from one country to another, and this can offer absolute or relative advantages to the three countries.

Under this market structure, three non-numeraire good markets exist in three countries. Each of the nine markets can be analyzed independently. A tariff on good B imported from country 3 does not affect the market for goods A and C in country 3, or the non-numeraire goods markets in the other countries. Each demand for goods is independent. There is no general equilibrium effect from wage change or other factors because all changes are absorbed in the numeraire good market. Production is linear, and so each market is segmented from other firms. Each firm sets a production amount for each market and produces the sum of

these. The domestic market for imported goods is under the oligopoly of two firms from two countries. Trade gains are made by the consumption of the good that a given country cannot produce, the absolute production cost advantage between countries, and changing a monopoly to a duopoly.

2.1.2 Equilibrium

During stage 3, firms compete in each market based on the optimal production decisions they have made for given tariffs. These decisions constitute a Cournot equilibrium. In each domestic market, two firms can produce each good. When a country cannot produce the good, two foreign firms compete in the domestic market. When a country can produce the good, one domestic firm and one foreign firm compete to produce and sell it. During stage 2, each country selects optimal tariffs on each foreign good in each market. Thus, to maximize total surplus, each country needs to set up four types of tariffs. For example, Country 1 will import good A from country 2 and 3, good B from country 3, and good C from country 2. As illustrated in (2.2), each firm maximizes profit for given tariffs, and equilibrium quantities and prices are determined.

Presented below is a case of a two-firm oligopoly. Denote total sales of good X on country i as Q_{iX}. This is the sum of the production of goods in each country and sold in country i. For example, $Q_{iA} = q_{i2A} + q_{i3A}$ for i=1,2,3 because good A is produced in countries 2 and 3. Then each profit becomes

$$\pi_{ijX} = q_{ijX}(p_{iX} - c_{jX} - \tau_{ijX}) = q_{ijX}(\alpha_{iX} - c_{jX} - Q_{iX} - \tau_{ijX}) \tag{2.3}$$

Now each equilibrium depends on $\{\alpha_{iX}, c_{jX}, \tau_{ijX}\}_{i,j=1,2,3,jX\neq 1A,2B,3C}^{X=A,B,C}$. When two firms from country j and k compete in the market, the Cournot equilibrium productions are

$$q_{ijX} = \frac{1}{3}(\alpha_{iX} - 2c_{jX} + c_{kX} - 2\tau_{ijX} + \tau_{ikX}). \tag{2.4}$$

for each good $X = A, B, C$ and each country $i, j, k = 1, 2, 3$ ($jX \neq 1A, 2B, 3C$, $kX \neq 1A, 2B, 3C$). The complete derivation appears in Appendix A.2.

Next we identify consumer surplus, tariff revenue, and firm profits on each market as functions of $\{\alpha_{iX}, c_{jX}, \tau_{ijX}\}_{i,j=1,2,3,jX\neq 1A,2B,3C}^{X=A,B,C}$. Assume that tariffs should be zero or positive, and that subsidy as a negative tariff is banned. Tariffs cannot be levied on domestic goods. In other words, when each country i can produce good X, τ_{iiX} must be zero. The domestic market equilibrium of good X in country i is given below. Assume that countries j and k produce good X in the market of country i. i can be the same country as j or k, but j and k must be different.

$$CS_{iX} = \frac{1}{2}Q_{iX}^2 = \frac{1}{18}(2\alpha_{iX} - c_{jX} - c_{kX} - \tau_{ijX} - \tau_{ikX})^2 \tag{2.5}$$

$$\pi_{ijX} = (P_{iX} - c_{jX} - \tau_{ijX})q_{ijX} = \frac{1}{9}(\alpha_{iX} - 2c_{jX} + c_{kX} - 2\tau_{ijX} + \tau_{ikX})^2 \tag{2.6}$$

$$\pi_{ikX} = \frac{1}{9}(\alpha_{iX} + c_{jX} - 2c_{kX} + \tau_{ijX} - 2\tau_{ikX})^2 \tag{2.7}$$

$$TR_{iX} = q_{ijX}\tau_{ijX} + q_{ikX}\tau_{ikX} \tag{2.8}$$

These elements depend on tariff τ_{ijX} and τ_{ikX}. When the tariff on an import from country j (τ_{ijX}) increases, profit π_{ijX} decreases and π_{ikX} increases due to the substitution decision of consumers. In this equilibrium, consumer surplus and tariff revenues are always one part of domestic surplus. When a domestic firm produces good X, its profit becomes part of the surplus of country i. Profit is zero when a country does not produce that good. (e.g., $\pi_{11A} = \pi_{21A} = \pi_{31A} = 0$) Denote $DS_{iX} \equiv CS_{iX} + TR_{iX} + \pi_{iiX}$, which is the domestic surplus from only the domestic market of good X.

Country i can acquire more firm profits from exporting. Denote $EX_{iX} \equiv \pi_{jiX} + \pi_{kiX}$; this is the profit from exporting good X. Denote DS_i as the sum of the domestic surplus for three domestic markets, and EX_i the sum of two exports that country i can produce. Total surplus TS_i is the sum of DS_i and EX_i. For example, when country i, j, k are different and

i cannot produce good A, total surplus of country i is

$$TS_i = \sum_{X=A,B,C} (CS_{iX} + TR_{iX} + \pi_{iiX}) + \sum_{Y=B,C} (\pi_{jiY} + \pi_{kiY}) \quad (2.9)$$

$$= \sum_{X=A,B,C} DS_{iX} + \sum_{Y=B,C} EX_{iY}. \quad (2.10)$$

TS_i represents total welfare of country i, and each country wants to maximize this total surplus. Note that EX_i does not depend on domestic tariff rates. On the other hand, foreign firm profits from import depend on tariff decisions of the domestic country, but become the part of the foreign countries' welfare. All markets are separate, and the effect of the tariff on the market is segmented.

2.2 Optimal Tariff Choices in Trade Agreements

In this section, I explain how each country identifies the optimal tariff for each trade agreement. Optimization depends on the trade agreements a country agrees to in stage 1. Even when the internal tariff for a trade agreement is zero, a decision regarding external tariffs depends on the type of trade agreement, and affects total surplus. In stage 2, each country identifies an optimal tariff that will maximize its total surplus. Next we solve equilibrium for a given $\{\alpha_{iX}, c_{jX}\}^{X=A,B,C}_{i,j=1,2,3,jX\neq 1A,2B,3C}$. In free trade, all tariffs between countries become zero. In this case, domestic surplus and exports for country 1 are

$$DS_1(G) = \frac{1}{18}(2\alpha_{1A} + c_{2A} + c_{3A})^2 + \frac{1}{18}(2\alpha_{1B} + c_{1B} + c_{3B})^2 + \frac{1}{18}(2\alpha_{1C} + c_{1C} + c_{2C})^2$$
$$+\frac{1}{9}(\alpha_{1B} - 2c_{1B} + c_{3B})^2 + +\frac{1}{9}(\alpha_{1C} - 2c_{1C} + c_{2C})^2 \quad (2.11)$$

$$EX_1(G) = \frac{1}{9}\{(\alpha_{2B} - 2c_{1B} + c_{3B})^2 + (\alpha_{3B} - 2c_{1B} + c_{3B})^2$$
$$+(\alpha_{2C} - 2c_{1C} + c_{2C})^2 + (\alpha_{3C} - 2c_{1C} + c_{2C})^2\} \quad (2.12)$$

when I denote (G) as the tariff of surplus value on global tariff-free trade regime. A detailed derivation is in Appendix A.3. Before checking properties of each trade agreement, I add one assumption.

Assumption 1 $\alpha_{iX} - 2c_{jX} + c_{kX} >= 0$ for all goods $X = A, B, C$ and countries $i, j, k = 1, 2, 3$.

Under this assumption, each α_{iX} is higher than c_{jX} for any case, and equilibrium production under free trade $q_{ijX}(G) = \frac{1}{3}(\alpha_{iX} - 2c_{jX} + c_{kX})$ becomes positive. Also, other productions under different trade agreements also become positive. I assume that all variable tariff or production quantities are positive. I will add more assumptions if needed, but Assumption 1 is enough for this section.

2.2.1 Trade War: No Agreement

When there is no trade agreement, each country maximizes its own total surplus without specific conditions. DS_{iX} depends on a tariff levied on good X, but other elements in total surplus do not. Thus, the equation below is satisfied. I denote (Φ) as the tariff or surplus value in a trade war.

- $\{\tau_{ijX}(\Phi)\} \equiv \arg\max TS_i = \arg\max DS_{iX}$ when country i imports the good X from country j.

Each country cannot produce one good and import that good from two countries. Thus, each country will decide on four tariffs for three goods. For example, country 1 has two tariffs to maximize surplus on domestic market A, but country 1 has only one tariff on markets B and C. Then the given tariff for a trade war state is

- $\tau_{ijX}(\Phi) = \frac{1}{8}(2\alpha_{iX} - 3c_{jX} + c_{kX})$ for each $(i, X) = (1, A), (2, B), (3, C)$.
- $\tau_{ijX}(\Phi) = \frac{1}{3}(\alpha_{iX} - c_{jX})$ otherwise.

I added calculation processes in Appendix A.4. Also, these tariffs are positive, as below,

$$(2\alpha_{iX} - 3c_{jX} + c_{kX}) = 5q_{ijX}(G) + q_{ikX}(G) \quad (2.13)$$

$$\alpha_{iX} - c_{jX} = q_{ijX}(G) + 2q_{ikX}(G) \quad (2.14)$$

, because all $q_{ijX}(G)$ are positive under Assumption 1.

When a firm from country j can produce product X at a low cost(c_{jX}), the firm from j acquires a large portion of the market by offering the same product at a lower cost. To obtain more tariff revenue or protect its domestic firm, country is government will levy a high tariff on the firm from j. When country k produces X at a low cost, imports from k to i increase and imports from j to i decrease. This substitution makes tariff revenue from country j decrease and the optimal tariff on good X from country j decrease. As a result, the domestic government places higher tariffs on a country that has the lower cost.[3] Profits from the exporting firm in country j decrease from technology development of the competing firm in k, but are partially covered by an optimal tariff decrease.

However, when country i can produce good X, the tariff on competing firm j does not depend on costs of the firm in i. In this case, if costs of domestic firm go up, the optimal tariff should decrease considering tariff revenue and consumer surplus, but it should increase considering firm profits. These two effects offset each other in this model. Profits of exporting firms depend on tariffs from foreign countries. Using this tariff decision rule, the surplus of each country in a trade war regime can be calculated.

2.2.2 Free Trade Agreement with New Optimal External Tariffs

When one country reaches a free trade agreement with another, its tariff decisions change. In this section, I assume that each country decides its optimal external tariff separately. I denote $(12|FTA)$ as the tariff or surplus value when country 1 and 2 establish an FTA and

3. This result is the same as **(author?)** [12] and **(author?)** [8].

follow this external tariff rule. Under this FTA, countries 1 and 2 levy zero tariffs on each other. The tariff that member country 1 and 2 imposes, $\tau_{12X}(12|FTA)$, becomes zero for all good X that country 2 can produce, and $\tau_{21Y}(12|FTA)$ becomes zero for all good Y that country 1 can produce. Next, countries 1 and 2 decide optimal external tariffs on country 3 separately. The optimal conditions for determining tariffs $\tau_{13B}(12|FTA)$ and $\tau_{23A}(12|FTA)$ do not change because country 2 cannot produce good B and country 1 cannot produce good A. For these cases, $\tau_{ijX}(12|FTA) = \tau_{ijX}(\Phi) = \frac{1}{3}(\alpha_{iX} - c_{jX})$.

The optimal condition to decide $\tau_{13A}(12|FTA)$ and $\tau_{23B}(12|FTA)$ changes. This tariff decision, which plays a role in this section, is generalized below

- $\tau_{ikX}(ij|FTA) \equiv \arg\max TS_i = \arg\max DS_{iX}$ with $\tau_{ijX}(ij|FTA) = 0$.

Since the total surplus DS_{iX} equation is the same regardless of the regime, we can achieve the same first order condition as in trade war cases, and when $\tau_{13A}(12|FTA) = 0$ is inserted, it becomes an optimal tariff. The optimal external tariff for each FTA member country i is

$$\tau_{ikX}(ij|FTA) = \frac{1}{11}(\alpha_{iX} + 4c_{jX} - 5c_{kX}). \tag{2.15}$$

The derivation appears in Appendix A.5. The optimal external tariff result indicates that the external tariff under the FTA is lower than the tariff under a trade war state. This is called "tariff complementarity".

Lemma 1 *(Tariff complementarity) Assume that country i imports good X from two countries, j and k. If country i and j establish an FTA, the external tariff on country k is less than the tariff in a trade war state. That is,* $\tau_{ikX}(ij|FTA) < \tau_{ikX}(\Phi)$.

In calculation, when τ_{12A} is given, optimal τ_{13A} is $\frac{1}{11}(\alpha_{1A} - 5c_{3A} + 4c_{2A} + 7\tau_{12A})$. With condition $\tau_{12A}(12|FTA) = 0$ under an FTA between countries 1 and 2, optimal tariff $\tau_{13A}(12|FTA)$ is lower than $\tau_{13A}(\Phi)$ under Assumption 1.

This equation also indicates that when τ_{12A} is given, as τ_{12A} decreases, τ_{13A} decreases.

When country 1 lowers its tariff on goods from country 2, the total unit cost of country 2 production, including production costs and tariffs, declines. Country 2 then can take more demand from country 1, and imports from country 3 will decline by substitution. The import decrease also causes tariff revenues from country 3 to decrease. When tariff revenue decreases, lowering the tariff rate will increase the tariff revenue. This process explains tariff complementarity on the FTA.

In non-member country 3, domestic market conditions do not change even if countries 1 and 2 establish an FTA. Country 3 will levy the same tariff as in a trade war regime. ($\tau_{31X}(12|FTA) = \tau_{31X}(\Phi)$ and $\tau_{32X}(12|FTA) = \tau_{32X}(\Phi)$) Therefore, $DS_3(12|FTA)$, which does not change, will be the same as surplus $DS_3(\Phi)$. Next, export firm profits depend on tariff decisions of countries 1 and 2. Country 3 exports goods A and B to countries 1 and 2. Among these countries, π_{13B} does not change because country 2 does not produce that good, and, as noted above, $\tau_{13B}(12|FTA) = \tau_{13B}(\Phi)$. Similarly π_{23A} does not change because $\tau_{23A}(12|FTA) = \tau_{23A}(\Phi)$.

π_{13A} and π_{23B} remain. $\pi_{13A} = \frac{1}{9}(\alpha_{1A} + c_{2A} - 2c_{3A} + \tau_{12A} - 2\tau_{13A})^2$ indicates that profits depend on both tariffs τ_{12A} and τ_{13A}. On the one hand, imports from country 3 to country 1 decrease because τ_{12A} becomes zero under the FTA, and π_{12A} increases because of the zero tariff. On the other hand and as shown in Lemma 1, the tariff on goods from country 3 decreases, and then imports from country 3 increase. The lemma below shows that the latter effect is larger than the former is. An FTA can provide a positive gain to an outside country.

Lemma 2 *(Non-member gains with absence of implicit coordination) If country i and j reach a free trade agreement and do not coordinate implicitly, then* $TS_k(ij|FTA) > TS_k(\Phi)$.

In other words, the total surplus of country k increases when the external tariff of two countries decreases sufficiently to satisfy $2\tau_{ikX}(\Phi) - \tau_{ijX}(\Phi) > 2\tau_{ikX}(ij|FTA)$. Element

$\tau_{ijX}(\Phi)$ indicates that an FTA of country i and j can be costly for a firm in country k that does not participate in an FTA. However, the relationship of $\tau_{ikX}(\Phi)$ and $\tau_{ikX}(ij|FTA)$ can produce gains for firms in country k. This is satisfied for all goods under Assumption 1, and then the surplus of country 3 increases through the FTA of countries 1 and 2.

2.2.3 Free Trade Agreement with Coordination

I have demonstrated how each country can maximize its surplus through separate, optimal, external tariff decisions when countries 1 and 2 agree to an FTA. However, this tariff change can allow country 3 to increase its surplus even if it does nothing. Under these conditions, the potential gain that country 3 obtains from accepting free trade ($TS_3(G) - TS_3(12|FTA)$) is low, and country 3 will reject free trade when the difference becomes negative. Then, FTA member countries can coordinate and keep their external tariffs high to discourage free-riding.

Specific, external tariff levels may vary; this paper stipulates the status-quo as a focal point for coordination. When two countries discuss an FTA in the real world, FTA is made from trade war state, and their optimal tariff before reaching the FTA is the same as the optimal tariff under a trade war regime. Member countries can keep the status-quo and consider this decision a focal point. They choose whether to keep the status-quo first. Only if the country decides to move their external tariff do they decide on a new tariff.

This high tariff on the status-quo is not optimal and cannot maximize domestic surplus. However, the high tariff increases trade inside FTA, and it can offset the loss of domestic surplus. Hence, this tariff policy is possible when both member countries agree to it. When one member does not keep its external policy high, the other member cannot earn export increases, and then setting its own separate, external tariff becomes the best choice. That is why I call this policy "implicit coordination." This is trade diversion, and it occurs when trade among member countries increases and trade between members and non-members decreases following creation of an FTA.

I denote $(12|FTA-co)$ as the tariff or surplus value when countries 1 and 2 reach an FTA and establish an external tariff comparable to that of a trade war regime. Under an FTA with this external tariff policy, $\tau_{12X}(12|FTA-co)$ and $\tau_{21X}(12|FTA-co)$ are zero for all goods X=A,B,C. $\tau_{13B}(12|FTA)$ and $\tau_{23A}(12|FTA)$ equal the tariff in a trade war state because they import the good from only country 3. So $\tau_{13B}(12|FTA-co) = \tau_{13B}(12|FTA)$ and $\tau_{23A}(12|FTA-co) = \tau_{23A}(12|FTA)$ are satisfied. Crucial tariffs are $\tau_{13A}(12|FTA-co)$ and $\tau_{23B}(12|FTA-co)$. Here, $\tau_{13A}(12|FTA-co) = \tau_{13A}(\Phi)$ and $\tau_{23B}(12|FTA-co) = \tau_{23B}(\Phi)$. When two countries use this implicit tariff coordination strategy, country 3 suffers reduced exports to member countries because trade increases between FTA member countries.

Lemma 3 *(Non-member losses under implicit coordination) If country i and j reach a free trade agreement and coordinate implicitly, ($\tau_{ikX}(ij|FTA-co) = \tau_{ikX}(\Phi)$ and $\tau_{jkX}(ij|FTA-co) = \tau_{jkX}(\Phi)$), then $TS_k(ij|FTA-co) < TS_k(\Phi)$.*

When FTA member countries 1 and 2 can decide their external tariff policies endogenously, they consider their total surplus $\{TS_1(12|FTA), TS_2(12|FTA)\}$ and $\{TS_1(12|FTA-co), TS_2(12|FTA-co)\}$ for two cases. I have already demonstrated that under an FTA $\tau_{13A}(12|FTA) = \frac{1}{11}(\alpha_{1A} + 4c_{2A} - 5c_{3A})$ is the optimal external tariff to maximize total surplus of country 1. However, $\tau_{13A}(12|FTA)$ maximizes only domestic surplus because export from country 1 is unaffected by the tariff. When country 1 chooses $\tau_{13A}(12|FTA-co) = \tau_{13A}(\Phi)$, which is higher than τ_{13A}^{12F}, import from country 3 decreases while import from country 2 increases because of substitution. Moreover, when country 2 chooses $\tau_{23B}(12|FTA-co) = \tau_{23B}(\Phi)$, it imports less from country 3 and more from country 1. In short, under the implicit external tariff coordination, each country loses its domestic surplus, but it regains profits from export through trade diversion. Implicit coordination is made when both countries can gain more from coordination than separate decisions. Proposition 1 below shows when coordination is possible.

Proposition 1 *(Condition for implicit tariff coordination) Suppose country i does*

not produce good X, and country j does not produce good Y. Then FTA with implicit coordination yields higher total surplus to both countries i and j than FTA without tariff coordination$(TS_i(ij|FTA-co) > TS_i(ij|FTA)$ *and* $TS_j(ij|FTA-co) > TS_j(ij|FTA))$ if and only if

$$\sqrt{\frac{77}{206}}(2\alpha_{iX} - 3c_{jX} + c_{kX}) < 2\alpha_{jY} - 3c_{iY} + c_{kY} < \sqrt{\frac{206}{77}}(2\alpha_{iX} - 3c_{jX} + c_{kX}), \quad (2.16)$$

That is, two external tariffs $\tau_{ijX}(\Phi)$ and $\tau_{jiY}(\Phi)$ are sufficiently similar.

