CESifo WORKING PAPERS

10767
2023

November 2023

The Free Rider Effect and Market Power in Trade Agreements

Woan Foong Wong

CESifo

Impressum:

CESifo Working Papers
ISSN 2364-1428 (electronic version)
Publisher and distributor: Munich Society for the Promotion of Economic Research - CESifo GmbH
The international platform of Ludwigs-Maximilians University's Center for Economic Studies and the ifo Institute
Poschingerstr. 5, 81679 Munich, Germany
Telephone +49 (0)89 2180-2740, Telefax +49 (0)89 2180-17845, email office@cesifo.de
Editor: Clemens Fuest
https://www.cesifo.org/en/wp
An electronic version of the paper may be downloaded
· from the SSRN website: www.SSRN.com
· from the RePEc website: www.RePEc.org
· from the CESifo website: https://www.cesifo.org/en/wp

CESifo *Working Paper No. 10767*

The Free Rider Effect and Market Power in Trade Agreements

Abstract

Regional trade agreements have proliferated in the past two decades while multilateral trade negotiations have stalled. Both these agreements are governed by the WTO and have to abide by the non-discriminatory (Most-Favored Nation, MFN) clause to varying degrees-regional agreements to a lesser extent than multilateral agreements. This paper investigates the free rider effect that can stem from the MFN clause and how it impacts country incentives towards these agreements. Free-riding occurs because countries cannot be excluded from the benefits of other countries' liberalizations and thus have less incentive to contribute to the cost of liberalization by signing trade agreements and offering their own market access. I extend the equilibrium model of endogenous trade liberalization via trade agreements developed by Saggi and Yildiz (2010) to better capture the effects of MFN. Within multilateral agreements, I show that the free rider effect eliminates global free trade as an equilibrium even when countries have symmetric market power. Within regional agreements, smaller countries are excluded more under the equilibrium with MFN compared to without.

JEL-Codes: F100, F130.

Keywords: trade agreements, tariffs, World Trade Organization, coalition proof Nash equilibrium, multilateral trade agreements, preferential trade agreements, welfare.

Woan Foong Wong
Department of Economics
University of Wisconsin-Madison
1180 Observatory Drive
USA – Madison, WI 53706
woanfoong.wong@wisc.edu

May 8, 2017
I would like to sincerely thank Robert W. Staiger, L. Kamran Bilir, Charles Engel, and Alan Sorensen for their guidance and time. Thanks to all participants in the UW-Madison International Economics Brown Bag Seminar (fall 2013) and Student Research Group workshops. Finally, I am grateful to Mark Colas, Andrea Guglielmo, Joel Han, Kegon Tan, Nathan Yoder, and countless other classmates, friends, and family for all their support. All remaining errors are my own.

1 Introduction

The World Trade Organization (WTO) now counts 160 countries in its membership, and together WTO-member countries account for 96% of world trade. At the same time, countries are signing free trade agreements at an extremely rapid rate while the Doha Round, the WTO's latest multilateral trade agreement, is floundering in its 15$^{\text{th}}$ year of negotiations.[1] Saggi and Yildiz (2010, S&Y) established that market power asymmetry between countries is a key factor in explaining country incentives towards trade agreements. In this paper I investigate another factor, the free rider effect.

The free rider effect can stem from the MFN clause, one of the two main regulations that govern the regional and multilateral trade agreements within the GATT/WTO framework. This clause (GATT Article I) requires its member countries to offer trade liberalizations to each other on a non-discriminatory basis, meaning all member countries must receive the same trade advantages as the "most-favored nation" of the country granting such treatment.[2] I refer to trade agreements among GATT/WTO members that liberalize on an MFN basis as multilateral trade agreements or *multilateralism*.

The other main regulation, GATT Article XXIV, permits member countries to pursue free trade agreements (FTAs) under which concessions to each other do not have to be extended to others (termed here as regional trade agreements or *regionalism*).[3] Two conditions must apply: (1) the trade barriers between the partner countries have to be substantially eliminated, and (2) the external trade barriers should not be increased on average. Under regionalism, MFN still applies to the FTA countries' treatment of the outside WTO member countries and vice versa.

While one benefit of the MFN clause is that it allows for smaller countries to participate in advantages that larger countries often grant to each other, this same benefit also offers an avenue for the failure of trade agreements.[4] The smaller country can choose to stay out

[1]In the 46-year period from 1948 to 1994, the General Agreement on Tariffs and Trade (GATT) received 124 notifications of such agreements. In less than half the time from the World Trade Organization's (WTO) creation in 1995-2013, there has been a more than a four fold increase of 575 such notifications (figure 1).

[2]Figure 2 shows a 3-country setting absent any trade agreement (hereby termed as the status quo trade regime Φ). Under MFN, country i has to extend the same tariff to countries j and k ($t_{ij}^{\Phi} = t_{ik}^{\Phi}$).

[3]Figure 3 shows a 3-country setting with an FTA between countries i and j. The dotted line indicates the FTA, which eliminates their mutual tariffs ($t_{ij} = t_{ji} = 0$). They then individually extend an external tariff to outside country k (t_{ik} and t_{jk}) while country k levies the status quo MFN tariff on them ($t_{ki}^{\Phi} = t_{kj}^{\Phi}$). Article XXIV also covers Customs Unions but it is not the focus of this paper.

[4]Smaller countries are defined as countries with less market power or the smaller importer countries in this model's competing exporter framework. They have relatively larger endowments and therefore higher export surplus from tariff reduction through trade liberalization.

of trade agreements because it cannot be excluded from the benefits from the agreements signed by other countries even though it did not contribute to the costs–in this case offering its own market access–of obtaining the outcome.

In order to study the free rider effect, I first extend the model by S&Y to four countries. This extension better captures the impact of the MFN clause and thus the free rider effect on the regional and multilateral agreement outcomes. S&Y developed a three country equilibrium theory of trade agreements in which the degree and nature (bilateral/regional or multilateral) of trade liberalization are endogenously determined.[5] However, with only three countries, the MFN clause do not apply to the FTA countries' treatment of the outsider country. When two countries sign an FTA, MFN requires them to treat all outside countries equally. But since there is only one outside country, this requirement is not binding. My model better incorporates the MFN effect with four countries. When two countries sign an FTA, they will have to extend the same MFN tariff to *two* outside countries–making the MFN constraint bind here for the FTA countries in addition to the outside countries.[6]

Secondly, I relax the MFN clause restriction on regional trade agreements in order to highlight its role on the country incentives to form regional trade agreements. I also employ a more diverse country assumption by including a medium sized country to allow for a richer set of predictions.

I show that global free trade is no longer an equilibrium in multilateralism even when countries are symmetric in market power because one country always chooses to stay out. This result is in contrast to S&Y. They find that global free trade is always the stable outcome for both multilateralism and regionalism when countries are symmetric. My result demonstrates that the free rider effect, when better incorporated, can drive country incentives in the absence of relative market power, particularly for multilateral agreements. As mentioned before, MFN stipulates that all member countries receive the same trade concessions regardless if they offer their own market access or not. So the incentive to offer their market access is dependent on the liberalization levels offered by other countries. The extent of liberalization by three countries who make up three fourths of the world is a lot more than two countries with two thirds of the market share in the world. This difference makes it profitable for one country to stay out of global free trade and free ride in the four country

[5] In S&Y, bilateralism indicates a trade agreement between countries under Article XXIV. The term regionalism will be used in this paper in place of bilateralism. This is because trade agreements in my model can involve more than 2 countries.

[6] Figure 4 shows a 4-country setting with an FTA between countries i and j (indicated by the dotted line). With four countries, the two countries in an FTA will have to extend the same external tariff to outside countries k and l under MFN while the outside countries have to do the same for both FTA countries.

model .

Additionally, I show that in the equilibrium with MFN, small countries are left out of more regional trade agreements compared to the equilibrium without. This is because the penalty of being outside of trade agreements are higher without MFN. So the larger countries have an incentive to stay in trade agreements more. However, removing MFN to allow for small countries to be included in more regional trade agreements is not necessarily socially optimal. When the equilibrium outcomes remain the same, total welfare under MFN is higher compared to without MFN. Total welfare is only lower in the parameter space where the smaller countries are left out under MFN but included when MFN is removed.

This paper studies the country incentives in Article XXIV and multilateral trade negotiations and how they relate to global free trade. However, the analysis of equilibrium outcomes beyond three countries is rarely done with the exception being Mrázová, Vines and Zissimos (2013). Aghion, Antràs and Helpman (2007) uses a leading-country bargaining model to study how free trade agreements are negotiated with subsets of countries or multilateral agreements with all countries at once. Fundamental differences between Aghion, Antràs and Helpman (2007) and my model include their use of a leading-country framework and their assumption of transferable utility, and my four country analysis.[7] As well, this paper complements the literature on free riders due to MFN. Ludema and Mayda (2009) modeled multilateral negotiations as a mechanism design problem with voluntary participation and has shown empirical evidence of the free rider problem using sector-level US tariff data. Baldwin (1989) pointed out that trade policy has the characteristic of a public good since the beneficiaries from a policy such as liberalization from trade agreements within the WTO cannot be excluded from its benefits, even though the country does not contribute to the outcome.

This paper also contributes to studies on the effects of allowing countries to form FTAs under Article XXIV on equilibrium trade agreement outcomes given country asymmetry. Mrázová, Vines and Zissimos (2013) analyzed the welfare effects of custom unions (CUs) formed within Article XXIV and without. Using a multi-country oligopology model with endogenous CUs formation, they use the substitutability between varieties to generate the CU equilibrium structure. Their focus on CUs is inherently different from this paper, since in CUs countries can coordinate on their external tariff while FTA countries are not able to. Also, there are substantially more incidences of FTAs than CUs–92% of RTAs are FTAs–and so this paper chooses to focus on FTAs.[8] However this paper's symmetric endowment as-

[7]Other earlier work include Freund (2000), Riezman (1999), and Bagwell and Staiger (1997).

[8]Of the 381 RTAs currently in force, 226 fall under GATT Article XXIV of which 209 are FTAs while

sumption for the 4-country WTO regionalism model is similar to their perfectly independent goods assumption, and my results are consistent with theirs in that global free trade is the equilibrium outcome.[9] Also, the substitution index across varieties in Mrázová, Vines and Zissimos (2013) is identical across countries, thus rendering the countries generally symmetric to each other. The optimal tariff of a CU then depends only on the size of the union. Seidmann (2009) studied both CUs and FTAs under Article XXIV in a three country sequential model where the agreements countries have already signed affect their strategic positions in future negotiations. Strategic interactions are not pursued in this paper since my model is static. Saggi, Woodland and Yildiz (2013) revisited the S&Y model to study global free trade outcomes when countries are given the option to form CUs under Article XXIV or to negotiate multilaterally instead. They continued to use the three country model and the same endowment asymmetry pattern.

Section 2 introduces the model's theoretical framework. Sections 3 and 4 present the multilateral and regional trade agreement outcomes respectively. Section 5 detail the equilibrium results when the MFN clause is relaxed and section 6 concludes.

2 Theoretical Framework

2.1 Model

The model used in this analysis is based on S&Y's adaptation of the partial equilibrium competing exporters framework in Bagwell and Staiger (1999*b*). There are four countries $(a, b, c, \text{and}\, d)$ and four (non-numeraire) goods $(A, B, C, \text{and}\, D)$. The demand function is derived from the quasilinear utility function

$$U(c_z) = \sum_{z=A,B,C,D} \left[\alpha c_z - \frac{1}{2}(c_z)^2\right] + w$$

where c_z denotes consumption of good z and w denotes the numeraire good. Demand for good z in country i is $d(p_i^z) = \alpha - p_i^z$ where $z = A, B, C, \text{or}\, D$. Country i is endowed with zero units of good I and e_i units of the other goods. All countries have large enough endowments of the freely traded numeraire good w that they consume in positive quantities. Since each

only 17 are custom unions.

[9] Countries in a CU are able to coordinate their external tariffs while FTA countries can not. In my model, the ability to coordinate on tariffs means that their mutual FTA tariffs will go to zero–the requirement of a regional agreement under the WTO. As such, our results are comparable under these circumstances.

country is endowed with only three goods while it demands all four, country i must import good I from its three competing exporters j, k, and l $(i, j, k, l = a, b, c, d)$. For example, country a imports good A from countries b, c, and d while it has e_a units of goods B, C, and D to export to countries b, c, and d respectively.

Let p_i^I be the price of good I in country i and t_{ij} be the tariff imposed by country i on its imports of good I from country j. The no-arbitrage condition for good I where $i, j, k, l = a, b, c, d$, and $i \neq j \neq k \neq l$ is:

$$p_i^I = p_j^I + t_{ij} = p_k^I + t_{ik} = p_l^I + t_{il} \tag{1}$$

Let m_i^I be country i's imports of good I. Without any endowment of good I, country i's imports are equal to its demand:

$$m_i^I = d\left(p_i^I\right) = \alpha - p_i^I \tag{2}$$

Let x_j^I be country j's exports of good I. Country j exports its endowment of good I after satisfying local demand:

$$x_j^I = e_j - \left[\alpha - p_j^I\right] \tag{3}$$

The market clearing condition for good I means that country i's imports should equal the total exports from the three other countries:

$$m_i^I = \sum_{j \neq i} x_j^I \tag{4}$$

The combined equations above implies that the equilibrium price of good I in country i is:

$$p_i^I = \frac{1}{3}\left[3\alpha - \sum_{j \neq i} e_j + \sum_{j \neq i} t_{ij}\right] \tag{5}$$

In this model country i can only levy a tariff on good I–the only non-numeraire good it imports since it has no endowment of this good. Thus each country has market power it can exploit via its tariffs–no country is a price taker. Assuming asymmetric endowments $e_a \leq e_b \leq e_c \leq e_d$, under free trade country a is the largest importer of the four countries (it imports $\frac{(e_b+e_c+e_d)}{4}$ units of good A) whereas country d is the smallest (it imports $\frac{(e_a+e_b+e_c)}{4}$ units of good D). Also, note that country i's imports of good I does not equal its exports of other non-numeraire goods–under free trade country a exports $\frac{(3e_a-e_b-e_d)}{4}$ units of good C to country c and $\frac{(3e_a-e_c-e_d)}{4}$ units of good B to country b. The sum of these exports is lower than its total imports of good A. In fact, given this assumption, country a imports more than it exports while country d exports more than it imports. This means that country a's foreign export supply elasticity is the highest–meaning it has the most market power–while country d's foreign export supply elasticity is the lowest–it has the least market power. For trade to be balanced, country a exports the numeraire good on top of goods B, C and D to countries $b, c,$ and d. By the same reasoning, country c imports the numeraire good from both its trading partners.

Since this is a partial equilibrium model, only the protected goods are considered in the welfare calculations. A country's welfare is defined as the sum of consumer surplus (CS), producer surplus (PS), and tariff revenue (TR) over all such goods.[10] Using equations 1 through 5 country i's welfare is then calculated as a function of endowment levels and tariffs.

The equilibrium concept used in this paper is coalition proof or stable Nash equilibrium from Bernheim, Peleg and Whinston (1987) as well as Dutta and Mutuswami (1997). The coalition-proof Nash equilibrium refines the Nash equilibrium by adopting a stronger notion of self-enforceability that allows joint deviations.

When negotiating trade agreements, a three stage game takes place under which each country is free to pursue either (a) no trade liberalization, (b) regional trade liberalization or (c) multilateral trade liberalization.[11] There are no intra-FTA transfers in the game. S&Y's 3-country model and their results are reproduced in appendix A.2.[12] The multilateral trade liberalization setup is explained below first followed by the regional setup.

2.2 Multilateralism

When countries choose to liberalize multilaterally, they first simultaneously announce whether they want to be in a multilateral agreement or not. This informs the resultant trade policy

[10]The welfare function's components are as follows:

$$CS_i = \frac{1}{2}\left[(m_i^I)^2 + (m_i^J)^2 + (m_i^K)^2 + (m_i^L)^2\right]$$

$$PS_i = (e_i - x_i^J)p_i^J + (e_i - x_i^K)p_i^K + (e_i - x_i^L)p_i^L + (p_j^J - t_{ij})x_i^J + (p_k^K - t_{ik})x_i^K + (p_l^L - t_{il})x_i^L$$

$$TR_i = t_{ij}x_j^I + t_{ik}x_k^I + t_{il}x_l^I$$

[11]It is acknowledged that options (b) and (c) can be pursued simultaneously in reality but this scenario is not explored in this paper.

[12]I was able to replicate all of S&Y's welfare levels under different policy regimes–bilateralism and multilateralism as detailed in Appendix A.1, S&Y. However, two of my welfare comparison levels under symmetry differ from S&Y. Please see Appendix A.1 for a detailed examination of this discrepancy.

regime. At the second stage, given the policy regime, countries choose their optimal tariffs. Lastly, international trade and consumption take place given the policy regime and tariffs.

The following trade policy regimes can emerge under multilateralism given a country i's choice set of $\Omega_i^M = \{\ \{\phi\}\,, \{M\}\ \}$:

(i) No agreement or status quo, $\langle\{\Phi\}\rangle$. This happens when no countries announce in favor of multilateral trade liberalization.

(ii) A multilateral trade agreement between two countries. The example $\left\langle\{ij^M\}\right\rangle$ happens when countries i and j announce in favor of multilateral trade liberalization while countries k and l announces against it.

(iii) A multilateral trade agreement between three countries. The example $\left\langle\{ijk^M\}\right\rangle$ happens when countries i, j, and k announce in favor of multilateral trade liberalization while country l announce against it.

(iv) Global Free Trade, $\langle\{F\}\rangle$. When all four countries announce in favor of multilateral trade liberalization, they will jointly choose the optimal set of tariffs which in this model is equal to zero–necessarily leading to global free trade.

When no FTAs are signed, the resulting regime is the status quo regime $\langle\{\Phi\}\rangle$ and each country imposes a non-discriminatory status quo tariff on its trading partners. Country i's optimal MFN tariff solves $\arg\max \omega_i(\Phi)$ where $i, j, k, l = a, b, c, d$:[13]

$$\tau_i^{\Phi} = \frac{e_j}{15} + \frac{e_k}{15} + \frac{e_l}{15} \tag{6}$$

Every country's status quo tariff increases in their trading partner's endowment, which reflects the country's role as the sole importer of its non-numeraire good. As the trading partner's endowment increases or its role as an importer decreases, its foreign export supply elasticity and thus market power decreases since its export surplus from additional access to the home country's market is now higher. This translates into a higher optimal tariff by the home country on its trading partner.

When countries i and j agree to sign a multilateral agreement ($1M$), $\left\langle\{ij^M\}\right\rangle$, by MFN they choose the tariff pair $\left(\tau_i^{1M}, \tau_j^{1M}\right)$ to maximize the sum of their welfare functions condition

[13]To differentiate the tariffs in the 4-country setting from S&Y's 3-country setting, τ is used as the symbol for tariffs instead of t. As well, the welfare ω is used instead of w.

upon them extending the same tariff to the outside countries ($\tau_i^{1M} = \tau_j^{1M} \equiv \tau^{1M}$):

$$\tau_i^{1M} = \frac{e_k}{7} - \frac{e_j}{7} + \frac{e_l}{7} \tag{7}$$

Here the multilateral tariff, which is extended to all countries regardless of whether they are part of the agreement or not, increases with the endowments of non-member countries l and k but decreases the endowment of partner country j. The positive effect of the non-member's endowment on the external tariff follows the same logic as the positive effect of countries' endowment on the status quo tariff (equation (6)). As the non-member's endowment increases, it has a higher export surplus from the home country's tariff reduction. So the home country can then optimally charge a higher external tariff to the non-member country. On the other hand since the home country's partner already has unrestricted access to its market, as the partner's endowment increases relative to the non-member, the home country will find it optimal to lower its tariff on the external member in order to keep the price of its import good low.[14]

When three countries, for example i, j, and k, agree to enter into a multilateral trade agreement $\langle \{ijk^M\} \rangle$, their optimal multilateral tariff $\left(\left(\tau_i^{2M}, \tau_j^{2M}, \tau_k^{2m}\right)\right.$ where $\tau_i^{2M} = \tau_j^{2M} = \tau_k^{2M} \equiv \tau^{2M}\left.\right)$ is:

$$\tau_i^{2M} = \frac{3\, e_l}{13} - \frac{e_j}{13} - \frac{e_k}{13} \tag{8}$$

Here again the multilateral tariff is decreasing in members' endowments but increasing in non-member l's endowment. Imposing symmetry to compare both tariffs, $\tau^{2M} < \tau^{1M}$ if $e_i = e$ for all $i = a, b, c, d$ shows that a multilateral agreement between three countries result in further tariff reduction than a multilateral agreement between only two. This shows that tariff complementarity effect applies here in addition to S&Y and Bagwell and Staiger (1999a,b), where subsequent trade agreements will induce member countries to reduce external tariffs on outside countries: $\tau^{2M} < \tau^{1M} < \tau^{\Phi}$ if $e_i = e$ for all $i = a, b, c, d$.

2.3 Regionalism

Under a regional approach to trade liberalization, countries simultaneously announce the countries which they want to sign an FTA with. Given the policy regime, countries choose their optimal tariffs and given both the policy regime and tariffs, international trade and consumption take place.

[14]This situation arises because there are no country budget constraints or upper bounds on consumption.

Given country i's choice set of $\Omega_i = \{\ \{\phi,\phi,\phi\},\ \{j,\phi,\phi\},\ \{\phi,k,\phi\},\ \{\phi,\phi,l\},\ \{j,k,\phi\},\ \{j,\phi,l\},\ \{\phi,k,l\},\ \{j,k,l\}\ \}$, the following trade regimes can emerge from the set of possible trade regimes:

(i) No agreement or status quo, $\langle\{\Phi\}\rangle$, when no FTA announcements match or when the only announcements are for the status quo (ϕ). MFN applies here since any country not in any FTAs (say country i) will have to extend a non-discriminatory tariff on all three other countries $j, k,$ and l.

(ii) One FTA in the regime. Example $\langle\{ij\}\rangle$ happens when countries i and j announce each others' names. Here Article XXIV applies to the FTA countries, while MFN applies to both sets of countries outside *and* inside the FTA. In the 3-country model, MFN only applied to the outside country in this regime.

(iii) Two independent FTAs. The example $\langle\{ij, kl\}\rangle$ happens when (1) countries i and j announce each others' name and (2) countries k and l announce each others' name.

(iv) Two independent FTAs with a common member country. The example $\langle\{ij, ik\}\rangle$ happens when (1) countries i and j announce each others' name and (2) countries i and k announce each others' name. This is termed a *hub and spoke* agreement where the hub country i has independent FTAs with each of the two spoke countries who do not have an FTA with each other. The notation from here on is condensed to $\langle\{ih\}\rangle$ for hub country i.

(v) Three independent FTAs with a common member country, hereby termed the *full hub and spoke* agreement. If the full hub country is i, $\left\langle\{ih^{jkl}\}\right\rangle$ happens when (1) countries i and j announce each others' name, (2) countries i and k announce each others' name, and (3) countries i and l announce each others' name. j, k, and l do not have FTAs with each other.

(vi) When there are more than four total FTAs in the trade regime, the hub and spoke notation in (v) is used to condense FTA notation. An example is $\left\langle\{ih^{jk}, lh^{jk}\}\right\rangle$. Here all four countries are in two FTAs each and so the hub notation is applied. Of course this hub notation can also be applied to countries j and k as well–there are multiple ways to document these trade regimes as explained below.

(vii) Global free trade, $\langle\{F\}\rangle$, when all countries announce each others' names.

A visual representation of all possible trade regimes are shown in figure 7. Table 2 presents the corresponding notation of all these trade regimes. The columns in the table and figure show total trade agreements in each trade regime while the rows the number of FTAs country i is involved in. There are more than one possible configuration for some trade regimes.[15] There are also multiple ways to describe these trade regimes.[16]

When countries i and j sign an FTA, the optimal external tariffs of the member countries in one FTA $1f$ on non-member countries k and l is:

$$\tau_i^{1f} = \frac{3\,e_k}{14} - \frac{5\,e_j}{14} + \frac{3\,e_l}{14} \quad \text{and} \quad \tau_j^{1f} = \frac{3\,e_k}{14} - \frac{5\,e_i}{14} + \frac{3\,e_l}{14} \tag{9}$$

Compared to the multilateral tariffs, there are now separate weights on each country's endowment compared since the FTA member countries can impose a different external tariff on the outside countries. The external tariff increases with the endowments of the non-member countries k and l, but decreases with the endowment of its own partner (i or j). The positive effect of the non-member's endowment on the external tariff follows the same logic as the positive effect of countries' endowment on the multilateral and status quo tariffs.

When a country signs two FTAs $2f$ (example $\langle\{ih^{jk}\}\rangle$), the optimal external tariffs of the member countries on non-member country l are:

$$\begin{aligned}
\tau_i^{2f} &= \frac{11\,e_l}{23} - \frac{5\,e_k}{23} - \frac{5\,e_j}{23} \\
\tau_j^{2f} &= \frac{11\,e_l}{23} - \frac{5\,e_k}{23} - \frac{5\,e_i}{23} \\
\tau_k^{2f} &= \frac{11\,e_l}{23} - \frac{5\,e_j}{23} - \frac{5\,e_i}{23}
\end{aligned} \tag{10}$$

Similar to the one FTA case, here the external tariff increases with the endowment of the non-member country l but decreases with the endowment of its own partner (i, j, or k). The difference here is the tariff's sensitivity to these endowments. This $2f$ external tariff is

[15] This multiple configuration situation happens 4 times: when there are two total FTAs and country i is in one of them, when there are three total FTAs and country i is in one and two of them, and when there are four total FTAs and country i is in two of them.

[16] As an example, when there are four FTAs in total and country i is included in one FTA, $\langle\{jh^{ikl}, kl\}\rangle$ is the combination where country j is in an FTA with three other countries while countries k and l have an FTA together. Another description possibility is $\langle\{jh^{il}, kh^{jl}\}\rangle$. A second example is when there are five FTAs in total and country i is included in two FTAs, $\langle\{kh^{ijl}, jh^{il}\}\rangle$. Here country i and country l each have two FTAs with countries j and k, while j and k are in FTAs with all countries. Another alternate way of writing this combination is $\langle\{jh^{ikl}, kh^{il}\}\rangle$ where all of j's FTAs are grouped together first. As such, figure 7 provides a more direct presentation of these trade regimes.

the same tariff that country i will extend to outside country l if it it is in a free trade area with countries j and k, where all these three countries have FTAs with each other (trade regime $\langle\{ih^{jk}, jk\}\rangle$). Imposing symmetry, the tariff complementarity effect applies here as well: $\tau^{2f} < \tau^{1f} < \tau^{\Phi}$.

2.4 Tariff Non-negativity Condition

It should be noted that both the multilateral and regional tariffs under this model can be optimally negative. This is because the home country's import good price is inversely related to the exports it receives from its trading partners, e_j and e_k (equation (5)). So if the partner's endowment is too large, in order to keep the home country's import good price low, it might be optimal for country i to subsidize trade from its outside countries by charging a negative external tariff. For example, negative tariffs happen for $1f$ when i's partner j's endowment e_j becomes larger than $\frac{6}{5}$ relative to the non-members' endowments (e_k or e_l) or when the outside country k or l's endowments become smaller than $\frac{2}{3}$ relative to the FTA member j's endowment e_j. For $2f$ tariffs this happens when i's FTA partners j or k's endowments become larger than $\frac{6}{5}$ relative to the non-members' endowment (e_l) or when outside country l's endowment becomes smaller than $\frac{10}{11}$ relative to the FTA members. This applies to $1m$ and $2m$ tariffs as well. Since this paper is focusing on tariffs and not export subsidies, a non-negativity condition will be imposed. The 2-FTA tariff condition $2f$ (equation (10)) is the most stringent and will be used to inform the assumption for non-negative tariffs: $\min\{e_i, e_j, e_k, e_l\} \geq \frac{10}{11} \max\{e_i, e_j, e_k, e_l\}$.[17]

The next section introduces the multilateralism country incentives and its stable Nash equilibrium. The first equilibrium employs a simple asymmetry assumption with two country types following S&Y and then includes a medium country as a third country type.

