Why are Trade Agreements Regional?

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Summary

This paper shows how distance may be used to coordinate on a unique equilibrium in which trade agreements are regional. Trade agreement formation is modeled as coalition formation. In a standard trade model with no distance between countries, a familiar problem of coordination failure arises giving rise to multiple equilibria; any one of many possible trade agreements can form. With distance between countries, and through strategic interaction in tariff setting, regional trade agreements generate larger rent-shifting effects than non regional agreements, which countries use to coordinate on a unique equilibrium. Under naive best responses, regional agreements give way to free trade.

Keywords: Coalition, Coordination, Trade Liberalization, Trade Agreement, Regionalism

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1. Introduction

Why do countries seek trade agreements (TAs) that are regional?[2] Prominent examples of TAs where members share common borders are the European Union (EU), the Mercado Comun del Cono Sur (MERCOSUR) and the North American Free Trade Agreement (NAFTA). It is well recognized that the 'pure' economic gains through trade creation from TAs are likely to be higher within regions than between them; see Wonnacott and Lutz (1989), Krugman (1991), and Summers (1991). And recent econometric work shows that (the inverse of) distance is a good predictor of TA membership; see Baier and Bergstrand (2004). Nevertheless, while the past literature shows that the expected gains to a regional agreement are higher than to a non-regional agreement, and that non-regional agreements may even be trade diverting, no attempt has been made before to provide a theory of how regional TAs might actually form.

This paper argues that there is a coordination problem at the heart of the TA formation process, and countries seek regional TAs as a way to solve that problem. There is undoubtedly significant 'pre-play communication' between policy-makers before a TA is formed. This point is used in the past literature to set aside problems of coordination. But in fact, the need for pre-play communication actually implies that there is a coordination problem to be resolved as part of that process. By setting the issue aside, the past literature suppresses a potentially significant explanation for why regionalism is a feature of the TA formation process. The main point brought to light in this paper, by setting the issue of coordination centre stage, is that countries can use geographical organization to solve their coordination problem. Thus, each country seeks other countries in its region, and only countries in its region, when forming a TA.[3]

[2] TA is a 'catch all' term that refers to all agreements in which a group of countries commit to trade among members preferentially. This encompasses free trade agreements (FTAs) in which members agree to remove internal tariff barriers but set external tariffs independently, and customs unions (CUs) which are like FTAs but with the additional requirement that members coordinate on common external tariffs. In practice, FTAs are more common but most of the academic literature focuses on CUs because they are analytically easier to handle. To focus the discussion on the regional nature of these agreements rather than the technical details of their operation, we will use the catch-all term TA wherever possible.

[3] There is a literature that looks at the feasibility of multilateral trade agreements when countries cannot write binding contracts over tariffs; see for example Bagwell and Staiger, (1997a,b), (1999), Bond and Syropoulos (1996), Bond (2001), Bond, Syropoulos and Winters (2001) and Bond, Riezman and Syropoulos (2004). All of these previous papers look at how agreements between sufficiently patient countries may be sustained through repeated interactions in the face of a short-run incentive to deviate. In the model of this present paper, there is no short-run incentive to deviate. The problem focused on instead is whether a

The model is based on Brander and Spencer (1984) and Yi (1996). Brander and Spencer (1984) show, in a two-country model, that rents made by foreign firms in the domestic market can be shifted back home by the government using tariffs. Yi (1996) uses a Brander-Spencer type model to show that a group of countries may obtain a higher payoff from TA formation than from moving to free trade. The present paper takes a special case of Yi's model and extends it by putting it in a regional setting.[4]

A new effect is revealed when a regional dimension is introduced to the model. One of Yi's key results (his Proposition 8) shows that a country would always prefer to leave its own TA in order to join another TA of equal or larger size, since the new TA that forms is larger. While fully acknowledging its importance we will show, in Proposition 5 of this present paper, that Yi's result is overturned in a regional setting. Without an agreement, since more rents are dissipated through transportation between regions than within them, there is more scope for rent-shifting within a region than across regions. TA formation within a region eliminates this greater harmful rent shifting among members, and in addition has greater beneficial terms-of-trade effects. Therefore, the value to a member of joining a regional TA of a given size is greater than the value of a TA across regions. This effect tends to push the countries of a region towards the formation of a regional TA.