This structure resembles the Prisoner's Dilemma. With or without coordination, lowering the external tariff is the best strategy for a one-shot game. However, the two participants will achieve a higher surplus from coordination if and only if they keep the status-quo through implicit coordination. Coordination is a crucial component of this strategy; each country can help the other only if both agree to coordinate. If country 1 wants coordination but country 2 does not, country 2 will choose its own optimal external tariff, in which case country 1 will choose its own optimal external tariff, and coordination between the two becomes impossible.

If country 1 decides to lower its external tariff on country 3, country 1 will get more of its domestic surplus. In response, country 2 will lower its external tariff as soon as possible, and this produces a loss for both countries. I assume that the trade agreement is established during stage 1, and that the tariff decision is set during stage 2. However, global trade is not a one-shot game, and arriving at a tariff decision takes much less time than negotiating a trade agreement. Each country can easily retaliate for defection by the other. In this sense, retaliation is assumed, and coordination becomes sustainable.[4]

Implicit tariff coordination changes also the attitude of country 3 toward global, tariff-free trade. The additional gain that comes from accepting free trade from a country outside the FTA is $TS_3(G) - TS_3(12|FTA)$, and this difference increases to $TS_3(G) - TS_3(12|FTA - co)$.

4. **(author?)** [23] approached this problem as tariff 'cooperation' of all three countries to place some tariff values, but this paper uses coordination of trade agreement members to keep the status-quo. Also, **(author?)** [23] used dynamic setup using discrete time and discount factors, but I skip that process here.

Country 3 has a greater incentive to jointly reduce tariff levels from another FTA or free trade negotiation, and countries 1 and 2 incur less negotiation costs from this. This is a contagion effect of the FTA because one FTA makes non-members more active than in another FTA. Total welfare in my setup does not include this effect from tariff coordination. Hence, total gain in reality is greater than the total surplus difference.

2.2.4 Customs Union

In previous sections, I demonstrated that 'implicit' coordination can be sustainable in free trade agreements. In a CU, coordination of the external tariff is 'explicit'; each member country must apply the same external tariff to the same good made in a given country. Once countries 1 and 2 establish a CU, the inside tariff of each becomes zero ($\tau_{12X} = \tau_{21X} = 0$ for X=A,B,C) and they need to decide what common, external tariff to place on goods from external country 3. Since country 3 is assumed to export two goods, A and B, countries 1 and 2 need to agree on two external tariffs. I denote $(12|CU)$ as a tariff or surplus value when countries 1 and 2 establish a CU. Countries 1 and 2 maximize the sum of the surplus for themselves by reaching an optimal decision regarding a common, external tariff.[5]

- $(\tau_{\cdot 3A}(12|CU), \tau_{\cdot 3B}(12|CU)) \equiv \arg\max TS_1 + TS_2$ with $\tau_{12X} = \tau_{21X} = 0$

In a free trade agreement, maximizing the total surplus involves the same process as maximizing the domestic surplus; export does not depend on the external tariff. In a CU, however, export inside the union also depends on a common external tariff. The export of good B from country 1 to 2 depends on an external tariff on country 2, $\tau_{23B}(12|CU)$. $\tau_{23B}(12|FTA)$ or $\tau_{23B}(12|FTA-co)$ is the same as $\tau_{23B}(\Phi)$, but $\tau_{23B}(12|CU)$ is the same as $\tau_{13B}(12|CU)$ in a CU, and determined by agreement of both countries. Before identifying its optimal external tariff, country 1 considers this export. Thus, the maximization above can be expressed as

- $\tau_{\cdot 3A}(12|CU) \equiv \arg\max(DS_{1A} + DS_{2A} + \pi_{12A})$ with $\tau_{12A} = \tau_{21A} = 0$

5. It is possible to assume that each country in a CU sets its common tariff with variable weight on their surpluses, but I assume that each maximizes the sum of its surplus for the sake of simplicity.

- $\tau_{\cdot 3B}(12|CU) \equiv \arg\max(DS_{1B} + DS_{2B} + \pi_{21B})$ with $\tau_{12B} = \tau_{21B} = 0$

Both countries cannot maximize their exports under either a trade war or free trade agreement. On the one hand, in a CU, two member countries can internalize some components (i.e., trade between CU members) of this externality, and this helps them maximize surplus. On the other hand, the two countries must have one common external tariff, and this produces a 'coordination cost'. In a CU, the optimal external tariff for country 3 is

$$\tau_{\cdot 3X}(12|CU) = \frac{1}{6}(\alpha_{1X} + \alpha_{2X} - 2c_{3X}) \tag{2.17}$$

for each good X=A,B. The derivation is presented in Appendix A.6.

If country 1 decides $\tau_{\cdot 3A}(12|CU)$, it wants to maximize DS_{1A}, at which point the tariff is $\frac{1}{11}(\alpha_{1A} + 4c_{2A} - 5c_{3A})$. If country 2 wants to maximize $DS_{2A} + \pi_{12A}$, its optimal tariff is $\frac{1}{7}(2\alpha_{1A} + 3\alpha_{2A} - 4c_{2A} - c_{3A})$. The former is less than the latter under Assumption 1. In a CU, each country wants a lower tariff for the good it cannot produce, and they also want a higher tariff for the good they can produce to protect their firms from firms in non-member countries. Optimal tariff $\tau_{\cdot 3A}(12|CU)$ is the weighted average of those two, and lies between the two just mentioned. Production costs of country 2, a member of the CU, do not have any effect on the optimal tariff because each effect on profit and domestic surplus offsets each other.

In this sense, each optimal tariff is determined in the middle of conflicting interests. As the common, optimal tariff becomes far from the optimal tariff for each country, the cost of the common, optimal tariff increases and can exceed the gain from trade between members. Also, this tariff decision has an effect on the domestic market of the goods that county can produce, and it makes welfare comparison complex. When both FTA and CU are possible, members compare the surplus under each type of agreement. Welfare comparison between FTA and CU is not as clear as Proposition 1. I explain this later in a simpler setup.

2.2.5 When Both Trade Agreements are Banned

When both CUs and free trade agreements are banned, two countries launch another kind of trade agreement to lower the tariff. Under the most-favored-nation (MFN) rule, they should lower their tariffs for all countries. This agreement is based on strict multilateralism. I denote $(12|multi)$ as the tariff or surplus value when countries 1 and 2 make this type of trade agreement. Country 3 cannot produce good C, and thus countries 1 and 2 have a tariff of zero. Their optimal decision for other goods (X=A,B) is

- $\tau_{\cdot A}(12|multi) \equiv \arg\max TS_1 + TS_2 = \arg\max(DS_{1A} + DS_{2A} + \pi_{12A})$
  with $\tau_{\cdot A}(12|multi) = \tau_{12A} = \tau_{13A} = \tau_{23A}$
- $\tau_{\cdot B}(12|multi) \equiv \arg\max TS_1 + TS_2 = \arg\max(DS_{1B} + DS_{2B} + \pi_{21B})$
  with $\tau_{\cdot B}(12|multi) = \tau_{13B} = \tau_{21X} = \tau_{23B}$

This trade agreement can internalize externality between trade agreement partners as CU, but the members must lower their tariffs exactly for non-member countries too. Thus, a non-member country can increase its exports to members because lowered tariffs apply to both member and non-member countries. Country 3 can protect firms from the outside and maintain its tariff as in a trade war state. In contrast, trade increases inside a trade agreement are limited because members cannot discriminate members and non-members. The optimal, external tariff of trade agreement members to country 3 is

$$\tau_{\cdot A}(12|multi) = \frac{1}{5}(\alpha_{2A} + c_{2A} - 2c_{3A}) \qquad \tau_{\cdot B}(12|multi) = \frac{1}{5}(\alpha_{1B} + c_{1B} - 2c_{3B}). \quad (2.18)$$

The derivation is presented in Appendix A.7.

As is the case of the CU, country 1 wants to maximize DS_{1A}, and country 2 wants to maximize $DS_{2A} + \pi_{12A}$. Then, the optimal tariff for country 1 is $\frac{1}{8}(2\alpha_{1A} - c_{2A} - c_{3A})$, and the optimal tariff for country 2 is $\frac{1}{7}(-2\alpha_{1A} + 3\alpha_{2A} + 4c_{2A} - 5c_{3A})$. The former is more than the latter under Assumption 1, and $\tau_{\cdot A}(12|multi)$ is the weighted average of those

two and lies between them. Under the MFN rule, each country wants a lower tariff for the good it can produce. Unlike the CU, each country cannot protect its firms from firms in non-member countries in this case, and lower tariffs are helpful to increase trade between members because the internal tariff is non-zero. The demand size of a country that cannot produce that good does not have an effect on tariffs because two effects on two countries offset each other. Therefore, each optimal tariff is determined in the middle of conflicting interests, as in a CU.

CHAPTER 3

PREFERENCE ON THE TYPE OF THE TRADE AGREEMENT

I explained why implicit coordination is profitable for FTA members, and I identified possible coordination costs in a stage 2, tariff decision within a CU. Before starting a discussion of stage 1, I examine how the two countries choose the type of trade agreement for a given asymmetry. Assume countries 2 and 3 negotiate to establish a trade agreement, and any type of trade agreement is possible. What type of trade agreement do the two countries prefer? Is the answer conditioned by endogenously decided implicit coordination in the FTA? This comparison shows the preference of two members when they have different demand sizes or production costs, and explains popularity of trade agreements in the process. Each considers losses and gains in markets, and identifies a preference. Also, this relates to equilibrium results because members will make an exclusive bloc when members' gains from making a trade agreement are higher than from reaching free trade.

Before starting analysis, I add one assumption to their negotiation.

Assumption 2 *When two countries negotiate a trade agreement, they can establish a CU only if they both agree to do so. If one country wishes to establish FTA, they undertake it.*

This assumption is helpful for calculations, but is also realistic because in terms of economic integration, the CU exists at a higher level than the FTA. In this model, I do not assume a dynamic bargaining process. Thus, when two countries express differing opinions, the result is uncertain without Assumption 2.

3.1 Symmetric Setup

There are several parameters in my setup, and it is difficult to observe all parameter changes in one graph. I add one assumption that there is no difference among goods in each country.

Assumption 3 $\alpha_{iA} = \alpha_{iB} = \alpha_{iC} = \alpha_i$ *for all countries* $i = 1, 2, 3$ *and goods.* $c_{jX} = c_{jY} = c_j$ *for all countries* $j = 1, 2, 3$ *and for two non-numeraire goods, X and Y, that country* j *produces.*

Now each country has the same demand size of all goods, and same cost for all goods that each country can produce. Each country may have only larger demand for all goods or less cost for all productions than other countries have. Below is the formal statement to assume symmetry between countries, but each country still cannot produce one non-numeraire good.

Assumption 3-1 $\alpha_i - c_j = e$ *for all* $i, j = 1, 2, 3$.

Then each tariff under each trade agreement can be calculated as below. When country 2 and 3 make a trade agreement, 1 cannot produce A, 2 cannot produce B, and 3 cannot produce C,

- $\tau_{21B}(\Phi) = \tau_{31C}(\Phi) = \frac{1}{4}e$, $\tau_{21C}(\Phi) = \tau_{31B}(\Phi) = \frac{1}{3}e$
- $\tau_{21B}(23|FTA) = \tau_{31C}(23|FTA) = \frac{1}{11}e$, $\tau_{21C}(23|FTA) = \tau_{31B}(23|FTA) = \frac{1}{3}e$
- $\tau_{21B}(23|FTA - co) = \tau_{31C}(23|FTA - co) = \frac{1}{4}e$,
  $\tau_{21C}(23|FTA - co) = \tau_{31B}(23|FTA - co) = \frac{1}{3}e$
- $\tau_{\cdot 1B}(23|CU) = \tau_{\cdot 1C}(23|CU) = \frac{1}{3}e$
- $\tau_{\cdot B}(23|multi) = \tau_{\cdot C}(23|multi) = \frac{1}{5}e$.

Under all results of trade agreements, non-member country 1 sets the same tariff on each good. Also, tariffs between 2 and 3 follow the rule above in a trade war state, and all tariffs of country 2 and 3 become $\frac{1}{5}e$ under multilateralism. In other cases, countries 2 and 3 make a PTA, and internal tariffs become zero. Next, we can calculate and compare total welfare under each trade agreement.

Proposition 2 *Assume countries i and j establish a trade agreement under a symmetric setup(Assumption 3).* Then,

$$TS_i(ij|CU) > TS_i(ij|FTA - co) > TS_i(ij|FTA) > TS_i(ij|multi) \tag{3.1}$$

First, inequality suggests that member countries favor CU regardless of coordination in a symmetric setup. Their welfare difference is small under coordination, but members can agree with making a CU because mandatory coordination in CU is not much more costly under a symmetric setup. I demonstrate that in a CU, each country wants to lower its tariff for the good it cannot produce. Country 2 cannot produce B, and its optimal tariff on CU is $\frac{1}{11}e$. However, the tariff on CU is $\frac{1}{3}e$, and Country 2 thinks that the tariff is too high. In contrast, country 3 can produce B, its optimal tariff on CU is $\frac{5}{7}e$, and it thinks that the common tariff is too low. In a symmetric setup, each country has same welfare from this CU, and it is higher than FTA. However, when each country has a different demand or cost, their welfare changes asymmetrically, and one country changes its preference and becomes favorable to the FTA.[1]

Second, the inequality is about implicit coordination in an FTA. This is a result from Proposition 1. As in (2.16), two countries favor coordination when their market sizes and costs are similar. The third inequality is about multilateralism. Then members cannot discriminate countries and cannot increase trade between members enough. It limits welfare

1. Any other asymmetry can change the third inequality. If the number of firms changes in each industry, or one of three countries can produce all three non-numeriare goods, agreements on CU become impossible.

of member countries, and in this case, it is less than any other trade agreements. In this sense, a trade agreement under multilateralism offers less welfare to members than any other trade agreements for an asymmetric setup, in subsections below too. This is the result from the same trial in two subsections below. So, I compare only FTAs (with or without coordination) and CUs for the next two subsections and skip trade agreements under multilateralism. [2] The role of the XXIV regulation appears in the last subsection.

3.2 Technology Difference

In this and the next subsection, I approach the preferences of countries in an asymmetric setup. For a better description, I denote relative technology development and demand size as

$$t_k \equiv \frac{(\alpha_1 - c_k) - (\alpha_1 - c_1)}{\alpha_1 - c_1} \qquad d_k \equiv \frac{(\alpha_k - c_1) - (\alpha_1 - c_1)}{\alpha_1 - c_1} \tag{3.2}$$

When t_k is high, country k has lower costs, or better technology, on all goods that country k produces than country 1. When d_k is high, country k has larger demand on all goods than country 1. I can also compare cost and demand asymmetries in a similar setup regardless of real demand or cost values. In addition to Assumption 3, I add assumptions to clarify the description in each subsection.

Assumption 3-2 *Assume countries 2 and 3 establish a trade agreement, and decide on their external tariff policy. Country 1 cannot produce A, 2 cannot produce B, and 3 cannot produce C.*

1. (i) $\alpha_1 - c_1 = e$, $\alpha = \alpha_1 = \alpha_2 = \alpha_3$

2. (ii) $-0.2 < t_2, t_3 < 0.25$, $4t_2 - 5t_3 < 1$, and $-5t_2 + 4t_3 < 1$.

Under this assumption, the demand size of all markets in all countries is same. (ii) defines the parameter range, set to exclude negative tariffs and production. Using the def-

2. This is because trade gains from discrimination are higher in this model setup.

inition above of t_2, under Assumption 3-2, $\alpha_2 - c_2$ is between $0.8e$ and $1.25e$. Country 2 produces good A and C with this cost/technology. Then each external tariff under each trade agreement is

- $\tau_{21B}(\Phi) = \frac{1}{8}(2 - t_3)e$, $\tau_{31C}(\Phi) = \frac{1}{8}(2 - t_2)e$,
  $\tau_{21C}(\Phi) = \tau_{31B}(\Phi) = \frac{1}{3}e$
- $\tau_{21B}(23|FTA) = \frac{1}{11}(1 - 4t_3)e$, $\tau_{31C}(23|FTA) = \frac{1}{11}(1 - 4t_2)e$,
  $\tau_{21C}(23|FTA) = \tau_{31B}(23|FTA) = \frac{1}{3}e$
- $\tau_{.1B}(23|CU) = \tau_{.1C}(23|CU) = \frac{1}{3}e$
- $\tau_{.B}(23|multi) = \frac{1}{5}(1 - t_3)e$, $\tau_{.C}(23|multi) = \frac{1}{5}(1 - t_2)e$.

External tariffs under the FTA with coordination are the same in a trade war state. Non-member country 1 levies the same tariff on each good in any case. Tariffs between 2 and 3 are determined from the rule above in a trade war state, and all tariffs of countries 2 and 3 become $\frac{1}{5}e$ under multilateralism. Internal tariffs become zero when two countries make an FTA or CU.

Under this assumption, external tariffs on goods that each country can produce, τ_{21C} and τ_{31B}, are the same in all cases. When each country cannot produce the good, an external tariff is highest with CU, next FTA with coordination, and lowest with FTA without coordination. Then we can calculate the total welfare for each case. To find whether two countries choose implicit coordination on an FTA, we can use (2.16). Then the condition of coordination is $\sqrt{\frac{77}{206}}(2 + 3t_2) < 2 + 3t_3 < \sqrt{\frac{206}{77}}(2 + 3t_2)$, and this is satisfied on all ranges of Assumption 3-2. Therefore, at any point of given space, countries 2 and 3 choose tariff coordination.

We can guess that FTA with coordination becomes more attractive than FTA without coordination versus a CU. Figure 1 demonstrates the welfare comparison between an FTA without coordination and a CU, and Figure 2 is about the same comparison between an

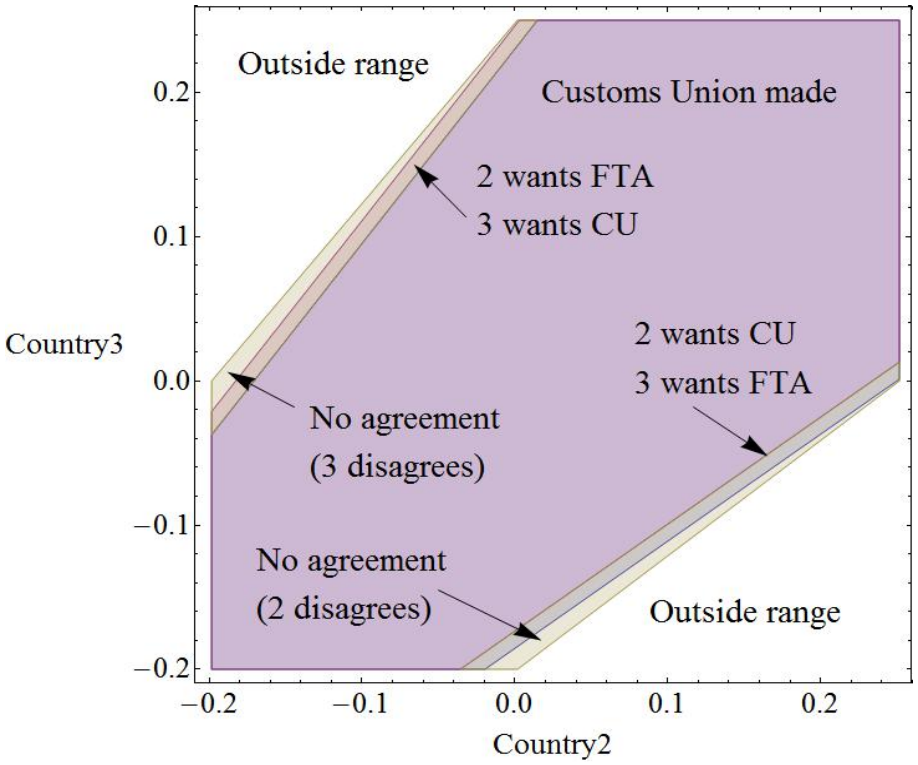

Figure 3.1: Choice: FTA without coordination and CU for cost asymmetry

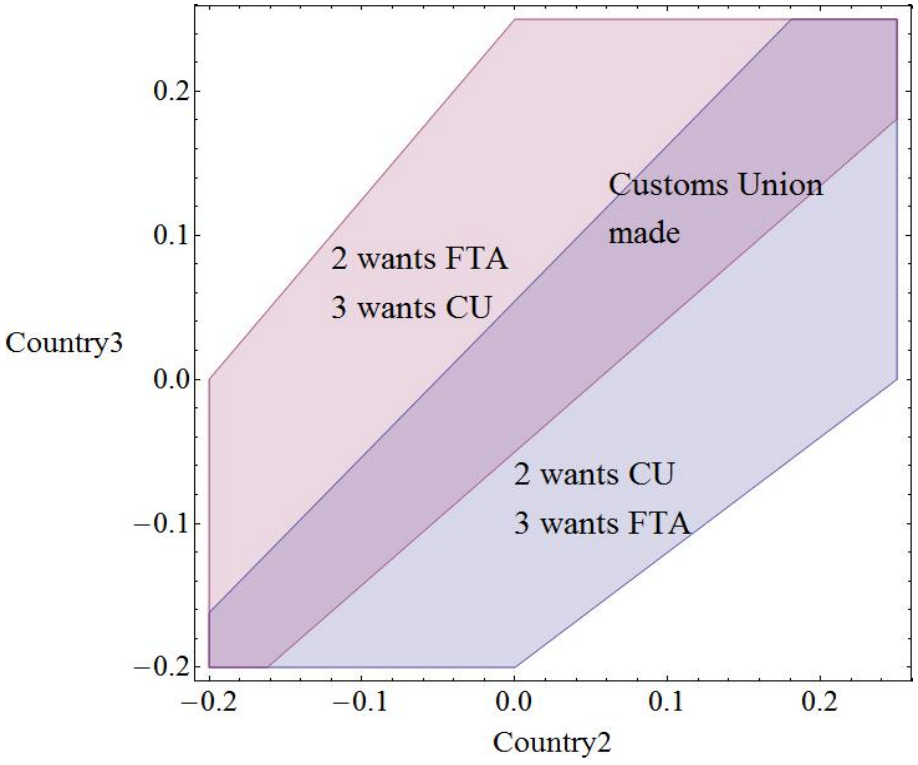

Figure 3.2: Choice: FTA with coordination and CU for cost asymmetry

FTA with tariff coordination and a CU. The horizontal axis in each figure represents t_2, and the vertical axis represents t_3. Triangles on each corner represent outside given ranges for Assumption 3-2. The region in which two countries make a CU is much smaller in Figure 2. We can also calculate the condition for agreement on the CU over the FTA, as below. Both countries choose the CU if and only if

- $\sqrt{\frac{11}{20}}(2+3t_2) < 2+3t_3 < \sqrt{\frac{20}{11}}(2+3t_2)$ over the FTA without coordination
- $\sqrt{\frac{53}{62}}(2+3t_2) < 2+3t_3 < \sqrt{\frac{62}{53}}(2+3t_2)$ over the FTA with coordination.