3 Multilateral Trade Agreements

The country incentives for multilateral trade agreements can be shown as follows:[18]

Lemma 1. *Let country i be a member of the multilateral agreement with country j under regime r^M but not under regime v^M and let the status of countries k, and l be the same under*

[17] This non-negativity condition is more restrictive than the 3-country model. This implies that in this 4-country model, countries have to be more homogeneous in size otherwise it would be optimal for trade to be subsidized in order to keep prices low.

[18] Welfare levels are reported in Appendix C.1 and are used to prove the following lemma.

both regimes. Then the following holds under multilateralism:

(i) $\frac{\partial \triangle \omega_i(r^M - v^M)}{\partial e_i} \geq 0$;

(ii) $\frac{\partial \triangle \omega_i(r^M - v^M)}{\partial e_j} \leq 0$; *and*

(iii) $\frac{\partial \triangle \omega_i(r^M - v)}{\partial e_x} \leq 0$ *for* $e_x = e_k, e_l$

In point (i), as the home country's endowment (i in this case) increases, their marginal welfare from signing one more multilateral trade agreement increases. This is because they become smaller importers relative to their exports thereby weakening their market power. Their trade liberalization loss decreases compared to their liberalization gain in export surplus since their own tariff reduction now applies to a smaller amount of imports.

On the other hand, when the endowment of the home country's potential partner (j) increases (in point (ii)), their marginal welfare from signing one more multilateral trade agreement decreases. This is because the home country becomes the bigger importer with more market power compared to its partner, meaning that the home country's liberalization loss is bigger due to the tariff reduction applying to a larger amount of imports. As such lemma 1 implies that countries prefer to form multilateral agreements with countries stronger in market power (with smaller endowments):

$$\omega_i(ij^{xM}) \geq \omega_i(ik^{xM}) \text{ iff } e_j \leq e_k, \ x = 1, 2 \tag{11}$$

In point (iii), a country's multilateral incentives to both outside countries' endowments are always negative. This is because under multilateralism countries i and j have to extend their negotiated tariffs to outside countries k and l. So as either countries k and l become weaker in market power (or gets larger in endowments), the smaller will be the export surplus increase that countries i and j get from the multilateral agreement since countries k and l now gain greater access to their markets.[19]

3.0.1 Baseline Equilibrium under Multilateralism

The stable Nash equilibrium under multilateralism will be solved under two different endowment asymmetry assumptions. First, this paper follows the asymmetric endowment pattern assumed by S&Y in the 3-country model with two country types as a baseline: three countries (denoted by s, s', and $\bar{s}$) who have larger endowments and thus are smaller importers

[19] These incentive results are the same as the S&Y multilateralism incentives in their 3-country model.

with weaker market power compared to a third (denoted by l).[20] The relative size of the larger importer will be constrained by the tariff non-negativity assumption mentioned earlier (equation (10)). For ease of reference, the larger endowment country will now be referred to as the smaller importer country with weaker market power and vice versa.

Next, the endowment pattern is expanded to include medium country: two smaller countries (denoted by s and s'), one large country with more market power (denoted by l), and one medium country whose endowment and thus market power is the average of a small and large country. This more diverse country type assumption will allow for a richer set of predictions, particularly for the MFN effect on regional trade agreement outcomes.

The following endowment asymmetry for the countries is employed for the baseline equilibrium:

Assumption 1.

$$e_l = \frac{e}{\theta} \leq e_s = e_{s'} = e_{\bar{s}} = e \textit{ and } 1 \leq \theta \leq \frac{11}{10} \tag{12}$$

For the stable equilibrium, we start by testing the stability of global free trade. Under assumption 1, we see that either the large country or one of the small country (say s) will have a profitable deviation from $\langle\{F\}\rangle$ to $\left\langle\{s\bar{s}s'^M\}\right\rangle$ or $\left\langle\{\bar{s}s'l^M\}\right\rangle$:

$$\triangle\, \omega_s(F - \{\bar{s}s'l^M\}) < 0 \text{ and } \triangle\, \omega_l(F - \{s\bar{s}s'^M\}) < 0 \text{ for all } \theta \tag{13}$$

In fact, being the outside country is the most profitable for both the large and one of the small countries:[21]

Lemma 2. *Under assumption 1, the welfare from being the outside country while the others are in a multilateral agreement is the highest over all other regimes for the large country ($\left\langle\{s\bar{s}s'^M\}\right\rangle$) and one of the small countries (say s in $\left\langle\{\bar{s}s'l^M\}\right\rangle$):*

$$\begin{aligned} \omega_l(\{s\bar{s}s'^M\}) > \max(\omega_l(F), \omega_l(\{\bar{s}s'l^M\}), \omega_l(\{\bar{s}s'^M\}), \omega_l(\{s'l^M\}), \omega_l(\Phi\}) \textit{ and} \\ \omega_s(\{\bar{s}s'l^M\}) > \max(\omega_s(F), \omega_s(\{s\bar{s}s'^M\}), \omega_s(\{\bar{s}s'^M\}), \omega_s(\{s'l^M\}), \omega_s(\Phi\}) \end{aligned} \tag{14}$$

The stable equilibria from multilateralism can be stated in the following proposition and is illustrated in figure 5 (see Appendix B.2 for proof):

[20] This notation is completely opposite to S&Y's notation. In S&Y's 3-country model the larger endowment countries (who are thus smaller importers) are termed l and l' while the smaller endowment country is termed s. I switched the notation because in this competing exporter framework, a country's import volume defines how much more market power it has and thus the tariff it can charge.

[21] Welfare levels are reported in Appendix B.1 and are used to prove the following lemma along with assumption 1.

Proposition 1. *The unique stable Nash equilibrium under 4-country multilateralism when countries are symmetric is a multilateral agreement with three countries while the fourth country stays out. This fourth country has a profitable incentive to not participate in the agreement and free ride from its benefit.*

There are two stable Nash equilibrium outcomes under 4-country multilateralism when countries are asymmetric given assumption 1. When countries are similar in market power, both these agreements are stable. The first is an agreement with all small countries while the large country stays out ($\langle\{s\bar{s}s'^M\}\rangle$) and the second agreement involves the large country while one small country stays out ($\langle\{\bar{s}s'l^M\}\rangle$). The small country's decision to not participate in the agreement is driven by the free rider effect while the large country's decision is due to its market power. When countries diverge further, the large country chooses to stay out of multilateral agreements permanently and only the agreement with small countries is stable.

Formally, the stable Nash equilibrium under 4-country multilateralism and assumption 1 is:

(i) $\langle\{s\bar{s}s'^M\}\rangle$ *and* $\langle\{\bar{s}s'l^M\}\rangle$ *are both stable when* $\theta \leq \theta_l(\{\bar{s}s'l^M\} - \{\bar{s}s'^M\})$.

(ii) $\langle\{s\bar{s}s'^M\}\rangle$ *is uniquely stable when* $\theta\ \theta_l(\{\bar{s}s'l^M\} - \{\bar{s}s'^M\})$.

When all four countries are symmetric, one of them will choose to stay out of multilateral agreements. As the country sizes differ moderately, there are two stable equilibria: one where a small country has an incentive to stay out of the multilateral agreements and another where the larger country stays out. When the degree of asymmetry is sufficiently large, the larger country will have an incentive to always stay out of the agreements. The symmetric and small country's decisions highlight the free rider effect from the MFN clause. It has been shown in lemma 1 that small countries always have an incentive to sign multilateral agreements with larger countries. However, here these countries can achieve higher welfare by staying out and free-riding from the trade liberalization benefits of the other three countries regardless of size.

This result is a departure from S&Y where global free trade is a stable outcome when countries are symmetric and moderately similar in size. One of their main results is the importance of country asymmetries in determining trade agreement incentives and they drew this conclusion from global free trade being the unique stable Nash equilibrium in multilateralism and regionalism when countries are symmetric. As country market power asymmetry increases in their model, the bigger country with more market power will ultimately choose to stay out thereby explaining the breaking down of trade agreements. In my model, I show a second mechanism at work by adding one more country–the free rider effect–which is a reflection of a country's absolute level of market power.

Starting from the symmetric case, the intuition behind the fourth country's decision to stay out of the agreements can be summarized into two factors. First, if the fourth country joins the resultant trade regime will be global free trade and it will not face any tariffs from its trading partners. This is the marginal benefit of joining: its exporters will have more market access to partner countries and its consumers can buy cheaper import goods. However, it will also no longer receive any tariff revenue. This is its marginal cost of joining. With four countries, its marginal cost of joining is larger than its marginal benefit. With three countries the reverse result is true.

To see the difference between the three and four country models, I present the symmetric multilateral and status quo tariffs in each. In the three country model each symmetric country makes up a third of the world and if the third country stays out the resultant two-country multilateral tariff is $\frac{e}{7}$. At this level of tariff which its consumers and exporters have to face, the country is better off joining and forgoing its status quo tariff revenue at $\frac{e}{4}$.

In the four country world however, the resultant three-country multilateral tariff if the fourth country stays out is now $\frac{e}{13}$, half of the initial two-country tariff in the three country model. Now the revenue it can generate from charging the status quo tariff at $\frac{e}{5}$ outweighs the cost its consumers and exporters face with such a small three-country multilateral tariff. This change in equilibria is driven by the low multilateral tariff. The extent of liberalization by three countries who make up three fourths of the world is a lot more and this makes it profitable for the outside country to free ride in the four country model instead of in the three. This result can be summarized in the following proposition:

Proposition 2. *Global free trade is no longer a multilateral trade agreement equilibrium due to the free rider effect in 4-country multilateralism. One country, regardless of market power, will choose to stay out of the multilateral agreement and free ride from its trading partners who are in the agreement. This equilibrium is stable when all countries are symmetric or moderately different in market power. This result is a departure from 3-country multilaralism where global free trade is an equilibrium. The free rider effect has important implications for multilateral trade agreements outcomes.*

It is important to note that these results highlight the structure of the competing exporter framework of this model. Countries have overlapping export goods (each pair of countries have three common export goods) but no overlapping import goods. As such, the sole importer country can charge a high tariff on its imports by being outside of the multilateral agreements but benefit from new market access negotiated by the participating countries. While this overlapping exports feature is also present in the 3-country model its effects are more pronounced here due to the introduction of one additional country and one additional traded good. As such a similar increment in the endowment asymmetry parameter θ in a 4-country model will have larger effects on the differences in market power and the multilateral liberalization (thus free rider effect) than in a 3-country model.

3.0.2 Equilibrium under Multilateralism with diverse country types

Now the following endowment asymmetry for the countries is assumed to include a medium country. For simplicity, the medium country's size is assumed to be the average of the small and large countries.

Assumption 2.

$$e_l = \frac{e}{\theta} \leq e_m = \frac{1}{2}e_l + \frac{1}{2}e \leq e_s = e_{s'} = e \textit{ and } 1 \leq \theta \leq \frac{11}{10} \tag{15}$$

For the stable equilibrium, we start by testing the stability of global free trade. Under assumption 2, we see that either the large, medium, or one of the small country (say s) will have a profitable deviation away from $\langle\{F\}\rangle$:

$$\triangle\omega_l(F - \{ss'm^M\}) < 0,\ \triangle\omega_m(F - \{ss'l^M\}) < 0 \text{ and } \triangle\omega_s(F - \{s'ml^M\}) < 0 \text{ for all } \theta \tag{16}$$

Similarly, being the outside country is the most profitable for all of these countries:[22]

Lemma 3. *Under assumption 2, the welfare from being the outside country while the others are in a multilateral agreement is the highest over all other regimes for all country types:*

$$\begin{aligned}
\omega_l(\{ss'm^M\}) >& \max(\omega_l(F), \omega_l(\{sml^M\}), \omega_l(\{ss'l^M\}), \omega_l(\{ss'm^M\}), \omega_l(\{ss'^M\}),\\
&\omega_l(\{sm^M\}), \omega_l(\{sl^M\}), \omega_l(\{ml^M\}), \omega_l(\Phi\})\\
\omega_m(\{ss'l^M\}) >& \max(\omega_m(F), \omega_m(\{sml^M\}), \omega_m(\{ss'm^M\}), \omega_m(\{ss'm^M\}), \omega_m(\{ss'^M\}),\\
&\omega_m(\{sm^M\}), \omega_m(\{sl^M\}), \omega_m(\{ml^M\}), \omega_m(\Phi\}) \quad \textit{and}\\
\omega_s(\{s'ml^M\}) >& \max(\omega_s(F), \omega_s(\{sml^M\}), \omega_s(\{ss'l^M\}), \omega_s(\{ss'm^M\}), \omega_s(\{ss'^M\}),\\
&\omega_s(\{sm^M\}), \omega_s(\{s'm^M\}), \omega_s(\{sl^M\}), \omega_s(\{s'l^M\}), \omega_s(\{ml^M\}), \omega_s(\Phi\})
\end{aligned} \tag{17}$$

[22] Welfare levels are reported in Appendix B.2 and are used to prove the following lemma along with assumption 2.

The stable equilibria from multilateralism can be stated in the following proposition and is illustrated in figure 6 (see Appendix B.3 for proof):

Proposition 3. *In a stable Nash equilibrium under 4-country multilateralism and more diverse country assumption 2, the free rider effect dominates initially when countries are more similar in market power. Trade regimes where one of each country type chooses to stay out are all stable: ($\langle\{ss'm^M\}\rangle$ for the large, $\langle\{ss'l^M\}\rangle$ for the medium, and $\langle\{sml^M\}\rangle$ for the small).*

When countries are more divergent in market power, the larger countries choose to stay out permanently. First the large country stays out of its agreement with the small countries ($\langle\{ss'l^M\}\rangle$) and then its agreement with the small and medium countries ($\langle\{sml^M\}\rangle$). When the country differences increase further, the medium country also chooses to stay out resulting in just a multilateral agreement between the small countries.

Formally, the stable Nash equilibrium under 4-country multilateralism and assumption 2 is:

(i) $\langle\{ss'l^M\}\rangle$, $\langle\{sml^M\}\rangle$, *and* $\langle\{ss'm^M\}\rangle$ *are stable when* $\theta \leq \theta_l(\{ss'^M\} - \{ss'l^M\})$.

(ii) $\langle\{sml^M\}\rangle$ *and* $\langle\{ss'm^M\}\rangle$ *are stable when* $\theta \in (\theta_l(\{ss'^M\} - \{ss'l^M\}), \theta_l(\{sm^M\} - \{sml^M\})]$.

(iii) $\langle\{ss'm^M\}\rangle$ *is uniquely stable when* $\theta \in (\theta_l(\{sm^M\} - \{sml^M\}), \theta_m(\{ss'^M\} - \{ss'm^M\})$.

(iv) $\langle\{ss'^M\}\rangle$ *is uniquely stable when* $\theta > \theta_m(\{ss'^M\} - \{ss'm^M\})$.

While the main results do not change from Proposition 1, the additional country type allows for both the free rider and market power asymmetry effects to be observed in stages. When countries are similar in sizes, any one of the three country types has an incentive to stay out and free ride. This results in multiple equilibria. As market power asymmetry diverges, the large country with more market power will choose to stay out permanently. When market power asymmetry is at its most divergent, the medium country will choose to stay out permanently as well and the smaller countries are left in a multilateral agreement with each other.

4 Regional Trade Agreements

To analyze the regional trade agreements in this model, I start with some general observations about the country incentives. Assuming countries are symmetric ($e_i = e$ for all $i = a, b, c, d$), table 3 presents the symmetric welfare levels calculated from the trade regimes in table 2 and figure 7.[23] A few observations can be drawn:

1. When a country does not participate in any FTAs (going down the second column), its welfare monotonically increases as the total number of FTAs being signed by other countries increases. This is due to the tariff complementarity effect mentioned earlier. The outside country does not give up its market access and treats the other countries on an MFN basis by extending its status quo tariff. On the other hand, it benefits from the decreasing external tariffs as the number of trade agreements signed by the other countries increase.

2. When a country has already signed an agreement with all the available countries (going down the last column), any subsequent trade agreements made between its partner countries with each other will decrease its welfare. This is because with each new trade agreement it will have to share its access to its partner's market with another country.

3. When a country is actively involved in signing trade agreements, i.e. being a part of every new FTA signed (moving across the diagonal), its welfare increase or decrease is path-dependent. A country's welfare increases with the new FTAs when it is not signing on to become a spoke country. Welfare also increases for a hub country when the number of its spokes increase.

Total welfare of countries in all the trade regimes are presented in table 4. Total welfare is higher under global free trade and lowest under status quo.

Relaxing the symmetry assumption, the country incentives for FTAs are established below.[24]

Lemma 4. *Let country j be an FTA partner of country i under regime r but not under regime v and let the status of countries k and l be the same under both regimes. Then the following holds under regionalism:* $\frac{\partial \triangle \omega_i(r-v)}{\partial e_j} \leq 0 \leq \frac{\partial \triangle \omega_i(r-v)}{\partial e_i}$.

Similar to the multilateral trade agreement incentives, as the home country's endowment (i in this case) increases their welfare gain from signing one more trade agreement increases. On the other hand, when the endowment of the home country's potential partner (j) increases, their welfare gain from signing an FTA with that partner decreases. So lemma 4

[23]The fractions have been converted to decimal points for easy reference. Actual fractions are shown in Appendix C.

[24]Welfare levels are reported in Appendix B.1 and are used to prove the following lemmas.

implies that countries prefer to form FTAs with larger countries:[25]

$$\omega_i(ij) \geq \omega_i(ik) \text{ iff } e_j \leq e_k \tag{18}$$

Country FTA incentives with respect to both outside countries' endowments depends on whether the outsiders already have an FTA with the potential partner or not:

Lemma 5. *Let country j be an FTA partner of country i under regime r but not under regime v and let the status of countries k and l be the same under both regimes. Then the following holds under regionalism:*

(i) $\frac{\partial \triangle \omega_i(r-v)}{\partial e_x} \leq 0$ *for* $e_x = e_k, e_l$ *if country x is an FTA partner of country j under regimes r and v; whereas*

(ii) $\frac{\partial \triangle \omega_i(r-v)}{\partial e_x} \geq 0$ *for* $e_x = e_k, e_l$ *if country x is not an FTA partner of country j under regimes r and v.*

When the outside countries (k and l) have an FTA with i's potential partner j, these outsiders already have free access to j's market. So as the outsiders' endowment increases, the trade liberalization benefit from i's FTA with j decreases since i and the outsiders export the same goods to j. If the outsiders do not have an FTA with j, their increase in endowment means that they now have a bigger incentive to sign FTAs since their export surplus gain from FTAs are now higher. So country i has a strategic advantage from an FTA with j since i and the outsiders are competitors for j's market. These FTA incentives are the same as the 3-country model.

Since the full hub country enjoys exclusive market access to all its spoke countries, the lemma below shows that it has no incentive to unilaterally revoke any or all of its FTAs with its spokes. However, a full hub regime is not stable since its spoke countries will unilaterally deviate away from the regime.

Lemma 6. *Welfare from full hub regime, $\omega_i(\{ih^{jkl}\})$, is the highest for country i compared to all other trade regimes, for all $i, j, k, l = a, b, c, d$. However, a spoke in a full hub regime will always unilaterally deviate away $\omega_j(\{ih^{kl}\} - \{ih^{jkl}\}) > 0$, for all $i, j, k, l = a, b, c, d$. As such, a full hub regime is not stable.*

[25] See lemma A-2a, Appendix A.2, for the incentives of the 3-country model.

4.0.1 Baseline Equilibrium under Regionalism

In deriving the stable agreements under regionalism, I start with the baseline endowment assumption 1 as well as the circumstances under which global free trade is stable. Since it has been established from lemma 4 and equation (18) that countries prefer FTAs with larger countries, the following lemma for the three smaller importer countries and their incentives towards global free trade can be stated:[26]

Lemma 7. *Under assumption 1, smaller countries have no unilateral or joint deviations away from global free trade under regionalism.*

Lemma 7 shows that the stability of global free trade depends on the preferences of the large importer country. By direct calculation,

$$\begin{aligned}
&\triangle\, \omega_l(F - \{sh^{l\bar{s}s'}, s'h^{l\bar{s}}\}) \geq 0 \text{ iff } \theta \leq \theta_l(F - \{sh^{l\bar{s}s'}, s'h^{l\bar{s}}\}) = 1.07676; \\
&\triangle\, \omega_l(F - \{sh^{l\bar{s}s'}, \bar{s}s'\}) \geq 0 \text{ iff } \theta \leq \theta_l(F - \{sh^{l\bar{s}s'}, \bar{s}s'\}) = 1.06353 \text{ and} \\
&\triangle\, \omega_l(F - \{sh^{\bar{s}s'}, \bar{s}s'\}) \geq 0 \text{ iff } \theta \leq \theta_l(F - \{sh^{\bar{s}s'}, \bar{s}s'\}) = 1.0139
\end{aligned} \tag{19}$$

The large country has a profitable deviation away from having two FTAs to none at all ($\triangle\omega_l(\{sh^{l\bar{s}s'}, s'h^{l\bar{s}}\} - \{sh^{\bar{s}s'}, \bar{s}s'\}) < 0$; for all θ). It also has a profitable deviation from having one FTA to none at all($\triangle\omega_l(\{sh^{l\bar{s}s'}, \bar{s}s'\} - \{sh^{\bar{s}s'}, \bar{s}s'\}) < 0$ for all θ). As such, together with equation (46) we can show that global free trade is stable when the large country decides to stay out iff $\theta < \theta_l(F - \{\bar{s}h^{ss'}, ss'\})$. The proposition for stable Nash equilibria under regionalism is follows (the rest of the proposition is proven in Appendix B.4):[27]

Proposition 4. *The unique stable Nash equilibrium under 4-country regionalism when countries are symmetric is global free trade. There are three stable Nash equilibrium outcomes when countries are asymmetric given assumption 1. When countries are similar in market power, global free trade is again the stable outcome. When countries are moderately divergent in market power, the large country stays out leaving the smaller countries in a free trade area with each other ($\langle\{\bar{s}h^{ss'}, ss'\}\rangle$).*

Formally, the stable equilibrium under 4-country regionalism and assumption 1 is:

(i) $\langle\{F\}\rangle$ *is uniquely stable when* $\theta \leq \theta_l(F - \{\bar{s}h^{ss'}, ss'\})$.

(ii) $\langle\{\bar{s}h^{ss'}, ss'\}\rangle$ *is uniquely stable when* $\theta > \theta_l(F - \{\bar{s}h^{ss'}, ss'\})$.

[26]See proof in Appendix B.4.

[27]For comparison, the equilibrium results of S&Y's 3-country model are reproduced in appendix A.2.

Figure 8 illustrates the stable Nash equilibrium for the 4-country model. Part (i) shows that global free trade is stable when countries are very similar in size. When countries are more different in sizes in part (ii), the large country chooses to stay out of FTAs and the smaller countries form FTAs with each other. This is because the large country receive higher welfare from charging the smaller countries its status quo tariff, even though MFN is binding, than forming FTAs with them.

Figure 11 compared both the stable equilibrium under 4-country regionalism and multilateralism. Here we see that global free trade is only achievable under regionalism due to the free-rider effect in 4-country multilaterliam. The general result from S&Y still holds here: a country that is reluctant to enter into trade agreements has a greater incentive to stay out of global free trade under multilateralism than regionalism. This result still holds with better incorporation of MFN effects, .

4.0.2 Equilibrium under Regionalism with diverse country types

Now the more diverse country type assumption 2 is applied. Similar to the previous section, the smaller countries have no unilateral or joint profitable deviations away from global free trade and the large country determines the stability of global free trade. The following proposition presents stable Nash equilibria under regionalism:[28]

Proposition 5. *In a stable Nash equilibrium under 4-country regionalism and more diverse country assumption 2, there are three stable equilibria. When countries are symmetric and similar in market power, global free trade is stable. When countries are moderately divergent in market power, the large country with the most market power stays out permanently leaving the medium and small countries in a free trade area with each other. When market power asymmetry is large, the medium country leaves and the small countries are left in an FTA.*

Formally, the stable Nash equilibrium under 4-country regionalism and assumption 2 is:

(i) $\langle\{F\}\rangle$ *is uniquely stable when* $\theta \leq \theta_l(F - \{ss'm\})$.

(ii) $\langle\{ss'm\}\rangle$ *is stable when* $\theta \in (\theta_l(F - \{ss'm\}), \theta_m(\{ss'\} - \{ss'm\})]$.

(iii) $\langle\{ss'\}\rangle$ *is uniquely stable when* $\theta > \theta_m(\{ss'\} - \{ss'm\})$.

Figure 9 illustrates the stable Nash equilibrium for the 4-country model with more country types. These results highlights the market power asymmetry effect and are intuitive since

[28] See Appendix B.5 for proof.

the country with the largest market power first exits from trade agreements followed by the country with the second largest market power. To investigate the effects of the MFN clause, the MFN restriction will be removed from the countries' trade agreement decisions and the resulting stable equilibria will be compared to these results.

5 Regional Trade Agreements without the MFN clause

The removal of the MFN clause allows for discriminatory tariffs in the presence and absence of FTAs. It results in two changes to the baseline model. First, the tariffs by countries who are not in any FTAs (status quo, ϕ) are no longer constrained by MFN. Second, countries in an FTA do not have to extend the same MFN tariff to the outside countries. Super-script N is used to denote the non-MFN regimes.

Without MFN, country i's optimal status quo tariffs ($\tau_{ij}^{N\Phi}, \tau_{ik}^{N\Phi}, \tau_{il}^{N\Phi}$) to impose on their trading partners should solve $\arg\max \omega_i(\Phi^N)$ where

$$\begin{aligned} \tau_{ij}^{N\Phi} &= \frac{2\,e_j}{5} - \frac{e_k}{10} - \frac{e_l}{10} \\ \tau_{ik}^{N\Phi} &= \frac{2\,e_k}{5} - \frac{e_j}{10} - \frac{e_l}{10} \\ \tau_{il}^{N\Phi} &= \frac{2\,e_l}{5} - \frac{e_k}{10} - \frac{e_j}{10} \end{aligned} \tag{20}$$

Note that when endowments are symmetric the non-MFN status quo tariff is the same as the MFN status quo tariff from equation (6), at $\frac{e}{5}$. But without the symmetry assumption, country i now adjusts its status quo tariff t_{ij}^{Φ} in two ways: (1) positively with the endowment change of the country it is imposing the tariff on (country j) due to j's lower foreign export supply elasticity (or higher export surplus) from its increased endowment, and (2) negatively towards the outside country's endowment (country k) as a result of tariff complementarity and in order to keep the price of its own imports low.