To get a better understanding of the intuition behind this result, consider the original proposals made in the 1960s for NAFTA - the North *Atlantic* Free Trade Agreement - between Canada, the UK and the US. Interpreted within the context of the present model, Canada and the US would have liked the UK to form a TA with them, but the UK ultimately obtained a higher payoff from the formation of an agreement with nearby EU nations. This was so because the gains to elimination of rent shifting within Europe and the terms-of-trade gains over North America were of greater value to the UK.[5]

country is able to form an agreement with the other countries that it would like to have as members - the problem of coordination.

[4]Yi's (1996) compares how 'open regionalism,' can help with the attainment of free trade compared to the outcome under 'exclusive regionalism' in which TA membership must be unanimous. While the present paper draws on Yi's analysis of exclusive regionalism, it does not address the question of whether open regionalism would be beneficial in a regional setting. Yi (1996) examines the stable equilibrium structure of TAs; an approach pioneered by Riezman (1985), that will be extended to a regional setting in the present paper.

[5]The underlying intuition is robust to the fact that the NAFTA proposals were obviously for an FTA while the EU is a CU. In a broader setting, the choice of trading arrangement may have a significant bearing on the outcome. This point is made by Riezman (1999), who endogenizes the decision by countries over whether to adopt a CU or FTA, showing that the choice of regime may affect whether free trade can be reached. (Also see Bloch's 2003 discussion of CUs versus FTAs, and Bond, Riezman and Syropoulos 2004.)

The problem of coordination has attracted significant attention in the abstract literature on coalition formation, from which it is widely understood that many equilibria can arise through the inability to coordinate or commit (see Bloch 2003 and Yi 2003 for reviews). To introduce the problem of coordination failure in the present context, TA formation is modelled based on Hart and Kurz's (1983) *simultaneous move exclusive membership game*. In their original game, simultaneously and without communicating, each player writes down a list of other players with whom he would like to form a coalition. The lists form intersecting sets of players and each of the intersecting sets forms a coalition. But if two players fail to name each other then neither ends up in the same coalition even if it would be mutually beneficial.

In the model of this present paper, each country writes down a list of others with whom it would like to form a TA. When transport costs between all countries are zero, so in effect there is no regional dimension to the model, the problem of coordination failure arises between them. Any one of many possible TAs may arise in equilibrium. On the other hand, when transport costs of trading between regions are relatively large (but not large enough to prohibit trade between regions) countries use the difference in rent-shifting effects within and between regions to coordinate on regional TA formation. TAs form simultaneously, one in each region, and each TA includes all countries in that region. This is the sense in which the coordination problem is resolved when a regional dimension is introduced to the model.[6]

A key concern about the implications of regionalism is whether or not it is consistent with the gradual attainment of efficiency; 'whether trade blocks are stepping blocks or stumbling blocks in the path to free trade' (Bhagwati 1993; this issue finds its roots in Viner 1950 and Lipsey 1960). The insights gained about regional TA formation from the model developed in the present paper may be helpful to this debate, because they show the limits to the conclusions of earlier research on this topic. An implication of Yi's Proposition 8 is that an equilibrium TA structure must be asymmetric. Countries use the advantage in the sequence of TA formation that they are exogenously granted to form a larger TA. The countries in the larger TA are better off even than under free trade because they enjoy more favorable

[6]It would be desirable to have an intermediate step in the analysis wherein the regional dimension is introduced to the model but the game of coalition formation is the same as used by Yi (1996), namely, Bloch's (1996) size announcement game. Unfortunately, this is not possible since Bloch's size announcement game does not guarantee existence of an equilibrium once asymmetry is introduced. See the discussion at the end of Section 2.5, after Proposition 6, for further discussion.

terms-of-trade effects over non-member countries. As a result, trade blocks are stumbling blocks in the path to free trade. In the present paper, no such advantages arise due to the fact that TA formation is simultaneous and because each country is uncertain about the outcome of the TA formation process. As a result TA formation can be symmetric, with no larger TA arising that would prefer the status quo to free trade. In that case regional TAs do ultimately facilitate free trade.[7]