Check the case of good B, which country 2 cannot produce. The optimal tariff on CU for country 2 is $\frac{1}{11}(1-4t_3)e$, and optimal tariff for country 3 is $\frac{1}{7}(5+4t_3)e$. As t_3 increases, the gap widens. Overall, country 3 can gain through increased productivity, but country 2 loses. When $t_2 = t_3$ and productivity increases equally, the gain from one industry is always higher than the loss from another. This is why two countries always choose CU when $t_2 = t_3$.

However, when one country has more developed technology than the other has, this relationship breaks down. When $t_2 > t_3$, optimization on the CU that maximizes the sum of two total welfare favors country 2 but becomes costly for country 3. Therefore, when two countries have different levels of technology, it becomes difficult to agree on the CU, and it is harder when FTA becomes attractive from implicit coordination. When two countries disagree, they choose an FTA under Assumption 2, but FTA without coordination can offer less welfare than a trade war state, and then countries 2 and 3 cannot make any trade agreement. This is shown in Figure 1.

3.3 Size of Demand Difference

In this section, I assess demand size asymmetry using relative size difference d_2 and d_3. I also need different assumptions in this subsection.

Assumption 3-3 *Assume countries 2 and 3 establish a trade agreement and decide on*

an external tariff policy. Country 1 cannot produce A, 2 cannot produce B, and 3 cannot produce C.

1. (i) $\alpha_1 - c_1 = e$, $c = c_1 = c_2 = c_3$
2. (ii) $-0.5 < d_2, d_3 < 1$, $d_2 - 2d_3 < 1$, and $-2d_2 + d_3 < 1$.

In this subsection, technology levels for all goods produced in all countries are assumed to be the same. (ii) define the parameter range, and all tariffs and production are non-negative in this range. As a result, $\alpha_2 - c_2$ is between $0.5e$ and $2e$ in this subsection. Each tariff under each trade agreement is

- $\tau_{21B}(\Phi) = \frac{1}{4}(1 + d_2)e$, $\tau_{21C}(\Phi) = \frac{1}{3}(1 + d_2)e$,
  $\tau_{31B}(\Phi) = \frac{1}{3}(1 + d_3)e$, $\tau_{31C}(\Phi) = \frac{1}{4}(1 + d_3)e$
- $\tau_{21B}(23|FTA) = \frac{1}{11}(1 + d_2)e$, $\tau_{21C}(23|FTA) = \frac{1}{3}(1 + d_2)e$,
  $\tau_{31B}(23|FTA) = \frac{1}{3}(1 + d_3)e$, $\tau_{31C}(23|FTA) = \frac{1}{11}(1 + d_3)e$
- $\tau_{.1B}(23|CU) = \tau_{.1C}(23|CU) = \frac{1}{6}(2 + d_2 + d_3)e$
- $\tau_{.B}(23|multi) = \frac{1}{5}(1 + d_3)e$, $\tau_{.C}(23|multi) = \frac{1}{5}(1 + d_2)e$.

External tariffs under the FTA with coordination are the same as a trade war state, and tariffs levied by country 1 or internal tariffs follow the same rule as in the previous subsection. However, in this setup, external tariffs on goods that each country can produce, τ_{21C} and τ_{31B}, also become different in the CU case. This tariff depends on two demand sizes from both member countries. However, the tariff amount order is the same for the good that each country cannot produce. The tariff is highest with CU, next FTA with coordination, and lowest with FTA without coordination.

In this setup, the condition of coordination in FTA is $\sqrt{\frac{77}{206}}(2 + 2d_2) < 2 + 2d_3 < \sqrt{\frac{206}{77}}(2 + 2d_2)$. Figure 3 describes how countries 2 and 3 choose an external tariff policy of FTA. Two triangles in the two corners represent the region outside the range given in

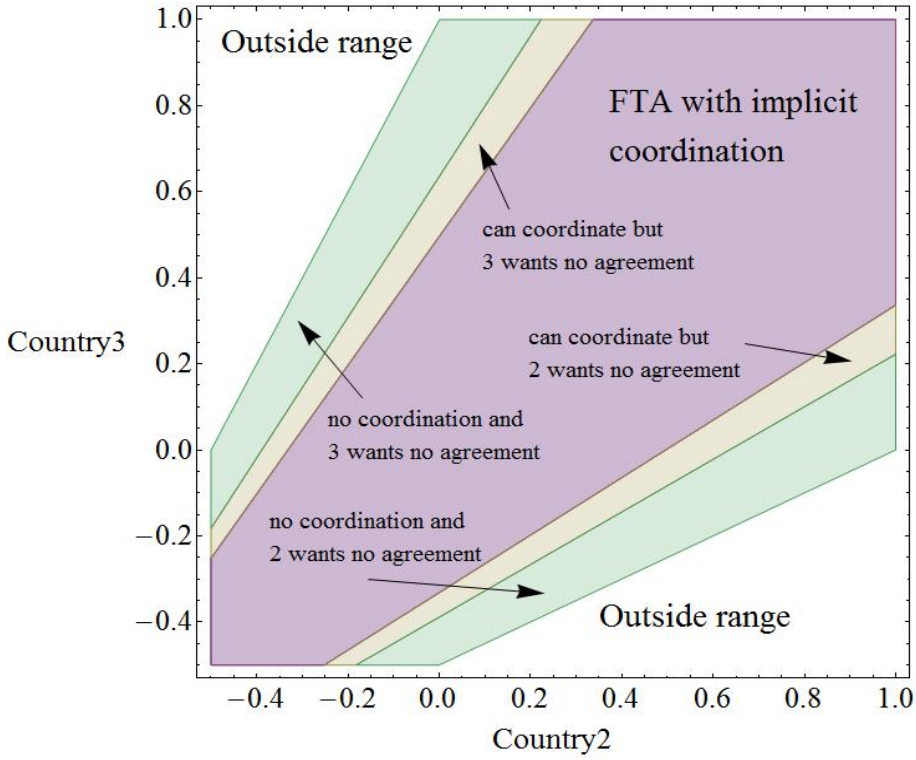

Figure 3.3: Choice: External tariff policy in FTA for demand size asymmetry

Assumption 3-3. As proposition 1 suggests, two countries choose implicit coordination when they are similar countries, but also FTA is possible only when making an FTA is better than a trade war state for both countries 2 and 3. An FTA can be a loss for domestic firms because they lose their portion in domestic markets. When market sizes are different, the country with the bigger markets loses more, and this loss makes the total gain from making an FTA negative. This is possible with both possible tariff policies.

The next step is the comparison between an FTA and CU. For the case of demand size asymmetry, it is impossible to get a simple condition of agreement on a CU as in the previous subsection. However, we know that implicit coordination can be chosen endogenously in a wide parameter region, and we can guess that the agreement on CU is harder when considering coordination in FTA. Figure 4 describes how countries 2 and 3 choose between an FTA and CU. CU is made only when d_2 and d_3 is similar in the middle.

A domestic market size increase in one country is helpful to get more domestic welfare.

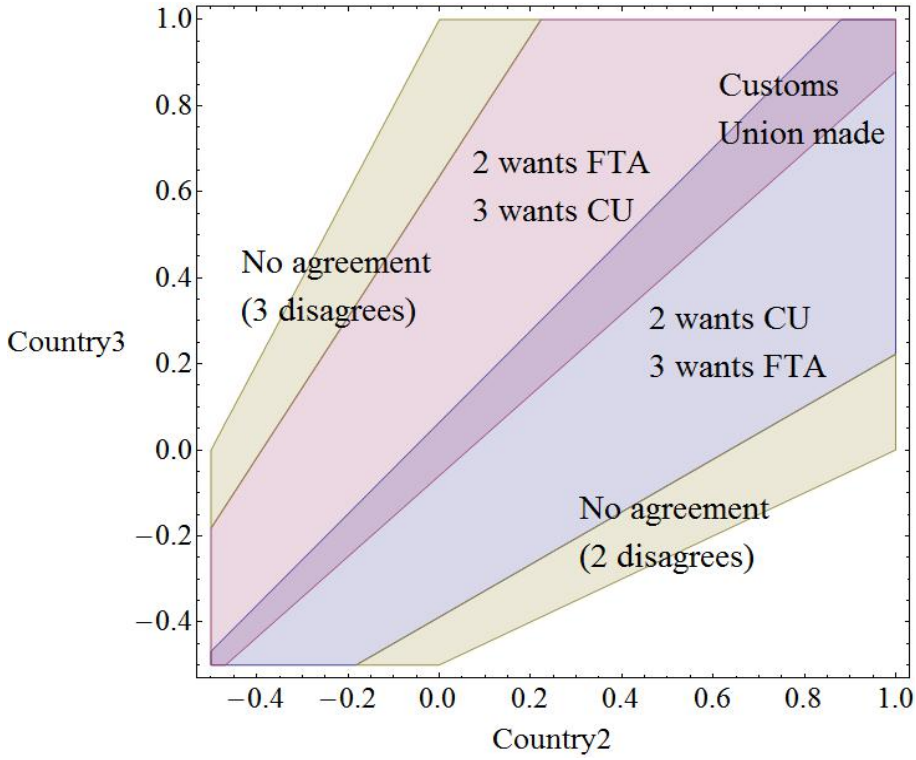

Figure 3.4: Choice: FTA with coordination and CU for demand size asymmetry

A high external tariff in the CU makes the country keep its domestic market share easily. That is why a bigger country becomes more favorable to the CU, and without considering coordination, two countries agree with making a CU for all given parameter ranges. In conclusion, for both types of asymmetry, an implicit coordination policy can be chosen endogenously, explaining why an FTA is more popular than a CU.

3.4 Role of the Article XXIV Regulation

The GATT/WTO Article XXIV ruled that FTA or CU members cannot raise external tariffs on average. This works as a constraint for trade agreement members regarding an external tariff decision. However, this condition is binding only for CUs, not FTAs, in this setup. When making an FTA, each country has two options for an external policy. From Lemma 1, the model satisfies tariff complementarity; separately determined external tariffs are lower than a trade war state. Keeping the status quo under implicit coordination is also acceptable

because it does not raise external tariffs.

The Article XXIV regulation has some effects only on CU. At first, let's use assumption 3-1 for a symmetric setup. Given this constraint, $\tau_{.1X}(23|CU)$ should not be greater than the weighted average of the tariffs of the two countries prior to the CU. Denote this tariff $\tau_{.1X}(23|CU-XXIV)$, the weighted average of the two external tariffs, ($\tau_{21X}(\Phi)$ and $\tau_{21X}(\Phi)$), and the weight is given as import amounts before a trade agreement is made. Under a symmetric setup, this constraint is binding, and it creates a welfare loss.

Proposition 3 *Assume countries i and j establish a trade agreement under a symmetric setup (Assumption 3)* and country k is a non-member. Then,

1. (i) The Article XXIV constraint is binding. ($\tau_{.kX}(ij|CU) > \tau_{.kX}(ij|CU-XXIV)$ for good X that only one member country can produce.)

2. (ii) This constraint makes a welfare loss but it still confirms that CU offers more welfare than FTA. ($TS_i(ij|FTA-co) < TS_i(ij|CU-XXIV) < TS_i(ij|CU)$)

In other words, when demand and cost conditions are symmetric, except that one country cannot produce one good, Article XXIV is binding, and the welfare of member countries declines. However, CU is still better for both members in a symmetric setup. Under the Article XXIV constraint and when two member countries coordinate their external tariff in the FTA, their welfare difference is minimized, but not enough to overturn that relationship.

I now apply assumptions 3-2 and 3-3 to find the result with asymmetry. Two tariffs below are optimal, external tariffs under each asymmetric assumption. Optimal, external tariffs without the tariff regulation, $\tau_{.1X}(23|CU)$, are higher than the tariffs below on the full ranges given in assumptions 3-2 and 3-3, meaning that the Article XXIV constraint is binding on CUs in any case.

- Assumption 3-2: $\tau_{.1B}(23|CU-XXIV) = \dfrac{-172+300t_3-27(t_3)^2}{24(-26+33t_3)}e$,
  $\tau_{.1C}(23|CU-XXIV) = \dfrac{-172+300t_2-27(t_2)^2}{24(-26+33t_2)}e$

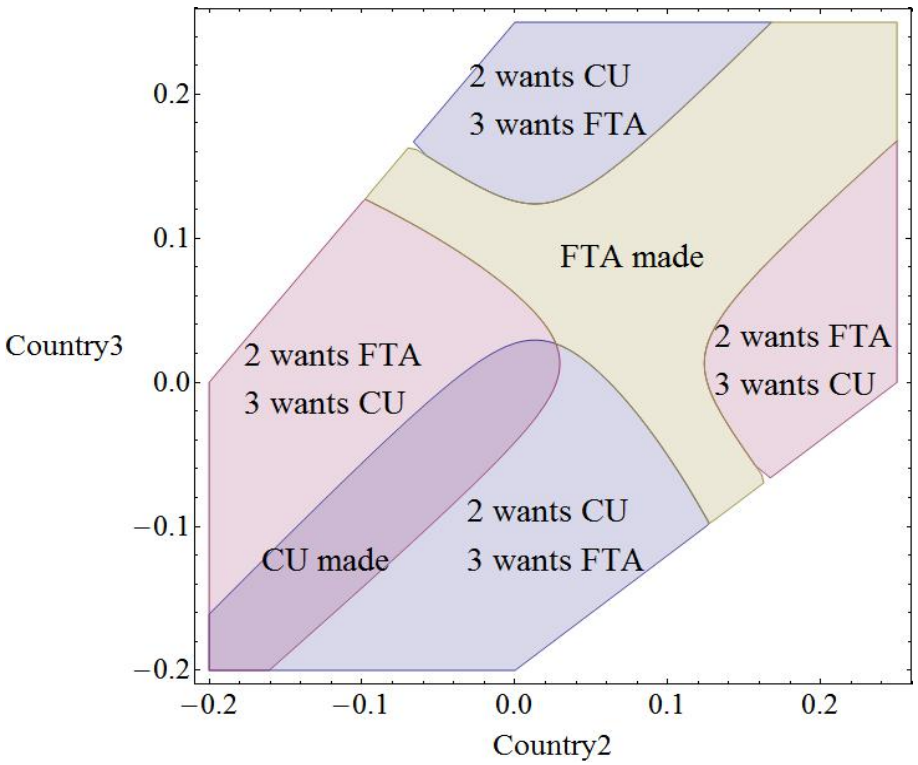

Figure 3.5: Choice: FTA with coordination and CU with constraint for cost asymmetry

- Assumption 3-3: $\tau_{.1B}(23|CU-XXIV) = \dfrac{43+54d_2+27(d_2)^2+32d_3+16(d_3)^2}{12(13+9d_2+4d_3)}e$,
  $\tau_{.1C}(23|CU-XXIV) = \dfrac{43+32d_2+16(d_2)^2+54d_3+27(d_3)^2}{12(13+4d_2+9d_3)}e$

I illustrate preferences on the Article XXIV tariff regulation for two countries for technology or size of demand asymmetry through additional figures.[3] In both cases, when two countries have similar parameters, both do not want the regulation. However, when one country has developed technology or larger demand, the other becomes favorable to the regulation because CU maximizes the sum of welfare and constrained optimization provides higher welfare to the inferior country. These figures are helpful to understand the role of tariff regulation, but note that implicit coordination on the FTA is made as an endogenous decision imposed on the two member countries, and the Article XXIV is given exogenously.

Figures 5 and 6 describe choices of countries 2 and 3 between an FTA and CU with

3. These additional figures are provided in an online appendix.

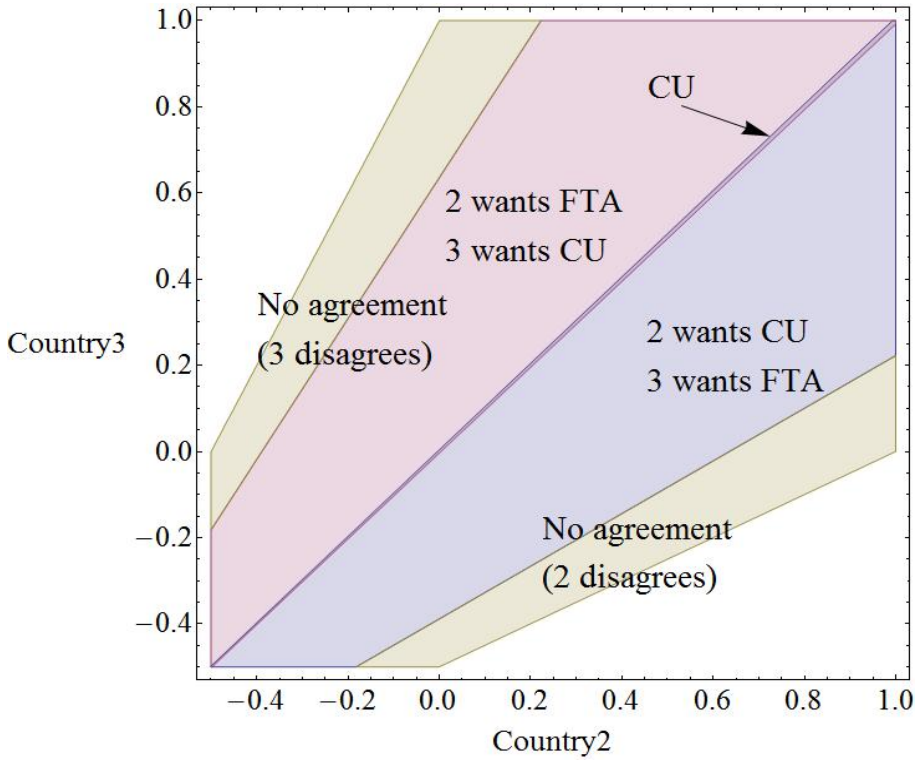

Figure 3.6: Choice: FTA with coordination and CU with constraint for demand size asymmetry

consideration on implicit coordination in the FTA, and the Article XXIV regulation is given. Agreement on making a CU becomes harder than the case without the constraint (see Figures 2 and 4) because when two countries are similar, both get a loss from the constraint and it makes a CU with the tariff regulation less attractive. When two asymmetries are high, inferior countries gain welfare from the constraint and it can make inferior countries choose CU over FTA. This is described in figure 7, and in some regions, inferior countries become favorable to CU. However, in those regions, a superior country prefers an FTA, and agreement on a CU is still impossible. Comparing an FTA without coordination and CU with the tariff regulation, two countries prefer a CU for the full range given in both asymmetry setups.