When two countries (say i and j) sign an FTA, the external tariffs of country i are not longer constrained to be the same on non-member countries k and l ($\tau_{ik}^{N1f} \neq \tau_{il}^{N1f}$):

$$\tau_{ik}^{N1f} = \frac{13\,e_k}{28} - \frac{5\,e_j}{14} - \frac{e_l}{28} \quad \text{and} \quad \tau_{il}^{N1f} = \frac{13\,e_l}{28} - \frac{5\,e_j}{14} - \frac{e_k}{28} \tag{21}$$

Compared to the external tariffs under MFN in equation (9), there are now separate weights on each of the outside countries' endowments. The non-MFN external tariff increases more with the endowment of the *specific* country it is applied on compared to the endowment of the second outside country. So if country k is smaller than country l, country i's tariff on k will be higher relative to country i's tariff on l ($\tau_{ik}^{N1f} > \tau_{il}^{N1f}$ if $e_k < e_l$).

Similar to before, smaller countries prefer to form FTAs with larger countries:[29]

Lemma 8. *Let country j be an FTA partner of country i under regime without MFN r^N but not under regime without MFN v^N and let the status of countries k and l be the same under both regimes. Then the following holds under regionalism:* $\frac{\partial \triangle \omega_i(r^N - v^N)}{\partial e_j} \leq 0 \leq \frac{\partial \triangle \omega_i(r^N - v^N)}{\partial e_i}$.

Additionally, all hub and spoke regimes are no longer stable since every spoke country, regardless of size, will have an incentive to deviate away.[30]

Lemma 9. *All hub and spoke regimes are no longer stable. Any spoke country, regardless of size, will have a profitable deviation away.*

5.1 Equilibrium under Non-MFN Regionalism

Equilibrium under the more diverse country type assumption 2 is presented here. The equilibrium under the more limited asymmetry assumption 1 is not included because the MFN and non-MFN equilibrium results are the same. This is due to the more limited country type assumption of one large country and three identical small countries. As established before, the large country determines the stability of trade agreements since it has more market power and the smaller countries always want to sign trade agreements with it. However, its decision to sign an FTA with a small country do not change with or without MFN because the small countries are all identical. So when the large country is in an FTA without MFN, it still treats both the outside small countries the same since they are identical in size even though it can discriminate against them individually. As such, in order to capture the effects of MFN by changing the FTA incentives of the large country, a medium country is introduced. The proposition for stable Nash equilibrium under regionalism without the MFN clause is as follows (the rest of the proposition is proven in Appendix C.2):

Proposition 6. *Comparing the equilibrium with and without MFN, small countries are excluded more from trade agreements more often under regionalism with the MFN clause. The free trade area equilibrium between medium and small countries is stable over a larger parameter space without the MFN clause.*

Formally, the stable equilibrium for non-MFN regionalism given assumption 2 is:

[29] Welfare levels are reported in Appendix C and are used to prove the following lemmas.
[30] See Appendix C.2 for proof.

(i) $\langle\{F\}\rangle$ *is uniquely stable when* $\theta \leq \theta_l(F - \{ss'm\})$.

(ii) $\langle\{ss'm\}\rangle$ *is stable when* $\theta \in (\theta_l(F - \{ss'm\}), \theta_m(\{ss'^N\} - \{ss'm\})]$ *and* $\theta_m(\{ss'^N\} - \{ss'm\}) > \theta_m(\{ss'\} - \{ss'm\})$

(iii) $\left\langle\{ss'^N\}\right\rangle$ *is uniquely stable when* $\theta > \theta_m(\{ss'^N\} - \{ss'm\})$.

Figure 12 illustrates the stable Nash equilibrium without MFN. Compared to the equilibrium with MFN, the parameter space under which global free trade is stable does not change. The differences come after the large country chooses to stay out of agreements when countries are moderately different in size. Without the MFN clause, there is a larger parameter space where the free trade area between the medium and small countries is stable. This is because the cost of staying out of trade agreements without MFN is higher for the medium country due to the discriminatory tariffs. As such, the medium country will stay in the free trade area with the small countries more and the small countries will be excluded less from trade agreements. Figure 13 illustrates both the stable equilibria for regionalism with and without the MFN clause.

Proposition 6 might lead to the conclusion that the MFN clause does not benefit small countries. The following proposition provides a total welfare perspective. If countries stayed in the same trade regimes in the MFN and non-MFN equilibrium, their total welfare is higher under MFN. However, total welfare is lower under MFN for the countries whose trade regimes switched. The total welfare of the free trade area between small and medium countries without MFN ($\left\langle\{ss'm^N\}\right\rangle$) is higher than total welfare of an FTA between the small countries in MFN ($\langle\{ss'\}\rangle$). As such, this paper cannot conclude that removing the MFN clause from regional trade agreements is socially optimal. The following proposition can be stated:[31]

Proposition 7. *If there is no regime change, total welfare of stable trade equilibrium regimes under the MFN clause is higher than or equal to total welfare without the clause. Total welfare under global free trade is the same with or without MFN. Total welfare under MFN is lower than without MFN when there is a regime change from an FTA between the small countries in MFN* ($\langle\{ss'\}\rangle$) *to the free trade area between small and medium countries without MFN* ($\left\langle\{ss'm^N\}\right\rangle$)*. Under assumption 2,*

[31] See Appendix for proof.

$$
\begin{aligned}
\sum_{e_l,e_m,e_s,e_{s'}} \omega(ss'm) &> \sum_{e_l,e_m,e_s,e_{s'}} \omega(ss'm^N) \ \ \textit{for all} \ \ \theta, \\
\sum_{e_l,e_m,e_s,e_{s'}} \omega(ss') &> \sum_{e_l,e_m,e_s,e_{s'}} \omega(ss'^N) \ \ \textit{for all} \ \ \theta, \ \ \textit{and} \\
\sum_{e_l,e_m,e_s,e_{s'}} \omega(ss') &< \sum_{e_l,e_m,e_s,e_{s'}} \omega(ss'm^N) \ \ \textit{for all} \ \ \theta
\end{aligned}
\tag{22}
$$

6 Conclusion

Recently, there has been a huge increase in regional trade agreements but multilateral negotiations have stalled. The literature studying the change in country incentives towards these trade agreements has established market power asymmetry as one important determinant. This means that trade agreements fail only when countries with more market power opts out. Regional and multilateral trade agreements are governed by the MFN clause to varying degrees and the MFN clause can create free-riders. By presenting a 4-country model that better incorporates the MFN clause, I show that the free rider effect is another avenue for trade agreements failure. I also allow for more diverse country types and analyze the contribution of the MFN clause to the stable equilibrium outcomes of regional trade agreements.

In my model, the free rider effect eliminates global free trade as a equilibrium in multilateral trade agreements. When symmetric in market power, any country will choose to stay out and free ride from the trade liberalization benefits of its partners. When countries are similar in size, any of the small, medium, or large country has the same free rider incentive to stay out. This is a departure from S&Y, the original model this paper is based on. Under regional trade agreements, smaller countries are excluded more from trade agreements under the MFN clause. While this result implies that the removal of the MFN clause would allow for more trade agreements between small and larger countries, this outcome is not necessarily socially optimal. If there is no regime change between the MFN and non-MFN equilibria, total welfare is higher when trade agreements abide by the MFN clause. However this is not true when there is a trade regime change. The total welfare of the free trade area between small and medium countries without MFN ($\langle\{ss'm^N\}\rangle$) is higher than total welfare of an FTA between the small countries in MFN ($\langle\{ss'\}\rangle$).

There is scope for future work with this model. First, the endowment asymmetry assumption employed in this paper abstracts from the principal supplier issue, which is a negotiation clause within the WTO whereby only the importing country is only required to negotiated with the main principal suppliers of its import good. Second, Bagwell and Staiger (1999*a*) highlights the necessity of reciprocity as well as MFN to achieve optimal tariffs. This model does not address reciprocity and instead models country agreements by their joint maximization. Third, this paper simplifies the trade liberalization options available to countries since in actuality a country can simultaneously engage in both regional and multilateral trade liberalizations. This will understandably complicate each country's individual choice sets.

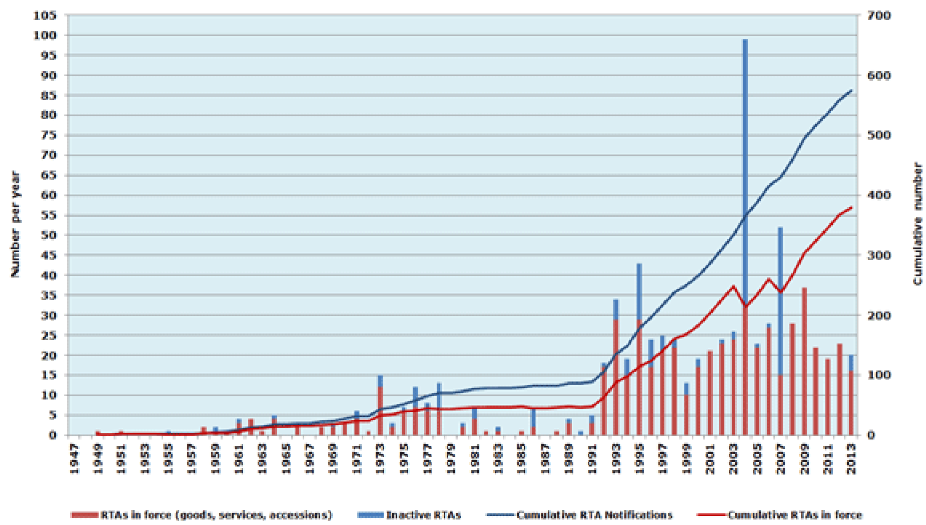


Figure 1: Number of WTO-notified Regional Trade Agreements from 1947-2013, both active and currently in negotiations

Source: Secretariat (n.d.)

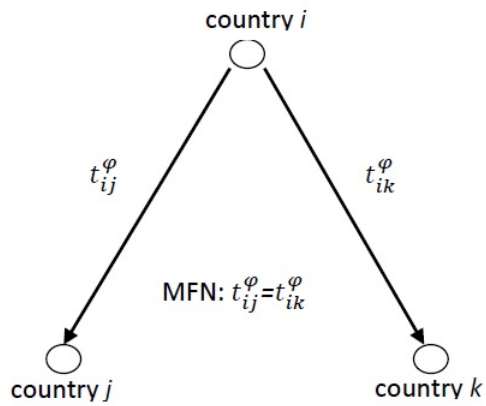


Figure 2: Three Country Model in Status Quo Trade Regime: country i has to apply the same status quo (MFN) tariff to the other two countries j and k.

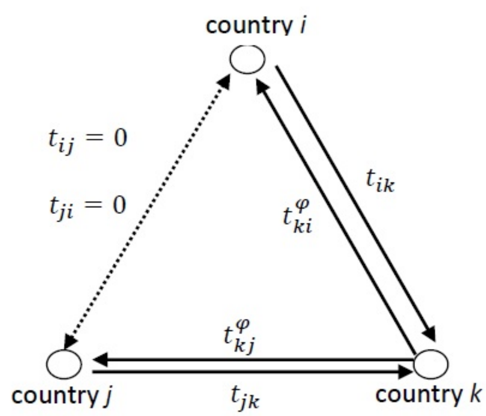


Figure 3: Three Country Model in FTA Trade Regime between countries i and j: FTA countries i and j eliminate their mutual tariffs while extending individually determined external tariffs t_{ik} and t_{jk} to outside country k. Country k applies status quo tariffs to i and j, which have to be the same under MFN.

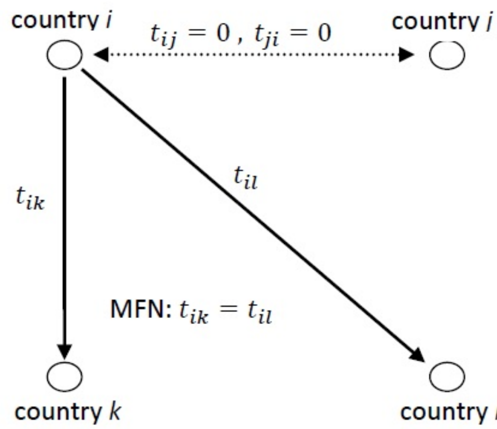


Figure 4: Four Country Model in FTA Trade Regime between countries i and j: FTA countries i and j eliminate their mutual tariffs while extending individually determined external tariffs t_{ik}, t_{il}, t_{jk} and t_{jl} to outside countries k and l. Due to MFN applying now on FTA countries as well, for country i both its external tariffs have to be the same $t_{ik} = t_{il}$.

Table 1: Welfare Levels of 4-Country Multilateral Trade Regimes under Symmetry

Total Countries in Agreement	Participation of Country i in Agreement	
	Out	In
Zero	$\langle\{\Phi\}\rangle$	N/A
	$33.0\,\alpha\,e - 1.14\,e^2$	N/A
Two	$\langle\{kl^m\}\rangle$	$\langle\{ij^m\}\rangle$
	$3.0\,\alpha\,e - 1.1341\,e^2$	$3.0\,\alpha\,e - 1.1386\,e^2$
Three	$\langle\{jkl^m\}\rangle$	$\langle\{ijk^m\}\rangle$
	$3.0\,\alpha\,e - 1.1201\,e^2$	$3.0\,\alpha\,e - 1.1338\,e^2$
Four	N/A	$\langle\{F\}\rangle$
	N/A	$3.0\,\alpha\,e - 1.125\,e^2$

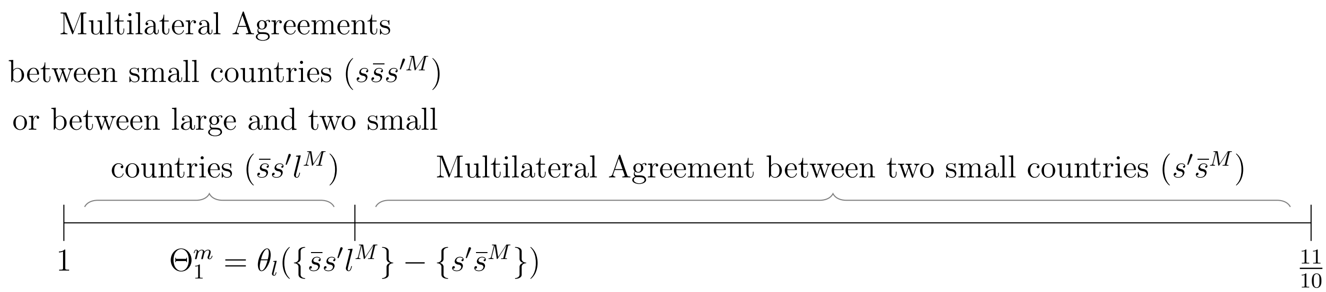


Figure 5: Stable Agreements under Multilateralism

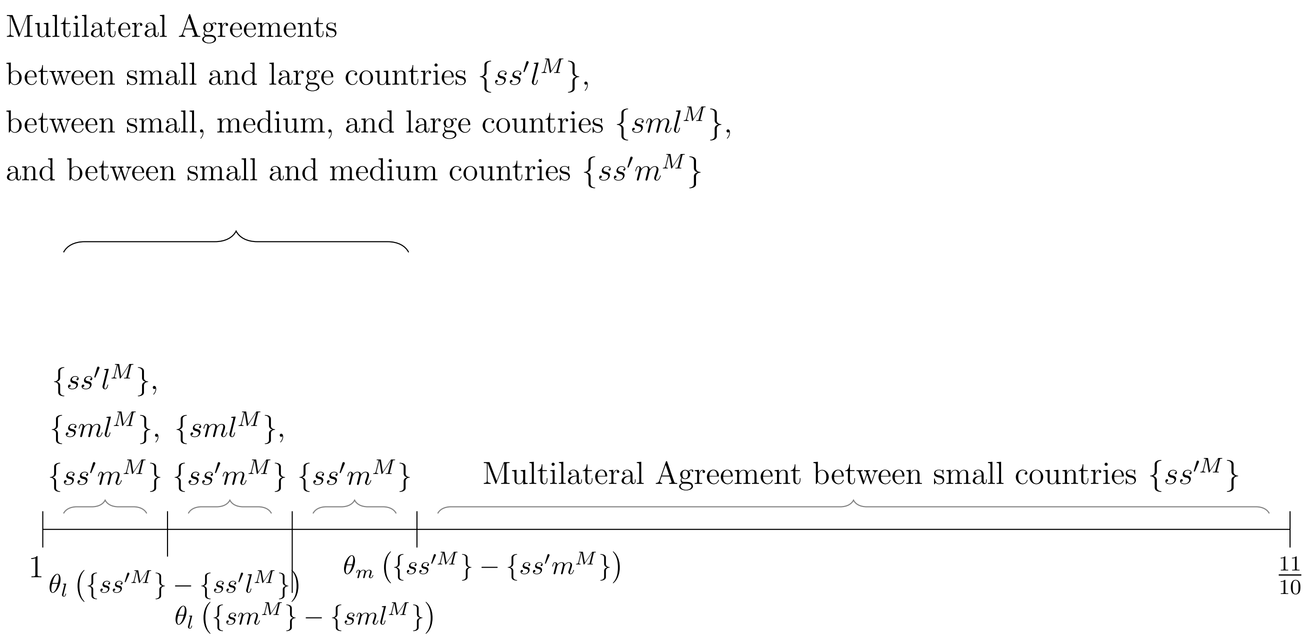


Figure 6: Stable Agreements under Multilateralism

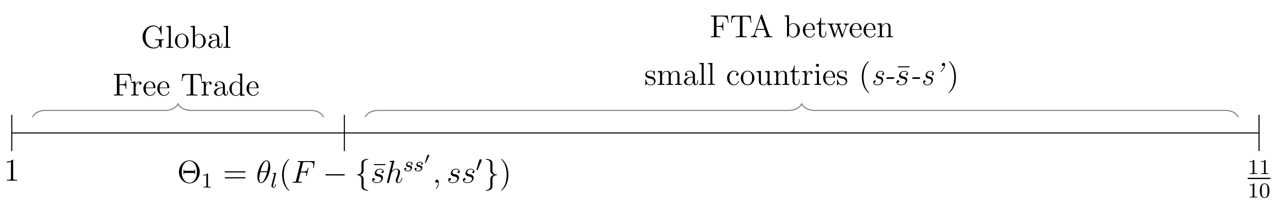


Figure 8: Stable Agreements under Regionalism

Figure 7: All Combinations of Trade Regimes: 4-Country Regionalism

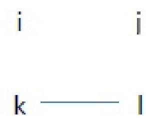
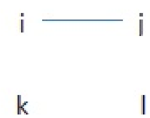
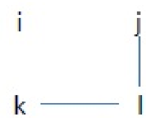
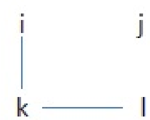
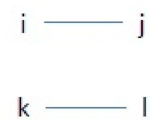
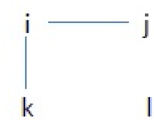
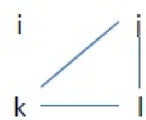
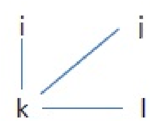
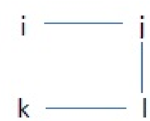
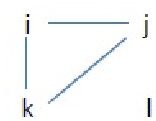
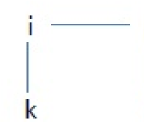
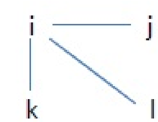
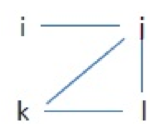
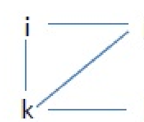
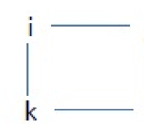
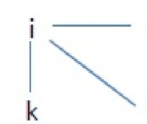
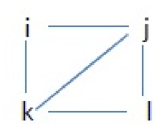
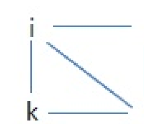
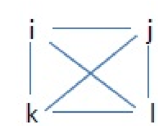
Total number of FTAs	Number of FTAs country *i* is involved in			
	0	**1**	**2**	**3**
0	**Φ**	**N/A**	**N/A**	**N/A**
1			**N/A**	**N/A**
2		 		**N/A**
3		 	 	
4	**N/A**		 	
5	**N/A**	**N/A**		
6	**N/A**	**N/A**	**N/A**	

Table 2: All Combinations of 4-Country Regional Trade Regimes

Total FTAs	Number of FTAs Country i is in			
	0 FTA	1 FTA	2 FTAs	3 FTAs
Zero	$\langle\{\Phi\}\rangle$	N/A	N/A	N/A
One	$\langle\{jk\}\rangle$	$\langle\{ij\}\rangle$	N/A	N/A
Two	$\langle\{lh^{jk}\}\rangle$	$\langle\{kh^{il}\}\rangle$, $\langle\{ij, kl\}\rangle$	$\langle\{ih^{jk}\}\rangle$	N/A
Three	$\langle\{lh^{kj}, kj\}\rangle$	$\langle\{kh^{ijl}\}\rangle$, $\langle\{ij, lh^{jk}\}\rangle$	$\langle\{ih^{jk}, jk\}\rangle$, $\langle\{ih^{jk}, jl\}\rangle$	$\langle\{ih^{jkl}\}\rangle$
Four	N/A	$\langle\{jh^{ikl}, kl\}\rangle$	$\langle\{kh^{ijl}, ij\}\rangle$,$\langle\{ih^{jk}, lh^{jk}\}\rangle$	$\langle\{ih^{jkl}, jl\}\rangle$
Five	N/A	N/A	$\langle\{kh^{ijl}, jh^{il}\}\rangle$	$\langle\{ih^{jkl}, lh^{jk}\}\rangle$
Six	N/A	N/A	N/A	$\langle\{F\}\rangle$

Table 3: Welfare Levels of Country i in 4-Country Regional Trade Regimes under Symmetry

Total FTAs	Number of FTAs Country i is in			
	0 FTA	1 FTA	2 FTAs	3 FTAs
Zero	$3\,\alpha\,e - 1.14e^2$	N/A	N/A	N/A
One	$3\,\alpha\,e - 1.1341e^2$	$3\,\alpha\,e - 1.1335e^2$	N/A	N/A
Two	$3\,\alpha\,e - 1.1305e^2$	$3\,\alpha\,e - 1.1373e^2$, $3\,\alpha\,e - 1.1276e^2$	$3\,\alpha\,e - 1.1158e^2$	N/A
Three	$3\,\alpha\,e - 1.1291e^2$	$3\,\alpha\,e - 1.1371e^2$, $3\,\alpha\,e - 1.1337e^2$	$3\,\alpha\,e - 1.1293e^2$, $3\,\alpha\,e - 1.1196e^2$	$3\,\alpha\,e - 1.0963e^2$
Four	N/A	$3\,\alpha\,e - 1.1358e^2$	$3\,\alpha\,e - 1.1292e^2$, $3\,\alpha\,e - 1.1257e^2$	$3\,\alpha\,e - 1.1099e^2$
Five	N/A	N/A	$3\,\alpha\,e - 1.1313e^2$	$3\,\alpha\,e - 1.1194e^2$
Six	N/A	N/A	N/A	$3\,\alpha\,e - 1.125e^2$

Table 4: Total Welfare of 4-Country Regional Trade Regimes under Symmetry

Total FTAs	Trade Regime Combinations and Total Welfare		
Zero	$\langle\{\Phi\}\rangle$: $12\,\alpha\,e - 4.56\,e^2$		
One	$\langle\{ij\}\rangle$: $12\,\alpha\,e - 4.5351\,e^2$		
Two	$\langle\{lh^{jk}\}\rangle$: $12\,\alpha\,e - 4.5208\,e^2$	$\langle\{ij, kl\}\rangle$: $12\,\alpha\,e - 4.5102\,e^2$	
Three	$\langle\{lh^{jk}, jk\}\rangle$: $12\,\alpha\,e - 4.5171\,e^2$	$\langle\{kh^{ijl}\}\rangle$: $12\,\alpha\,e - 4.5077\,e^2$	$\langle\{ij, lh^{jk}\}\rangle$: $12\,\alpha\,e - 4.5065\,e^2$
Four	$\langle\{jh^{ikl}, kl\}\rangle$: $12\,\alpha\,e - 4.5040\,e^2$	$\langle\{ih^{jk}, lh^{jk}\}\rangle$: $12\,\alpha\,e - 4.5028\,e^2$	
Five	$\langle\{kh^{ijl}, jh^{il}\}\rangle$: $12\,\alpha\,e - 4.5014\,e^2$		
Six	$\langle\{F\}\rangle$: $12\,\alpha\,e - 4.5\,e^2$		

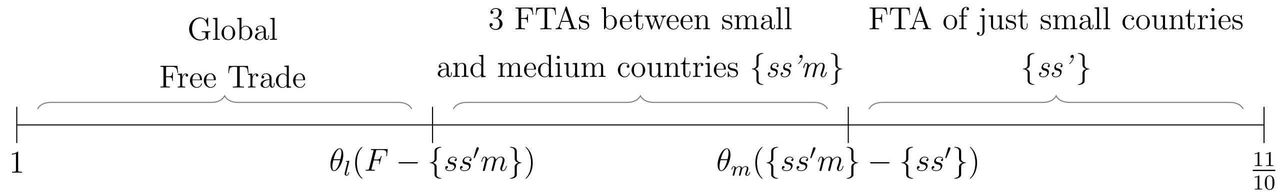


Figure 9: Stable Agreements under Regionalism given more diverse country types (assumption 2)

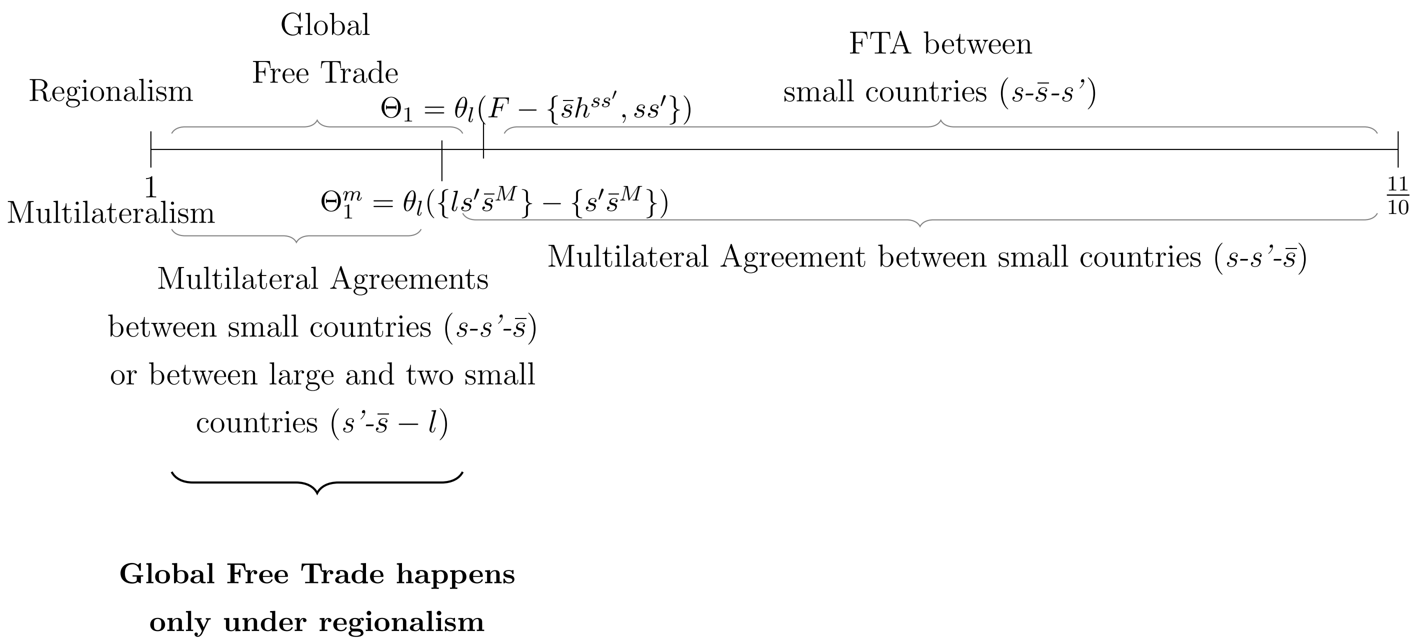


Figure 10: Comparison of Stable Agreements under 4-Country Regionalism and Multilateralism