It might seem disturbing that the discussion has not focused more on traditional Vinerian notions of trade creation and trade diversion when motivating regional trade agreements. However, Krishna (2003) shows that the traditional Vinerian trade-creation-trade-diversion calculus does not seem to justify regionalism. It therefore seems fair to look for motivation based in the more recent trade literature on increasing returns to scale in order to motivate the formation of TAs that are regional. Also, the model is highly stylized, particularly in terms of its regional structure. Therefore, it should be kept in mind that the results are only suggestive. Clearly, the next step is to move towards more sophisticated and realistic underlying models of the world economy of the kind developed by Whalley (1985). Nevertheless, even though the policy analysis is based around Cournot competition, and strong assumptions are made about functional forms, the results seem intuitively plausible, and may be indicative of a general driving force towards regionalism for which there appears to be substantial evidence.[8]

The paper proceeds as follows. Section 2 introduces the basic trade model and uses it to explore the economic effects of TA formation in regions. Section 3 introduces the TA formation game. Section 4 shows that, in the TA formation game, when transport costs are zero there are multiple equilibria and no predictions can be made as to which will prevail. Section 5 shows that when transport costs are positive, this provides a mechanism through which countries are able to coordinate on a unique equilibrium in which regional TAs form.

[7]The literature on the dynamic path of trade liberalization examines the possibility that TA formation gives way to world free trade at a later stage. In addition to Riezman (1999) see Aghion, Antras and Helpman (2004), Ornelas (2005) and Seidmann (2006) for recent contributions. Building on Baldwin (1996), Krishna (1998) shows how political interests can undermine the progression from regionalism to multilateralism. Ethier (1998a, b) considers how multilateral liberalization may give way to regionalism. See Bagwell and Staiger (1998) on how TAs undermine the principles by which multilateral trade liberalization is achieved. Also, see Bagwati, Greenaway and Panagariya (1998) for a recent literature review on the dynamics of regionalism.

[8]The same underlying motivation towards regionalism as identified in this paper is demonstrated in a quite different framework (and for quite different purposes) by Egger and Larch (2006). See the discussion after Proposition 5 for further details.

Section 6 then examines the extent to which regional TA formation may subsequently give way to free trade. Conclusions are drawn in Section 7.

2. A Model of Trade Agreements in Regions

We will work with a familiar model of international trade based on Cournot competition. Let N be the set of countries. Each country has a representative consumer, firm, and government, each denoted by its corresponding country identifier as $i \in N$.

There are six countries; $N = \{1,2,3,4,5,6\}$. This is different from a standard TA formation model, which would typically have just three countries. A three-country framework is the simplest possible framework in which TA formation can be examined, since a minimum of two countries are required to form a TA and at least one country must remain outside so that the effects on a non-member can be analyzed. But to extend this simple basic approach to a regional setting requires a set-up based on two regions, each of which has three countries. So in our model, there is a *regional structure* that partitions N into two regions; $R_1 = \{1,2,3\}$ and $R_2 = \{4,5,6\}$.

Regions are some distance apart from one another. Let d_{ij} measure the distance between any two countries $i, j \in N$. Again, to keep the analysis as simple as possible, we will say that if countries i and j are *not* in the same region then $d_{ij} = d$ while if i and j are in the same region then $d_{ij} = 0$.

So that we can examine whether TA formation evolves towards free trade, we will make the model of TA formation dynamic with three periods. Within a period, the sequence of events is as follows. First, TA formation takes place. Next, taking trading arrangements as given, firms make production decisions. Finally, consumption takes place. We will adopt the usual inductive approach of solving this sequence backwards.