In this section, I compared the choices of each country under varying conditions. Unless we consider implicit coordination, the popularity of the FTA is difficult to explain. When two countries coordinate implicitly, welfare from FTA increases to a level close to that of the CU, and the coordination cost produced by participation in the CU increases as asymmetry increases, making agreement on the CU impossible. When the Article XXIV tariff regulation is considered, the popularity of the FTA is explained much better, as in the figures.

CHAPTER 4

TRADE LIBERALIZATION GAME

During stage 1, countries become players in the trade liberalization game while knowing what the equilibrium will be under each trade agreement relationship (explained in previous sections). The rule of the game is given, and four regimes are possible: (1) neither the FTA or the CU is possible, (2) only the FTA is possible, (3) only the CU is possible, (4) the FTA and the CU are possible. When an FTA and CU are impossible, each country can establish a trade agreement under the MFN rule. This can be thought of as (strict) multilateralism.

There are three players, countries 1, 2, and 3. Each player can decide whether to propose a trade agreement with two other countries, with the goal of maximizing its total surplus. I assume that international transfer is impossible, and that each country arrives at its decision by comparing the surpluses produced under each game result.[1] Four strategies are possible: (1) do not propose a trade agreement (ϕ), (2 and 3) propose a trade agreement with only one country(ρ_j),(ρ_k), and (4) propose a trade agreement with two countries (ρ_M). The strategy set of country 1 is $\{\phi, \rho_2, \rho_3, \rho_M\}$. The countries undertake their strategies simultaneously, and a trade agreement occurs only when two countries propose one to one another. For example, when only free trade agreement is possible, assume that countries 1, 2, and 3 choose their strategies $\{\rho_2\}, \{\rho_M\}, \{\rho_1\}$, respectively. Then an FTA of countries 1 and 2 is made because both countries want it. Countries 1 and 3 do not reach agreement because country 3 wants one but country 1 does not. Countries 2 and 3 cannot arrange an FTA because country 3 does not want one. Global, tariff-zero free trade between these countries is possible only when all three choose ρ_M. I assume that this trade agreement proposal requires a very small $\epsilon(> 0)$ negotiation cost. Costly talk is observed in the real world. I assume this for analytical convenience. Thus, a state with an unrealized trade agreement proposal cannot be in equilibrium.

1. If international transfer is impossible, there is another Pareto-efficient outcome besides global free trade. Pareto-efficiency is still satisfied even when a third non-member country free-rides and rejects free trade. This paper is not about Pareto-efficiency.

I assume that global, tariff-free trade $\{G\}$ is desirable and will identify conditions to reach $\{G\}$ as an equilibrium under each regime. There are two kinds of potential deviations from free trade: free-riding and exclusive bloc. Free-riding is the refusal of one country outside of the trade agreement. When one country finds that they can get more welfare as a non-member of one type of trade agreement than a member of global free trade, they choose free-riding and become a non-member. A non-member country levies the same tariffs $\tau(\Phi)$ regardless of the type of trade agreement of the members. Therefore, domestic surplus of a non-member country does not depend on the trade regime. The free-riding decision depends on export profits of firms in non-member countries.

When external tariffs of member countries are low, an outside country can get higher welfare and more easily choose to be a free-rider. A free-rider enjoys increased exports at no cost in domestic markets. This is a contrast in the sense that each country gets more export profits in exchange for domestic surplus loss in global, tariff-free trade. Given that this choice is a unilateral deviation in one country, free trade cannot be a Nash equilibrium when free-riding is possible.

The other type of deviation is the exclusive bloc. Two countries can establish a trade agreement that excludes a third country and that refuse free trade when establishing an exclusive bloc offers a higher surplus than accepting a third country and reaching global free trade. This is possible when the determined external tariff in trade agreement is high. It is important to note that deviation from one state can proceed from a coalition of two countries. For example, when $\{12\}$ presents to countries 1 and 2 a higher total surplus than can be achieved under free trade $\{G\}$, the two countries can deviate from $\{G\}$ to $\{12\}$ by excluding country 3. This deviation of a coalition of two countries is not considered in the basic Nash equilibrium, which needs to block all deviations of each player, but does not consider coalition deviation.

Hence, in this game, I employ the concept of the "Coalition-proof" Nash equilibrium (CPNE), which **(author?)** [6] defines. A deviation within a coalition of two or three countries

is considered only when it is "self-enforcing". The deviation strategy of the coalition is defined as self-enforcing when the coalition strategy creates Nash equilibrium for all coalition members under a given strategy choice of the player outside of the coalition. When a self-enforcing deviation by one coalition from one state is possible, that state cannot be a CPNE. A CPNE must be proof to all self-enforcing coalitions. [2]

Next, I discuss what occurs when only one type of trade agreement is possible. I assume that parameters are limited to the range that makes global free trade desirable and all production and tariffs positive.

4.1 Free Trade Agreement

I assume that an FTA is the only possible type of trade agreement in this section. First, I check the possibility of free-riding. Within an FTA between two countries, two external, tariff policy options are possible: separate decision of each country, or implicit coordination that both countries keep the status-quo. Proposition 1 indicates that two countries will coordinate implicitly when a joint choice provides a better result than a separate decision for each country does. Free-riding is possible for country 3 when $TS_3(G) < TS_3(12|FTA - co)$ if countries 1 and 2 coordinate implicitly ($TS_1(12|FTA - co) > TS_1(12|FTA)$ and $TS_2(12|FTA - co) > TS_2(12|FTA)$). Otherwise, when implicit coordination is impossible, free-riding appears when $TS_3(G) < TS_3(12|FTA)$. When comparing these two cases, free-riding is easier when each country does not coordinate its external tariff.

Proposition 4 *(Implicit coordination and free-riding) If countries i and j establish an FTA, $TS_k(ij|FTA) > TS_k(ij|FTA-co)$. In other words, implicit coordination (i.e., keeping the status-quo) makes less free-riding of non-member country k than non-coordination does (i.e., separate optimization).*

2. The correct definition of CPNE needs mathematical induction on the number of players. See **(author?)** [6] or **(author?)** [17] for details.

This is natural because the decision to free-ride depends on external tariff decisions of member countries. The proposition indicates that when countries in an FTA coordinate implicitly, they can prevent free-riding and push outside countries to negotiate for another FTA or free trade, but it does not confirm that coordination always makes it easier to achieve free trade due to the possibility of other cases such as an exclusive bloc of FTA members. I denote $(ij|FTA*)$ as an endogenous decision of the external tariff policy in an FTA.

$$(ij|FTA*) = (ij|FTA-co) \text{ if } TS_x(ij|FTA-co) > TS_x(ij|FTA) \text{ for x=i,j} \quad (4.1)$$

$$(ij|FTA*) = (ij|FTA) \text{ otherwise} \quad (4.2)$$

Then each country considers the endogenous external tariff policy decisions of other members before deviation.

Next, I consider a 'hub-and-spoke' state, $\{1-hub\}$, which is possible only with FTAs. In this state, two FTAs exist, and one country that has both FTAs becomes a hub. The hub country sets all its tariffs to zero. Only two spoke countries maintain a positive tariff with each other. The tariff rate is the same as the tariff under an FTA without coordination because country 1 has a zero tariff and it cannot coordinate with any country. This situation make becoming a hub attractive.

Lemma 4 $TS_i(i-hub) > TS_i(G)$ for all i. The total surplus gained in a hub of two FTAs is always larger than the surplus gained as the member of global free trade.

How about 'spoke' countries? Assume that countries 1 and 2 make a FTA, and country 1 becomes a hub by making another FTA with country 3. Country 2 loses its ability to export to countries 1 and 3 from the FTA of country 1 and 3. Instead, implicit coordination is not possible under 'hub-and-spoke' state. Country 2 lowers its tariff on country 3 and its domestic surplus can increase as a result. But the decrease in its exports is greater than the increase in its domestic surplus in most cases. Also, country 3 can gain from an FTA with country 1, but this does not provide exclusive advantages because country 1 has an FTA

with country 2. Hence, gains from this FTA are limited in this sense.

In comparison to free trade, 'spoke' countries have zero tariffs with a 'hub' country, and only low tariffs with the other spoke country. Therefore, becoming a 'spoke' country is closer to free trade and can be better than free trade. That is, when an FTA is possible, each country can choose to be not only a free-rider by nullifying FTAs with both countries, but also a 'spoke' country by nullifying only one FTA with one country. To explain an exclusive bloc case carefully, I assume that each country does not deviate alone for these reasons ($TS_j(i-hub) < TS_j(G)$ for all $i \neq j$) when I assess exclusive bloc conditions below. With this assumption, two spoke countries always establish another FTA with each other to achieve global free trade and 'hub and spoke' cannot be a stable equilibrium.

Two FTA member countries establish an exclusive economic bloc when they can acquire more surplus from this coordination policy than from accepting a non-member country. This decision depends on the choice of external tariff policy. Consider the case of a coalition comprised of countries 1 and 2 that deviate from $\{G\}$ to $\{12\}$. This deviation of the coalition depends on coordination: (1) when $TS_1(G) < TS_1(12|FTA-co)$ and $TS_2(G) < TS_2(12|FTA-co)$ if the two countries coordinate, and (2) when $TS_1(G) < TS_1(12|FTA)$ and $TS_2(G) < TS_2(12|FTA)$ if at least one country declines to coordinate. If two countries can decide it endogenously, it is $TS_1(G) < TS_1(12|FTA*)$ and $TS_2(G) < TS_2(12|FTA*)$. An exclusive bloc is made only when both coalition members agree to it.

Becoming a hub confirms more welfare than free trade does for any country, as shown in lemma 4. When the current state is one FTA and one non-member, such as when an exclusive bloc is made, each FTA member can become a hub of two FTAs by making another FTA with a non-member. However, when the current state is global free trade, a country can be a hub only if two others nullify FTA by their decision. Each country cannot become a hub from their own choice when free trade is already made. In other words, 'hub-and-spoke' can be moved to global, tariff-free trade when two 'spoke' countries make an FTA with each other, regardless of the opinion of a hub country.

From this, we find that there are three states $\{G\} \to \{12|FTA*\} \to \{1-hub\} \to \{G\}$ in which circling deviation is possible. Below I summarize each condition for each deviation.

1. $\{G\} \to \{12|FTA*\}$: $TS_1(G) < TS_1(12|FTA*)$ and $TS_2(G) < TS_2(12|FTA*)$
2. $\{12|FTA*\} \to \{1-hub\}$: $TS_1(12|FTA*) < TS_1(1-hub)$ and $TS_3(12|FTA*) < TS_3(1-hub)$
3. $\{1-hub\} \to \{G\}$: $TS_2(1-hub) < TS_2(G)$ and $TS_3(1-hub) < TS_3(G)$

All three conditions can be satisfied together. Consider the case $TS_1(G) < TS_1(12|FTA*) < TS_1(1-hub)$. $TS_1(G) < TS_1(1-hub)$ is always satisfied by lemma 4. $TS_1(G) < TS_1(12|FTA*)$ is above condition 1, and it typifies the exclusive bloc. $TS_1(12|FTA*) < TS_1(1-hub)$ is above condition 2, and this is a possible case from lemma 4. Other conditions on non-member or spoke countries are uncertain regarding whether they can be satisfied. Condition 1 prevents global free trade from being a stable equilibrium. Condition 2 prevents the exclusive bloc from becoming a stable equilibrium, and condition 3 prevents the hub-and-spoke from being a stable equilibrium. Therefore, any state looks unstable if three conditions are satisfied.

However, the CPNE must be coalition-proof for only the self-enforcing deviation. Assume all three conditions are satisfied, and establishment of an exclusive bloc against country 3 from global free trade. For this deviation to occur, both countries 1 and 2 must nullify their FTAs with country 3. However, for country 1, a better option is to maintain its connection with country 3 and let only country 2 break its connection with country 3. Then, only the relationship between countries 2 and 3 will be broken, and country 1 can become a hub of two FTAs. A deviation strategy is "self-enforcing" when that joint strategy is a Nash equilibrium strategy for a given strategy choice of other countries. When $TS_1(G) < TS_1(12|FTA*) < TS_1(1-hub)$, deviation $\{G\} \to \{12|FTA*\}$ is attractive, but $\{1-hub\}$ is a better state for country 1, and then country 1 will defect. This is possible because country 3 maintains FTAs with both countries.

This possibility indicates that deviation $\{G\} \rightarrow \{12|FTA*\}$ is not self-enforcing when $TS_1(G) < TS_1(12|FTA*) < TS_1(1-hub)$. Only when $TS_1(12|FTA*) > TS_1(1-hub)$ and $TS_2(12|FTA*) > TS_2(2-hub)$, deviation from global free trade to an exclusive bloc is self-enforcing, at which point global free-trade becomes unstable. When country 1 defects, that move is not $\{G\} \rightarrow \{12|FTA*\} \rightarrow \{1-hub\}$, but $\{G\} \rightarrow \{1-hub\}$.

In contrast, $\{12|FTA*\} \rightarrow \{1-hub\}$ deviation is best for country 1 because becoming a hub is better than free trade when $TS_1(G) < TS_1(12|FTA*) < TS_1(1-hub)$. Country 3 cannot do anything with country 2 when the strategy of country 2, which has an FTA with country 1 but not with country 3, is given. Therefore, this deviation is self-enforcing only when condition 2 is satisfied. Finally, the $\{1-hub\} \rightarrow \{G\}$ deviation is also tricky. However, I explained all unilateral deviation cases already, and exclude those cases concerning checking for exclusive blocs. That is, condition 3 is always satisfied if each country does not choose unilateral deviation, and when condition 3 is satisfied, making a free trade is best for countries 2 and 3 for a given choice by country 1, which has two FTAs with countries 2 and 3. Countries 2 and 3 want to be a hub, but for country 1, which has an FTA with both countries, the free trade choice is best. Hence, this deviation too is self-enforcing.

In short, when (1) condition 2 and 3 are satisfied and (2) $TS_1(G) < TS_1(12|FTA*) < TS_1(1-hub)$ or $TS_2(G) < TS_2(12|FTA*) < TS_2(2-hub)$ is satisfied, the $\{G\} \rightarrow \{12|FTA\}/\{12|FTA*\}$ deviation is not self-enforcing, and $\{G\}$ becomes a Coalition-proof Nash equilibrium (CPNE). A "stable" exclusive bloc can be established only when $TS_1(12|FTA*) > TS_1(1-hub)$ and $TS_2(12|FTA*) > TS_2(2-hub)$ are satisfied. In addition, to prevent defection, $TS_1(12|FTA*) > TS_1(13|FTA*)$ and $TS_2(12|FTA*) > TS_2(23|FTA*)$ must be satisfied too. Then $\{12|FTA*\}$ can become a CPNE.

In conclusion, cases below free trade cannot be a CPNE when only an FTA is possible. I assume that countries i and j choose an FTA, and k becomes a non-member for that case. The first and second cases are unilateral deviations, and the deviations are always self-enforcing.

1. $TS_k(G) < TS_k(ij|FTA*)$: k becomes a free-rider.

2. $TS_j(i-hub) > TS_j(G)$: j deviates.

3. $TS_i(ij|FTA*) > TS_i(i-hub)$, $TS_i(ij|FTA*) > TS_i(ik|FTA*)$, $TS_j(ij|FTA*) > TS_j(j-hub)$, and $TS_j(ij|FTA*) > TS_j(jk|FTA*)$: i and j make a exclusive bloc.

for any $i, j, k = 1, 2, 3$ and $i \neq j \neq k$. Otherwise, $\{G\}$ become a unique CPNE. When countries i and j do not coordinate, free-riding increases, the second condition does not change, and the exclusive bloc decreases as a result. Therefore, overall equilibrium results about considering coordination can be compared only through numerical application in the next section.[3]

4.2 Customs Union

In a CU, a 'hub-and-spoke' trade agreement structure is impossible. When three countries express interest in arranging two trade agreements, I assume that the 'hub' country must choose one of two countries. For example, states such as $\{1-hub\}$ are impossible in a CU, and country 1 must choose one of countries 2 or 3 because an FTA is banned. In this case, deviation from $\{G\} \rightarrow \{12C\}$ is self-enforcing because defection to the 'hub-and-spoke' is impossible. Therefore, under a CU, a free trade cannot be a CPNE, and $\{ij|CU\}$ is a CPN when any of the conditions below are satisfied.

- $TS_k(G) < TS_k(ij|CU)$: k becomes a free-rider.

- $TS_i(G) < TS_i(ij|CU)$ and $TS_j(G) < TS_j(ij|CU)$: i and j establish an exclusive bloc.

for $i, j, k = 1, 2, 3$ and $i \neq j \neq k$. In this case, one country cannot deviate to a 'hub-and-spoke' state. Also, free-riding is not a severe problem because external tariffs of CU members are relatively high. However, that comparison becomes uncertain when asymmetry increases.

3. I do not consider retaliation or threat of deviation or defection in this paper.

Comparison of the exclusive bloc is tricky. When an FTA is the rule, a bloc is created when both countries can get more welfare from an FTA bloc than becoming a hub. When a CU is the rule, a bloc is created when both countries can get more from a CU bloc than from keeping global free trade. In lemma 4, $TS_i(i-hub) > TS_i(G)$ is shown, and therefore when welfare from an FTA bloc and CU bloc are the same, an exclusive bloc is created easily with a CU. However, welfare changes with the type of trade agreement, and the correct calculation is complex. The second deviation case of FTAs is not considered because 'hub-and-spoke' is impossible. Therefore, to demonstrate that it is easier for an FTA, rather than a CU, to achieve free trade, numerical results are needed.

4.3 Multilateralism

This case and the CU have the same structure, and so in both cases, conditions that prevent free trade from becoming a CPNE are similar. Free trade cannot be a CPNE and $\{ij|multi\}$ is a CPNE when

- $TS_k(G) < TS_k(ij|multi)$: k becomes a free-rider.
- $TS_i(G) < TS_i(ij|multi)$ and $TS_j(G) < TS_j(ij|multi)$:i and j establish an exclusive bloc.

for $i, j, k = 1, 2, 3$ and $i \neq j \neq k$. However, this case provides a different result in a CU because the common, optimal tariff is different. $\tau_{.3X}\{12|multi\}$ is less than $\tau_{.3X}\{12|CU\}$ for most cases, and these tariffs are applied to all countries, both members and non-members. This feature makes free-riding much easier under multilateralism. The exclusive bloc is difficult to create because trade agreement members can get much welfare in comparison to other trade agreements, as shown in Proposition 2.

4.4 When Both FTA and CU are Possible

I identify the result when there are two trade agreement options between countries, which occurs under the current WTO regime. I assume that the two countries in the trade agreement can decide post hoc what type of trade agreement to establish. Therefore, the strategy set of country 1 is $\{\phi, \rho_2, \rho_3, \rho_M\}$. $\{\rho_i\}$ is the proposal to country i for any trade agreement. When all three countries reach trade agreements with each other, free trade is achieved, at which point the type of trade agreement in place is no longer relevant. When one agreement is made, member countries need to discuss what type of trade agreement to establish. Since transfer between countries is assumed impossible, the two countries choose based on a surplus comparison. When two countries cannot reach consensus about what type of trade agreement to establish, Assumption 2 is applied, and an FTA is established instead. A CU can be established only when both countries agree to make a CU. I denote $(ij|full)$ as an endogenous decision of trade agreement type and an external tariff policy when countries i and j make a trade agreement.

$$(ij|full) = (ij|CU) \text{ if } TS_x(ij|CU) > TS_x(ij|FTA*) \text{ for x=i,j} \tag{4.3}$$

$$(ij|full) = (ij|FTA*) \text{ otherwise} \tag{4.4}$$

Therefore both members can get more or same welfare than under the FTA regime. $TS_x(ij|CU) \geqq TS_x(ij|FTA*)$ for all member x.