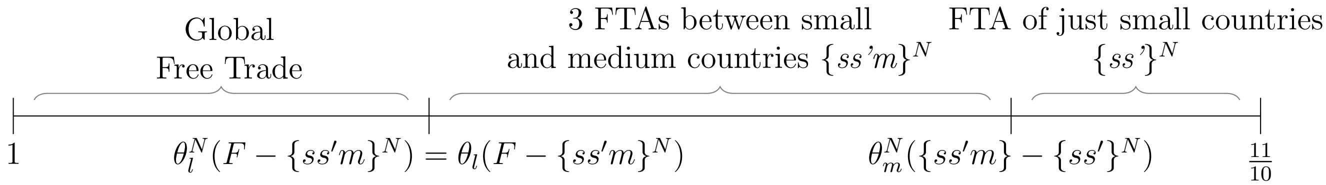
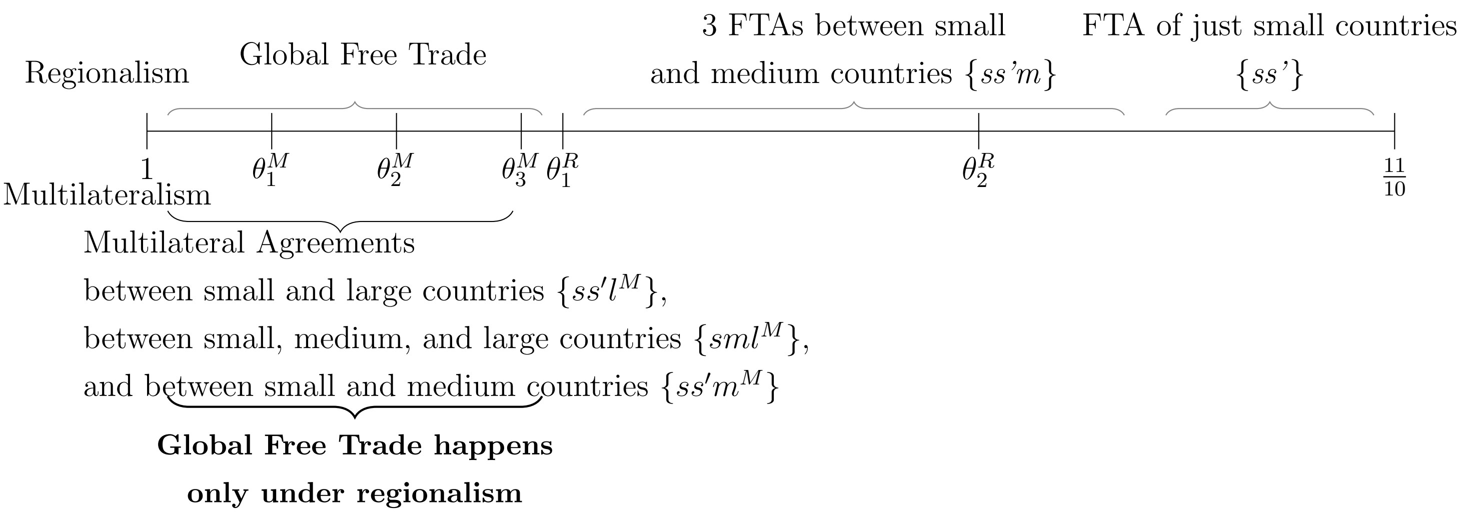


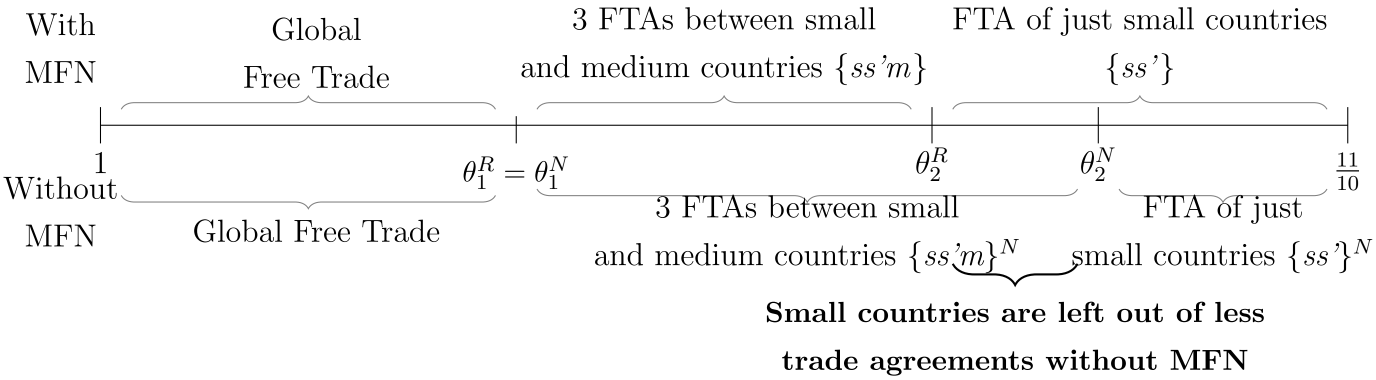
Figure 12: Stable Agreements under Regionalism with no MFN clause given more diverse country types (assumption 2)



Note: $\theta_1^M = \theta_l(\{ss'^M\} - \{ss'l^M\})$, $\theta_2^M = \theta_l(\{sm^M\} - \{sml^M\})$, $\theta_3^M = \theta_m(\{ss'^M\} - \{ss'm^M\})$,

$\theta_1^R = \theta_l(F - \{ss'm\})$, $\theta_2^R = \theta_m(\{ss'm\} - \{ss'\})$

Figure 11: Comparison of Stable Agreements under 4-Country Regionalism and Multilateralism given more diverse country types (assumption 2)



Note: $\theta_1^R = \theta_1^N = \theta_l^N(F - \{ss'm\}^N) = \theta_l(F - \{ss'm\})$, $\theta_2^R = \theta_m(\{ss'm\} - \{ss'\})$, $\theta_2^N = \theta_m^N(\{ss'm\}^N - \{ss'\}^N)$

Figure 13: Comparison of Stable Agreements under Regionalism with and without the MFN clause given more diverse country types (assumption 2)

A Appendix: Baseline Model Results and Replication Discrepancy

A.1 Replication Discrepancy

I was able to replicate all of S&Y's welfare functions for both bilateralism and multilateralism as detailed in Appendix A.1, S&Y. However, when taking the difference across these welfare functions some of my calculations are not the same as S&Y. This appendix section explores this discrepancy. Specifically, the discrepancies are:

1. The welfare difference in moving to global free trade from being in an FTA, $\triangle w_i(F-ij)$. In S&Y, $\triangle w_i(F-ij) = \frac{101}{6}\left(\frac{e}{22}\right)^2$ whereas in my calculations $\triangle w_i(F-ij) = \frac{101}{6}\left(\frac{e}{44}\right)^2$.
2. The welfare difference from moving to the outside of an FTA from being a spoke, $\triangle w_j(ik-ih)$. In S&Y, $\triangle w_j(ik-ih) = \frac{161}{2}\left(\frac{e}{132}\right)^2$ whereas in my calculations $\triangle w_i(F-ij) = 19\left(\frac{e}{66}\right)^2$.

First I replicate S&Y's welfare levels and show that they match S&Y's results in the first part of Appendix A.1. Then I calculate the welfare differences (which is where our discrepancies lie) in two ways: (1) by using S&Y's reported welfare functions in the first part of Appendix A.1, and (2) by using my own welfare functions.

The following are S&Y's welfare levels under different policy regimes, taken directly from

Appendix A.1, S&Y:

$$\begin{aligned}
w_i^{S\&Y}(F) &= \frac{\left(\frac{e_i}{3}+\frac{e_j}{3}+\frac{e_k}{3}\right)^2}{2} - e_i\left(\frac{2\,e_i}{3}-2\,\alpha+\frac{e_j}{3}+\frac{e_k}{3}\right)+\frac{{e_i}^2}{18}+\frac{{e_j}^2}{18}+\frac{{e_k}^2}{18}\\
w_i^{S\&Y}(\Phi) &= \frac{\left(\frac{3\,e_i}{8}+\frac{3\,e_j}{8}\right)^2}{2} - e_i\left(\frac{3\,e_i}{4}-2\,\alpha+\frac{3\,e_j}{8}+\frac{3\,e_k}{8}\right)+\frac{\left(\frac{3\,e_i}{8}+\frac{3\,e_k}{8}\right)^2}{2}+\left(\frac{e_j}{4}+\frac{e_k}{4}\right)^2\\
w_i^{S\&Y}(ij) &= \frac{\left(\frac{3\,e_i}{8}+\frac{3\,e_j}{8}\right)^2}{2} - e_i\left(\frac{73\,e_i}{88}-2\,\alpha+\frac{3\,e_j}{8}+\frac{2\,e_k}{11}\right)-\frac{e_j\,e_k}{11}+\frac{\left(\frac{5\,e_i}{11}+\frac{2\,e_k}{11}\right)^2}{2}+\frac{3\,{e_j}^2}{22}+\frac{2\,{e_k}^2}{11}\\
w_i^{S\&Y}(jk) &= \frac{\left(\frac{7\,e_i}{11}+\frac{e_j}{11}\right)^2}{2} - e_i\left(\frac{14\,e_i}{11}-2\,\alpha+\frac{e_j}{11}+\frac{e_k}{11}\right)+\frac{\left(\frac{7\,e_i}{11}+\frac{e_k}{11}\right)^2}{2}+\left(\frac{e_j}{4}+\frac{e_k}{4}\right)^2\\
w_i^{S\&Y}(ih) &= \frac{\left(\frac{5\,e_i}{11}+\frac{2\,e_j}{11}\right)^2}{2} - e_i\left(\frac{10\,e_i}{11}-2\,\alpha+\frac{2\,e_j}{11}+\frac{2\,e_k}{11}\right)+\frac{\left(\frac{5\,e_i}{11}+\frac{2\,e_k}{11}\right)^2}{2}+\frac{\left(\frac{e_j}{3}+\frac{e_k}{3}\right)^2}{2}\\
w_i^{S\&Y}(jh) &= \frac{\left(\frac{7\,e_i}{11}+\frac{e_j}{11}\right)^2}{2} - e_i\left(\frac{32\,e_i}{33}-2\,\alpha+\frac{e_j}{11}+\frac{e_k}{3}\right)-\frac{e_j\,e_k}{11}+\frac{\left(\frac{e_i}{3}+\frac{e_k}{3}\right)^2}{2}+\frac{3\,{e_j}^2}{22}+\frac{2\,{e_k}^2}{11}
\end{aligned} \tag{23}$$

Simplifying S&Y's results from equation 23 yields:

$$\begin{aligned}
w_i^{S\&Y}(F) &= -\frac{5\,{e_i}^2}{9}-\frac{2\,e_i\,e_j}{9}-\frac{2\,e_i\,e_k}{9}+2\,\alpha\,e_i+\frac{{e_j}^2}{9}+\frac{e_j\,e_k}{9}+\frac{{e_k}^2}{9}\\
w_i^{S\&Y}(\Phi) &= -\frac{39\,{e_i}^2}{64}-\frac{15\,e_i\,e_j}{64}-\frac{15\,e_i\,e_k}{64}+2\,\alpha\,e_i+\frac{17\,{e_j}^2}{128}+\frac{e_j\,e_k}{8}+\frac{17\,{e_k}^2}{128}\\
w_i^{S\&Y}(ij) &= -\frac{10159\,{e_i}^2}{15488}-\frac{15\,e_i\,e_j}{64}-\frac{12\,e_i\,e_k}{121}+2\,\alpha\,e_i+\frac{291\,{e_j}^2}{1408}-\frac{e_j\,e_k}{11}+\frac{24\,{e_k}^2}{121}\\
w_i^{S\&Y}(jk) &= -\frac{105\,{e_i}^2}{121}-\frac{4\,e_i\,e_j}{121}-\frac{4\,e_i\,e_k}{121}+2\,\alpha\,e_i+\frac{129\,{e_j}^2}{1936}+\frac{e_j\,e_k}{8}+\frac{129\,{e_k}^2}{1936}\\
w_i^{S\&Y}(ih) &= -\frac{85\,{e_i}^2}{121}-\frac{12\,e_i\,e_j}{121}-\frac{12\,e_i\,e_k}{121}+2\,\alpha\,e_i+\frac{157\,{e_j}^2}{2178}+\frac{e_j\,e_k}{9}+\frac{157\,{e_k}^2}{2178}\\
w_i^{S\&Y}(jh) &= -\frac{775\,{e_i}^2}{1089}-\frac{4\,e_i\,e_j}{121}-\frac{2\,e_i\,e_k}{9}+2\,\alpha\,e_i+\frac{17\,{e_j}^2}{121}-\frac{e_j\,e_k}{11}+\frac{47\,{e_k}^2}{198}
\end{aligned} \tag{24}$$

From my own calculations, my replicated welfare levels are:

$$\begin{aligned}
w_i(F) &= -\frac{5\,e_i^2}{9} - \frac{2\,e_i\,e_j}{9} - \frac{2\,e_i\,e_k}{9} + 2\,\alpha\,e_i + \frac{e_j^2}{9} + \frac{e_j\,e_k}{9} + \frac{e_k^2}{9} \\
w_i(\Phi) &= -\frac{39\,e_i^2}{64} - \frac{15\,e_i\,e_j}{64} - \frac{15\,e_i\,e_k}{64} + 2\,\alpha\,e_i + \frac{17\,e_j^2}{128} + \frac{e_j\,e_k}{8} + \frac{17\,e_k^2}{128} \\
w_i(ij) &= -\frac{10159\,e_i^2}{15488} - \frac{15\,e_i\,e_j}{64} - \frac{12\,e_i\,e_k}{121} + 2\,\alpha\,e_i + \frac{291\,e_j^2}{1408} - \frac{e_j\,e_k}{11} + \frac{24\,e_k^2}{121} \\
w_i(jk) &= -\frac{105\,e_i^2}{121} - \frac{4\,e_i\,e_j}{121} - \frac{4\,e_i\,e_k}{121} + 2\,\alpha\,e_i + \frac{129\,e_j^2}{1936} + \frac{e_j\,e_k}{8} + \frac{129\,e_k^2}{1936} \\
w_i(ih) &= -\frac{85\,e_i^2}{121} - \frac{12\,e_i\,e_j}{121} - \frac{12\,e_i\,e_k}{121} + 2\,\alpha\,e_i + \frac{157\,e_j^2}{2178} + \frac{e_j\,e_k}{9} + \frac{157\,e_k^2}{2178} \\
w_i(jh) &= -\frac{775\,e_i^2}{1089} - \frac{4\,e_i\,e_j}{121} - \frac{2\,e_i\,e_k}{9} + 2\,\alpha\,e_i + \frac{17\,e_j^2}{121} - \frac{e_j\,e_k}{11} + \frac{47\,e_k^2}{198}
\end{aligned} \tag{25}$$

My replicated welfare levels in equation 25 are exactly the same as S&Y's results (equation 23). Using the welfare levels in equation 23, S&Y listed a subset of welfare differences Appendix A.1 under symmetry. This is where the discrepancy is. I first show the asymmetric welfare differences and then impose symmetry to make my calculations comparable with S&Y's. S&Y's welfare differences, calculated from their initial asymmetric welfare levels in equation 23, are:

$$\begin{aligned}
\triangle w_i^{S\&Y}(ij-\Phi) &= -\frac{721\,e_i^2}{15488} + \frac{1047\,e_i\,e_k}{7744} + \frac{13\,e_j^2}{176} - \frac{19\,e_j\,e_k}{88} + \frac{1015\,e_k^2}{15488} \\
\triangle w_i^{S\&Y}(ih-F) &= -\frac{160\,e_i^2}{1089} + \frac{134\,e_i\,e_j}{1089} + \frac{134\,e_i\,e_k}{1089} - \frac{85\,e_j^2}{2178} - \frac{85\,e_k^2}{2178} \\
\triangle w_i^{S\&Y}(ih-ij) &= -\frac{721\,e_i^2}{15488} + \frac{1047\,e_i\,e_j}{7744} - \frac{18761\,e_j^2}{139392} + \frac{20\,e_j\,e_k}{99} - \frac{25\,e_k^2}{198} \\
\triangle w_i^{S\&Y}(F-jk) &= \frac{340\,e_i^2}{1089} - \frac{206\,e_i\,e_j}{1089} - \frac{206\,e_i\,e_k}{1089} + \frac{775\,e_j^2}{17424} - \frac{e_j\,e_k}{72} + \frac{775\,e_k^2}{17424} \\
\triangle w_k^{S\&Y}(ij-\Phi) &= -\frac{2001\,e_k^2}{7744} + \frac{1559\,e_k\,e_i}{7744} + \frac{1559\,e_k\,e_j}{7744} - \frac{1025\,e_i^2}{15488} - \frac{1025\,e_j^2}{15488} \\
\triangle w_j^{S\&Y}(F-ih) &= \frac{170\,e_j^2}{1089} - \frac{206\,e_j\,e_i}{1089} - \frac{32\,e_i^2}{1089} + \frac{20\,e_i\,e_k}{99} - \frac{25\,e_k^2}{198} \\
\triangle w_j^{S\&Y}(ik-ih) &= -\frac{170\,e_j^2}{1089} + \frac{206\,e_j\,e_k}{1089} - \frac{13\,e_i^2}{176} + \frac{19\,e_i\,e_k}{88} - \frac{2975\,e_k^2}{17424} \\
\triangle w_i^{S\&Y}(F-ij) &= \frac{13991\,e_i^2}{139392} + \frac{7\,e_i\,e_j}{576} - \frac{134\,e_i\,e_k}{1089} - \frac{1211\,e_j^2}{12672} + \frac{20\,e_j\,e_k}{99} - \frac{95\,e_k^2}{1089}
\end{aligned} \tag{26}$$

My replication of these differences, calculated from equation 25, are:

$$
\begin{aligned}
\triangle w_i(ij-\Phi) &= -\frac{721\,{e_i}^2}{15488}+\frac{1047\,e_i\,e_k}{7744}+\frac{13\,{e_j}^2}{176}-\frac{19\,e_j\,e_k}{88}+\frac{1015\,{e_k}^2}{15488}\\
\triangle w_i(ih-F) &= -\frac{160\,{e_i}^2}{1089}+\frac{134\,e_i\,e_j}{1089}+\frac{134\,e_i\,e_k}{1089}-\frac{85\,{e_j}^2}{2178}-\frac{85\,{e_k}^2}{2178}\\
\triangle w_i(ih-ij) &= -\frac{721\,{e_i}^2}{15488}+\frac{1047\,e_i\,e_j}{7744}-\frac{18761\,{e_j}^2}{139392}+\frac{20\,e_j\,e_k}{99}-\frac{25\,{e_k}^2}{198}\\
\triangle w_i(F-jk) &= \frac{340\,{e_i}^2}{1089}-\frac{206\,e_i\,e_j}{1089}-\frac{206\,e_i\,e_k}{1089}+\frac{775\,{e_j}^2}{17424}-\frac{e_j\,e_k}{72}+\frac{775\,{e_k}^2}{17424}\\
\triangle w_k(ij-\Phi) &= -\frac{2001\,{e_k}^2}{7744}+\frac{1559\,e_k\,e_i}{7744}+\frac{1559\,e_k\,e_j}{7744}-\frac{1025\,{e_i}^2}{15488}-\frac{1025\,{e_j}^2}{15488}\\
\triangle w_j(F-ih) &= \frac{170\,{e_j}^2}{1089}-\frac{206\,e_j\,e_i}{1089}-\frac{32\,{e_i}^2}{1089}+\frac{20\,e_i\,e_k}{99}-\frac{25\,{e_k}^2}{198}\\
\triangle w_j(ik-ih) &= -\frac{170\,{e_j}^2}{1089}+\frac{206\,e_j\,e_k}{1089}-\frac{13\,{e_i}^2}{176}+\frac{19\,e_i\,e_k}{88}-\frac{2975\,{e_k}^2}{17424}\\
\triangle w_i(F-ij) &= \frac{13991\,{e_i}^2}{139392}+\frac{7\,e_i\,e_j}{576}-\frac{134\,e_i\,e_k}{1089}-\frac{1211\,{e_j}^2}{12672}+\frac{20\,e_j\,e_k}{99}-\frac{95\,{e_k}^2}{1089}
\end{aligned}
\tag{27}
$$

As can be seen, my difference calculations are the same as S&Y's results. After imposing symmetry, S&Y's differences from equation 26 are:

$$
\begin{aligned}
\triangle w_i^{S\&Y}(ij-\Phi) &= \frac{47\,e^2}{3872}\\
\triangle w_i^{S\&Y}(ih-F) &= \frac{23\,e^2}{1089}\\
\triangle w_i^{S\&Y}(ih-ij) &= \frac{1039\,e^2}{34848}\\
\triangle w_i^{S\&Y}(F-jk) &= \frac{13\,e^2}{1452}\\
\triangle w_k^{S\&Y}(ij-\Phi) &= \frac{23\,e^2}{1936}\\
\triangle w_j^{S\&Y}(F-ih) &= \frac{29\,e^2}{2178}\\
\triangle w_j^{S\&Y}(ik-ih) &= \frac{19\,e^2}{4356}\\
\triangle w_i^{S\&Y}(F-ij) &= \frac{101\,e^2}{11616}
\end{aligned}
\tag{28}
$$

Similarly, with the symmetric assumption, my results from equation 27 are:

$$\begin{aligned}
\triangle w_i(ij-\Phi) &= \frac{47\,e^2}{3872} \\
\triangle w_i(ih-F) &= \frac{23\,e^2}{1089} \\
\triangle w_i(ih-ij) &= \frac{1039\,e^2}{34848} \\
\triangle w_i(F-jk) &= \frac{13\,e^2}{1452} \\
\triangle w_k(ij-\Phi) &= \frac{23\,e^2}{1936} \\
\triangle w_j(F-ih) &= \frac{29\,e^2}{2178} \\
\triangle w_j(ik-ih) &= \frac{19\,e^2}{4356} \\
\triangle w_i(F-ij) &= \frac{101\,e^2}{11616}
\end{aligned} \tag{29}$$

From these calculations, my replication and the derived calculations from S&Y's initial welfare levels are the same. However, in S&Y's Appendix A.1, the following are reported:

$$\begin{aligned}
\triangle w_j(ik-ih) &= \frac{161}{2}\left(\frac{e}{132}\right)^2 = \frac{161e^2}{34848} \\
\triangle w_i(F-ij) &= \frac{101}{6}\left(\frac{e}{22}\right)^2 = \frac{101e^2}{2904}
\end{aligned}$$

A.2 Baseline Model Results

Below are the optimal tariffs under regionalism. Under $\langle\{\Phi\}\rangle$ each country imposes a status quo MFN tariff on its trading partners where for $i, j, k = a, b, c$:

$$t_{ij} = t_{ik} = t_i^{\Phi} \equiv \arg\max w_i(\Phi) = \frac{e_j + e_k}{8} \tag{30}$$

An FTA between two countries say for i and j ($\langle\{ij\}\rangle$) requires complete removal of their mutual tariffs, $t_{ij} = t_{ij} = t_{ji} = 0$ under Article XXIV. These countries then individually impose external tariffs on the non-member country (k) where $t_{ik} \equiv t_i^f \equiv \arg\max w_i\,(t_{ij})$ and

$t_{jk} \equiv t_j^f \equiv \arg\max w_j(t_{ij})$ respectively:[32]

$$t_i^f = \frac{5e_k - 4e_j}{11} \text{ and } t_j^f = \frac{5e_k - 4e_i}{11} \tag{31}$$

When countries i and j agree to sign the multilateral agreement $\langle\{ij^m\}\rangle$ they choose the tariff pair (t_i^m, t_j^m) to maximize the sum of their welfare functions subject to $t_ij = t_ik \equiv t_i^m$ and $t_ji = t_jk \equiv t_j^m$:

$$\left(t_i^m, t_j^m\right) \equiv \arg\max\left[w_i(ij^m) + w_j(ij^m)\right] \text{ where } t_i^m = \frac{2e_k - e_j}{7} \text{ and } t_j^m = \frac{2e_k - e_i}{7} \tag{32}$$

The country incentives for regional and multilateral agreements in the baseline model are as follows. They are discussed in comparison to the incentives in the extensions.

Lemma A-2a. Within the WTO framework, let country j be an FTA partner of country i under regime r but not under regime v and let the status of country k be the same under both regimes (i.e. either i is an FTA partner of country i under both regimes or not). then the following holds: $\frac{\partial \triangle w_i(r-v)}{\partial e_j} \leq 0 \leq \frac{\triangle w_i(r-v)}{\partial e_i}$.

Lemma A-2b. Within the WTO framework, let country i be an FTA partner of country i under regime r but not under regime v and let the status of country k be the same under both regimes (i.e. either it is a partner of country i under both regimes or not). Then,

(i) $\frac{\partial \triangle w_i(r-v)}{\partial e_k} \leq 0$ if country k is an FTA partner of country j under regimes r and v; whereas

(ii) $\frac{\triangle w_i(r-v)}{\partial e_k} \geq 0$ if country k is not an FTA partner of country j under regimes r and v.

Lemma A-3. $w_i(ih) > max\{w_i(ij), w_i(F), w_i(\Phi)\}$ for all $i, j = a, b, c$

The lemma above shows that a hub country has no incentives to unilaterally revoke one or both of its FTAs because it derives the highest welfare from this trade regime relative to any other.

Lemma A-4. Under multilateralism, the following hold:

(i) $\frac{\partial \triangle w_i(ij^m - \Phi)}{\partial e_i} > 0$, $\frac{\partial \triangle w_i(ij^m - \Phi)}{\partial e_j} < 0$, and $\frac{\partial \triangle w_i(ij^m - \Phi)}{\partial e_k} < 0$; and

(ii) $\frac{\partial \triangle w_i(F - ij^m)}{\partial e_i} > 0$, $\frac{\partial \triangle w_i(F - ij^m)}{\partial e_j} < 0$, and $\frac{\partial \triangle w_i(F - ij^m)}{\partial e_k} < 0$.

[32] Note here that the second requirement of Article XXIV is only met if a country's external tariff is lower than its status quo tariff to the same country $t_i^f < t_i^\Phi \rightarrow max(e_i, e_j, e_k) < \frac{43}{29} min(e_i, e_j, e_k)$ when $i, j, k = a, b, c$. This condition is satisfied under the endowment asymmetry patterns assumptions made in later sections.

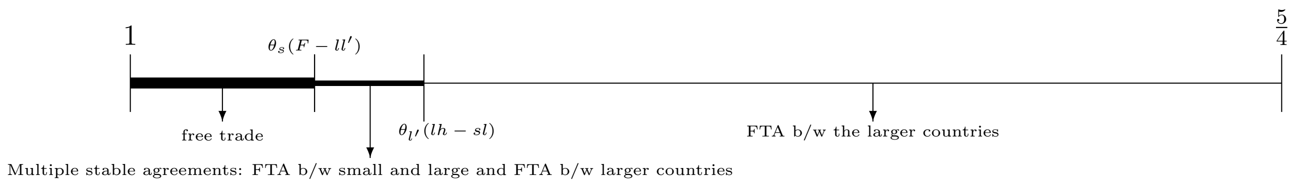


Figure 14: Stable Agreements under Regionalism (S&Y 2010)

The stable trade agreement regionalism/bilateralism equilibrium from S&Y, with their original notation, are as follows (see figure 14 for illustrated equilibrium):[33]

Proposition A-3a. Under assumption S&Y within the WTO framework, the stable trade regime equilibria under regionalism are:

(i) $\langle\{F\}\rangle$ is uniquely stable when $\theta \leq \theta_s(F - ll')$;

(ii) Both $\langle\{sl\}\rangle$ and $\langle\{ll'\}\rangle$ are stable when $\theta_s(F - ll') < \theta \leq \theta_{l'}(lh - sl)$; and

(iii) $\langle\{ll'\}\rangle$ is uniquely stable when $\theta > \theta_{l'}(lh - sl)$

Under multilateralism, the following stable Nash equilibrium holds with S&Y's original notation (see figure 15):

Proposition A-3b. Under assumption S&Y, $\langle\{F\}\rangle$ is stable under multilateralism when $\theta \leq \theta_s(F - ll'^m)$. Otherwise, $\langle\{ll'^m\}\rangle$ is stable.

When countries are allowed to negotiate under both Articles I and XXIV (but not simultaneously), S&Y shows that global free trade is easier to achieve than if they were allowed to only negotiate under multilaterlism only.

Table 5: Welfare Levels of Bilateral Trade Regimes under Symmetry

Total FTAs	Number of FTAs Country i is in			
	0 FTA	1 FTA	2 FTAs	3 FTAs
Zero	$3\,\alpha\,e - \frac{57e^2}{50}$	N/A	N/A	N/A
One	$3\,\alpha\,e - \frac{5557\,e^2}{4900}$	$3\,\alpha\,e - \frac{2777\,e^2}{2450}$	N/A	N/A
Two	$3\,\alpha\,e - \frac{586049\,e^2}{518420}$	$3\,\alpha\,e - \frac{5895991\,e^2}{5184200}, 3\,\alpha\,e - \frac{221\,e^2}{196}$	$3\,\alpha\,e - \frac{62873\,e^2}{56350}$	N/A
Three	$3\,\alpha\,e - \frac{5973\,e^2}{5290}$	$3\,\alpha\,e - \frac{1783\,e^2}{1568}, 3\,\mathrm{alpha}\,e - \frac{235087\,e^2}{207368}$	$3\,\alpha\,e - \frac{29871\,e^2}{26450}, 3\,\alpha\,e - \frac{232167\,e^2}{207368}$	$3\,\alpha\,e - \frac{1719\,e^2}{1568}$
Four	N/A	$3\,\alpha\,e - \frac{134585\,e^2}{118496}$	$3\,\alpha\,e - \frac{936603\,e^2}{829472}, 3\,\alpha\,e - \frac{1191\,e^2}{1058}$	$3\,\alpha\,e - \frac{920615\,e^2}{829472}$
Five	N/A	N/A	$3\,\alpha\,e - \frac{9575\,e^2}{8464}$	$3\,\alpha\,e - \frac{9475\,e^2}{8464}$
Six	N/A	N/A	N/A	$3\,\alpha\,e - \frac{9\,e^2}{8}$

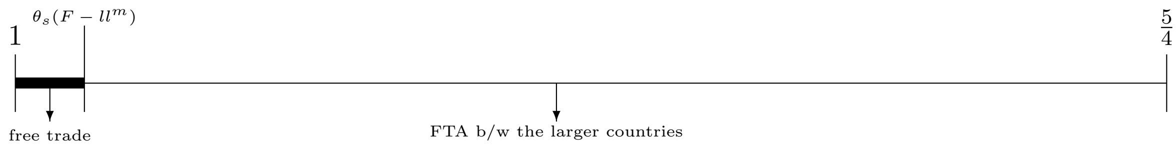


Figure 15: Stable Agreements under Multilateralism (S&Y 2010)

B Appendix: Multilateralism and Regionalism

B.1 Welfare Functions

Below are the welfare functions for regional trade regimes:

$$\langle\{\Phi\}\rangle = -\frac{52\,{e_i}^2}{75} - \frac{88\,e_i\,e_j}{225} - \frac{88\,e_i\,e_k}{225} - \frac{88\,e_i\,e_l}{225} + 3\,\alpha\,e_i + \frac{47\,{e_j}^2}{450} + \frac{31\,e_j\,e_k}{225} + \frac{31\,e_j\,e_l}{225} + \frac{47\,{e_k}^2}{450} + \frac{31\,e_k\,e_l}{225} + \frac{47\,{e_l}^2}{450}$$

$$\langle\{jk\}\rangle = -\frac{36067\,{e_i}^2}{44100} - \frac{10649\,e_i\,e_j}{44100} - \frac{10649\,e_i\,e_k}{44100} - \frac{45\,e_i\,e_l}{98} + 3\,\alpha\,e_i + \frac{6301\,{e_j}^2}{88200} + \frac{31\,e_j\,e_k}{225} + \frac{271\,e_j\,e_l}{2940} + \frac{6301\,{e_k}^2}{88200} + \frac{271\,e_k\,e_l}{2940} + \frac{473\,{e_l}^2}{2940}$$

$$\langle\{ij\}\rangle = -\frac{17617\,{e_i}^2}{22050} - \frac{88\,e_i\,e_j}{225} - \frac{3056\,e_i\,e_k}{11025} - \frac{3056\,e_i\,e_l}{11025} + 3\,\alpha\,e_i + \frac{337\,{e_j}^2}{1575} - \frac{e_j\,e_k}{3150} - \frac{e_j\,e_l}{3150} + \frac{1292\,{e_k}^2}{11025} + \frac{8\,e_k\,e_l}{49} + \frac{1292\,{e_l}^2}{11025}$$

$$\left\langle\{jh^{kl}\}\right\rangle = -\frac{104739\,{e_i}^2}{103684} - \frac{9\,e_i\,e_j}{98} - \frac{27333\,e_i\,e_k}{103684} - \frac{27333\,e_i\,e_l}{103684} + 3\,\alpha\,e_i + \frac{113\,{e_j}^2}{2940} + \frac{271\,e_j\,e_k}{2940} + \frac{271\,e_j\,e_l}{2940} + \frac{313819\,{e_k}^2}{3110520} + \frac{589\,e_k\,e_l}{7935} + \frac{313819\,{e_l}^2}{3110520}$$

$$\left\langle\{kh^{il}\}\right\rangle = -\frac{36510311\,{e_i}^2}{46657800} - \frac{33213\,e_i\,e_j}{103684} - \frac{10649\,e_i\,e_k}{44100} - \frac{48476\,e_i\,e_l}{119025} + 3\,\alpha\,e_i + \frac{29801\,{e_j}^2}{207368} - \frac{9\,e_j\,e_k}{196} + \frac{676\,e_j\,e_l}{3703} + \frac{15961\,{e_k}^2}{88200} - \frac{e_k\,e_l}{3150} + \frac{127724\,{e_l}^2}{833175}$$

$$\langle\{ij,kl\}\rangle = -\frac{181\,{e_i}^2}{196} - \frac{45\,e_i\,e_j}{98} - \frac{25\,e_i\,e_k}{196} - \frac{25\,e_i\,e_l}{196} + 3\,\alpha\,e_i + \frac{53\,{e_j}^2}{196} - \frac{9\,e_j\,e_k}{196} - \frac{9\,e_j\,e_l}{196} + \frac{33\,{e_k}^2}{392} + \frac{8\,e_k\,e_l}{49} + \frac{33\,{e_l}^2}{392}$$

$$\left\langle\{ih^{jl}\}\right\rangle = -\frac{9973\,{e_i}^2}{11025} - \frac{3056\,e_i\,e_j}{11025} - \frac{8\,e_i\,e_k}{49} - \frac{3056\,e_i\,e_l}{11025} + 3\,\alpha\,e_i + \frac{28141\,{e_j}^2}{253575} - \frac{75\,e_j\,e_k}{1127} + \frac{1043\,e_j\,e_l}{5175} + \frac{487\,{e_k}^2}{2254} - \frac{75\,e_k\,e_l}{1127} + \frac{28141\,{e_l}^2}{253575}$$

$$\left\langle\{lh^{kj},kj\}\right\rangle = -\frac{672\,{e_i}^2}{529} - \frac{36\,e_i\,e_j}{529} - \frac{36\,e_i\,e_k}{529} - \frac{36\,e_i\,e_l}{529} + 3\,\alpha\,e_i + \frac{649\,{e_j}^2}{15870} + \frac{589\,e_j\,e_k}{7935} + \frac{589\,e_j\,e_l}{7935} + \frac{649\,{e_k}^2}{15870} + \frac{589\,e_k\,e_l}{7935} + \frac{649\,{e_l}^2}{15870}$$

$$\left\langle\{kh^{ijl}\}\right\rangle = -\frac{1263\,{e_i}^2}{1568} - \frac{327\,e_i\,e_j}{784} - \frac{9\,e_i\,e_k}{98} - \frac{327\,e_i\,e_l}{784} + 3\,\alpha\,e_i + \frac{261\,{e_j}^2}{1568} - \frac{9\,e_j\,e_k}{196} + \frac{23\,e_j\,e_l}{112} + \frac{29\,{e_k}^2}{196} - \frac{9\,e_k\,e_l}{196} + \frac{261\,{e_l}^2}{1568}$$

$$\left\langle\{ij,lh^{jk}\}\right\rangle = -\frac{202151\,{e_i}^2}{207368} - \frac{27333\,e_i\,e_j}{103684} - \frac{66\,e_i\,e_k}{529} - \frac{26713\,e_i\,e_l}{103684} + 3\,\alpha\,e_i + \frac{43633\,{e_j}^2}{207368} - \frac{473\,e_j\,e_k}{7406} - \frac{9\,e_j\,e_l}{196} + \frac{310\,{e_k}^2}{3703} + \frac{676\,e_k\,e_l}{3703} + \frac{24945\,{e_l}^2}{207368}$$

$$\left\langle\{ih^{jk},jk\}\right\rangle = -\frac{88933\,{e_i}^2}{119025} - \frac{48476\,e_i\,e_j}{119025} - \frac{48476\,e_i\,e_k}{119025} - \frac{96\,e_i\,e_l}{529} + 3\,\alpha\,e_i + \frac{17507\,{e_j}^2}{119025} + \frac{1043\,e_j\,e_k}{5175} - \frac{25\,e_j\,e_l}{529} + \frac{17507\,{e_k}^2}{119025} - \frac{25\,e_k\,e_l}{529} + \frac{225\,{e_l}^2}{1058}$$

$$\left\langle\{ih^{jk},jl\}\right\rangle = -\frac{184171\,{e_i}^2}{207368} - \frac{25\,e_i\,e_j}{196} - \frac{33213\,e_i\,e_k}{103684} - \frac{7604\,e_i\,e_l}{25921} + 3\,\alpha\,e_i + \frac{703\,{e_j}^2}{9016} + \frac{703\,e_j\,e_k}{4508} - \frac{75\,e_j\,e_l}{1127} + \frac{28513\,{e_k}^2}{207368} - \frac{25\,e_k\,e_l}{529} + \frac{13073\,{e_l}^2}{51842}$$

$$\left\langle\{ih^{jkl}\}\right\rangle = -\frac{99\,{e_i}^2}{98} - \frac{8\,e_i\,e_j}{49} - \frac{8\,e_i\,e_k}{49} - \frac{8\,e_i\,e_l}{49} + 3\,\alpha\,e_i + \frac{81\,{e_j}^2}{1568} + \frac{65\,e_j\,e_k}{784} + \frac{65\,e_j\,e_l}{784} + \frac{81\,{e_k}^2}{1568} + \frac{65\,e_k\,e_l}{784} + \frac{81\,{e_l}^2}{1568}$$

$$\left\langle\{jh^{ikl},kl\}\right\rangle = -\frac{18039\,{e_i}^2}{16928} - \frac{36\,e_i\,e_j}{529} - \frac{1875\,e_i\,e_k}{8464} - \frac{1875\,e_i\,e_l}{8464} + 3\,\alpha\,e_i + \frac{557\,{e_j}^2}{3703} - \frac{473\,e_j\,e_k}{7406} - \frac{473\,e_j\,e_l}{7406} + \frac{12615\,{e_k}^2}{118496} + \frac{23\,e_k\,e_l}{112} + \frac{12615\,{e_l}^2}{118496}$$

$$\left\langle\{kh^{ijl},ij\}\right\rangle = -\frac{638819\,{e_i}^2}{829472} - \frac{327\,e_i\,e_j}{784} - \frac{26713\,e_i\,e_k}{103684} - \frac{2355\,e_i\,e_l}{8464} + 3\,\alpha\,e_i + \frac{5779\,{e_j}^2}{36064} + \frac{703\,e_j\,e_k}{4508} - \frac{9\,e_j\,e_l}{368} + \frac{23657\,{e_k}^2}{207368} - \frac{25\,e_k\,e_l}{529} + \frac{3985\,{e_l}^2}{16928}$$

$$\left\langle\{ih^{jk},lh^{jk}\}\right\rangle = -\frac{497\,{e_i}^2}{529} - \frac{66\,e_i\,e_j}{529} - \frac{66\,e_i\,e_k}{529} - \frac{224\,e_i\,e_l}{529} + 3\,\alpha\,e_i + \frac{41\,{e_j}^2}{529} + \frac{73\,e_j\,e_k}{529} - \frac{25\,e_j\,e_l}{529} + \frac{41\,{e_k}^2}{529} - \frac{25\,e_k\,e_l}{529} + \frac{305\,{e_l}^2}{1058}$$

$$\left\langle\{ih^{jkl},kl\}\right\rangle = -\frac{44211\,{e_i}^2}{51842} - \frac{96\,e_i\,e_j}{529} - \frac{7604\,e_i\,e_k}{25921} - \frac{7604\,e_i\,e_l}{25921} + 3\,\alpha\,e_i + \frac{817\,{e_j}^2}{16928} + \frac{865\,e_j\,e_k}{8464} + \frac{865\,e_j\,e_l}{8464} + \frac{72801\,{e_k}^2}{829472} + \frac{65\,e_k\,e_l}{784} + \frac{72801\,{e_l}^2}{829472}$$

$$\left\langle\{lh^{ijk},jh^{ik}\}\right\rangle = -\frac{7287\,{e_i}^2}{8464} - \frac{1875\,e_i\,e_j}{8464} - \frac{3\,e_i\,e_k}{8} - \frac{1875\,e_i\,e_l}{8464} + 3\,\alpha\,e_i + \frac{1697\,{e_j}^2}{16928} - \frac{9\,e_j\,e_k}{368} + \frac{73\,e_j\,e_l}{529} + \frac{95\,{e_k}^2}{368} - \frac{9\,e_k\,e_l}{368} + \frac{1697\,{e_l}^2}{16928}$$

$$\left\langle\{ih^{jkl},kh^{jl}\}\right\rangle = -\frac{12439\,{e_i}^2}{16928} - \frac{2355\,e_i\,e_j}{8464} - \frac{224\,e_i\,e_k}{529} - \frac{2355\,e_i\,e_l}{8464} + 3\,\alpha\,e_i + \frac{601\,{e_j}^2}{8464} + \frac{865\,e_j\,e_k}{8464} + \frac{e_j\,e_l}{8} + \frac{2097\,{e_k}^2}{16928} + \frac{865\,e_k\,e_l}{8464} + \frac{601\,{e_l}^2}{8464}$$

$$\langle\{F\}\rangle = -\frac{21\,{e_i}^2}{32} - \frac{3\,e_i\,e_j}{8} - \frac{3\,e_i\,e_k}{8} - \frac{3\,e_i\,e_l}{8} + 3\,\alpha\,e_i + \frac{3\,{e_j}^2}{32} + \frac{e_j\,e_k}{8} + \frac{e_j\,e_l}{8} + \frac{3\,{e_k}^2}{32} + \frac{e_k\,e_l}{8} + \frac{3\,{e_l}^2}{32}$$

[33] For the proof, please see S&Y (2010).

Below are the welfare functions for multilateral trade regimes:

$$\langle\{\Phi\}\rangle = -\frac{52\,{e_i}^2}{75} - \frac{88\,e_i\,e_j}{225} - \frac{88\,e_i\,e_k}{225} - \frac{88\,e_i\,e_l}{225} + 3\,\alpha, e_i + \frac{47\,{e_j}^2}{450} + \frac{31\,e_j\,e_k}{225} + \frac{31\,e_j\,e_l}{225} + \frac{47\,{e_k}^2}{450} + \frac{31\,e_k\,e_l}{225} + \frac{47\,{e_l}^2}{450}$$
$$\langle\{ij^m\}\rangle = -\frac{57643\,{e_i}^2}{88200} - \frac{88\,e_i\,e_j}{225} - \frac{4631\,e_i\,e_k}{11025} - \frac{4631\,e_i\,e_l}{11025} + 3\,\alpha, e_i + \frac{7397\,{e_j}^2}{88200} + \frac{1684\,e_j\,e_k}{11025} + \frac{1684\,e_j\,e_l}{11025} + \frac{337\,{e_k}^2}{3150} + \frac{e_k\,e_l}{7} + \frac{337\,{e_l}^2}{3150}$$
$$\langle\{jk^m\}\rangle = \frac{8101\,{e_j}^2}{88200} + \frac{31\,e_j\,e_k}{225} + \frac{94\,e_j\,e_l}{735} - \frac{7687\,e_j\,e_i}{22050} + \frac{8101\,{e_k}^2}{88200} + \frac{94\,e_k\,e_l}{735} - \frac{7687\,e_k\,e_i}{22050} + \frac{169\,{e_l}^2}{1470} - \frac{20\,e_l\,e_i}{49} - \frac{7948\,{e_i}^2}{11025} + 3\,\alpha\,e_i$$
$$\langle\{ijk^m\}\rangle = -\frac{24313\,{e_i}^2}{38025} - \frac{14186\,e_i\,e_j}{38025} - \frac{14186\,e_i\,e_k}{38025} - \frac{80\,e_i\,e_l}{169} + 3\,\alpha\,e_i + \frac{6529\,{e_j}^2}{76050} + \frac{4504\,e_j\,e_k}{38025} + \frac{27\,e_j\,e_l}{169} + \frac{6529\,{e_k}^2}{76050} + \frac{27\,e_k\,e_l}{169} + \frac{3\,{e_l}^2}{26}$$
$$\langle\{jkl^m\}\rangle = \frac{439\,{e_j}^2}{5070} + \frac{304\,e_j\,e_k}{2535} + \frac{304\,e_j\,e_l}{2535} - \frac{54\,e_j\,e_i}{169} + \frac{439\,{e_k}^2}{5070} + \frac{304\,e_k\,e_l}{2535} - \frac{54\,e_k\,e_i}{169} + \frac{439\,{e_l}^2}{5070} - \frac{54\,e_l\,e_i}{169} - \frac{132\,{e_i}^2}{169} + 3\,\alpha\,e_i$$
$$\langle\{F\}\rangle = -\frac{21\,{e_i}^2}{32} - \frac{3\,e_i\,e_j}{8} - \frac{3\,e_i\,e_k}{8} - \frac{3\,e_i\,e_l}{8} + 3\,\alpha\,e_i + \frac{3\,{e_j}^2}{32} + \frac{e_j\,e_k}{8} + \frac{e_j\,e_l}{8} + \frac{3\,{e_k}^2}{32} + \frac{e_k\,e_l}{8} + \frac{3\,{e_l}^2}{32}$$

B.2 Baseline Multilateralism

Proof of Proposition 1 Since global free trade is no longer a stable outcome (lemma 2), there are first two stable 3-country multilateral agreements to test: $\left\langle\{\bar{s}s'l^M\}\right\rangle$ and $\left\langle\{s\bar{s}s'^M\}\right\rangle$. From lemma 2, the outside country will not deviate from these agreements so we only need to check the deviations from the countries in the agreements.

The smaller country in any of these multilateral agreements has no incentive to unilaterally deviate away:[34]

$$\triangle\,\omega_{s'}(\{\bar{s}l^M\} - \{\bar{s}s'l^M\}) < 0 \ \text{ and } \ \triangle\,\omega_{s'}(\{s\bar{s}^M\} - \{s\bar{s}s'^M\}) < 0 \ \text{ for all } \ \theta \tag{33}$$

This is not true of the large country in $\left\langle\{\bar{s}s'l^M\}\right\rangle$. It has a profitable unilateral deviation away from the agreement as its relative market power increases:

$$\triangle\,\omega_l(\{\bar{s}s'^M\} - \{\bar{s}s'l^M\}) > 0 \ \text{ iff } \ \theta \geq \theta_l(\{\bar{s}s'^M\} - \{\bar{s}s'l^M\}) = 1.006 \tag{34}$$

In fact, all the countries in these multilateral agreements prefer global free trade:

$$\begin{gathered}\triangle\omega_{s'}(F - \{\bar{s}s'l^M\}) > 0\ ,\ \triangle\,\omega_{\bar{s}}(F - \{\bar{s}s'l^M\}) > 0 \text{ and } \triangle\,\omega_l(F - \{\bar{s}s'l^M\}) > 0 \text{ for all } \theta \\ \triangle\omega_s(F - \{s\bar{s}s'^M\}) > 0\ ,\ \triangle\,\omega_{s'}(F - \{s\bar{s}s'^M\}) > 0 \text{ and } \triangle\,\omega_{\bar{s}}(F - \{s\bar{s}s'^M\}) > 0 \text{ for all } \theta\end{gathered} \tag{35}$$

As such, the stability of these agreements depend on the outside country. However as

[34] Also, we know from lemma 1 that $\frac{\partial\triangle\omega_i(ijk^M - jk^M)}{\partial e_k} < 0$ and $\frac{\partial\triangle\omega_i(ij^M - \Phi)}{\partial e_k} < 0$ and under symmetry $\triangle\omega_i(ijk^M - jk^M) > 0$ and $\triangle\omega_i(ij^M - \Phi) > 0$. Therefore, $\triangle\omega_{s'}(\{s\bar{s}s'^M\} - \{\Phi\}) > 0$ and $\triangle\,\omega_{s'}(\{ss'^M\} - \{\Phi\}) > 0$ for all θ. So no small country will deviate from either three country multilateral agreement, $\left\langle\{\bar{s}s'l^M\}\right\rangle$ and $\left\langle\{s\bar{s}s'^M\}\right\rangle$.

seen in earlier calculations both the outside countries would rather stay out of the agreements than go to global free trade (equation (13)). So there are two stable multilateral equilibria when countries are relatively similar in market power: $\langle\{s\bar{s}s'^M\}\rangle$ and $\langle\{\bar{s}s'l^M\}\rangle$. As their relative differences in market power increases, the larger country will choose to stay out of the 3-country multilateral agreement with two other smaller countries leaving the unique multilateral equilibrium with two smaller countries: $\langle\{s'\bar{s}^M\}\rangle$

B.3 Multilateralism with diverse country types

Proof of Proposition 3 Similar to the baseline equilibrium under multilateralism, global free trade is no longer a stable outcome (lemma 3). As such, there are three stable 3-country multilateral agreements to test: $\langle\{s'ml^M\}\rangle$, $\langle\{ss'l^M\}\rangle$, and $\langle\{ss'm^M\}\rangle$. From lemma 3, the country outside these 3-country multilateral agreements will not deviate from these agreements so we only need to check the deviations from the countries in these agreements.

The smaller country in any of these multilateral agreements has no incentive to unilaterally deviate away:

$$\begin{aligned}&\triangle\omega_s(\{s'l^M\}-\{ss'l^M\})<0,\ \ \triangle\omega_s(\{s'm^M\}-\{ss'm^M\})<0,\ \text{ and}\\&\triangle\omega_s(\{ml^M\}-\{sml^M\})<0\ \text{ for all }\ \theta\end{aligned}\tag{36}$$

This is not the case for both the medium and larger country. Each of these stable equilibria are tested in turn. When countries have a relative small difference in market power, the larger country has a profitable unilateral deviation from its multilateral agreement with the two smaller countries ($\langle\{ss'l^M\}\rangle$):

$$\triangle\,\omega_l(\{ss'^M\}-\{ss'l^M\})>0\ \text{ iff }\ \theta\geq\theta_l(\{ss'^M\}-\{ss'l^M\})=1.006\tag{37}$$

When the four countries have a moderate difference in market power, the larger country has a profitable unilateral deviation from its multilateral agreement with the medium and smaller countries ($\langle\{sml^M\}\rangle$):

$$\triangle\,\omega_l(\{sm^M\}-\{sml^M\})>0\ \text{ iff }\ \theta\geq\theta_l(\{sm^M\}-\{sml^M\})=1.008\tag{38}$$

When the four countries have a larger difference in market power, the medium country also has a profitable unilateral deviation from its multilateral agreement with the two smaller countries ($\langle\{ss'm^M\}\rangle$):

$$\triangle\,\omega_m(\{ss'^M\}-\{ss'm^M\})>0 \;\text{ iff }\; \theta\geq\theta_m(\{ss'^M\}-\{ss'm^M\})=1.012 \tag{39}$$

Similar to the baseline case, all the countries in these multilateral agreements prefer global free trade:

$$\begin{gathered}\triangle\omega_s(F-\{ss'l^M\})>0 \;\text{ and }\; \triangle\,\omega_l(F-\{ss'l^M\})>0 \;\text{ for all }\; \theta \\ \triangle\omega_s(F-\{ss'm^M\})>0 \;\text{ and }\; \triangle\,\omega_m(F-\{ss'm^M\})>0 \;\text{ for all }\; \theta \\ \triangle\omega_s(F-\{sml^M\})>0,\; \triangle\,\omega_m(F-\{sml^M\})>0,\;\text{ and }\; \triangle\,\omega_l(F-\{sml^M\})>0 \text{ for all } \theta\end{gathered} \tag{40}$$

As such, the stability of these agreements depend on the outside country. However as seen in earlier calculations all the outside countries would rather stay out of the 3-country agreements than join the agreements resulting in global free trade (lemma 3). As a result, there are three stable multilateral equilibria when countries are relatively similar in market power: $\langle\{ss'l^M\}\rangle$, $\langle\{ss'm^M\}\rangle$, and $\langle\{sml^M\}\rangle$. When the relative market power differences is small, the larger country will choose to stay out of the 3-country multilateral agreement with two other smaller countries leaving two stable multilateral equilibrium: $\langle\{ss'm^M\}\rangle$ and $\langle\{sml^M\}\rangle$. When the relative market power differences is moderate, the larger country will choose to unilaterally deviate from the agreement with the small and medium countries leaving one stable multilateral equilibrium: $\langle\{ss'm^M\}\rangle$. When the relative market power differences is large, the medium country will choose to stay out of the remaining 3-country multilateral agreement leaving the two smaller countries in an agreement with each other: $\langle\{ss'^M\}\rangle$.