When two agreements are made, the hub country can choose between becoming a hub of two FTAs or the member of one CU or one FTA, but Assumption 2 applies. When the hub country wants one or two FTAs, it is determined as an FTA because establishing a CU requires agreement from both countries. When the hub country wants one CU, the CU is created only if the other member accepts the CU. Otherwise, one FTA is made. Consequently, when they negotiate the type of trade agreement, each country considers whether implicit coordination will occur in the FTA case, and each compares the surplus produced in the FTA

case and in a CU. I denote $(i - hub|full)$ as an endogenous decision of a trade agreement result when two agreements $i-j$ and $i-k$ are made. Country i can decide on the agreement to maximize its surplus with the expectation from decisions of other countries.

$$TS_i(i - hub|full) \equiv \max(TS_i(ij|full), TS_i(ik|full), TS_i(i - hub)) \tag{4.5}$$

As a result hub country can get more or same welfare than under the FTA regime. $TS_i(i - hub|full) \geqq TS_i(i - hub)$

I identify the free-riding case first. When one country refuses free trade, two countries must decide what type of trade agreement will maximize their surplus. As a result, each country can infer how the two other countries will evaluate trade agreement options, and each will choose the free-riding option only if it increases surplus under the trade agreement type and the external tariff policy the two other countries select. Country k chooses to be a free-rider when $TS_k(G) < TS_k(ij|full)$. Because k is a non-member, the effect of permission of CU is uncertain.

Next is the case when one country nullifies only one FTA and makes the other a hub country. Then, a hub country decides on a trade agreement for its surplus, and the nullifying decision depends on this decision. Therefore, country k nullifies an FTA with country j when $TS_k(G) < TS_k(i - hub|full)$. In compared to the FTA regime, the effect of permission on CU is also uncertain. However if country i can choose k as a new partner instead of j, that surplus as a "bloc member" can be higher than surplus as a "spoke". Each results depends on the choice of country i and country k will move with the expectation on country i.

The final consideration is an exclusive bloc. To find the condition, we need to answer the question of whether deviation from free trade to an economic bloc is self-enforcing. When FTA is the only possible trade agreement, two countries (say, 1 and 2) can deviate by nullifying FTAs with one other country (say, 3) simultaneously. Then country 1 can defect country 2 by not nullifying an FTA with country 3. This is NOT $\{G\} \rightarrow \{12|FTA*\} \rightarrow$

$\{1-hub\}$, but $\{G\} \rightarrow \{1-hub\}$. However, making a CU bloc is tricky. Two countries must agree on common external tariffs before excluding country 3, and defection means breaching this agreement, but I do not consider a commitment effect of trade agreements in this paper, and hence I assume that defection on a CU agreement is also possible. A stable exclusive bloc is made when $TS_i(ij|full) > TS_i(i-hub)$, $TS_i(ij|full) > TS_i(ik|full)$, $TS_j(ij|full) > TS_j(j-hub)$, and $TS_j(ij|full) > TS_j(jk|full)$.

In short, conditions to block free trade are different with FTA-only cases. However, in section 3, I find that when implicit coordination is possible, it is difficult to agree on CU. A detailed comparison of asymmetry appears in the next section.

CHAPTER 5

NUMERICAL APPLICATION

This section describes the equilibrium result of the trade liberalization game in the previous section, with technology or demand size asymmetry. I use t_k and d_k for relative technology and size of demand development, respectively. To simplify the setup, I use Assumption 3-2 for the technology difference and assumption 3-3 for the size of demand difference. However, this section covers the equilibrium of trade liberalization game. In section 3, I assume that countries 2 and 3 decide on the type of trade agreement, but in this section, all three countries are players of the trade liberalization game.

Global, tariff-free trade is desirable in the sense that the joint surplus of three countries in a free trade state is higher than in any other states, among results of trade liberalization games, in all parametric ranges. When three countries have the same cost and demand size (Assumption 3-1), they reach global free trade in any case. However, when asymmetry is assumed, the region in which free trade is achievable depends on the rule that controls FTAs and CUs.

5.1 Technology Difference

Use assumption 3-2 and set the parameter range to $-0.2 < t_2, t_3 < 0.25$, $4t_2 - 5t_3 < 1$, and $-5t_2 + 4t_3 < 1$. When FTA is the only possible type of trade agreement, there are three reasons to refuse free trade. Free-riding and creating an exclusive bloc depend on implicit coordination possibilities, but creating a "hub-and-spoke" does not. I describe it as shaded areas for each figure and explain it through figures on online Appendix. Six kinds of shaded areas overlap, and in those areas, one or more countries nullifies one FTA and makes the other country a hub. If country 1 nullifies an FTA with country 3, country 2 becomes a hub of two FTAs. It shows that the country that has less developed technology tends to become a spoke and wants to nullify an FTA with a country that has the most developed technology.

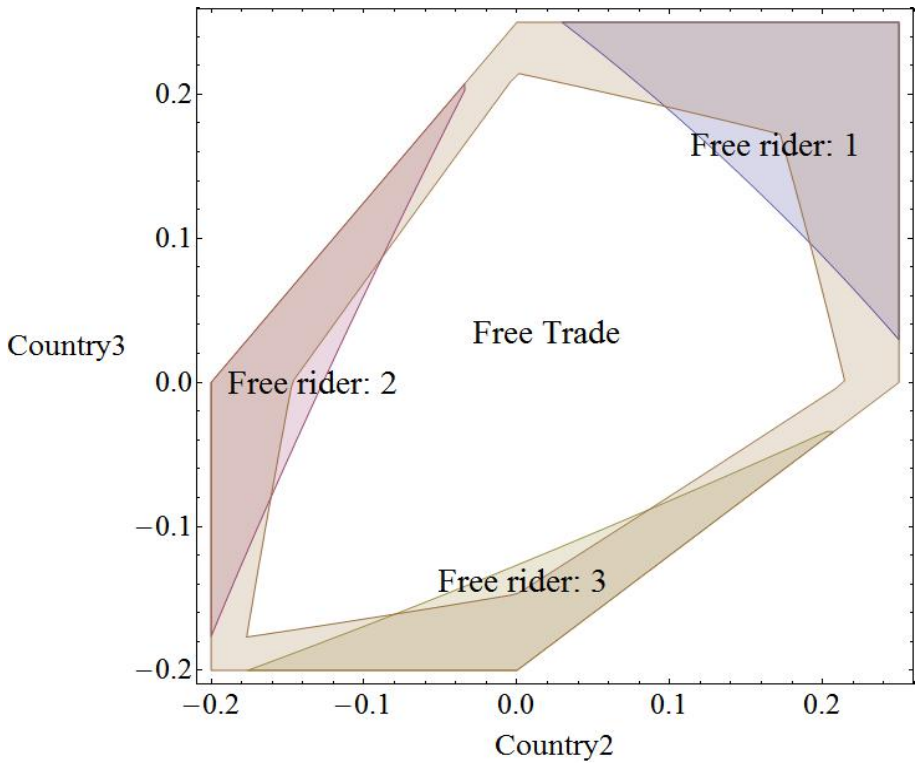

Figure 5.1: FTA without coordination: equilibrium result for cost asymmetry

In those cases, loss of export is small, and gains from tariff revenue and consumer surplus increases are high. That less-developed country then prefers becoming a spoke country.

FTA without coordination and FTA with coordination are illustrated in Figures 7 and 8, respectively. Becoming a spoke does not depend on that coordination, and creating an exclusive bloc does not appear in FTA. Only free-riding appears in Figure 7. When each FTA member does not coordinate, they choose their own optimal external tariff. This is lower than the status quo, and then non-members can enjoy export increases with no cost in their domestic markets. In this setup, lower-developed countries can be free-riders because protecting domestic markets is more crucial than increasing export for them. Other developed countries can get more gains from export profits, and becoming a free-rider is costly.

In contrast, when two countries can choose coordination and keep the status quo, there is no free-riding. Each country must lose much export profit if they choose to be a non-member,

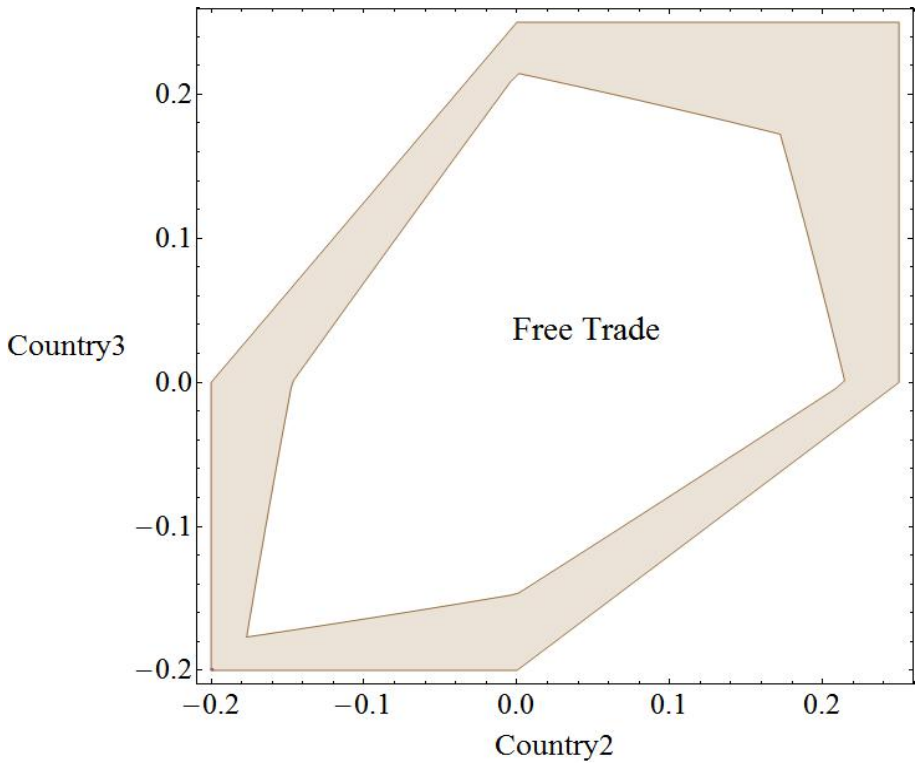

Figure 5.2: FTA with coordination: equilibrium result for cost asymmetry

and then deviation becomes more costly. Also, an economic bloc cannot be at equilibrium because coalition deviation cannot be self-enforcing, explained in section 4. When member countries can choose their external tariff policies endogenously, they choose coordination in most parameter ranges, and free-riding or creating an exclusive bloc does not occur. However, making a "hub-and-spoke," still exists.

When only making a CU is possible, free-riding disappears, and making a "hub-and-spoke" is also impossible. However, two countries that have less-developed technology can make a CU and exclude developed country. This is illustrated in Figure 9. Each region in which exclusive CUs are made is located at the corner. If external tariffs are regulated by the Article XXIV, this bloc range decreases slightly. Figure 10 is about multilateralism. Two member countries can make trade agreements but they must apply the MFN rule, and tariffs should be the same for members and non-members. Therefore, free-riding becomes easier, as in the figure. This regime is dominated by an FTA regime.

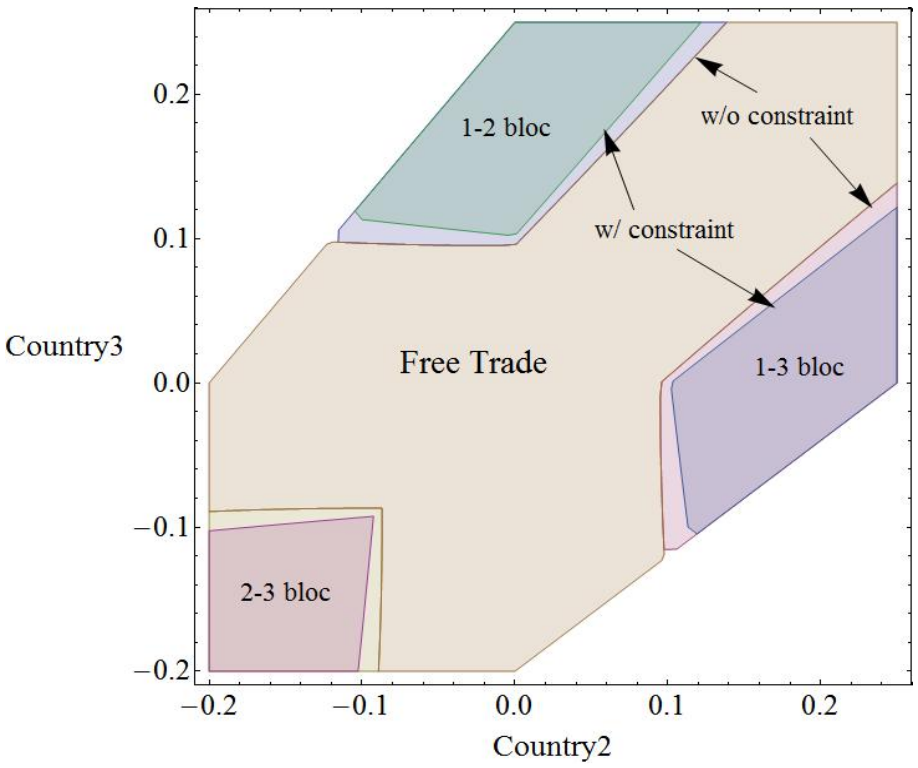

Figure 5.3: Customs Union without/with the constraint: equilibrium result for cost asymmetry

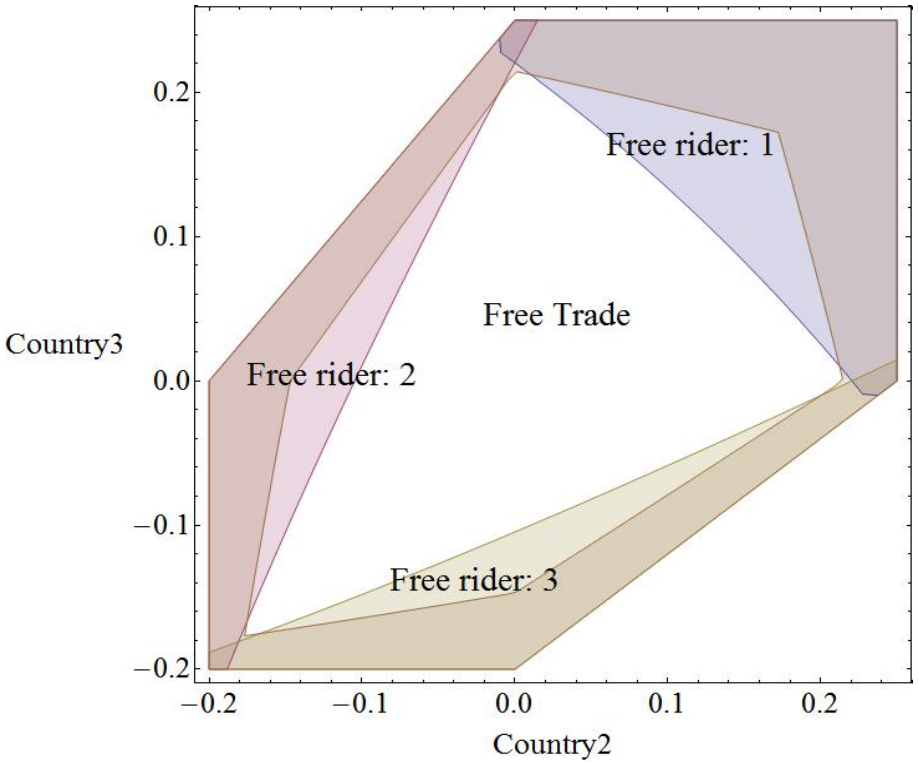

Figure 5.4: Multilateralism: equilibrium result for cost asymmetry

When both FTA and CU are possible, there is no free-riding and an exclusive bloc. Only making a "hub-and-spoke" is possible, as in Figure 8. This result is the same when only FTA with coordination is possible. However, they have the same results regardless of coordination in FTA or the Article XXIV regulation. Even when FTA members cannot coordinate as a rule, they do not free-ride if CU is a possible alternative. I found that member countries mostly choose CU over FTA without implicit coordination in section 3. When one member deviates and tries to be a free-rider, the other two members can choose CU. Then free-riding becomes costly because CU usually places a higher, common, external tariff. On the other hand, CU cannot be an exclusive bloc because each country can defect each other to be a hub of two FTAs. Therefore, an exclusive bloc is also restrained when both trade agreements are possible.

In conclusion, when FTA with implicit tariff coordination is possible, or when both FTA and CU are possible, it is best to reach free trade. However, as we see in the figures, regions that achieve free trade are difficult to compare between FTA and CU. When technology is different, CU also provides good liberalization game results. However, it does not work with demand size asymmetry.

5.2 Size of Demand Difference

In this section, I apply assumption 3-3 to find an equilibrium result of the trade liberalization game. The parameter range is $-0.5 < d_2, d_3 < 1$, $d_2 - 2d_3 < 1$, and $-2d_2 + d_3 < 1$. When members can create only an FTA, making a "hub-and-spoke" does not depend on tariff coordination of members. I describe it as shaded areas for each figure and applies to all FTA cases. Figures on online Appendix shows that the country that has large demand wants to nullify an FTA with a small country. Through FTA, each country loses its domestic market share but increases profits from export. The large country loses more from a trade agreement, and becomes passive with making agreements and wants to deviate. I place this result in the background for comparison, and use a lower range, $-0.4 < d_2, d_3 < 0.5$, because

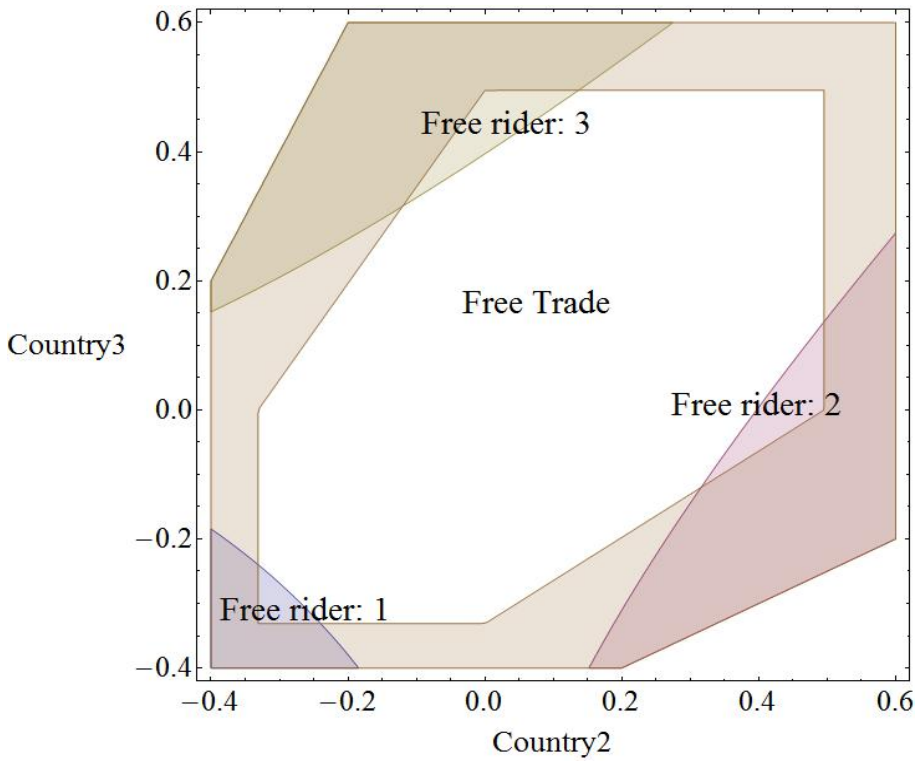

Figure 5.5: FTA without coordination: equilibrium result for demand asymmetry

anything outside of this range cannot reach free trade in any case.

Figures 11 and 12 illustrate the case of FTA, without and with tariff coordination, respectively. In the technology-difference case, free-riding becomes severe when implicit tariff coordination is impossible and an exclusive bloc appears when tariff coordination is possible. In both cases, the large country tries to deviate and refuses tariff free trade by creating a bloc or becoming a free-rider. The technology-difference FTA with coordination is definitely better to reach free trade, but with a demand difference, it is difficult to tell. When two members can decide their external tariff policies, the result is the same as in figure 12 because they favor coordination in most parameter ranges.

Equilibrium results when only CU is an option, as in figure 13. This time, free trade becomes much harder to achieve than the regime with FTAs is. Creating an exclusive bloc becomes much easier, and the fact that "hub-and-spoke" is impossible cannot help. Basically, this is because when creating an FTA is impossible, defection to become a hub is

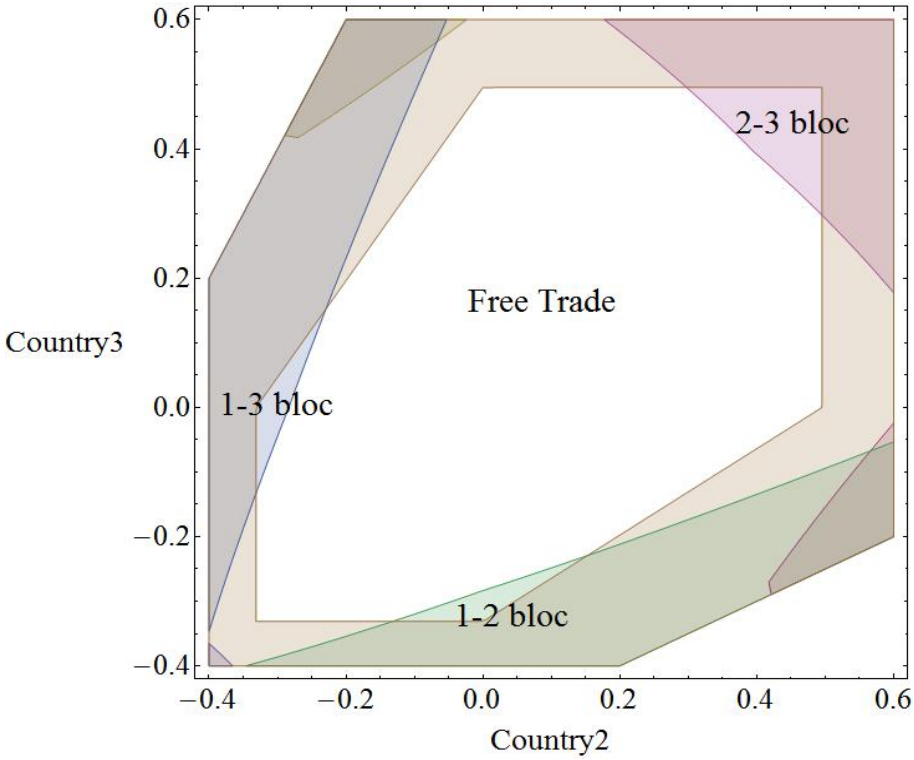

Figure 5.6: FTA with coordination: equilibrium result for demand asymmetry

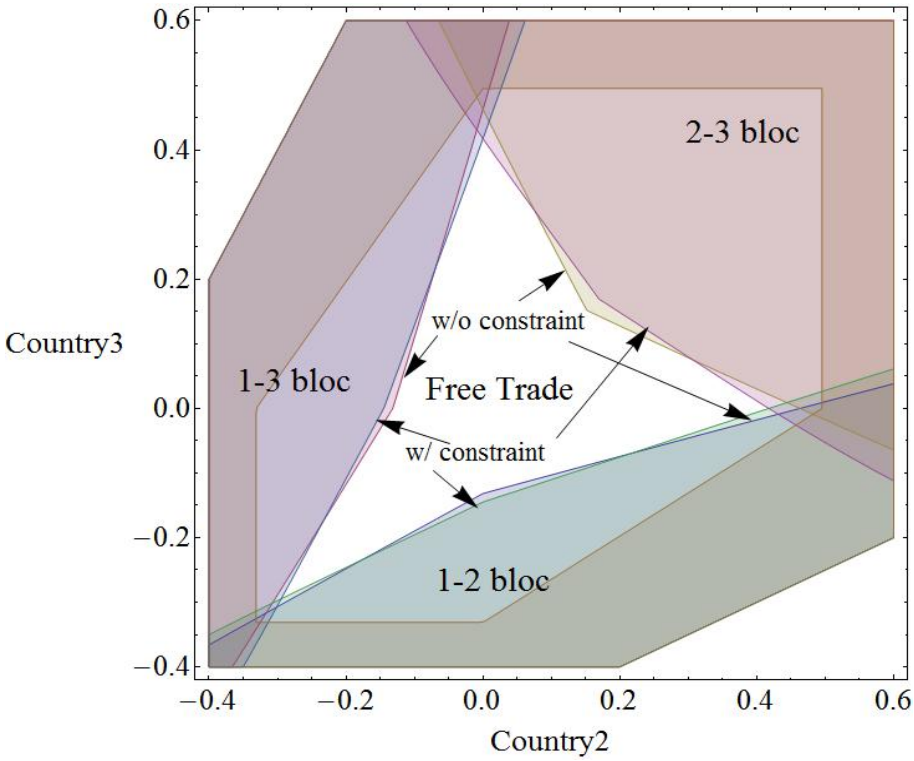

Figure 5.7: Customs Union without/with the constraint: equilibrium result for demand asymmetry

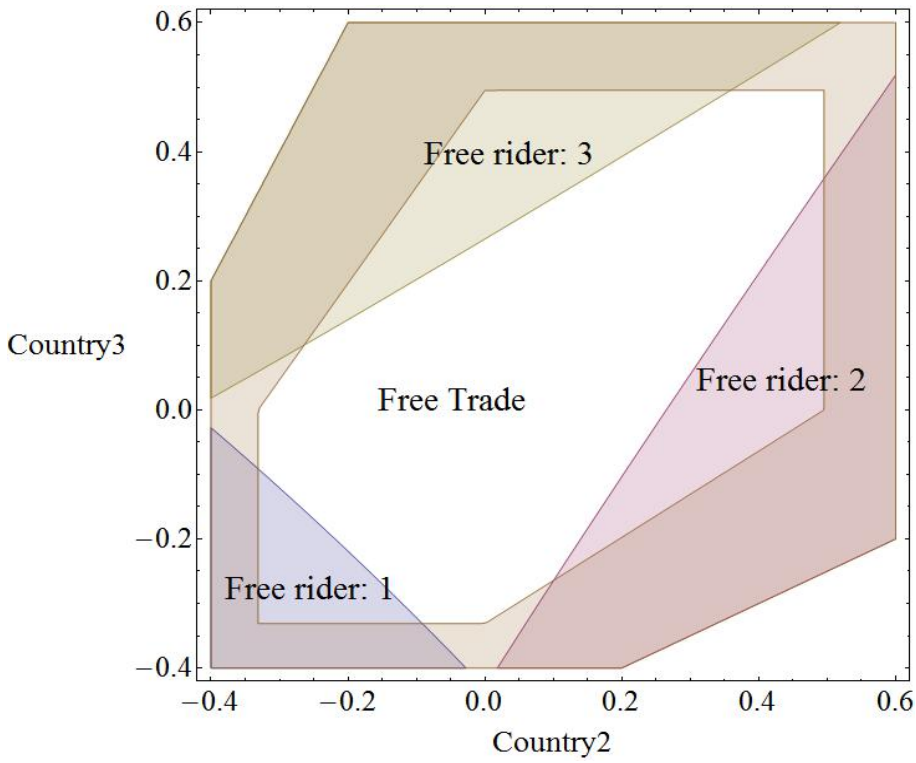

Figure 5.8: Multilateralism: equilibrium result for demand asymmetry

also banned, and then each trade bloc becomes stable. The multilateralism case appears in figure 14. Free-riding is severe, and reaching free trade is harder.

When both FTAs and CUs are possible, equilibrium results vary with given conditions. I place those graphs in figure on online appendix. That difference is not large, but the case with coordination in FTA and tariff regulation is best for achieving free trade. And the case without coordination and without tariff regulation is worst. Figure 15 illustrates comparison of four cases. Figure 16 describes comparison of figure 12 and the best case when both FTA and CU are possible. That results is not as good as only-FTA case but that difference is very small.

In conclusion, with the technology-difference case, FTA shows the best results to achieve free trade. When members can choose tariff coordination, they choose coordination in most parameter ranges, and that makes it easier to achieve free trade. The multilateralism regime has a free-riding problem, and the regime with only CU has an exclusive bloc problem. Also,

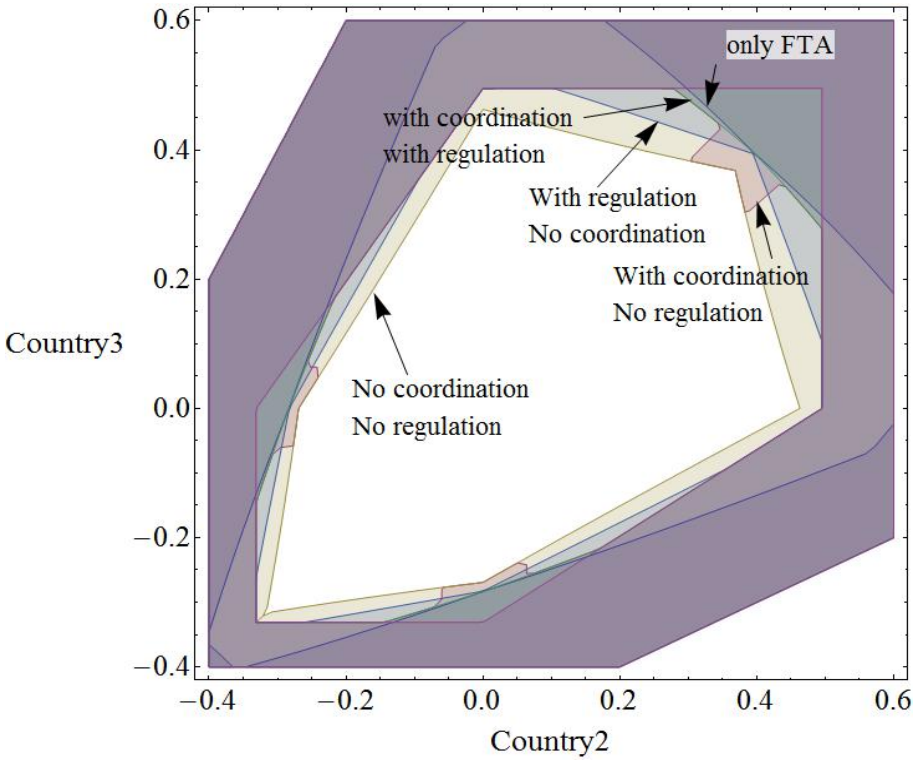

Figure 5.9: Comparison 1: equilibrium result for demand asymmetry

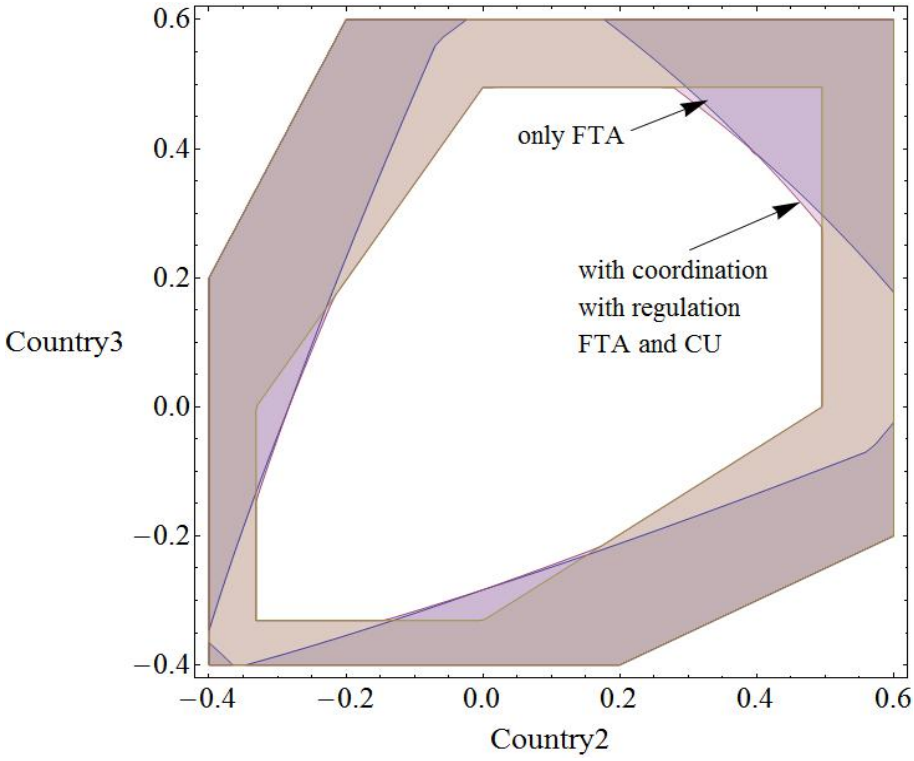

Figure 5.10: Comparison 2: equilibrium result for demand asymmetry

when FTAs and CUs are possible, equilibrium results are not much different from the case in which only FTAs are possible because each country can choose FTA over CU, but creating a bloc is still harder due to defection.

CHAPTER 6

A SIMPLE APPLICATION: CHINA, JAPAN, AND USA

In this section, I apply my setup to a real example. I used cost asymmetry and demand asymmetry separately in previous sections, but now I put those together. I assume that country 1 is the United States, country 2 is Japan, and country 3 is China. Japan has smaller demand but technology is the same as the United States. China has underdeveloped technology but market demand size is the same as in the United States. I write this argument as Assumption 3-4 below.

Assumption 3-4 *Country 1 cannot produce A, 2 cannot produce B, and 3 cannot produce C.*

1. (i) $\alpha_1 - c_1 = e$, $\alpha = \alpha_1 = \alpha_3$, $c = c_1 = c_2$

2. (ii) $-0.2 < t_3 < 0.1$, $-0.5 < d_3 < 0.1$, $1 + 4t_3 + 2d_2 < 0$.

Previous results show that the country that has developed technology has greater incentive to jointly reduce tariff levels on trade because it can enjoy more trade gains from increased exports. The country with the larger demand tends to deviate from free trade or trade agreements to maintain its domestic market share. Among the three countries, China becomes most passive on trade agreements. China also has lower technology and a larger market.

With this assumption, calculation becomes more complex, but can produce figures through a similar process. I put these figures on online Appendix. One describes deviation, creating a "hub-and-spoke". The United States can also deviate, but the most passive country is China. China can be a free-rider for FTA without coordination case. Next is the FTA with tariff coordination. In this case, China wants to create a trade bloc with the United States, which is less active with trading than Japan. Figure 8 is the CU case. We know that an exclusive bloc is easier to create in CU, and the bloc range is larger than in the FTA case. I

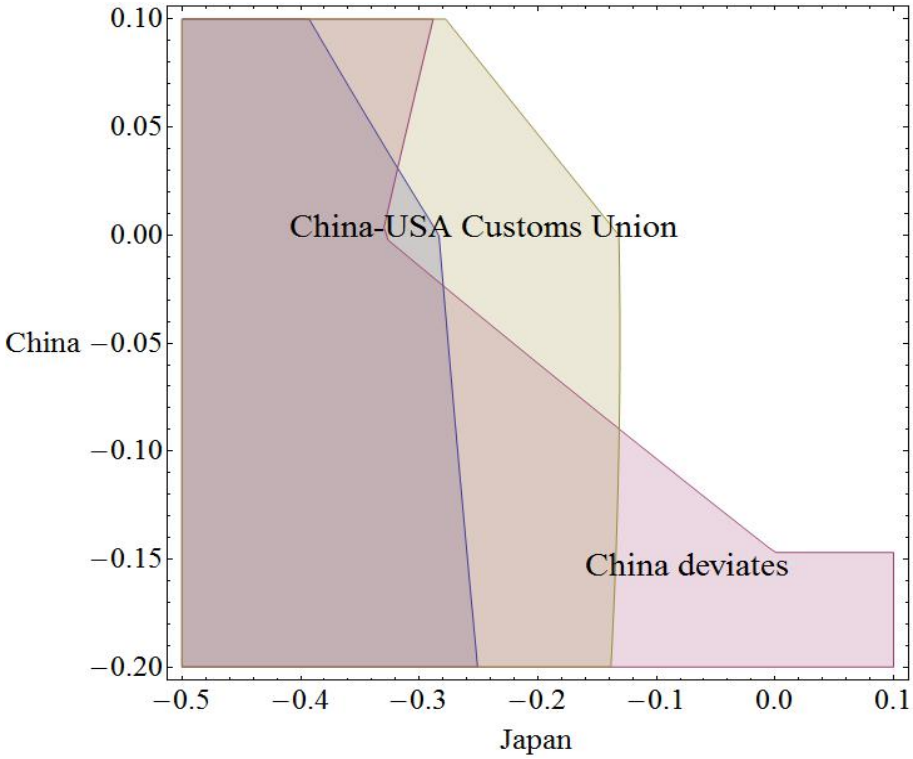

Figure 6.1: Application: Comparison between customs union and FTA

also place the FTA figure in figure 28. In this case, both FTA and CU have similar results regarding reaching free trade.

As in Figure 17, if the technology gap in China is wider than Japans demand gap, CU is better for reaching all-nation, tariff free trade. Otherwise, if the market size gap of Japan is wider than the technology gap in China, FTA is better for achieving free trade. When both FTA and CU are possible, the result is similar to FTA with coordination. Currently, the United States is trying to launch FTAs called The Trans-Pacific Partnership (TPP) with countries, including Japan, and this is also supported by my research. However, this is only an example to connect my research to the real world. Other elements such as politics link with this problem. To estimate or calibrate it more accurately, the model should be developed more.

CHAPTER 7

CONCLUSION

This paper describes tariff coordination in FTAs and CUs. FTA members establish external tariffs on non-member countries to maximize their surpluses, and they can coordinate implicitly by keeping the status-quo. This strategy works when both FTA members agree to it. Two FTA members can choose to coordinate endogenously when demand or technology differences between them are not high. In CU, tariff coordination is mandatory, though it incurs costs. When economic conditions of participant members differ, the CU option is costly, and this can render the option unattractive to at least one of the two members. Consequently, when member countries select an external tariff policy or a trade agreement type, an FTA with implicit tariff coordination becomes attractive. This explains why the FTA is popular and tariff complementarity is infrequent in developed countries.

When coordination is considered, FTA can be the best means of establishing global, tariff free trade in the world economy. This paper examines the parametric region in which global free trade becomes a Coalition-proof Nash Equilibrium under asymmetric production costs or demand sizes of three countries. An FTA with implicit tariff coordination has the widest range, making free trade a Coalition-proof Nash Equilibrium.

There are two explanations for why an FTA with implicit coordination supports global free trade. The free-riding of non-member countries becomes difficult because the higher external tariff produced by the implicit coordination of members causes surplus losses in non-member countries. Establishing an exclusive bloc is difficult because when there are two member countries, each has an incentive to defect the other and become a hub of two FTAs. In most cases, becoming a hub produces a higher surplus than establishing a bloc. Deviations from tariff free trade cannot be self-enforcing because the FTA is flexible. When an FTA cannot be established, an exclusive bloc can be established easily under CU because participant countries cannot defect each other; that is, the bloc is a self-enforcing deviation.

I conclude that it is better for the WTO to allow FTAs and CUs to engage in free

trade. My model does not examine the bargaining process in trade negotiations or political economic viewpoints. This paper also indicates that contagion in an FTA is possible because an FTA makes non-member countries lose their exports, and causes them to establish other FTAs.

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APPENDIX A

DERIVATIONS

A.1 Market Equilibrium in Closed Economy

A.1.1 Utility and Demand

Utility for good A,B,C and numeraire good ψ is

$$U = \sum_{X=A,B,C} (\alpha_X q_X - \frac{1}{2} q_X^2) + q_\psi \tag{A.11}$$

and budget constraint is $M = \sum_{X=A,B,C}(p_X q_X) + p_\psi q_\psi$. Get Lagrange equation through utility maximization with budget constraint and get FOCs as below.

$$\lambda p_X = \alpha_X - q_X \quad (X = A, B, C) \tag{A.12}$$

$$\lambda p_\psi = 1 \tag{A.13}$$

$$M = \sum_{X=A,B,C} (p_X q_X) + p_\psi q_\psi \tag{A.14}$$

These equations can be solved.

$$\lambda* = \frac{1}{p_\psi} \tag{A.15}$$

$$d(p_X) = \alpha_X - \lambda p_X = \alpha_X - \frac{p_X}{p_\psi} \quad (X = A, B, C) \tag{A.16}$$

$$d(p_\psi) = (M - \sum_{X=A,B,C} (p_X(d(p_X)))) \frac{1}{p_\psi} \tag{A.17}$$

$$= (M - \sum_{X=A,B,C} (p_X(\alpha_X - \frac{p_X}{p_\psi}))) \frac{1}{p_\psi} \tag{A.18}$$

So when $p_\psi = 1$, each demand becomes $d(p_X) = \alpha_X - p_X$ where $X = A$, B, and C. And all consumers buy non-numeraire goods first and spend remaining money on numeriare good. I

will show that assumption $p_\psi = 1$ is fine in next part.