B.4 Baseline Regionalism

Proof of Lemma 6 Also, we can establish that all countries have a profitable deviation away from being a spoke for a full hub country. From lemma 5 ($\frac{\partial\triangle\omega_s(\{lh^{\bar{s}s'}\}-\{lh^{s\bar{s}s'}\})}{\partial e_{s'}}\leq 0$), we show that the smaller country will always unilaterally deviate from a full hub:

$$\triangle\,\omega_s(\{lh^{\bar{s}s'}\}-\{lh^{s\bar{s}s'}\})>0 \text{ for all } \theta \tag{41}$$

Due to lemma 4, the deviation from a full hub arrangement applies as well for the larger country:

$$\triangle\, \omega_l(\{sh^{\bar{s}s'}\} - \{sh^{l\bar{s}s'}\}) > 0 \text{ for all } \theta \tag{42}$$

In fact, from lemmas 4 the larger country has a profitable deviation from any hub and spoke trade regime:

$$\triangle\, \omega_l(\{ss'\} - \{sh^{ls'}\}) > 0 \text{ and } \triangle\, \omega_l(\{sh^{\bar{s}s'}, \bar{s}s'\} - \{sh^{l\bar{s}s'}, \bar{s}s'\}) > 0 \text{ for all } \theta \tag{43}$$

Proof of Lemma 7. Lemmas 4 and 5 imply that $\frac{\partial \triangle \omega_s(F - \{\bar{s}h^{lss'}, s'h^{sl}\})}{\partial e_l} \leq 0$ (two FTA deviation) and $\frac{\partial \triangle \omega_s(F - \{\bar{s}h^{lss'}, lh^{ss'}\})}{\partial e_l} \leq 0$ (one FTA deviation). Since global free trade is a Nash equilibrium under symmetry, the smaller country under free trade has no unilateral incentive to deviate:

$$\triangle\, \omega_s(F - \{\bar{s}h^{lss'}, s'h^{ls}\}) > 0 \text{ and } \triangle\, \omega_s(F - \{\bar{s}h^{lss'}, lh^{ss'}\}) > 0 \text{ for all } \theta \tag{44}$$

From the results below, no large country has any profitable unilateral deviation away from global free trade:

$$\begin{aligned} \frac{\partial \triangle\, \omega_s(F - \{\bar{s}h^{ls'}, ls'\})}{\partial e_l} &= \underbrace{\frac{\partial \triangle\, \omega_s(F - \{\bar{s}h^{lss'}, lh^{ss'}\})}{\partial e_l}}_{\leq 0} + \underbrace{\frac{\partial \triangle\, \omega_s(\{\bar{s}h^{lss'}, lh^{ss'}\} - \{\bar{s}h^{lss'}, ls'\})}{\partial e_l}}_{\leq 0} \\ &+ \underbrace{\frac{\partial \triangle\, \omega_s(\{\bar{s}h^{lss'}, ls'\} - \{\bar{s}h^{ls'}, ls'\})}{\partial e_l}}_{\leq 0} \leq 0 \end{aligned} \tag{45}$$

This result still holds when the position of countries l and $\bar{s}$ are switched. Therefore, a smaller country (say s) prefers $\langle\{F\}\rangle$ to being an outsider to all FTAs $\langle\{\{\bar{s}h^{ls'}, ls'\}\rangle$, meaning they have no incentive to deviate from free trade:

$$\triangle\, \omega_s(F - \{\bar{s}h^{ls'}, ls'\}) > 0 \text{ for all } \theta \tag{46}$$

Given the trade asymmetry pattern assumed in assumption 1 and equation 44, joint deviations to any hub and spoke regimes do not happen. Here are the following joint deviations from global free trade that needs to be considered:

(JF1) Joint deviation of l and s from $\langle\{F\}\rangle$ to $\langle\{sl\}\rangle$

(JF2) Joint deviation of s and s' from $\langle\{F\}\rangle$ to $\langle\{ss'\}\rangle$

(JF3) Joint deviation of s, s', and l from $\langle\{F\}\rangle$ to $\left\langle\{sh^{ls'}, ls'\}\right\rangle$

(JF4) Joint deviation of s, s', and $\bar{s}$ from $\langle\{F\}\rangle$ to $\left\langle\{sh^{\bar{s}s'}, \bar{s}s'\}\right\rangle$

(JF5) Joint deviation of s, s', and $\bar{s}$, or s, s', and l, or all four countries from $\langle\{F\}\rangle$ to $\langle\{\Phi\}\rangle$

For (JF1), under symmetry no countries benefit from jointly deviating from free trade to a single FTA between them, $\triangle\omega_i(F - \{ij\}) = \frac{83\,e^2}{9800} > 0$. Since under asymmetry with assumption 1, $\triangle\omega_s(F - \{sl\})$ is monotonically decreasing in θ and we can show that $\triangle\omega_s(F - \{sl\}) > 0$.[35] As such, (JF1) is ruled out.

Since countries prefer to form FTAs with larger importer country (from lemma 4), we can rule out the smaller countries wanting to jointly deviate to form an FTA from (JF1). So (JF2) cannot occur.

For (JF3), under symmetry no three countries will benefit from jointly deviating from free trade to form FTAs amongst themselves, $\triangle\omega_i(F - \{ih^{jk}, jk\}) = \frac{459\,e^2}{105800} > 0$. Under asymmetry, $\triangle\omega_s(F - \{sh^{ls'}, ls'\})$ is monotonically decreasing in θ.[36] As such, (JF3) can be ruled out, $\triangle\omega_s(F - \{sh^{ls'}, ls'\}) > 0$.

Similar to the argument in ruling out (JF2) from (JF1), countries preference for larger FTA partners and (JF3) eliminates the possibility for (JF4).

Lastly, (JF5) can be ruled out because of $\triangle\omega_s(F - \{sl\}) > 0$ and lemma 4.

Also, we can establish that all countries have a profitable deviation away from being a spoke for a full hub country. From lemma 6 and lemma 5 ($\frac{\partial\triangle\omega_s(\{lh^{\bar{s}s'}\} - \{lh^{s\bar{s}s'}\})}{\partial e_{s'}} \leq 0$), we show that the smaller country will always unilaterally deviate from a full hub:

$$\triangle\,\omega_s(\{lh^{\bar{s}s'}\} - \{lh^{s\bar{s}s'}\}) > 0 \text{ for all } \theta \tag{47}$$

Due to lemma 4, the deviation from a full hub arrangement applies as well for the larger country:

$$\triangle\,\omega_l(\{sh^{\bar{s}s'}\} - \{sh^{l\bar{s}s'}\}) > 0 \text{ for all } \theta \tag{48}$$

In fact, from lemmas 4 and 6 the larger country has a profitable deviation from any hub and spoke trade regime:

$$\triangle\,\omega_l(\{ss'\} - \{sh^{ls'}\}) > 0 \text{ and } \triangle\,\omega_l(\{sh^{\bar{s}s'}, \bar{s}s'\} - \{sh^{l\bar{s}s'}, \bar{s}s'\}) > 0 \text{ for all } \theta \tag{49}$$

35 $\frac{\partial\triangle\omega_s(F-\{sl\})}{\partial\theta} = -\frac{e^2\,(6722\,\theta - 6059)}{25200\,\theta^3} < 0$

36 $\frac{\partial\triangle\omega_s(F-\{sh^{ls'}, ls'\})}{\partial\theta} = -\frac{e^2\,(243742\,\theta - 203149)}{1904400\,\theta^3} < 0$

Proof of Proposition 4. Given assumption 1, we can establish that all countries have a joint profitable deviation from status quo.

Under symmetry, countries always benefit from forming a bilateral FTA. From lemma 5, $\frac{\partial \triangle \omega_s(ss'-\Phi)}{\partial e_l} \geq 0$. Since at the smallest endowment level for l $\triangle \omega_s(ss'-\Phi)|_{\theta=\frac{11}{10}} > 0$, we know that $\langle\{\Phi\}\rangle$ is not stable:

$$\triangle\, \omega_s(ss'-\Phi) > 0 \text{ for all } \theta \tag{50}$$

With the country preference for FTAs with larger countries and the equation above, we can also state that:

$$\triangle\, \omega_s(sl-\Phi) > 0 \text{ for all } \theta \tag{51}$$

From the larger country's perspective in $\langle\{sl\}\rangle$, we know that from part (i) of lemma 4 that $\frac{\partial \triangle \omega_l(sl-\Phi)}{\partial e_l} \geq 0$. Since at the smallest endowment level for l $\triangle \omega_l(sl-\Phi)|_{\theta=\frac{11}{10}} > 0$, this implies that the larger importer country always prefers an FTA to status quo:

$$\triangle\, \omega_l(sl-\Phi) > 0 \text{ for all } \theta \tag{52}$$

From the stability calculation of $\langle\{F\}\rangle$, directly outside of global free trade the larger country prefers a trade regime with 3 FTAs where it is the outside country and the other smaller countries are all in FTAs with one another, $\left\langle\{\bar{s}^{ss'}, ss'\}\right\rangle$. The coalitional deviations from this trade regime are as follows:

(JSSS1) Deviation of s and l from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\langle\{sl, \bar{s}s'\}\rangle$

(JSSS2) Deviation of s and s' from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\left\langle\{sh^{\bar{s}s'}\}\right\rangle$

(JSSS3) Deviation of l, s, and s' from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\left\langle\{lh^{ss'}, ss'\}\right\rangle$

(JSSS4) Deviation of l, s, and s' from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\left\langle\{sh^{ls'}\}\right\rangle$

(JSSS5) Deviation of l, s, and s' from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\left\langle\{lh^{ss'}\}\right\rangle$

(JSSS6) Deviation of l, s, and s' from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\langle\{sl\}\rangle$

(JSSS7) Deviation of s, s', and $\bar{s}$ from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\langle\{ss'\}\rangle$

(JSSS8) Deviation of all countries from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\langle\{\Phi\}\rangle$

(JSSS9) Deviation of all countries from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\langle\{F\}\rangle$

(JSSS10) Deviation of all countries from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\left\langle\{sh^{l\bar{s}}, s'h^{l\bar{s}}\}\right\rangle$

(JSSS11) Deviation of all countries from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\left\langle\{sh^{ls'}, \bar{s}s'\}\right\rangle$

(JSSS12) Deviation of all countries from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\left\langle\{sh^{l\bar{s}s'}, \bar{s}s'\}\right\rangle$

(JSSS13) Deviation of all countries from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\left\langle\{sh^{l\bar{s}s'}, s'h^{l\bar{s}}\}\right\rangle$

(JSSS14) Deviation of all countries from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\left\langle\{sh^{l\bar{s}s'}\}\right\rangle$

(JSSS15) Deviation of all countries from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\left\langle\{sh^{l\bar{s}s'}, s'l\}\right\rangle$

(JSSS16) Deviation of all countries from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\left\langle\{lh^{s\bar{s}s'}\}\right\rangle$

(JSSS17) Deviation of all countries from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\left\langle\{lh^{s\bar{s}s'}, s\bar{s}\}\right\rangle$

(JSSS18) Deviation of all countries from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\left\langle\{lh^{s\bar{s}s'}, \bar{s}h^{ss'}\}\right\rangle$

(JSSS19) Deviation of all countries from $\left\langle\{\bar{s}h^{ss'}, ss'\}\right\rangle$ to $\langle\{lh^{s\bar{s}}, s'\bar{s}\}\rangle$

For (JSSS1), country s always profits from giving up its two FTAs with smaller countries in exchange for one FTA with the more desirable large country.

$$\triangle\,\omega_s(\{sl, \bar{s}s'\} - \{\bar{s}h^{ss'}, ss'\}) > 0 \text{ for all } \theta \tag{53}$$

From lemma 4, country l will benefit less from forming FTAs as such it is only profitable for country l when it is smaller:

$$\triangle\,\omega_l(\{sl, \bar{s}s'\} - \{\bar{s}h^{ss'}, ss'\}) > 0 \text{ iff } \theta \leq \theta_l(\{sl, \bar{s}s'\} - \{\bar{s}h^{ss'}, ss'\}) = 1.008717 \tag{54}$$

However, when country l is this similar in market power to the smaller countries, it prefers global free trade ruling out (JSSS1):

$$\triangle\,\omega_l(\{F\} - \{sl, \bar{s}s'\}) > 0 \text{ iff } \theta \leq \theta_l(\{F\} - \{sl, \bar{s}s'\}) = 1.02210 \tag{55}$$

(JSSS2) cannot happen since from lemma 4 small country s or $\bar{s}$ prefers to form FTAs and will not drop one of its two FTAs to become a spoke:

$$\triangle\,\omega_s(\{sh^{\bar{s}s'}\} - \{\bar{s}h^{ss'}, ss'\}) < 0 \text{ for all } \theta \tag{56}$$

For (JSSS3), countries s and s' would agree to the deviation because they always derive higher welfare from an FTA with a larger country. The large country is then the decider between being part of a three FTA arrangement with two small countries or not. However the large country has no profitable deviation–(JSSS3) is ruled out:

$$\triangle\, \omega_l(\{lh^{ss'}, ss'\} - \{\bar{s}h^{ss'}, ss'\}) < 0 \text{ for all } \theta \tag{57}$$

(JSSS4) can be ruled out since country l will never be a spoke country (lemma 6):

$$\triangle\, \omega_l(\{sh^{ls'}\} - \{\bar{s}h^{ss'}, ss'\}) < 0 \text{ for all } \theta \tag{58}$$

Since the smaller countries s and s' won't give up two of their FTAs to become spokes to the large country, (JSSS5) cannot happen:

$$\triangle\, \omega_s(\{lh^{ss'}\} - \{\bar{s}h^{ss'}, ss'\}) < 0 \text{ for all } \theta \tag{59}$$

(JSSS6) is ruled out because country l gets higher welfare from being an outsider country:

$$\triangle\, \omega_l(\{sl\} - \{\bar{s}h^{ss'}, ss'\}) < 0 \text{ for all } \theta \tag{60}$$

For (JSSS7) countries s or s' do not have a profitable deviation in revoking one of their FTAs:

$$\triangle\, \omega_s(\{ss'\} - \{\bar{s}h^{ss'}, ss'\}) < 0 \text{ for all } \theta \tag{61}$$

However, country $\bar{s}$ chooses to stay out of both its FTAs if the endowment asymmetry parameter gets large enough:

$$\triangle\, \omega_{\bar{s}}(\{ss'\} - \{\bar{s}h^{ss'}, ss'\}) > 0 \text{ iff } \theta \leq \theta_{\bar{s}}(\{ss'\} - \{\bar{s}h^{ss'}, ss'\}) = 1.04983 \tag{62}$$

When this happens, the large country has a profitable deviation to an FTA with outside country $\bar{s}$:

$$\triangle\, \omega_l(\{l\bar{s}, ss'\} - \{ss'\}) > 0 \text{ for all } \theta \tag{63}$$

This is reciprocated by the small outside country $\bar{s}$ since it always prefers an FTA with a larger country:

$$\triangle\, \omega_{\bar{s}}(\{l\bar{s}, ss'\} - \{ss'\}) > 0 \text{ for all } \theta \tag{64}$$

This results in the trade regime $\langle\{l\bar{s}, ss'\}\rangle$ which is unstable as proven from (JSSS1). As such, (JSSS7) is also ruled out.

(JSSS8) can be ruled out since the small countries will not profit by being in status quo from their free trade area . In fact, two small countries will jointly deviate to an FTA than be in status quo.

$$\triangle\,\omega_s(\{\Phi\} - \{\bar{s}h^{ss'}, ss'\}) < 0 \text{ for all } \theta \tag{65}$$

(JSSS9) is conditional on the global free trade stability calculation earlier in equation (46).

For (JSSS10), the small countries who will enter into an FTA with the large country in exchange for dropping one of its pre-existing FTAs will see a profitable deviation:

$$\triangle\,\omega_s(\{sh^{l\bar{s}}, s'h^{l\bar{s}}\} - \{\bar{s}h^{ss'}, ss'\}) > 0 \text{ for all } \theta \tag{66}$$

However, the large country will not enter into two FTAs from its position outside of the free trade area unless it is very similar in market power to the smaller countries:

$$\triangle\,\omega_l(\{sh^{l\bar{s}}, s'h^{l\bar{s}}\} - \{\bar{s}h^{ss'}, ss'\}) > 0 \text{ iff } \theta \le \theta_l(\{sh^{l\bar{s}}, s'h^{l\bar{s}}\} - \{\bar{s}h^{ss'}, s'\}) = 1.01856 \tag{67}$$

However, when all countries are that similar in market power, the smaller countries s and s' in two FTAs each have a joint profitable deviation to sign one more FTA:

$$\triangle\,\omega_s(\{sh^{l\bar{s}s'}, s'h^{l\bar{s}}\} - \{sh^{l\bar{s}}, s'h^{l\bar{s}}\}) > 0 \text{ for all } \theta \tag{68}$$

The larger country prefers global free trade to this new regime within parameter space $[1, 1.01855]$ from equation (46) hence (JSSS10) is ruled out.

(JSSS11) is out here because a large country will always deviate away from being a spoke country from lemma 6. The same goes for (JSSS12).

(JSSS13) cannot happen because the large country would rather stay out of the free trade area than join in any FTAs:

$$\triangle\,\omega_s(\{sh^{l\bar{s}s'}, s'h^{l\bar{s}}\} - \{\bar{s}h^{ss'}, ss'\}) < 0 \text{ for all } \theta \tag{69}$$

(JSSS14) can be ruled out since country l will never be a spoke country (equation (48) and lemma 6).

(JSSS15) is ruled out because country l will not deviate:

$$\triangle\,\omega_l(\{sh^{l\bar{s}s'}, s'l\} - \{\bar{s}h^{ss'}, ss'\}) < 0 \text{ for all } \theta \tag{70}$$

(JSSS16) is ruled out since the smaller countries will not be a spoke to a full hub country (equation (47) and lemma 6).

For (JSSS17), from lemma 5 the small countries with only one FTA will not deviate since it will experience a welfare loss from dropping 2 FTAs to be in one FTA with the large country:

$$\triangle\,\omega_{s'}(\{lh^{s\bar{s}s'}, s\bar{s}\} - \{\bar{s}h^{ss'}, ss'\}) < 0 \text{ for all } \theta \tag{71}$$

In fact, it will have a joint profitable deviation to form another FTA with one of the two other small countries with two FTAs each. So (JSSS17) does not happen.

For (JSSS18), the small country in two FTAs each will always have a joint profitable deviation to go all the way to global free trade so it is ruled out:

$$\triangle\,\omega_s(\{F\} - \{lh^{s\bar{s}s'}, \bar{s}h^{ss'}\}) > 0 \text{ and } \triangle\,\omega_{s'}(\{F\} - \{lh^{s\bar{s}s'}, \bar{s}h^{ss'}\}) > 0 \;\text{ for all } \theta \tag{72}$$

Finally, (JSSS19) cannot happen because both the small countries in one FTA each will jointly sign an additional FTA together

$$\triangle\,\omega_s(\{lh^{s\bar{s}}, s'h^{s\bar{s}}\} - \{lh^{s\bar{s}}, s'\bar{s}\}) > 0 \text{ and } \triangle\,\omega_{s'}(\{lh^{s\bar{s}}, s'h^{s\bar{s}}\} - \{lh^{s\bar{s}}, s'\bar{s}\}) > 0 \;\text{ for all } \theta \tag{73}$$

As such, $\langle\{\bar{s}h^{ss'}, ss'\}\rangle$ is the only stable trade regime outside of global free trade.

B.5 Regionalism with diverse country types

Proof of Proposition 5. Given assumption 2, we first establish global free trade as a stable equilibria. From lemma 6, all full hub trade regimes are not stable and deviations to these regimes will not be considered. From below, the smaller countries have no incentive to unilaterally deviation from global free trade:

$$\begin{aligned} &\triangle\,\omega_s(F - \{mh^{ss'l}, s'h^{sl}\}) > 0, \;\; \triangle\omega_s(F - \{lh^{ss'm}, mh^{ss'}\}) > 0, \\ &\triangle\,\omega_s(F - \{lh^{ss'm}, s'h^{sm}\}) > 0, \;\; \text{and} \;\; \triangle\,\omega_s(F - \{lh^{s'm}, s'm\}) > 0 \;\; \text{for all} \;\; \theta \end{aligned} \tag{74}$$

The medium country, however, has a profitable deviation from global free trade:

$$\triangle\,\omega_m(F - \{lh^{ss'}, ss'\}) > 0 \;\text{ iff }\; \theta \leq \theta_m(F - \{lh^{ss'}, ss'\}) = 1.09 \tag{75}$$

Similarly, the larger country has a profitable deviation away from global free trade:

$$\triangle\,\omega_l(F - \{mh^{ss'}, ss'\}) > 0 \;\text{ iff }\; \theta \leq \theta_l(F - \{mh^{ss'}, ss'\}) = 1.017 \tag{76}$$

Since $\theta_l(F-\{mh^{ss'}, ss'\}) < \theta_m(F-\{lh^{ss'}, ss'\})$, the larger country's deviation to a 3-country regional trade agreements with the exclusion of the larger country ($\{mh^{ss'}, ss'\}$) binds. As such, global free trade is unstable from unilateral deviation by the larger country.

Next the following joint deviations from global free trade are considered:

(JF1) Joint deviation of l and m from $\langle\{F\}\rangle$ to $\langle\{ml\}\rangle$

(JF2) Joint deviation of m and s from $\langle\{F\}\rangle$ to $\langle\{sm\}\rangle$

(JF3) Joint deviation of l and s from $\langle\{F\}\rangle$ to $\langle\{sl\}\rangle$

(JF4) Joint deviation of s and s' from $\langle\{F\}\rangle$ to $\langle\{ss'\}\rangle$

(JF5) Joint deviation of s, s', and l from $\langle\{F\}\rangle$ to $\left\langle\{lh^{ss'}, ss'\}\right\rangle$

(JF6) Joint deviation of s, s', and m from $\langle\{F\}\rangle$ to $\left\langle\{mh^{ss'}, ss'\}\right\rangle$

(JF7) Joint deviation of s, m, and l from $\langle\{F\}\rangle$ to $\langle\{lh^{sm}, sm\}\rangle$

(JF8) Joint deviation of any three countries or all four countries from $\langle\{F\}\rangle$ to $\langle\{\Phi\}\rangle$

(JF1), (JF2), (JF3), and (JF4) are ruled out since each of these countries don't have a joint profitable deviation from global free trade to an FTA with each other.

By the same direct calculation as above, the joint deviations in (JF5), (JF6), (JF7), and (JF8) can also be ruled out. This is because there are at least one country that does not have a profitable deviation away from global free trade to these regimes.

From global free trade, the large country has an incentive to deviation unilaterally out of all trade agreements leaving a 3-country regional trade agreements between the medium and two smaller countries ($\{mh^{ss'}, ss'\}$). In fact, the large country has no incentive to join any one or two trade agreements with the other countries once it stays out:

$$\begin{gathered}\triangle\,\omega_l(\{mh^{ss'}, ss'\} - \{mh^{ss'}, sh^{s'l}\}) > 0, \;\; \triangle\omega_l(\{mh^{ss'}, ss'\} - \{mh^{ss'l}, ss'\}) > 0, \\ \triangle\,\omega_l(\{mh^{ss'}, ss'\} - \{mh^{ss'l}, sh^{s'l}\}) > 0, \;\text{ and }\; \triangle\,\omega_l(\{mh^{ss'}, ss'\} - \{sh^{s'ml}, s'h^{sl}\}) > 0 \;\text{ for all }\; \theta\end{gathered} \tag{77}$$

Next, the coalitional deviations from the 3-country regional trade agreements between the medium and two smaller countries ($\{mh^{ss'}, ss'\}$) are considered:

(JSSM1) Joint deviation of any three countries or all four countries from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{\Phi\}\rangle$

(JSSM2) Joint deviation of s and s' from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{ss'\}\rangle$

(JSSM3) Joint deviation of l and s from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{sl\}\rangle$

(JSSM4) Joint deviation of m and s from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{sm\}\rangle$

(JSSM5) Joint deviation of m and l from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{ml\}\rangle$

(JSSM6) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{ml, ss'\}\rangle$

(JSSM7) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{s'l, sm\}\rangle$

(JSSM8) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{sh^{s'm}\}\rangle$

(JSSM9) Joint deviation of s, s', and l from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{sh^{s'l}\}\rangle$

(JSSM10) Joint deviation of s, s', and m from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{mh^{ss'}\}\rangle$

(JSSM11) Joint deviation of s, m, and l from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{mh^{sl}\}\rangle$

(JSSM12) Joint deviation of s, s', and l from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{lh^{ss'}\}\rangle$

(JSSM13) Joint deviation of s, m, and l from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{lh^{sm}\}\rangle$

(JSSM14) Joint deviation of s, m, and l from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{lh^{sm}, sm\}\rangle$

(JSSM15) Joint deviation of s, s', and l from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{lh^{ss'}, ss'\}\rangle$

(JSSM16) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{sh^{s'ml}\}\rangle$

(JSSM17) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{mh^{ss'l}\}\rangle$

(JSSM18) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{lh^{ss'm}\}\rangle$

(JSSM19) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{lh^{s'm}, ss'\}\rangle$

(JSSM20) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{lh^{s'm}, sm\}\rangle$

(JSSM21) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{sh^{s'm}, s'l\}\rangle$

(JSSM22) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{mh^{sl}, ss'\}\rangle$

(JSSM23) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}\rangle$ to $\langle\{s'h^{sml}, ml\}\rangle$

(JSSM24) Joint deviation of all countries from $\left\langle\{mh^{ss'}, ss'\}\right\rangle$ to $\left\langle\{lh^{ss'm}, ss'\}\right\rangle$

(JSSM25) Joint deviation of all countries from $\left\langle\{mh^{ss'}, ss'\}\right\rangle$ to $\left\langle\{s'h^{sml}, sm\}\right\rangle$

(JSSM26) Joint deviation of all countries from $\left\langle\{mh^{ss'}, ss'\}\right\rangle$ to $\left\langle\{sh^{s'ml}, s'l\}\right\rangle$

(JSSM27) Joint deviation of all countries from $\left\langle\{mh^{ss'}, ss'\}\right\rangle$ to $\left\langle\{mh^{ss'l}, s'l\}\right\rangle$

(JSSM28) Joint deviation of all countries from $\left\langle\{mh^{ss'}, ss'\}\right\rangle$ to $\left\langle\{mh^{ss'l}, ss'\}\right\rangle$

(JSSM29) Joint deviation of all countries from $\left\langle\{mh^{ss'}, ss'\}\right\rangle$ to $\left\langle\{lh^{ss'm}, s'm\}\right\rangle$

(JSSM30) Joint deviation of all countries from $\left\langle\{mh^{ss'}, ss'\}\right\rangle$ to $\left\langle\{lh^{s'm}, sh^{s'm}\}\right\rangle$

(JSSM31) Joint deviation of all countries from $\left\langle\{mh^{ss'}, ss'\}\right\rangle$ to $\left\langle\{lh^{ss'}, mh^{ss'}\}\right\rangle$

(JSSM32) Joint deviation of all countries from $\left\langle\{mh^{ss'}, ss'\}\right\rangle$ to $\left\langle\{lh^{ss'm}, s'h^{sm}\}\right\rangle$

(JSSM33) Joint deviation of all countries from $\left\langle\{mh^{ss'}, ss'\}\right\rangle$ to $\left\langle\{lh^{ss'm}, mh^{ss'}\}\right\rangle$

(JSSM34) Joint deviation of all countries from $\left\langle\{mh^{ss'}, ss'\}\right\rangle$ to $\left\langle\{sh^{s'ml}, s'h^{ml}\}\right\rangle$

(JSSM35) Joint deviation of all countries from $\left\langle\{mh^{ss'}, ss'\}\right\rangle$ to $\left\langle\{mh^{ss'l}, sh^{s'l}\}\right\rangle$

(JSSM36) Joint deviation of all countries from $\left\langle\{mh^{ss'}, ss'\}\right\rangle$ to $\langle\{F\}\rangle$

(JSSM1) can be ruled out since none of the countries have a profitable deviation to status quo.