A.1.2 Production cost and Supply

When wage is w, profit for firm producing good X π_X is $p_X q_X - q_X c_X w$. Also wage $w = p_\psi$ because market is competitive for numeraire good production and profit on that production becomes zero. Monopoly firm can decide their production to maximize profit π_X. Using above demand equation, price is p_X is $p_\psi(\alpha_X - d(p_X))$. When demand $d(p_X)$ is same to supply q_X, profit is

$$\pi_X = p_X q_X - q_X c_X w = p_\psi(\alpha_X - q_X - c_X)q_X. \tag{A.19}$$

Then optimal production is $q_X = \frac{\alpha_X - c_X}{2}$ and price and profit are

$$\begin{aligned} p_X &= p_\psi(\alpha_X - x_X) = p_\psi \frac{\alpha_X + c_X}{2} && \text{(A.110)} \\ \pi_X &= p_X q_X - q_X c_X w = p_\psi(\frac{\alpha_X - c_X}{2})\frac{\alpha_X - c_X}{2}. && \text{(A.111)} \end{aligned}$$

A.1.3 Market equilibrium

Assume that this country cannot produce good C. And denote L is given labor in that country. The amount of labor for production of non-numeraire good A and B is

$$c_A q_A + c_B q_B = c_A \frac{\alpha_A - c_A}{2} + c_B \frac{\alpha_B - c_B}{2} \tag{A.112}$$

and remaining labor is employed on production of numeraire good ψ. Then production of ψ is

$$q_\psi = L - (c_A \frac{\alpha_A - c_A}{2} + c_B \frac{\alpha_B - c_B}{2}). \tag{A.113}$$

Total wage is Lp_φ and total profit is $\pi_A + \pi_B = p_\psi((\frac{\alpha_A - c_A}{2})^2 + (\frac{\alpha_B - c_B}{2})^2)$. Total income for expenditure is

$$M = p_\psi(L + (\frac{\alpha_A - c_A}{2})^2 + (\frac{\alpha_B - c_B}{2})^2). \tag{A.114}$$

C is not produced. Then, demand on numeraire good $d(p_\psi) = (M - p_A(\alpha_A - \frac{p_A}{p_\psi}) + p_B(\alpha_B - \frac{p_B}{p_\psi}))/p_\psi$ is

$$\begin{aligned}
d(p_\psi) &= (M - p_A q_A - p_B q_B)/p_\psi \\
&= (p_\psi(L + (\frac{\alpha_A - c_A}{2})^2 + (\frac{\alpha_B - c_B}{2})^2) - p_\psi \frac{\alpha_A + c_A}{2}\frac{\alpha_A - c_A}{2} - p_\psi \frac{\alpha_B + c_B}{2}\frac{\alpha_B - c_B}{2})/p_\psi \\
&= L + (\frac{\alpha_A - c_A}{2})^2 - \frac{\alpha_A + c_A}{2}\frac{\alpha_A - c_A}{2} + (\frac{\alpha_B - c_B}{2})^2 - \frac{\alpha_B + c_B}{2}\frac{\alpha_B - c_B}{2} \\
&= L - (c_A \frac{\alpha_A - c_A}{2} + c_B \frac{\alpha_B - c_B}{2}) \\
&= q_\psi
\end{aligned}$$

All market is in equilibrium regardless of wage and now I can assume that wage $w = p_\psi = 1$. Then also λ becomes 1 by $\lambda p_\psi = 1$. In short, each market equilibrium result is

$$\begin{aligned}
d(p_X) &= \alpha_X - p_X && \text{(A.115)} \\
q_X &= \frac{\alpha_X - c_X}{2} && \text{(A.116)} \\
p_X &= \frac{\alpha_X + c_X}{2} && \text{(A.117)} \\
\pi_X &= (\frac{\alpha_X - c_X}{2})^2 && \text{(A.118)} \\
q_\psi &= L - (c_A \frac{\alpha_A - c_A}{2} + c_B \frac{\alpha_B - c_B}{2}) && \text{(A.119)}
\end{aligned}$$

for $X = A, B$. Then consumer surplus $\frac{1}{2}q_A^2 = \frac{(\alpha_A - c_A)^2}{8}$ and profit $\pi_A = (\frac{\alpha_A - c_A}{2})^2$ are social surplus (or increased welfare) from the existence of a monopoly firm in industry A.

$$DS_A = \frac{(\alpha_A - c_A)^2}{8} + (\frac{\alpha_A - c_A}{2})^2 = \frac{3(\alpha_A - c_A)^2}{8} \tag{A.120}$$

I will call this sum as domestic surplus in this paper.

A.2 Derivation of Cournot Equilibrium

I assume equilibrium in only one country and use simpler notation without 'country'. There are two firms 1 and 2 in the market. Two production costs can be different and tariffs are levied. Using demand $q_{1A} + q_{2A} = d(x_A) = \alpha_A - p_A$, profit of firm 1 is

$$\pi_{1A} = p_{1A}q_{1A} - q_{1A}(c_{1A} + \tau_{1A}) = (\alpha_A - q_{1A} - q_{2A} - c_{1A} - \tau_{1A})q_{1A}. \tag{A.221}$$

Then optimal production to maximize profit is

$$q_{1A} = \frac{1}{2}(\alpha_A - q_{2A} - c_{1A} - \tau_{1A}). \tag{A.222}$$

And also firm 2 will decide their optimal production like this.

$$q_{2A} = \frac{1}{2}(\alpha_A - q_{1A} - c_{2A} - \tau_{2A}) \tag{A.223}$$

These two conditions are solved as $q_{1A} = \frac{1}{3}(\alpha_A - 2c_{1A} - 2\tau_{1A} + c_{2A} + \tau_{2A})$ and $q_{2A} = \frac{1}{3}(\alpha_A - 2c_{2A} - 2\tau_{2A} + c_{1A} + \tau_{1A})$. And $Q_A = \frac{1}{3}(2\alpha_A - c_{1A} - c_{2A} - \tau_{1A} - \tau_{2A})$. This process can be generalized as when there are n firms in the market.

$$\begin{aligned}
\pi_{jX} &= P_X(= \alpha_X - Q_X)q_{jX} - q_{jX}c_{jX} - q_{jX}\tau_{jX} \\
&= q_{jX}(\alpha_X - c_{jX} - \tau_{jX} - Q_X) && \text{(A.224)} \\
q_{jX} &\equiv \arg\max \pi_{jX} = \frac{1}{2}(\alpha_X - c_{jX} - \tau_{jX} - (Q_X - q_{jX})) && \text{(A.225)} \\
Q_X &= \sum_k q_{kX} = \frac{1}{2}\sum_k(\alpha_X - c_{kX} - \tau_{kX}) - \frac{n}{2}Q_X + \frac{1}{2}Q_X && \text{(A.226)} \\
Q_X &= \frac{1}{n+1}\sum_k(\alpha_X - c_{kX} - \tau_{kX}). && \text{(A.227)}
\end{aligned}$$

Then generalization of this equation is

$$q_{jX} = \alpha_X - c_{jX} - \tau_{jX} - Q_X = (\alpha_X - c_{jX} - \tau_{ijX}) - \sum_k \frac{\alpha_X - c_{kX} - \tau_{kX}}{n+1}. \quad \text{(A.228)}$$

And maximized profit is

$$\pi_{jX} = q_{jX}(\alpha_X - c_{jX} - \tau_{jX} - Q_X) = q_{jX}^2 \quad \text{(A.229)}$$

for each good X=A,B,C and each country j can produce good X.

Next check the case of each country. For country 1, they cannot produce good A and import good A from two countries.

$$\begin{aligned}
CS_{1A} &= \frac{1}{2}Q_{1A}^2 = \frac{1}{18}(2\alpha_{1A} - c_{2A} - c_{3A} - \tau_{12A} - \tau_{13A})^2 && \text{(A.230)}\\
TR_{1A} &= q_{12A}\tau_{12A} + q_{13A}\tau_{13A} \\
&= \frac{1}{3}\tau_{12A}(\alpha_{1A} - 2c_{2A} + c_{3A} - 2\tau_{12A} + \tau_{13A}) \\
&\quad + \frac{1}{3}\tau_{13A}(\alpha_{1A} + c_{2A} - 2c_{3A} + \tau_{12A} - 2\tau_{13A}) && \text{(A.231)}\\
\pi_{12A} &= (P_{1A} - c_{2A} - \tau_{12A})q_{12A} = \frac{1}{9}(\alpha_{1A} - 2c_{2A} + c_{3A} - 2\tau_{12A} + \tau_{13A})^2 && \text{(A.232)}\\
\pi_{13A} &= (P_{1A} - c_{3A} - \tau_{13A})q_{13A} = \frac{1}{9}(\alpha_{1A} + c_{2A} - 2c_{3A} + \tau_{12A} - 2\tau_{13A})^2 && \text{(A.233)}
\end{aligned}$$

Here $DS_{1A} = CS_{1A} + TR_{1A}$. There's no profit for country 1 here because country 1 cannot produce and export good A. When tariff on import from country 2 (τ_{12A}) increases, then profit π_{12A} decreases and π_{13A} increases from substitution decision of consumers. Instead domestic and foreign markets of good B and C provides firm profits in country 1. Result

from markets of good B is as below. Market equilibrium for good C is as similar.

$$CS_{1B} = \frac{1}{2}Q_{1B}^2 = \frac{1}{18}(2\alpha_{1B} - c_{1B} - c_{3B} - \tau_{13B})^2 \quad \text{(A.234)}$$

$$TR_{1B} = q_{13B}\tau_{13B} = \frac{1}{3}\tau_{13B}(\alpha_{1B} + c_{1B} - 2c_{3B} - 2\tau_{13B}) \quad \text{(A.235)}$$

$$\pi_{11B} = (P_{1B} - c_{1B})q_{11B} = \frac{1}{9}(\alpha_{1B} - 2c_{1B} + c_{3B} + \tau_{13B})^2 \quad \text{(A.236)}$$

$$\pi_{13B} = (P_{1B} - c_{3B} - \tau_{13B})q_{13B} = \frac{1}{9}(\alpha_{1B} + c_{1B} - 2c_{3B} - 2\tau_{13B})^2 \quad \text{(A.237)}$$

$$\pi_{21B} = (P_{2B} - c_{1B} - \tau_{21B})q_{21B} = \frac{1}{9}(\alpha_{2B} - 2c_{1B} + c_{3B} - 2\tau_{21B} + \tau_{23B})^2 \quad \text{(A.238)}$$

$$\pi_{31B} = (P_{3B} - c_{1B} - \tau_{31B})q_{31B} = \frac{1}{9}(\alpha_{3B} - 2c_{1B} + c_{3B} - 2\tau_{31B})^2 \quad \text{(A.239)}$$

In this setup $DS_{1B} = CS_{1B} + TR_{1B} + \pi_{11B}$. Additionally country 1 gets more welfare from export. $(EX_{1B} = \pi_{21B} + \pi_{31B})$

When two countries trade goods and their amount is different (imbalanced trade), numeraire good ψ moves and it made trade balance. When country 1 import good A from country 2, labor in country 1 move to industry ψ from A and labor in country 2 move to industry A from industry ψ. Then country 1 export good ψ as same amount of import and it makes trade balance and it keeps wage same to 1 as before starting trade.

Labor is always fully employed in this model. And profit from production of numeraire good is always zero from perfect competition. Demand for numeraire good does not depend on price of numeraire good. Each consumer spends remaining money on numeraire good after buying non-numeraire good. And that money is from labor wage, firm profits, and tariff revenue. Firm profits and tariff revenue are already counted as total welfare and total labor wage is always same. Therefore I do not need to think numeraire good market in welfare calculations.

A.3 Global tariff-free trade

When tariff is zero for all countries, each market equilibrium will be

$$
\begin{aligned}
q_{ijX} &= \frac{1}{3}(\alpha_{iX} - 2c_{jX} + c_{kX}) && \text{(A.340)}\\
q_{ikX} &= \frac{1}{3}(\alpha_{iX} + c_{jX} - 2c_{kX}) && \text{(A.341)}\\
CS_{iX} &= \frac{1}{2}Q_{iX}^2 = \frac{1}{18}(2\alpha_{iX} + c_{jX} + c_{kX})^2 && \text{(A.342)}\\
\pi_{ijX} &= q_{ijX}^2 = \frac{1}{9}(\alpha_{iX} - 2c_{jX} + c_{kX})^2 && \text{(A.343)}
\end{aligned}
$$

$TR_{iX} = 0$ in this setup. So $DS_{iX} = CS_{iX}$ when country i cannot produce good X and import it from two countries. When country i can produce good Y and import it from only one country, say k, domestic surplus is

$$
\begin{aligned}
DS_{iY} &= CS_{iY} + \pi_{iiY}\\
&= \frac{1}{18}(2\alpha_{iY} + c_{iY} + c_{kY})^2 + \frac{1}{9}(\alpha_{iY} - 2c_{iY} + c_{kY})^2\\
&= \frac{1}{6}(3(\alpha_{iY} - c_{iY})^2 - 2(\alpha_{iY} - c_{iY})(\alpha_{iY} - c_{kY}) + (\alpha_{iY} - c_{kY})^2). \quad \text{(A.344)}
\end{aligned}
$$

Then $DS_i(G)$ and $EX_i(G)$ are sum of each domestic surplus and exports. Take the example of country 1. Then result is as below.

$$
\begin{aligned}
DS_1(G) &= \frac{1}{18}(2\alpha_{1A} + c_{2A} + c_{3A})^2 + \frac{1}{18}(2\alpha_{1B} + c_{1B} + c_{3B})^2 + \frac{1}{18}(2\alpha_{1C} + c_{1C} + c_{2C})^2\\
&\quad + \frac{1}{9}(\alpha_{1B} - 2c_{1B} + c_{3B})^2 + + \frac{1}{9}(\alpha_{1C} - 2c_{1C} + c_{2C})^2 \quad \text{(A.345)}\\
EX_1(G) &= \frac{1}{9}\{(\alpha_{2B} - 2c_{1B} + c_{3B})^2 + (\alpha_{3B} - 2c_{1B} + c_{3B})^2\\
&\quad + (\alpha_{2C} - 2c_{1C} + c_{2C})^2 + (\alpha_{3C} - 2c_{1C} + c_{2C})^2\} \quad \text{(A.346)}
\end{aligned}
$$

A.4 Trade War (No agreement)

Take the example of country 1. When country 1 cannot produce good,

- $(\tau_{12A}(\Phi), \tau_{13A}(\Phi)) \equiv \arg\max TS_1 = \arg\max DS_{1A} = \arg\max(CS_{1A} + TR_{1A})$

Market equilibrium when one country import good A from two is

$$\begin{aligned} CS_{1A} &= \frac{1}{2}Q_{1A}^2 = \frac{1}{18}(2\alpha_{1A} - c_{2A} - c_{3A} - \tau_{12A} - \tau_{13A})^2 && \text{(A.447)} \\ TR_{1A} &= q_{12A}\tau_{12A} + q_{13A}\tau_{13A} \\ &= \frac{1}{3}\tau_{12A}(\alpha_{1A} - 2c_{2A} + c_{3A} - 2\tau_{12A} + \tau_{13A}) \\ &\quad + \frac{1}{3}\tau_{13A}(\alpha_{1A} + c_{2A} - 2c_{3A} + \tau_{12A} - 2\tau_{13A}) && \text{(A.448)} \\ DS_{1A} &= \frac{1}{18}(2\alpha_{1A} - c_{2A} - c_{3A} - \tau_{12A} - \tau_{13A})^2 + \frac{1}{3}\tau_{12A}(\alpha_{1A} - 2c_{2A} + c_{3A} - 2\tau_{12A} + \tau_{13A}) \\ &\quad + \frac{1}{3}\tau_{13A}(\alpha_{1A} + c_{2A} - 2c_{3A} + \tau_{12A} - 2\tau_{13A}) && \text{(A.449)} \end{aligned}$$

FOCs to maximize this domestic surplus are

$$\begin{aligned} 0 &= -\frac{1}{9}(2\alpha_{1A} - c_{2A} - c_{3A} - \tau_{12A} - \tau_{13A}) + \frac{1}{3}(\alpha_{1A} - 2c_{2A} + c_{3A} - 4\tau_{12A} + 2\tau_{13A}) \\ &\Longrightarrow 11\tau_{12A} = \alpha_{1A} - 5c_{2A} + 4c_{3A} + 7\tau_{13A} && \text{(A.450)} \\ 0 &= -\frac{1}{9}(2\alpha_{1A} - c_{2A} - c_{3A} - \tau_{12A} - \tau_{13A}) + \frac{1}{3}(\alpha_{1A} + c_{2A} - 2c_{3A} + 2\tau_{12A} - 4\tau_{13A}) \\ &\Longrightarrow 11\tau_{13A} = \alpha_{1A} + 4c_{2A} - 5c_{3A} + 7\tau_{12A} && \text{(A.451)} \end{aligned}$$

Then

$$\begin{aligned} 121\tau_{12A}(\Phi) &= 11\alpha_{1A} - 55c_{2A} + 44c_{3A} + 77\tau_{13A}(\Phi) \\ &= 11\alpha_{1A} - 55c_{2A} + 44c_{3A} + 7(\alpha_{1A} + 4c_{2A} - 5c_{3A} + 7\tau_{12A}(\Phi)) \\ &\Longrightarrow 72\tau_{12A}(\Phi) = 18\alpha_{1A} - 27c_{2A} + 9c_{3A} \\ &\Longrightarrow \tau_{12A}(\Phi) = \frac{1}{8}(2\alpha_{1A} - 3c_{2A} + c_{3A}) && \text{(A.452)} \\ &\Longrightarrow \tau_{13A}(\Phi) = \frac{1}{8}(2\alpha_{1A} + c_{2A} - 3c_{3A}) && \text{(A.453)} \end{aligned}$$

When country 1 can produce the good,

- $\tau_{13B}(\Phi) \equiv \arg\max TS_1 = \arg\max DS_{1B}(\Phi)$
- $\tau_{12C}(\Phi) \equiv \arg\max TS_1 = \arg\max DS_{1C}(\Phi)$

$$
\begin{aligned}
CS_{1B} &= \frac{1}{2}Q_{1B}^2 = \frac{1}{18}(2\alpha_{1B} - c_{1B} - c_{3B} - \tau_{13B})^2 && \text{(A.454)}\\
TR_{1B} &= q_{13B}\tau_{13B} = \frac{1}{3}\tau_{13B}(\alpha_{1B} + c_{1B} - 2c_{3B} - 2\tau_{13B}) && \text{(A.455)}\\
\pi_{11B} &= (P_{1B} - c_{1B})q_{11B} = \frac{1}{9}(\alpha_{1B} - 2c_{1B} + c_{3B} + \tau_{13B})^2 && \text{(A.456)}
\end{aligned}
$$

Total surplus and FOC is

$$
\begin{aligned}
DS_{1B}(\Phi) &= \frac{1}{18}(2\alpha_{1B} - c_{1B} - c_{3B} - \tau_{13B})^2 + \frac{1}{3}\tau_{13B}(\alpha_{1B} + c_{1B} - 2c_{3B} - 2\tau_{13B})\\
&\quad + \frac{1}{9}(\alpha_{1B} - 2c_{1B} + c_{3B} + \tau_{13B})^2 && \text{(A.457)}\\
FOC &: 0 = -\frac{1}{9}(2\alpha_{1B} - c_{1B} - c_{3B} - \tau_{13B}(\Phi)) && \text{(A.458)}\\
&\quad + \frac{1}{3}(\alpha_{1B} + c_{1B} - 2c_{3B} - 4\tau_{13B}(\Phi)) + \frac{2}{9}(\alpha_{1B} - 2c_{1B} + c_{3B} + \tau_{13B}(\Phi))\\
&\Longrightarrow 9\tau_{13B}(\Phi) = 3\alpha_{1B} - 3c_{3B}\\
&\Longrightarrow \tau_{13B}(\Phi) = \frac{1}{3}(\alpha_{1B} - c_{3B}) && \text{(A.459)}
\end{aligned}
$$

Similarly $\tau_{12C}(\Phi) = \frac{1}{3}(\alpha_{1C} - c_{2C})$.