While the two small countries do not have an incentive to forgot their 3-country trade area with the medium country to form an FTA between the two of them, (JSSM2) cannot be ruled out since the medium country has an incentive to unilaterally deviate from this trade area once its relative market power gets large enough:

$$\begin{aligned}
&\triangle\,\omega_s(\{ss'\} - \{mh^{ss'}, ss'\}) < 0 \ \text{ for all } \ \theta, \\
&\triangle\,\omega_{s'}(\{ss'\} - \{mh^{ss'}, ss'\}) < 0 \ \text{ for all } \ \theta, \\
&\triangle\,\omega_m(\{ss'\} - \{mh^{ss'}, ss'\}) > 0 \ \text{ iff } \ \theta \geq \theta_m(\{ss'\} - \{mh^{ss'}, ss'\}) = 1.035
\end{aligned} \tag{78}$$

(JSSM3), (JSSM4), and (JSSM5) can be ruled out since none of these countries have a profitable deviation away from a 3-country trade agreement regime to an FTA with each other.

For (JSSM6), the medium country always has a positive deviation to a trade regime where it is in an FTA with the large country while the two small countries are in an FTA of their own. The large and small countries have a profitable deviation to this regime if their market power differences are relatively small:

$$\begin{aligned}
&\triangle\, \omega_m(\{ml, ss'\} - \{mh^{ss'}, ss'\}) > 0 \ \text{ for all } \ \theta, \\
&\triangle\, \omega_l(\{ml, ss'\} - \{mh^{ss'}, ss'\}) > 0 \ \text{ iff } \ \theta \leq \theta_l(\{ml, ss'\} - \{mh^{ss'}, ss'\}) = 1.017, \\
&\triangle\, \omega_s(\{ml, ss'\} - \{mh^{ss'}, ss'\}) > 0 \ \text{ iff } \ \theta \leq \theta_s(\{ml, ss'\} - \{mh^{ss'}, ss'\}) = 1.027
\end{aligned} \tag{79}$$

However, from the testing the stability of global free trade above, we know that global free trade is a stable outcome when the relative market power parameter is less than 1.017. In fact, each of these countries have a profitable joint deviation to global free trade from this regime. As such, (JSSM6) is not a stable outcome. This applies to (JSSM7) as well. There are certainly parameter space where all countries have an incentive to deviation to a trade regime where the medium and small countries have an FTA while the large and other small countries have another. But all of these countries have a profitable deviation to global free trade from this regime. So (JSSM7) is ruled out as well.

Joint deviations to the hub and spoke regimes in (JSSM8), (JSSM9), (JSSM10), (JSSM10), (JSSM11), (JSSM12), and (JSSM13) cannot occur because at least one spoke country from these regimes will deviation.

For (JSSM14), the large country has no incentive to join a 3-country free trade area with the medium and one small countries. So joint deviation to (JSSM14) is not possible. The large country also has no profitable deviation to a 3-country free trade area with the two smaller countries which rules out (JSSM15).

From lemma 6, full hub regimes are unstable and so deviations to all three full hub regimes in (JSSM16), (JSSM17), and (JSSM18) will not take place.

(JSSM19) and (JSSM20) can be ruled out since the small country in these regimes with one agreement (with another small country in (JSSM19) and with a medium country in (JSSM20)) does not have an incentive to deviate. The same is the case for the large countries in (JSSM21) and (JSSM22).

(JSSM23), (JSSM24), (JSSM25), (JSSM26), (JSSM27), (JSSM28), and (JSSM29) are trade regimes with four FTAs and one country being a full hub. None of these regimes will occur since at least one country does not have a profitable deviation to becoming a spoke.

There exists a profitable joint deviation for all countries to (JSSM30), a trade regime with four FTAs with each country is in two $\left\langle \{lh^{s'm}, sh^{s'm}\} \right\rangle$. The medium and both small countries always have an incentive to join this regime while the large country will do so as the relative market power differences between them declines past a certain point:

$$\begin{aligned}
&\triangle\,\omega_m(\{lh^{s'm}, sh^{s'm}\} - \{mh^{ss'}, ss'\}) > 0 \ \text{ for all } \ \theta, \\
&\triangle\,\omega_s(\{lh^{s'm}, sh^{s'm}\} - \{mh^{ss'}, ss'\}) > 0 \ \text{ for all } \ \theta, \\
&\triangle\,\omega_{s'}(\{lh^{s'm}, sh^{s'm}\} - \{mh^{ss'}, ss'\}) > 0 \ \text{ for all } \ \theta, \ \text{ and} \\
&\triangle\,\omega_l(\{lh^{s'm}, sh^{s'm}\} - \{mh^{ss'}, ss'\}) > 0 \ \text{ iff } \ \theta \leq \theta_l(\{lh^{s'm}, sh^{s'm}\} - \{mh^{ss'}, ss'\}) = 1.021
\end{aligned} \tag{80}$$

However, both the small and medium countries without an FTA with each other have a joint profitable deviation to form an FTA together and so (JSSM30) will not occur:

$$\begin{aligned}
&\triangle\,\omega_m(\{mh^{ss'l}, s'h^{sl}\} - \{lh^{s'm}, sh^{s'm}\}) > 0 \ \text{ for all } \ \theta, \\
&\triangle\,\omega_{s'}(\{mh^{ss'l}, s'h^{sl}\} - \{lh^{s'm}, sh^{s'm}\}) > 0 \ \text{ for all } \ \theta,
\end{aligned} \tag{81}$$

This results in a five trade agreement regime where the other small and large country are only in two FTAs. From equation 77, this is one of the regimes which the large country will deviate from to stay out of all trade agreements.

The above case is similar to (JSSM31), a trade regime with four FTAs $\langle\{lh^{ss'}, mh^{ss'}\}\rangle$. Here again there will exist some circumstances where the large country has an incentive to deviate to this trade regime while all the other countries always has an incentive to do so. However, the two small countries who are in two FTAs each and not with one another will have a profitable deviation to sign an FTA together:

$$\begin{aligned}
&\triangle\,\omega_s(\{sh^{s'ml}, s'h^{ml}\} - \{lh^{s'm}, sh^{s'm}\}) > 0 \ \text{ for all } \ \theta, \\
&\triangle\,\omega_{s'}(\{sh^{s'ml}, s'h^{ml}\} - \{lh^{s'm}, sh^{s'm}\}) > 0 \ \text{ for all } \ \theta,
\end{aligned} \tag{82}$$

This means that (JSSM31) is not a stable outcome. In fact, the larger country will choose to stay out of the new trade regime where both small countries have an FTA with each other on top of the four FTAs already (equation 77).

While each country can have an incentive to deviate to (JSSM32), there is no overlap in their parameter space which rules it out:

$$\begin{aligned}
&\triangle\, \omega_m(\{lh^{ss'm}, s'h^{sm}\} - \{mh^{ss'}, ss'\}) > 0 \;\text{ iff }\; \theta \geq \theta_m(\{lh^{ss'm}, s'h^{sm}\} - \{mh^{ss'}, ss'\}) = 1.081,\\
&\triangle\, \omega_s(\{lh^{ss'm}, s'h^{sm}\} - \{mh^{ss'}, ss'\}) > 0 \;\text{ iff }\; \theta \geq \theta_s(\{lh^{ss'm}, s'h^{sm}\} - \{mh^{ss'}, ss'\}) = 1.025,\\
&\triangle\, \omega_{s'}(\{lh^{ss'm}, s'h^{sm}\} - \{mh^{ss'}, ss'\}) > 0 \;\text{ for all }\; \theta, \;\text{ and}\\
&\triangle\, \omega_l(\{lh^{ss'm}, s'h^{sm}\} - \{mh^{ss'}, ss'\}) > 0 \;\text{ iff }\; \theta \leq \theta_l(\{lh^{ss'm}, s'h^{sm}\} - \{mh^{ss'}, ss'\}) = 1.042
\end{aligned} \tag{83}$$

The same case applies to (JSSM33) which rules it out as well:

$$\begin{aligned}
&\triangle\, \omega_{s'}(\{lh^{ss'm}, mh^{ss'}\} - \{mh^{ss'}, ss'\}) > 0 \;\text{ iff }\; \theta \geq \theta_{s'}(\{lh^{ss'm}, mh^{ss'}\} - \{mh^{ss'}, ss'\}) = 1.081,\\
&\triangle\, \omega_s(\{lh^{ss'm}, mh^{ss'}\} - \{mh^{ss'}, ss'\}) > 0 \;\text{ iff }\; \theta \geq \theta_s(\{lh^{ss'm}, mh^{ss'}\} - \{mh^{ss'}, ss'\}) = 1.081,\\
&\triangle\, \omega_m(\{lh^{ss'm}, mh^{ss'}\} - \{mh^{ss'}, ss'\}) > 0 \;\text{ for all }\; \theta, \;\text{ and}\\
&\triangle\, \omega_l(\{lh^{ss'm}, mh^{ss'}\} - \{mh^{ss'}, ss'\}) > 0 \;\text{ iff }\; \theta \leq \theta_l(\{lh^{ss'm}, mh^{ss'}\} - \{mh^{ss'}, ss'\}) = 1.048
\end{aligned} \tag{84}$$

(JSSM34) and (JSSM35) does not occur since the large country will prefer to stay out of all trade agreements compared to staying in these regimes (equation 77).

Lastly, global free trade in (JSSM36) occurs when the large country has a profitable incentive to join as described earlier (equation 76).

From all these cases, only the trade regime with an FTA between the small countries cannot be ruled out ($\{ss'\}$). Global free trade is the stable outcome when $\theta \in [1, 1.017]$ and free trade area $\{mh^{ss'}, ss'\}$ is the stable outcome when $\theta \in (1.017, 1.035]$. Joint deviations from the $\{ss'\}$ regime are considered below outside of global free trade and free trade area $\{mh^{ss'}, ss'\}$. As shown earlier, since there are some trade regimes that are not stable like full hub regimes and times with four FTAs and one country being a full hub, they are not considered here:

(JSS1) Joint deviation of any countries from $\langle\{ss'\}\rangle$ to $\langle\{\Phi\}\rangle$

(JSS2) Joint deviation of s and l from $\langle\{ss'\}\rangle$ to $\langle\{sl\}\rangle$

(JSSM3) Joint deviation of l and s from $\langle\{ss'\}\rangle$ to $\langle\{sm\}\rangle$

(JSSM4) Joint deviation of m and s from $\langle\{ss'\}\rangle$ to $\langle\{ml\}\rangle$

(JSSM5) Joint deviation of m and l from $\langle\{ss'\}\rangle$ to $\langle\{ml, ss'\}\rangle$

(JSSM6) Joint deviation of all countries from $\langle\{ss'\}\rangle$ to $\langle\{sl, s'm\}\rangle$

(JSSM7) Joint deviation of all countries from $\langle\{ss'\}\rangle$ to $\langle\{lh^{sm}, sm\}\rangle$

(JSSM8) Joint deviation of all countries from $\langle\{ss'\}\rangle$ to $\left\langle\{lh^{ss'}, ss'\}\right\rangle$

(JSSM9) Joint deviation of all countries from $\langle\{ss'\}\rangle$ to $\left\langle\{lh^{ss'm}, s'h^{sm}\}\right\rangle$

(JSSM10) Joint deviation of all countries from $\langle\{ss'\}\rangle$ to $\left\langle\{lh^{ss'm}, mh^{ss'}\}\right\rangle$

(JSSM11) Joint deviation of all countries from $\langle\{ss'\}\rangle$ to $\left\langle\{sh^{s'ml}, s'h^{ml}\}\right\rangle$

(JSSM12) Joint deviation of all countries from $\langle\{ss'\}\rangle$ to $\left\langle\{mh^{ss'l}, sh^{s'l}\}\right\rangle$

(JSS1) does not occur since the small countries will always prefer to be in an FTA than not.

While a small country will always prefer an FTA with a large country over one with a small country, (JSS2) is ruled out since the large country will only have a profitable deviation when its relative market power difference is smaller and this parameter space is when global free trade is a stable outcome:

$$\triangle\, \omega_l(\{sl\} - \{ss'\}) > 0 \;\text{ iff }\; \theta \leq \theta_l(\{sl\} - \{ss'\}) = 1.009 \tag{85}$$

(JSS3) is also not possible since the medium country has a profitable deviation only when its relative market power difference is within the parameter space for global free trade:

$$\triangle\, \omega_m(\{sm\} - \{ss'\}) > 0 \;\text{ iff }\; \theta \leq \theta_m(\{sm\} - \{ss'\}) = 1.007 \tag{86}$$

This applies to (JSS4) as well:

$$\triangle\, \omega_l(\{ml\} - \{ss'\}) > 0 \;\text{ iff }\; \theta \leq \theta_l(\{ml\} - \{ss'\}) = 1.0023 \tag{87}$$

(JSS5) can occur since the large and medium countries have a profitable deviation to form FTAs with each other. However this outcome is not stable since the large country and a small country will have a profitable deviation away to form an FTA with each other and the medium country has an incentive to deviate from that. The same applies for (JSS6), (JSS7), and (JSS8).

In (JSS9), the two remaining countries in two FTAs—one small and medium countries—will have an incentive to form an FTA together which results in global free trade. However, with this level of market power difference the large country will always stay out so (JSS9) is not stable. The same applies to (JSS10), (JSS11), and (JSS12). Both the remaining countries not in an FTA will sign one resulting in global free trade but the large country will be deviate away.

In conclusion, the equilibrium outcome for regionalism with a more diverse country type is this: global free trade is stable when $\theta \in [1, 1.017]$, a free trade area between the small and medium countries $\{mh^{ss'}, ss'\}$ is stable when $\theta \in (1.017, 1.035]$, and an FTA between the small countries $\{ss'\}$ is stable outside of that.

C Appendix: Regionalism without MFN

C.1 Welfare Functions

Below are the welfare functions for regional trade regimes without MFN:

$$\omega_i \left\langle \{\Phi\} \right\rangle = -\frac{63\, {e_a}^2}{50} - \frac{2\, e_a\, e_b}{25} - \frac{2\, e_a\, e_c}{25} - \frac{2\, e_a\, e_d}{25} + 3\, \alpha, e_a + \frac{21\, {e_b}^2}{100} - \frac{9\, e_b\, e_c}{100} - \frac{9\, e_b\, e_d}{100} + \frac{21\, {e_c}^2}{100} - \frac{9\, e_c\, e_d}{100} + \frac{21\, {e_d}^2}{100}$$

$$\omega_i \left\langle \{ij\} \right\rangle = -\frac{2883\, {e_a}^2}{2450} - \frac{2\, e_a\, e_b}{25} - \frac{149\, e_a\, e_c}{1225} - \frac{149\, e_a\, e_d}{1225} + 3\, \alpha, e_a + \frac{107\, {e_b}^2}{700} - \frac{43\, e_b\, e_c}{700} - \frac{43\, e_b\, e_d}{700} + \frac{1037\, {e_c}^2}{4900} - \frac{17\, e_c\, e_d}{196} + \frac{1037\, {e_d}^2}{4900}$$

$$\omega_i \left\langle \{ih^{jl,N}\} \right\rangle = -\frac{2679\, {e_a}^2}{2450} - \frac{149\, e_a\, e_b}{1225} - \frac{8\, e_a\, e_c}{49} - \frac{149\, e_a\, e_d}{1225} + 3\, \alpha, e_a + \frac{18127\, {e_b}^2}{225400} - \frac{75\, e_b\, e_c}{1127} + \frac{323\, e_b\, e_d}{2300} + \frac{487\, {e_c}^2}{2254} - \frac{75\, e_c\, e_d}{1127} + \frac{18127\, {e_d}^2}{225400}$$

$$\omega_i \left\langle \{ih^{jkl,N}\} \right\rangle = -\frac{99\, {e_a}^2}{98} - \frac{8\, e_a\, e_b}{49} - \frac{8\, e_a\, e_c}{49} - \frac{8\, e_a\, e_d}{49} + 3\, \alpha, e_a + \frac{81\, {e_b}^2}{1568} + \frac{65\, e_b\, e_c}{784} + \frac{65\, e_b\, e_d}{784} + \frac{81\, {e_c}^2}{1568} + \frac{65\, e_c\, e_d}{784} + \frac{81\, {e_d}^2}{1568}$$

$$\omega_i \left\langle \{jk^{N}\} \right\rangle = -\frac{24807\, {e_a}^2}{19600} - \frac{667\, e_a\, e_b}{9800} - \frac{667\, e_a\, e_c}{9800} - \frac{33\, e_a\, e_d}{392} + 3\, \alpha, e_a + \frac{1017\, {e_b}^2}{4900} - \frac{9\, e_b\, e_c}{100} - \frac{181\, e_b\, e_d}{1960} + \frac{1017\, {e_c}^2}{4900} - \frac{181\, e_c\, e_d}{1960} + \frac{829\, {e_d}^2}{3920}$$

$$\omega_i \left\langle \{jh^{kl}\} \right\rangle = -\frac{526343\, {e_a}^2}{414736} - \frac{11\, e_a\, e_b}{196} - \frac{31569\, e_a\, e_c}{414736} - \frac{31569\, e_a\, e_d}{414736} + 3\, \alpha, e_a + \frac{201\, {e_b}^2}{980} - \frac{181\, e_b\, e_c}{1960} - \frac{181\, e_b\, e_d}{1960} + \frac{868957\, {e_c}^2}{4147360} - \frac{489\, e_c\, e_d}{5290} + \frac{868957\, {e_d}^2}{4147360}$$

$$\omega_i \left\langle \{jh^{kl}, kl\} \right\rangle = -\frac{672\, {e_a}^2}{529} - \frac{36\, e_a\, e_b}{529} - \frac{36\, e_a\, e_c}{529} - \frac{36\, e_a\, e_d}{529} + 3\, \alpha, e_a + \frac{549\, {e_b}^2}{2645} - \frac{489\, e_b\, e_c}{5290} - \frac{489\, e_b\, e_d}{5290} + \frac{549\, {e_c}^2}{2645} - \frac{489\, e_c\, e_d}{5290} + \frac{549\, {e_d}^2}{2645}$$

$$\omega_i \left\langle \{kh^{il}\} \right\rangle = -\frac{22828431\, {e_a}^2}{20736800} - \frac{55089\, e_a\, e_b}{414736} - \frac{667\, e_a\, e_c}{9800} - \frac{3329\, e_a\, e_d}{13225} + 3\, \alpha, e_a + \frac{174749\, {e_b}^2}{829472} - \frac{25\, e_b\, e_c}{392} - \frac{999\, e_b\, e_d}{14812} + \frac{737\, {e_c}^2}{4900} - \frac{43\, e_c\, e_d}{700} + \frac{91739\, {e_d}^2}{370300}$$

$$\omega_i \left\langle \{ij, kl\} \right\rangle = -\frac{927\, {e_a}^2}{784} - \frac{33\, e_a\, e_b}{392} - \frac{43\, e_a\, e_c}{392} - \frac{43\, e_a\, e_d}{392} + 3\, \alpha, e_a + \frac{121\, {e_b}^2}{784} - \frac{25\, e_b\, e_c}{392} - \frac{25\, e_b\, e_d}{392} + \frac{41\, {e_c}^2}{196} - \frac{17\, e_c\, e_d}{196} + \frac{41\, {e_d}^2}{196}$$

$$\omega_i \left\langle \{kh^{ijl}\} \right\rangle = -\frac{1669\, {e_a}^2}{1568} - \frac{45\, e_a\, e_b}{196} - \frac{11\, e_a\, e_c}{196} - \frac{45\, e_a\, e_d}{196} + 3\, \alpha, e_a + \frac{183\, {e_b}^2}{784} - \frac{25\, e_b\, e_c}{392} - \frac{5\, e_b\, e_d}{112} + \frac{29\, {e_c}^2}{196} - \frac{25\, e_c\, e_d}{392} + \frac{183\, {e_d}^2}{784}$$

$$\omega_i \left\langle \{jh^{ik}, kl\} \right\rangle = -\frac{915991\, {e_a}^2}{829472} - \frac{31569\, e_a\, e_b}{414736} - \frac{66\, e_a\, e_c}{529} - \frac{49723\, e_a\, e_d}{207368} + 3\, \alpha, e_a + \frac{126393\, {e_b}^2}{829472} - \frac{473\, e_b\, e_c}{7406} - \frac{25\, e_b\, e_d}{392} + \frac{6183\, {e_c}^2}{29624} - \frac{999\, e_c\, e_d}{14812} + \frac{25433\, {e_d}^2}{103684}$$

$$\omega_i \left\langle \{ih^{jk}, jk\} \right\rangle = -\frac{24759\, {e_a}^2}{26450} - \frac{3329\, e_a\, e_b}{13225} - \frac{3329\, e_a\, e_c}{13225} - \frac{96\, e_a\, e_d}{529} + 3\, \alpha, e_a + \frac{12329\, {e_b}^2}{105800} + \frac{323\, e_b\, e_c}{2300} - \frac{25\, e_b\, e_d}{529} + \frac{12329\, {e_c}^2}{105800} - \frac{25\, e_c\, e_d}{529} + \frac{225\, {e_d}^2}{1058}$$

$$\omega_i \left\langle \{ih^{jk}, kl\} \right\rangle = -\frac{844071\, {e_a}^2}{829472} - \frac{43\, e_a\, e_b}{392} - \frac{55089\, e_a\, e_c}{414736} - \frac{7604\, e_a\, e_d}{25921} + 3\, \alpha, e_a + \frac{703\, {e_b}^2}{9016} + \frac{1245\, e_b\, e_c}{9016} - \frac{75\, e_b\, e_d}{1127} + \frac{65913\, {e_c}^2}{829472} - \frac{25\, e_c\, e_d}{529} + \frac{13073\, {e_d}^2}{51842}$$

$$\omega_i \left\langle \{jh^{ikl}, kl\} \right\rangle = -\frac{18039\, {e_a}^2}{16928} - \frac{36\, e_a\, e_b}{529} - \frac{1875\, e_a\, e_c}{8464} - \frac{1875\, e_a\, e_d}{8464} + 3\, \alpha, e_a + \frac{557\, {e_b}^2}{3703} - \frac{473\, e_b\, e_c}{7406} - \frac{473\, e_b\, e_d}{7406} + \frac{27427\, {e_c}^2}{118496} - \frac{5\, e_c\, e_d}{112} + \frac{27427\, {e_d}^2}{118496}$$

$$\omega_i \left\langle \{kh^{ijl}, ij\} \right\rangle = -\frac{373103\, {e_a}^2}{414736} - \frac{45\, e_a\, e_b}{196} - \frac{49723\, e_a\, e_c}{207368} - \frac{2355\, e_a\, e_d}{8464} + 3\, \alpha, e_a + \frac{1843\, {e_b}^2}{18032} + \frac{1245\, e_b\, e_c}{9016} - \frac{9\, e_b\, e_d}{368} + \frac{23657\, {e_c}^2}{207368} - \frac{25\, e_c\, e_d}{529} + \frac{3985\, {e_d}^2}{16928}$$

$$\omega_i \left\langle \{ih^{jk}, lh^{jk}\} \right\rangle = -\frac{497\, {e_a}^2}{529} - \frac{66\, e_a\, e_b}{529} - \frac{66\, e_a\, e_c}{529} - \frac{224\, e_a\, e_d}{529} + 3\, \alpha, e_a + \frac{41\, {e_b}^2}{529} + \frac{73\, e_b\, e_c}{529} - \frac{25\, e_b\, e_d}{529} + \frac{41\, {e_c}^2}{529} - \frac{25\, e_c\, e_d}{529} + \frac{305\, {e_d}^2}{1058}$$

$$\omega_i \left\langle \{ih^{jkl}, kl\} \right\rangle = -\frac{44211\, {e_a}^2}{51842} - \frac{96\, e_a\, e_b}{529} - \frac{7604\, e_a\, e_c}{25921} - \frac{7604\, e_a\, e_d}{25921} + 3\, \alpha, e_a + \frac{817\, {e_b}^2}{16928} + \frac{865\, e_b\, e_c}{8464} + \frac{865\, e_b\, e_d}{8464} + \frac{72801\, {e_c}^2}{829472} + \frac{65\, e_c\, e_d}{784} + \frac{72801\, {e_d}^2}{829472}$$

$$\omega_i \left\langle \{jh^{ikl}, kh^{il}\} \right\rangle = -\frac{7287\, {e_a}^2}{8464} - \frac{1875\, e_a\, e_b}{8464} - \frac{3\, e_a\, e_c}{8} - \frac{1875\, e_a\, e_d}{8464} + 3\, \alpha, e_a + \frac{1697\, {e_b}^2}{16928} - \frac{9\, e_b\, e_c}{368} + \frac{73\, e_b\, e_d}{529} + \frac{95\, {e_c}^2}{368} - \frac{9\, e_c\, e_d}{368} + \frac{1697\, {e_d}^2}{16928}$$

$$\omega_i \left\langle \{ih^{jkl}, kh^{jl}\} \right\rangle = -\frac{12439\, {e_a}^2}{16928} - \frac{2355\, e_a\, e_b}{8464} - \frac{224\, e_a\, e_c}{529} - \frac{2355\, e_a\, e_d}{8464} + 3\, \alpha, e_a + \frac{601\, {e_b}^2}{8464} + \frac{865\, e_b\, e_c}{8464} + \frac{e_b\, e_d}{8} + \frac{2097\, {e_c}^2}{16928} + \frac{865\, e_c\, e_d}{8464} + \frac{601\, {e_d}^2}{8464}$$

$$\omega_i \left\langle \{F\} \right\rangle = -\frac{21\, {e_a}^2}{32} - \frac{3\, e_a\, e_b}{8} - \frac{3\, e_a\, e_c}{8} - \frac{3\, e_a\, e_d}{8} + 3\, \alpha, e_a + \frac{3\, {e_b}^2}{32} + \frac{e_b\, e_c}{8} + \frac{e_b\, e_d}{8} + \frac{3\, {e_c}^2}{32} + \frac{e_c\, e_d}{8} + \frac{3\, {e_d}^2}{32}$$

C.2 Regionalism with diverse country types

Proof of Lemma 9 Without the MFN clause, discriminatory tariffs are allowed. On one hand, this means that countries staying outside of FTAs, particularly smaller countries, are now punished more for it in the form of higher tariffs. On the other hand, there is now relatively lower benefits to being in FTAs since countries not in any trade agreements can extract more tariff revenue using discriminatory tariffs on its partners. In terms of hub and spoke regimes, the absence of the MFN clause renders all of them unstable.