Before getting surplus, I denote $\gamma_{ijX} = \alpha_{iX} - c_{jX}$ for notational convenience. Then, market equilibrium when country 1 cannot produce A is

$$
\begin{aligned}
CS_{1A} &= \frac{1}{2}Q_{1A}^2 = \frac{1}{18}(\gamma_{12A} + \gamma_{13A} - \tau_{12A} - \tau_{13A})^2\\
TR_{1A} &= q_{12A}\tau_{12A} + q_{13A}\tau_{13A}\\
&= \frac{1}{3}(\tau_{12A}(2(\gamma_{12A} - \tau_{12A}) - \gamma_{13A} + \tau_{13A}) + \tau_{13A}(2(\gamma_{13A} - \tau_{13A}) - \gamma_{12A} + \tau_{12A}))\\
\pi_{12A} &= (P_{1A} - c_{2A} - \tau_{12A})q_{12A} = \frac{1}{9}(2\gamma_{12A} - 2\tau_{12A} - \gamma_{13A} + \tau_{13A})^2\\
\pi_{13A} &= (P_{1A} - c_{3A} - \tau_{13A})q_{13A} = \frac{1}{9}(2\gamma_{13A} - 2\tau_{13A} - \gamma_{12A} + \tau_{12A})^2.
\end{aligned}
$$

Result from markets of good B is as below. Market equilibrium for good C is as similar.

$$\begin{aligned}
CS_{1B} &= \frac{1}{2}Q_{1B}^2 = \frac{1}{18}(\gamma_{11B} + \gamma_{13B} - \tau_{13B})^2 \\
TR_{1B} &= q_{13B}\tau_{13B} = \frac{1}{3}\tau_{13B}(2(\gamma_{13B} - \tau_{13B}) - \gamma_{11B}) \\
\pi_{11B} &= (P_{1B} - c_{1B})q_{11B} = \frac{1}{9}(2\gamma_{11B} - \gamma_{13B} + \tau_{13B})^2 \\
\pi_{13B} &= (P_{1B} - c_{3B} - \tau_{13B})q_{13B} = \frac{1}{9}(2\gamma_{13B} - 2\tau_{13B} - \gamma_{11B})^2 \\
\pi_{21B} &= (P_{2B} - c_{1B} - \tau_{21B})q_{21B} = \frac{1}{9}(2\gamma_{21B} - 2\tau_{21B} - \gamma_{23B} + \tau_{23B})^2 \\
\pi_{31B} &= (P_{3B} - c_{1B} - \tau_{31B})q_{31B} = \frac{1}{9}(2\gamma_{31B} - 2\tau_{31B} - \gamma_{33B})^2
\end{aligned}$$

Then welfare level is as below.

$$\begin{aligned}
DS_1(\Phi) &= \frac{1}{16}(3\gamma_{12A}^2 - 2\gamma_{12A}\gamma_{13A} + 3\gamma_{13A}^2) \\
&\quad + \frac{1}{18}(9\gamma_{11B}^2 - 6\gamma_{11B}\gamma_{13B} + 4\gamma_{13B}^2) + \frac{1}{18}(9\gamma_{11C}^2 - 6\gamma_{11B}\gamma_{12C} + 4\gamma_{12C}^2) \qquad \text{(A.460)} \\
EX_1(\Phi) &= (\frac{3\gamma_{21B} - \gamma_{23B}}{8})^2 + (\frac{4\gamma_{31B} - 3\gamma_{33B}}{9})^2 \\
&\quad + (\frac{4\gamma_{21C} - 3\gamma_{22C}}{9})^2 + (\frac{3\gamma_{31C} - \gamma_{32C}}{8})^2 \qquad \text{(A.461)} \\
TS_1(\Phi) &= DS_1(\Phi) + EX_1(\Phi) \qquad \text{(A.462)}
\end{aligned}$$

A.5 Free Trade Agreement

- $\tau_{13A}(12|FTA) \equiv \arg\max TS_1 = \arg\max DS_{1A}$ with $\tau_{12A}(12|FTA) = 0$

We can use same domestic surplus with $\tau_{12A}(12|FTA) = 0$.

$$DS_{1A} = \frac{1}{18}(2\alpha_{1A} - c_{2A} - c_{3A} - \tau_{13A})^2 + \frac{1}{3}\tau_{13A}(\alpha_{1A} + c_{2A} - 2c_{3A} - 2\tau_{13A}) \qquad \text{(A.563)}$$

FOCs to maximize this domestic surplus are

$$\begin{aligned} 0 &= -\frac{1}{9}(2\alpha_{1A} - c_{2A} - c_{3A} - \tau_{13A}(12|FTA)) + \frac{1}{3}(\alpha_{1A} + c_{2A} - 2c_{3A} - 4\tau_{13A}(12|FTA)) \\ &\Longrightarrow 11\tau_{13A}(12|FTA) = \alpha_{1A} + 4c_{2A} - 5c_{3A} \end{aligned} \tag{A.564}$$

$\tau_{23B}(12|FTA)$ is also determined through similar process. When they coordinate implicitly, $\tau_{12A}(12|FTA - co)$ and $\tau_{23B}(12|FTA - co)$ is same to $\tau_{12A}(\Phi)$ and $\tau_{23B}(\Phi)$, respectively.

A.6 Customs Union

- $\tau_{\cdot 3A}(12|CU) \equiv \arg\max(DS_{1A} + DS_{2A} + \pi_{12A})$ with $\tau_{12A} = \tau_{21A} = 0$
- $\tau_{\cdot 3B}(12|CU) \equiv \arg\max(DS_{1B} + DS_{2B} + \pi_{21B})$ with $\tau_{12B} = \tau_{21B} = 0$

Then each elements are

$$DS_{1A} = \frac{1}{18}(2\alpha_{1A} - c_{2A} - c_{3A} - \tau_{\cdot 3A})^2 + \frac{1}{3}\tau_{\cdot 3A}(\alpha_{1A} + c_{2A} - 2c_{3A} - 2\tau_{\cdot 3A}) \tag{A.665}$$

$$\begin{aligned} DS_{2A} &= \frac{1}{18}(2\alpha_{2A} - c_{2A} - c_{3A} - \tau_{\cdot 3A})^2 + \frac{1}{3}\tau_{\cdot 3A}(\alpha_{2A} + c_{2A} - 2c_{3A} - 2\tau_{\cdot 3A}) \\ &\quad + \frac{1}{9}(\alpha_{2A} - 2c_{2A} + c_{3A} + \tau_{\cdot 3A})^2 \end{aligned} \tag{A.666}$$

$$\pi_{12A} = (P_{1A} - c_{2A})q_{12A} = \frac{1}{9}(\alpha_{1A} - 2c_{2A} + c_{3A} + \tau_{\cdot 3A})^2 \tag{A.667}$$

Then FOC for maximization is

$$\begin{aligned} 0 &= -\frac{1}{9}(2\alpha_{1A} - c_{2A} - c_{3A} - \tau_{\cdot 3A}) + \frac{1}{3}(\alpha_{1A} + c_{2A} - 2c_{3A} - 4\tau_{\cdot 3A}) \\ &\quad -\frac{1}{9}(2\alpha_{2A} - c_{2A} - c_{3A} - \tau_{\cdot 3A}) + \frac{1}{3}(\alpha_{2A} + c_{2A} - 2c_{3A} - 4\tau_{\cdot 3A}) \\ &\quad +\frac{2}{9}(\alpha_{2A} - 2c_{2A} + c_{3A} + \tau_{\cdot 3A}) + \frac{2}{9}(\alpha_{1A} - 2c_{2A} + c_{3A} + \tau_{\cdot 3A}) \end{aligned} \tag{A.668}$$

Using FOC, $\tau_{\cdot 3A}(12|CU) = \frac{1}{6}(\alpha_{1A} + \alpha_{2A} - 2c_{3A})$.

In this process, DS_{1A} is on country 1 and DS_{2A} and π_{12A} is the part of welfare in country 2. To maximize surplus of country 1, optimal tariff is $\frac{1}{11}(\alpha_{1A}+4c_{2A}-5c_{3A})$. Also country 2 wants $\frac{1}{7}(2\alpha_{1A}+3\alpha_{2A}-4c_{2A}-c_{3A})$. $\frac{1}{11}(\alpha_{1A}+4c_{2A}-5c_{3A})-\frac{1}{7}(2\alpha_{1A}+3\alpha_{2A}-4c_{2A}-c_{3A})$ is $\frac{1}{77}(-15\alpha_{1A}-33\alpha_{2A}+72c_{2A}-24c_{3A})$. This is negative under Assumption 1 and (2.14)

A.7 Multilateralism

- $\tau_{\cdot A}(12|multi) \equiv \arg\max TS_1 + TS_2 = \arg\max(DS_{1A} + DS_{2A} + \pi_{12A})$
  with $\tau_{\cdot A}(12|multi) = \tau_{12A} = \tau_{13A} = \tau_{23A}$

- $\tau_{\cdot B}(12|multi) \equiv \arg\max TS_1 + TS_2 = \arg\max(DS_{1B} + DS_{2B} + \pi_{21B})$
  with $\tau_{\cdot B}(12|multi) = \tau_{13B} = \tau_{21X} = \tau_{23B}$

Each domestic surplus elements are same to customs union case but tariff become different.

$$\begin{aligned}
DS_{1A} &= \frac{1}{18}(2\alpha_{1A}-c_{2A}-c_{3A}-2\tau_{\cdot A})^2+\frac{1}{3}\tau_{\cdot A}(2\alpha_{1A}-c_{2A}-c_{3A}-2\tau_{\cdot A}) && \text{(A.769)}\\
DS_{2A} &= \frac{1}{18}(2\alpha_{2A}-c_{2A}-c_{3A}-\tau_{\cdot A})^2+\frac{1}{3}\tau_{\cdot 3A}(\alpha_{2A}+c_{2A}-2c_{3A}-2\tau_{\cdot A})\\
&\quad +\frac{1}{9}(\alpha_{2A}-2c_{2A}+c_{3A}+\tau_{\cdot A})^2 && \text{(A.770)}\\
\pi_{12A} &= (P_{1A}-c_{2A})q_{12A}=\frac{1}{9}(\alpha_{1A}-2c_{2A}+c_{3A}-\tau_{\cdot A})^2 && \text{(A.771)}
\end{aligned}$$

Then FOC for maximization is

$$\begin{aligned}
0 &= -\frac{2}{9}(2\alpha_{1A}-c_{2A}-c_{3A}-2\tau_{\cdot A})+\frac{1}{3}(2\alpha_{1A}-c_{2A}-c_{3A}-4\tau_{\cdot A})\\
&\quad -\frac{1}{9}(2\alpha_{2A}-c_{2A}-c_{3A}-\tau_{\cdot A})+\frac{1}{3}(\alpha_{2A}+c_{2A}-2c_{3A}-4\tau_{\cdot A})\\
&\quad +\frac{2}{9}(\alpha_{2A}-2c_{2A}+c_{3A}+\tau_{\cdot A})-\frac{2}{9}(\alpha_{1A}-2c_{2A}+c_{3A}-\tau_{\cdot A}) && \text{(A.772)}
\end{aligned}$$

Using FOC, $\tau_{\cdot A}(12|multi) = \frac{1}{15}(3\alpha_{2A}+3c_{2A}-6c_{3A}) = \frac{1}{5}(\alpha_{2A}+c_{2A}-2c_{3A})$. $\tau_{\cdot B}(12|multi)$ is also determined through similar process. In this process, DS_{1A} is on country 1 and DS_{2A} and π_{12A} is the part of welfare in country 2. To maximize surplus of country 1,

optimal tariff is $\frac{1}{8}(2\alpha_{1A} - c_{2A} - c_{3A})$. Also country 2 wants $\frac{1}{7}(-2\alpha_{1A} + 3\alpha_{2A} + 4c_{2A} - 5c_{3A})$. $\frac{1}{8}(2\alpha_{1A} - c_{2A} - c_{3A}) - \frac{1}{7}(-2\alpha_{1A} + 3\alpha_{2A} + 4c_{2A} - 5c_{3A})$ is $\frac{1}{56}(30\alpha_{1A} - 24\alpha_{2A} - 39c_{2A} + 33c_{3A})$. This is positive under Assumption 1 and (2.14).

APPENDIX B

MATHEMATICAL PROOFS

Proof of Lemma 1 $\tau_{ikX}(\Phi) - \tau_{ikX}(ij|FTA) = \frac{1}{88}(14\alpha_{iX} - 21c_{jX} + 7c_{kX}) = \frac{7}{88}\tau_{ijX}(\Phi)$ and this is positive from (2.14). ■

Proof of Lemma 2 $DS_k(ij|FTA) = DS_k(\Phi)$ and only exports from country k are important for total surplus comparison. For good X that country i cannot product, export from k to i is $\frac{1}{9}(\alpha_{iX} + c_{jX} - 2c_{kX} + \tau_{ijX} - 2\tau_{ikX})^2$. Therefore, we can compare $-2\tau_{ikX} + \tau_{ijX}$ for the trade war case and the FTA case. In FTA, $\tau_{ijX}(ij|FTA) = 0$. Therefore, when $2\tau_{ikX}(\Phi) - \tau_{ijX}(\Phi) > 2\tau_{ikX}(ij|FTA)$, exports of good A from k to i increase when there is an i-j FTA.

This condition can be solved as

$$\begin{aligned} & 2\tau_{ikX}(\Phi) - \tau_{ijX}(\Phi) - 2\tau_{ikX}(ij|FTA) \\ = \; & \frac{1}{8}(2(2\alpha_{iX} + c_{jX} - 3c_{kX}) - (2\alpha_{iX} - 3c_{jX} + c_{kX})) - \frac{2}{11}(\alpha_{iX} + 4c_{jX} - 5c_{kX}) \\ = \; & \frac{1}{88}(6\alpha_{iX} - 9c_{jX} + 3c_{kX}) = \frac{3}{88}\tau_{ijX}(\Phi) > 0. \end{aligned}$$

Under Assumption 1 and (2.14), $\tau_{ijX}(\Phi) > 0$ and export from k to i increases under $(ij|FTA)$. Similarly, when $\tau_{jiY}(\Phi) > 0$, export from k to j increases under an FTA. ■

Proof of Lemma 3 $DS_k(ij|FTA - co) = DS_k(\Phi)$ and only exports from country k are significant in total surplus comparisons. Export from country k to i is $\pi_{ikX}(\Phi) = \frac{1}{9}(\alpha_{iX} + c_{jX} - 2c_{kX} + \tau_{ijX} - 2\tau_{ikX})^2$. To identify export change, we must compare $2\tau_{ikX}(\Phi) - \tau_{ijX}(\Phi)$ and $2\tau_{ikX}(ij|FTA - co) - \tau_{ijX}(ij|FTA - co)$.

Due to the FTA, $\tau_{ijX}(ij|FTA - co)$ is defined as zero, and $\tau_{ikX}(ij|FTA - co) = \tau_{ikX}(\Phi)$ and $\tau_{jkX}(ij|FTA - co) = \tau_{jkX}(\Phi)$ are assumed. Under Assumption 1 and (2.14), $\tau_{ijX}(\Phi)$

is positive, $2\tau_{ikX}(\Phi)-\tau_{ijX}(\Phi) < 2\tau_{ikX}(\Phi) = 2\tau_{ikX}(ij|FTA-co)-\tau_{ijX}(ij|FTA-co)$, and then $\pi_{ikA}(\Phi) > \pi_{ikA}(ij|FTA-co)$. Export from country j to i is similar.■

Proof of Proposition 1 Assume that countries 1 and 2 establish an FTA, and then identify what country 1 gets from each policy. Due to tariff coordination, country 1 loses its domestic surplus within the market for good A ($DS_{1A}(12|FTA-co) < DS_{1A}(12|FTA)$), but now country 1 can export more of good B to country 2 ($\pi_{21B}(12|FTA-co) > \pi_{21B}(12|FTA)$). Other elements of the total surplus remain the same. All elements are as below.

$$
\begin{aligned}
CS_{1A}(12|FTA) &= \frac{1}{242}(7\alpha_{1A}-5c_{2A}-2c_{3A})^2 && \text{(B1)}\\
TR_{1A}(12|FTA) &= \frac{1}{121}(\alpha_{1A}+4c_{2A}-5c_{3A})(3\alpha_{1A}+c_{2A}-4c_{3A}) && \text{(B2)}\\
\pi_{21B}(12|FTA) &= \frac{4}{121}(2\alpha_{2B}-3c_{1B}+c_{3B})^2 && \text{(B3)}\\
CS_{1A}(12|FTA-co) &= \frac{1}{1152}(14\alpha_{1A}-9c_{2A}-5c_{3A})^2 && \text{(B4)}\\
TR_{1A}(12|FTA-co) &= \frac{1}{96}(2\alpha_{1A}+c_{2A}-3c_{3A})(2\alpha_{1A}+3c_{2A}-5c_{3A}) && \text{(B5)}\\
\pi_{21B}(12|FTA-co) &= \frac{25}{576}(2\alpha_{2B}-3c_{1B}+c_{3B})^2 && \text{(B6)}
\end{aligned}
$$

Denote $\Delta(CS_{1A}) \equiv CS_{1A}(12|FTA) - CS_{1A}(12|FTA-co)$ and all $\Delta(*)$ similarly. The difference of each element is then

$$
\begin{aligned}
\Delta(CS_{1A})+\Delta(TR_{1A}) &= \frac{1}{22}(\frac{7}{24})^2(2\alpha_{1A}-3c_{2A}+c_{3A})^2 > 0 && \text{(B7)}\\
\Delta(\pi_{21B}) &= -\frac{721}{24^2\cdot 121}(2\alpha_{2B}-3c_{1B}+c_{3B})^2 < 0 && \text{(B8)}
\end{aligned}
$$

Then $\Delta(TS_1)$ is the sum of the two elements above.

$$
\begin{aligned}
\Delta(TS_1) &= \frac{7}{2}(\frac{1}{264})^2\{77(2\alpha_{1A}-3c_{2A}+c_{3A})^2-206(2\alpha_{2B}-3c_{1B}+c_{3B})^2\} && \text{(B9)}\\
\Delta(TS_1)<0 &\iff 77(2\alpha_{1A}-3c_{2A}+c_{3A})^2 < 206(2\alpha_{2B}-3c_{1B}+c_{3B})^2 && \text{(B10)}
\end{aligned}
$$

A similar process shows that $TS_2(12|FTA) < TS_2((12|FTA-co) \iff 206(\tau_{12A}(\Phi))^2 <$

$77(\tau_{21B}(\Phi))^2$. ■

Proof of Proposition 2 Calculation results are as below.

- $TS_i(ij|CU) = TS_j(ij|CU) = \frac{1681}{1296}e$
- $TS_i(ij|FTA-co) = TS_j(ij|FTA-co) = \frac{3353}{2592}e$
- $TS_i(ij|FTA) = TS_j(ij|FTA) = \frac{198793}{156816}e$
- $TS_i(ij|multi) = TS_j(ij|multi) = \frac{7901}{6480}e$. ■

Proof of Proposition 3 (i)

$$\tau_{\cdot kX}(ij|CU-XXIV) = \frac{q_{ikX}\tau_{ikX}(\Phi)+q_{jkX}\tau_{jkX}(\Phi)}{q_{ikX}+q_{jkX}} \tag{B11}$$

$$= \frac{\frac{1}{4}\cdot\frac{1}{4}+\frac{1}{9}\cdot\frac{1}{3}}{\frac{1}{4}+\frac{1}{9}} = \frac{43}{156}e < \frac{1}{3}e = \tau_{\cdot kX}(ij|CU) \tag{B12}$$

(ii)

- $TS_i(ij|FTA-co) = TS_j(ij|FTA-co) = \frac{3353}{2592}e$
- $TS_i(ij|CU) = TS_j(ij|CU) = \frac{1681}{1296}e$
- $TS_i(ij|CU-XXIV) = TS_j(ij|CU-XXIV) = \frac{17710}{13689}e$. ■

Proof of Proposition 4 Lemma 2 suggests that $TS_k(ij|FTA) > TS_k(\Phi)$, and Lemma 3 that $TS_k(\Phi) > TS_k(ij|FTA-co)$. So, $TS_k(ij|FTA) > TS_k(ij|FTA-co)$ is satisfied. Assume that $TS_k(ij|FTA) > TS_k(G) > TS_k(ij|FTA-co)$. Under each regime *, free-riding occurs when $TS_k(ij|*) > TS_k(G)$. In this case, country k chooses free-riding when each of the two FTA member countries chooses its tariff separately. If two countries coordinate implicitly, country k cannot opt to free-ride. ■

Proof of Lemma 4 Assume that country i becomes a hub of two FTAs with countries j and k. The domestic surplus is comparable to that of the domestic surplus under free trade because country i levies no tariff on its imports. See exports from i to k. Under global, tariff-free trade, $\pi_{kiX}(G) = \frac{1}{9}(\alpha_{kX} - 2c_{iX} + c_{jX})^2$ is satisfied. When country i is a hub of two FTAs, country k levies a tariff on country j. Exports will be $\pi_{kiX}(1 - hub) = \frac{1}{9}(\alpha_{kX} - 2c_{iX} + c_{jX} + \tau_{kjX}(ik|FTA))^2$, always higher than export under free trade when the tariff is positive. The export from i to j is similar. ■