This applies to hub and spoke regimes with two spokes where the hub can be any of the small, medium, or large countries:

$$\begin{aligned}
&\triangle\, \omega_m(\{ss'\}^N - \{sh^{s'm}\}^N) > 0 \ \ \forall \ \ \theta \ \text{ and } \ \triangle\, \omega_l(\{ss'\}^N - \{sh^{s'l}\}^N) > 0 \ \ \forall \ \ \theta, \\
&\triangle\, \omega_l(\{sm\}^N - \{mh^{sl}\}^N) > 0 \ \ \forall \ \ \theta \ \text{ and } \ \triangle\, \omega_s(\{s'm\}^N - \{mh^{ss'}\}^N) > 0 \ \ \forall \ \ \theta, \\
&\triangle\, \omega_m(\{sl\}^N - \{lh^{sm}\}^N) > 0 \ \ \forall \ \ \theta, \\
&\triangle\, \omega_s(\{lh^{ss'}, ss'\}^N - \{lh^{ss'}\}^N) > 0 \ \ \forall \ \ \theta \ \text{ and } \ \triangle\, \omega_{s'}(\{lh^{ss'}, ss'\}^N - \{lh^{ss'}\}^N) > 0
\end{aligned} \tag{88}$$

where the first line shows that the medium and large countries will always deviate away from a small country hub regime with two spokes when they are one of the spokes. The second line shows that the large and small countries will also always deviate away from a medium country hub regime with two spokes when they are one of the spokes. In the third line, the medium country spoke of a large country hub regime with two spokes will always deviate away. Lastly, the two smaller spoke countries in a large country hub with two spokes will jointly form another FTA which also renders the hub regime unstable.

Similar to lemma 6, all full hub and spoke regimes are also unstable:

$$\begin{aligned}
&\triangle\, \omega_l(\{sh^{s'm}\}^N - \{sh^{s'ml}\}^N) > 0, \ \ \triangle\omega_m(\{sh^{s'l}\}^N - \{sh^{s'ml}\}^N) > 0, \ \text{ and} \\
&\triangle\, \omega_{s'}(\{sh^{ml}\}^N - \{sh^{s'ml}\}^N) > 0 \ \ \forall \ \ \theta, \\
&\triangle\, \omega_l(\{mh^{ss'}\}^N - \{mh^{ss'l}\}^N) > 0, \ \ \triangle\omega_s(\{mh^{s'l}\}^N - \{mh^{ss'l}\}^N) > 0, \ \text{ and} \\
&\triangle\, \omega_{s'}(\{mh^{sl}\}^N - \{mh^{ss'l}\}^N) > 0 \ \ \forall \ \ \theta, \\
&\triangle\, \omega_l(\{sh^{ss'N}\}^N - \{sh^{s'mlN}\}^N) > 0, \ \ \triangle\omega_m(\{sh^{s'lN}\}^N - \{sh^{s'mlN}\}^N) > 0, \ \text{ and} \\
&\triangle\, \omega_{s'}(\{sh^{mlN}\}^N - \{sh^{s'mlN}\}^N) > 0 \ \ \forall \ \ \theta
\end{aligned} \tag{89}$$

On top of these, any regimes where a country is a spoke are also unstable. This includes 3 trade agreement regimes where two countries have two FTAs including with each other while the other two are spokes with only one FTA each. The countries with two FTAs each are like hub countries since the countries that they have FTAs with don't have FTAs with each other. The following holds:

$$\begin{aligned}
&\triangle\,\omega_m(\{s'h^{sl}\}^N - \{lh^{s'm}, ss'\}^N) > 0 \;\; \forall \;\; \theta, \\
&\triangle\,\omega_l(\{sh^{s'm}\}^N - \{mh^{sl}, ss'\}^N) > 0 \;\; \forall \;\; \theta, \\
&\triangle\,\omega_l(\{sh^{s'm}\}^N - \{sh^{s'm}, s'l\}^N) > 0, \;\; \text{and} \;\; \triangle\,\omega_m(\{s'h^{s'l}\}^N - \{sh^{s'm}, s'l\}^N) > 0 \;\; \forall \;\; \theta, \\
&\triangle\,\omega_s(\{lh^{s'm}, sh^{s'm}\}^N - \{lh^{s'm}, sm\}^N) > 0, \;\; \text{and} \;\; \triangle\,\omega_{s'}(\{lh^{s'm}, sh^{s'm}\}^N - \{lh^{s'm}, sm\}^N) > 0 \;\; \forall \;\; \theta
\end{aligned} \tag{90}$$

In the first three cases (first three lines), the medium or large countries always deviate away from the regime. In the fourth case where the two small countries are the spokes, both small countries have a joint profitable deviation to form an FTA with each other which also makes the original regime unstable.

Lastly, trade regimes with four trade agreements with one full hub country and one spoke are also not stable since the spoke country will always deviate away:

$$\begin{aligned}
&\triangle\,\omega_s(\{s'h^{ml}, ml\}^N - \{s'h^{sml}, ml\}^N) > 0 \;\; \forall \;\; \theta, \\
&\triangle\,\omega_m(\{lh^{ss'}, ss'\}^N - \{lh^{ss'm}, ss'\}^N) > 0 \;\; \forall \;\; \theta, \\
&\triangle\,\omega_l(\{s'h^{sm}, sm\}^N - \{s'h^{sml}, sm\}^N) > 0 \;\; \forall \;\; \theta, \\
&\triangle\,\omega_m(\{lh^{ss'}, ss'\}^N - \{lh^{ss'm}, ss'\}^N) > 0 \;\; \forall \;\; \theta, \\
&\triangle\,\omega_m(\{sh^{s'l}, s'l\}^N - \{sh^{s'ml}, s'l\}^N) > 0 \;\; \forall \;\; \theta, \\
&\triangle\,\omega_s(\{mh^{s'l}, s'l\}^N - \{mh^{ss'l}, s'l\}^N) > 0 \;\; \forall \;\; \theta, \\
&\triangle\,\omega_l(\{mh^{ss'}, ss'\}^N - \{mh^{ss'l}, ss'\}^N) > 0 \;\; \forall \;\; \theta, \;\; \text{and} \\
&\triangle\,\omega_s(\{lh^{s'm}, s'm\}^N - \{lh^{ss'm}, s'm\}^N) > 0 \;\; \forall \;\; \theta
\end{aligned} \tag{91}$$

Proof of Proposition 6 Given assumption 2, we first establish global free trade as a stable equilibria. From lemma 9, all hub and spoke trade regimes are not stable and deviations to these regimes will not be considered. From below, the smaller countries have no incentive to unilaterally deviation from global free trade:

$$\begin{aligned}
&\triangle\,\omega_s(F - \{mh^{ss'l}, s'h^{sl}\}^N) > 0, \;\; \triangle\omega_s(F - \{lh^{ss'm}, mh^{ss'}\}^N) > 0, \\
&\triangle\,\omega_s(F - \{lh^{ss'm}, s'h^{sm}\}^N) > 0, \;\; \text{and} \;\; \triangle\,\omega_s(F - \{lh^{s'm}, s'm\}^N) > 0 \;\; \text{for all} \;\; \theta
\end{aligned} \tag{92}$$

The medium country, however, has a profitable deviation from global free trade:

$$\triangle\,\omega_m(F - \{lh^{ss'}, ss'\}^N) > 0 \;\; \text{iff} \;\; \theta \leq \theta_m(F - \{lh^{ss'}, ss'\}^N) = 1.072 \tag{93}$$

Similarly, the larger country has a profitable deviation away from global free trade:

$$\triangle\, \omega_l(F - \{mh^{ss'}, ss'\}^N) > 0 \text{ iff } \theta \leq \theta_l(F - \{mh^{ss'}, ss'\}^N) = 1.017 \tag{94}$$

Since $\theta_l(F - \{mh^{ss'}, ss'\}^N) < \theta_m(F - \{lh^{ss'}, ss'\}^N)$, the larger country's deviation to a 3-country regional trade area with the exclusion of the larger country ($\{mh^{ss'}, ss'\}^N$) binds. As such, global free trade is unstable from unilateral deviation by the larger country.

Next the following joint deviations from global free trade are considered:

(JF1) Joint deviation of l and m from $\langle\{F\}\rangle$ to $\left\langle\{ml\}^N\right\rangle$

(JF2) Joint deviation of m and s from $\langle\{F\}\rangle$ to $\left\langle\{sm\}^N\right\rangle$

(JF3) Joint deviation of l and s from $\langle\{F\}\rangle$ to $\left\langle\{sl\}^N\right\rangle$

(JF4) Joint deviation of s and s' from $\langle\{F\}\rangle$ to $\left\langle\{ss'\}^N\right\rangle$

(JF5) Joint deviation of s, s', and l from $\langle\{F\}\rangle$ to $\left\langle\{lh^{ss'}, ss'\}^N\right\rangle$

(JF6) Joint deviation of s, s', and m from $\langle\{F\}\rangle$ to $\left\langle\{mh^{ss'}, ss'\}^N\right\rangle$

(JF7) Joint deviation of s, m, and l from $\langle\{F\}\rangle$ to $\left\langle\{lh^{sm}, sm\}^N\right\rangle$

(JF8) Joint deviation of any three countries or all four countries from $\langle\{F\}\rangle$ to $\left\langle\{\Phi\}^N\right\rangle$

(JF1), (JF2), (JF3), and (JF4) are ruled out since each of these countries don't have a joint profitable deviation from global free trade to an FTA with each other.

By the same direct calculation as above, the joint deviations in (JF5), (JF6), (JF7), and (JF8) can also be ruled out. This is because there are at least one country that does not have a profitable deviation away from global free trade to these regimes.

From global free trade, the large country has an incentive to deviation unilaterally out of all trade agreements leaving a 3-country regional trade agreements between the medium and two smaller countries ($\{mh^{ss'}, ss'\}^N$). In fact, the large country has no incentive to join any one or two trade agreements with the other countries once it stays out:

$$\begin{aligned}&\triangle\, \omega_l(\{mh^{ss'}, ss'\}^N - \{mh^{ss'}, sh^{s'l}\}^N) > 0, \ \ \triangle\omega_l(\{mh^{ss'}, ss'\}^N - \{mh^{ss'l}, ss'\}^N) > 0,\\ &\triangle\, \omega_l(\{mh^{ss'}, ss'\}^N - \{mh^{ss'l}, sh^{s'l}\}^N) > 0, \text{ and } \triangle\, \omega_l(\{mh^{ss'}, ss'\}^N - \{sh^{s'ml}, s'h^{sl}\}^N) > 0 \text{ for all } \theta\end{aligned} \tag{95}$$

Next, the coalitional deviations from the 3-country regional trade agreements between the medium and two smaller countries ($\{mh^{ss'}, ss'\}^N$) are considered. All hub and spoke regimes are excluded from consideration due to its established instability (lemma 9):

(JSSM1) Joint deviation of any three countries or all four countries from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{\Phi\}^N\rangle$

(JSSM2) Joint deviation of s and s' from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{ss'\}^N\rangle$

(JSSM3) Joint deviation of l and s from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{sl\}^N\rangle$

(JSSM4) Joint deviation of m and s from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{sm\}^N\rangle$

(JSSM5) Joint deviation of m and l from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{ml\}^N\rangle$

(JSSM6) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{ml, ss'\}^N\rangle$

(JSSM7) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{s'l, sm\}^N\rangle$

(JSSM8) Joint deviation of s, m, and l from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{lh^{sm}, sm\}^N\rangle$

(JSSM9) Joint deviation of s, s', and l from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{lh^{ss'}, ss'\}^N\rangle$

(JSSM10) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{lh^{s'm}, sh^{s'm}\}^N\rangle$

(JSSM11) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{lh^{ss'}, mh^{ss'}\}^N\rangle$

(JSSM12) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{lh^{ss'm}, s'h^{sm}\}^N\rangle$

(JSSM13) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{lh^{ss'm}, mh^{ss'}\}^N\rangle$

(JSSM14) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{sh^{s'ml}, s'h^{ml}\}^N\rangle$

(JSSM15) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{mh^{ss'l}, sh^{s'l}\}^N\rangle$

(JSSM16) Joint deviation of all countries from $\langle\{mh^{ss'}, ss'\}^N\rangle$ to $\langle\{F\}^N\rangle$

(JSSM1) can be ruled out since none of the countries have a profitable deviation to status quo.

While the two small countries do not have an incentive to forgot their 3-country trade area with the medium country to form an FTA between the two of them, (JSSM2) cannot be ruled out since the medium country has an incentive to unilaterally deviate from this trade area once its relative market power gets large enough:

$$\begin{aligned}
&\triangle\,\omega_s(\{ss'\}^N - \{mh^{ss'}, ss'\}^N) < 0 \text{ for all } \theta, \\
&\triangle\,\omega_{s'}(\{ss'\}^N - \{mh^{ss'}, ss'\}^N) < 0 \text{ for all } \theta, \\
&\triangle\,\omega_m(\{ss'\}^N - \{mh^{ss'}, ss'\}^N) > 0 \text{ iff } \theta \geq \theta_m(\{ss'\}^N - \{mh^{ss'}, ss'\}^N) = 1.055
\end{aligned} \tag{96}$$

(JSSM3), (JSSM4), and (JSSM5) can be ruled out since none of these countries have a profitable deviation away from a 3-country trade agreement regime to an FTA with each other.

For (JSSM6), the medium country always has a positive deviation to a trade regime where it is in an FTA with the large country while the two small countries are in an FTA of their own. The large and small countries have a profitable deviation to this regime if their market power differences are relatively small:

$$\begin{aligned}
&\triangle\,\omega_m(\{ml, ss'\}^N - \{mh^{ss'}, ss'\}^N) > 0 \text{ for all } \theta, \\
&\triangle\,\omega_l(\{ml, ss'\}^N - \{mh^{ss'}, ss'\}^N) > 0 \text{ iff } \theta \leq \theta_l(\{ml, ss'\}^N - \{mh^{ss'}, ss'\}^N) = 1.039, \\
&\triangle\,\omega_s(\{ml, ss'\}^N - \{mh^{ss'}, ss'\}^N) > 0 \text{ iff } \theta \leq \theta_s(\{ml, ss'\}^N - \{mh^{ss'}, ss'\}^N) = 1.039
\end{aligned} \tag{97}$$

However, from the testing the stability of global free trade above, we know that global free trade is a stable outcome when the relative market power parameter is less than 1.017. In fact, each of these countries have a profitable joint deviation to global free trade from this regime. As such, (JSSM6) is not a stable outcome. This applies to (JSSM7) as well. There are certainly parameter space where all countries have an incentive to deviation to a trade regime where the medium and small countries have an FTA while the large and other small countries have another. But all of these countries have a profitable deviation to global free trade from this regime. So (JSSM7) is ruled out as well.

For (JSSM8), the large country has no incentive to join a 3-country free trade area with the medium and one small countries. So joint deviation to (JSSM8) is not possible. The large country also has no profitable deviation to a 3-country free trade area with the two smaller countries which rules out (JSSM9).

There exists a profitable joint deviation for all countries to (JSSM10), a trade regime with four FTAs with each country is in two $\langle \{lh^{s'm}, sh^{s'm}\}^N \rangle$. The medium and both small countries always have an incentive to join this regime while the large country will do so as the relative market power differences between them declines past a certain point:

$$
\begin{aligned}
&\triangle\,\omega_m(\{lh^{s'm}, sh^{s'm}\}^N - \{mh^{ss'}, ss'\}^N) > 0 \ \text{ for all } \ \theta,\\
&\triangle\,\omega_s(\{lh^{s'm}, sh^{s'm}\}^N - \{mh^{ss'}, ss'\}^N) > 0 \ \text{ for all } \ \theta,\\
&\triangle\,\omega_{s'}(\{lh^{s'm}, sh^{s'm}\}^N - \{mh^{ss'}, ss'\}^N) > 0 \ \text{ for all } \ \theta, \ \text{ and}\\
&\triangle\,\omega_l(\{lh^{s'm}, sh^{s'm}\}^N - \{mh^{ss'}, ss'\}^N) > 0 \ \text{ iff } \ \theta \leq \theta_l(\{lh^{s'm}, sh^{s'm}\}^N - \{mh^{ss'}, ss'\}^N) = 1.021
\end{aligned}
\tag{98}
$$

However, both the small and medium countries without an FTA with each other have a joint profitable deviation to form an FTA together and so (JSSM10) will not occur:

$$
\begin{aligned}
&\triangle\,\omega_m(\{mh^{ss'l}, s'h^{sl}\}^N - \{lh^{s'm}, sh^{s'm}\}^N) > 0 \ \text{ for all } \ \theta,\\
&\triangle\,\omega_{s'}(\{mh^{ss'l}, s'h^{sl}\}^N - \{lh^{s'm}, sh^{s'm}\}^N) > 0 \ \text{ for all } \ \theta,
\end{aligned}
\tag{99}
$$

This results in a five trade agreement regime where the other small and large country are only in two FTAs. From equation 95, this is one of the regimes which the large country will deviate from to stay out of all trade agreements.

The above case is similar to (JSSM11), a trade regime with four FTAs $\langle\{lh^{ss'}, mh^{ss'}\}^N\rangle$. Here again there will exist some circumstances where the large country has an incentive to deviate to this trade regime while all the other countries always has an incentive to do so. However, the two small countries who are in two FTAs each and not with one another will have a profitable deviation to sign an FTA together:

$$
\begin{aligned}
&\triangle\,\omega_s(\{sh^{s'ml}, s'h^{ml}\}^N - \{lh^{s'm}, sh^{s'm}\}^N) > 0 \ \text{ for all } \ \theta,\\
&\triangle\,\omega_{s'}(\{sh^{s'ml}, s'h^{ml}\}^N - \{lh^{s'm}, sh^{s'm}\}^N) > 0 \ \text{ for all } \ \theta,
\end{aligned}
\tag{100}
$$

This means that (JSSM11) is not a stable outcome. In fact, the larger country will choose to stay out of the new trade regime where both small countries have an FTA with each other on top of the four FTAs already (equation 95).

While each country can have an incentive to deviate to (JSSM12), there is no overlap in their parameter space which rules it out:

$$\begin{aligned}
&\triangle\,\omega_m(\{lh^{ss'm}, s'h^{sm}\}^N - \{mh^{ss'}, ss'\}^N) > 0 \ \text{ iff } \ \theta \geq \theta_m(\{lh^{ss'm}, s'h^{sm}\}^N - \{mh^{ss'}, ss'\}^N) = 1.047,\\
&\triangle\,\omega_s(\{lh^{ss'm}, s'h^{sm}\}^N - \{mh^{ss'}, ss'\}^N) > 0 \ \text{ iff } \ \theta \geq \theta_s(\{lh^{ss'm}, s'h^{sm}\}^N - \{mh^{ss'}, ss'\}^N) = 1.045,\\
&\triangle\,\omega_{s'}(\{lh^{ss'm}, s'h^{sm}\}^N - \{mh^{ss'}, ss'\}^N) > 0 \ \text{ for all } \ \theta, \ \text{ and}\\
&\triangle\,\omega_l(\{lh^{ss'm}, s'h^{sm}\}^N - \{mh^{ss'}, ss'\}^N) > 0 \ \text{ iff } \ \theta \leq \theta_l(\{lh^{ss'm}, s'h^{sm}\}^N - \{mh^{ss'}, ss'\}^N) = 1.041
\end{aligned} \tag{101}$$

The same case applies to (JSSM13) which rules it out as well:

$$\begin{aligned}
&\triangle\,\omega_{s'}(\{lh^{ss'm}, mh^{ss'}\}^N - \{mh^{ss'}, ss'\}^N) > 0 \ \text{ iff } \ \theta \geq \theta_{s'}(\{lh^{ss'm}, mh^{ss'}\}^N - \{mh^{ss'}, ss'\}^N) = 1.045,\\
&\triangle\,\omega_s(\{lh^{ss'm}, mh^{ss'}\}^N - \{mh^{ss'}, ss'\}^N) > 0 \ \text{ iff } \ \theta \geq \theta_s(\{lh^{ss'm}, mh^{ss'}\}^N - \{mh^{ss'}, ss'\}^N) = 1.045,\\
&\triangle\,\omega_m(\{lh^{ss'm}, mh^{ss'}\}^N - \{mh^{ss'}, ss'\}^N) > 0 \ \text{ for all } \ \theta, \ \text{ and}\\
&\triangle\,\omega_l(\{lh^{ss'm}, mh^{ss'}\}^N - \{mh^{ss'}, ss'\}^N) > 0 \ \text{ iff } \ \theta \leq \theta_l(\{lh^{ss'm}, mh^{ss'}\}^N - \{mh^{ss'}, ss'\}^N) = 1.047
\end{aligned} \tag{102}$$

(JSSM14) and (JSSM15) does not occur since the large country will prefer to stay out of all trade agreements compared to staying in these regimes (equation 95).

Lastly, global free trade in (JSSM16) occurs when the large country has a profitable incentive to join as described earlier (equation 94.

From all these cases, only the trade regime with an FTA between the small countries cannot be ruled out ($\{ss'\}^N$). Global free trade is the stable outcome when $\theta \in [1, 1.017]$ and free trade area $\{mh^{ss'}, ss'\}^N$ is the stable outcome when $\theta \in (1.017, 1.035]$. Joint deviations from the $\{ss'\}^N$ regime are considered below outside of global free trade and free trade area $\{mh^{ss'}, ss'\}^N$. As shown earlier, since there are some trade regimes that are not stable like full hub regimes and times with four FTAs and one country being a full hub, they are not considered here:

(JSS1) Joint deviation of any countries from $\langle\{ss'\}^N\rangle$ to $\langle\{\Phi\}^N\rangle$

(JSS2) Joint deviation of s and l from $\langle\{ss'\}^N\rangle$ to $\langle\{sl\}^N\rangle$

(JSSM3) Joint deviation of l and s from $\langle\{ss'\}^N\rangle$ to $\langle\{sm\}^N\rangle$

(JSSM4) Joint deviation of m and s from $\langle\{ss'\}^N\rangle$ to $\langle\{ml\}^N\rangle$

(JSSM5) Joint deviation of m and l from $\langle\{ss'\}^N\rangle$ to $\langle\{ml, ss'\}^N\rangle$

(JSSM6) Joint deviation of all countries from $\langle\{ss'\}^N\rangle$ to $\langle\{sl, s'm\}^N\rangle$

(JSSM7) Joint deviation of all countries from $\langle\{ss'\}^N\rangle$ to $\langle\{lh^{sm}, sm\}^N\rangle$

(JSSM8) Joint deviation of all countries from $\langle\{ss'\}^N\rangle$ to $\langle\{lh^{ss'}, ss'\}^N\rangle$

(JSSM9) Joint deviation of all countries from $\langle\{ss'\}^N\rangle$ to $\langle\{lh^{ss'm}, s'h^{sm}\}^N\rangle$

(JSSM10) Joint deviation of all countries from $\langle\{ss'\}^N\rangle$ to $\langle\{lh^{ss'm}, mh^{ss'}\}^N\rangle$

(JSSM11) Joint deviation of all countries from $\langle\{ss'\}^N\rangle$ to $\langle\{sh^{s'ml}, s'h^{ml}\}^N\rangle$

(JSSM12) Joint deviation of all countries from $\langle\{ss'\}^N\rangle$ to $\langle\{mh^{ss'l}, sh^{s'l}\}^N\rangle$

(JSS1) does not occur since the small countries will always prefer to be in an FTA than not.

While a small country will always prefer an FTA with a large country over one with a small country, (JSS2) is ruled out since the large country will only have a profitable deviation when its relative market power difference is smaller and this parameter space is when global free trade is a stable outcome:

$$\triangle\, \omega_l(\{sl\}^N - \{ss'\}^N) > 0 \text{ iff } \theta \leq \theta_l(\{sl\}^N - \{ss'\}^N) = 1.008 \tag{103}$$

(JSS3) is also not possible since the medium country has a profitable deviation only when its relative market power difference is within the parameter space for global free trade:

$$\triangle\, \omega_m(\{sm\}^N - \{ss'\}^N) > 0 \text{ iff } \theta \leq \theta_m(\{sm\}^N - \{ss'\}^N) = 1.017 \tag{104}$$

This applies to (JSS4) as well:

$$\triangle\, \omega_l(\{ml\}^N - \{ss'\}^N) > 0 \text{ iff } \theta \leq \theta_l(\{ml\}^N - \{ss'\}^N) = 1.013 \tag{105}$$

(JSS5) can occur since the large and medium countries have a profitable deviation to form FTAs with each other. However this outcome is not stable since the large country and a small country will have a profitable deviation away to form an FTA with each other and the medium country has an incentive to deviate from that. The same applies for (JSS6), (JSS7), and (JSS8).

In (JSS9), the two remaining countries in two FTAs—one small and medium countries—will have an incentive to form an FTA together which results in global free trade. However, with this level of market power difference the large country will always stay out so (JSS9) is not stable. The same applies to (JSS10), (JSS11), and (JSS12). Both the remaining countries not in an FTA will sign one resulting in global free trade but the large country will be deviate away.

In conclusion, the equilibrium outcome for regionalism with a more diverse country type is this: global free trade is stable when $\theta \in [1, 1.017]$, a free trade area between the small and medium countries $\{mh^{ss'}, ss'\}^N$ is stable when $\theta \in (1.017, 1.055]$, and an FTA between the small countries $\{ss'\}^N$ is stable outside of that.

References

Aghion, Philippe, Pol Antràs, and Elhanan Helpman. 2007. "Negotiating free trade." *Journal of International Economics*, 73(1): 1–30.

Bagwell, Kyle, and Robert W Staiger. 1997. "Multilateral tariff cooperation during the formation of free trade areas." *International Economic Review*, 291–319.

Bagwell, Kyle, and Robert W. Staiger. 1999*a*. "An Economic Theory of GATT." *American Economic Review*, 89(1): 215–248.

Bagwell, Kyle, and Robert W Staiger. 1999*b*. "Regionalism and multilateral tariff cooperation." In *International trade policy and the Pacific Rim.* , ed. John Piggott and Alan Woodland, 157–190. Springer.

Baldwin, Robert E. 1989. "The political economy of trade policy." *The Journal of Economic Perspectives*, 3(4): 119–135.

Bernheim, B Douglas, Bezalel Peleg, and Michael D Whinston. 1987. "Coalition-proof nash equilibria i. concepts." *Journal of Economic Theory*, 42(1): 1–12.

Dutta, Bhaskar, and Suresh Mutuswami. 1997. "Stable networks." *Journal of economic theory*, 76(2): 322–344.

Freund, Caroline. 2000. "Multilateralism and the endogenous formation of preferential trade agreements." *Journal of International Economics*, 52(2): 359–376.

Ludema, Rodney D, and Anna Maria Mayda. 2009. "Do countries free ride on MFN?" *Journal of international Economics*, 77(2): 137–150.

Mrázová, Monika, David Vines, and Ben Zissimos. 2013. "Is the GATT/WTO's Article XXIV bad?" *Journal of International Economics*, 89(1): 216–232.

Riezman, Raymond. 1999. "Can Bilateral Trade Agreements Help to Induce Free Trade?" *The Canadian Journal of Economics / Revue canadienne d'Economique*, 32(3): 751–766.

Saggi, Kamal, Alan Woodland, and Halis Murat Yildiz. 2013. "On the relationship between preferential and multilateral trade liberalization: the case of customs unions." *American Economic Journal: Microeconomics*, 5(1): 63–99.

Saggi, Kamal, and Halis Murat Yildiz. 2010. "Bilateralism, multilateralism, and the quest for global free trade." *Journal of International Economics*, 81(1): 26–37.

Secretariat, WTO. n.d.. "Regional Trade Agreement: Facts and Figures." *https://www.wto.org/english/tratop_e/region_e/regfac_e.htm*, Accessed: 2017-05-03.

Seidmann, Daniel J. 2009. "Preferential trading arrangements as strategic positioning." *Journal of International Economics*, 79(1): 143–159.