2.1. Preferences and Production

There are two goods in the model, denoted M and X. Good M is chosen as the numeraire. Countries are endowed with equal quantities of M, which is transferred internationally to settle the balance of trade. By assumption, each country is endowed with a sufficient quantity of M to ensure that it consumes a positive quantity in equilibrium. The term M_i measures consumption of M in country i.[9]

All the firms in the model, one in each country, produce the homogeneous product X. We will use x_{ij} to denote the quantity produced by the firm in country j for the market in country i, and X_i as the quantity produced by all firms for sale in country i:

$$X_i = \sum_{j \in N} x_{ij}. \tag{2.1}$$

Consumer preferences are approximated by the following quasi-linear function:

$$u_i = v(X_i) + M_i = eX_i - \frac{1}{2}X_i^2 + M_i, \tag{2.2}$$

where e is a parameter. This functional form is relatively simple, focusing attention on the impact of product differentiation by distance.[10]

The inverse demand curve of consumer i is obtained in the usual way by differentiating (2.2) with respect to x_{ij}:

$$p_i(X_i) = \frac{dv}{dx_{ij}} = e - X_i. \tag{2.3}$$

Firm j's (marginal) cost to produce a unit of X for sale in country i consists of three components: a private per unit cost, c, which is the same for all firms; the tariff levied by government i on imports from j, t_{ij}; the transport cost of shipping from j to i, captured simply by d_{ij}. Thus, firm j's per-unit production cost for each market i is given by the function

$$c_{ij} = c + t_{ij} + d_{ij}. \tag{2.4}$$

We will assume that firms perceive markets as being segmented, and so they compete by choosing quantities in each country.[11] Firm j chooses x_{ij} to maximize profits in each market

[9]Note that since all countries are endowed with M and produce X, there is no scope in the present model for trade diversion. That is, TA formation cannot lower welfare by inducing countries to import more from TA partners that do not have a comparative advantage. In the present setting, the gains and losses to TA formation are driven instead by strategic considerations; this is a common feature of the recent literature. In the conclusions we will discuss how it might be possible to extend the insights of the present model to a Heckscher-Ohlin setting in which it is possible also to consider trade diversion.

[10]This function for preferences is also used by Ornelas (2005). Yi (1996) has a more general form of this preference function which allows X to be horizontally differentiated. The model of this present paper could be extended in that direction but this would complicate the analysis considerably and would risk obscuring the effects resulting from the organization of countries into regions.

[11]This assumption is made for analytical simplicity, but approximates the weaker assumption that firms compete over capacities.

i, denoted π_{ij}:

$$\underset{\{x_{ij}\}}{\text{Max}}\ \pi_{ij} = (p_i - c_{ij})\, x_{ij}, \tag{2.5}$$

where p_i is determined according to the inverse demand curve $p_i(X_i)$ given by (2.3).

Setting the first derivative of (2.5) equal to zero obtains the first order condition for firm j. Summing first order conditions over all $j \in N$, in Cournot equilibrium,[12]

$$x_{ij} = \frac{(e-c) + \sum_{k \in N} d_{ik} + \sum_{k \in N} t_{ik}}{7} - d_{ij} - t_{ij}. \tag{2.6}$$

Output by firm j for market i depends negatively on d_{ij} and t_{ij}; the smaller the distance to market, and the lower the tariff, the larger the rents available from shipping to country i and so the higher the quantity produced. In contrast, output by firm j depends positively on the distance from country i to all other markets and the tariff set by country i on imports from all countries other than j. Note that the strength of demand relative to cost helps to determine the rents available to firm j as well; $e - c$ is common to all markets and can be made large enough to ensure that $x_{ij} > 0$ for all i, j.

2.2. Welfare

Profits of domestic firms and tariff revenues are rebated back to consumers. Also, there is perfect competition in the world market for transportation. Based on these assumptions and the model set-up, country i's welfare can be expressed in terms of four economic components: domestic consumer surplus, C_i; the domestic firm's profit at home and abroad, π_{ii} and $\sum_{j \in N \setminus i} \pi_{ji}$ respectively ($j \neq i$)); tariff revenue, T_i; shipping revenue, D_i. Country i's welfare is denoted w_i:

$$w_i = C_i + \pi_{ii} + \sum_{j \in N \setminus i} \pi_{ji} + T_i + D_i, \tag{2.7}$$

where $C_i = \frac{1}{2}(e - p_i)\, X_i$, $T_i = \sum_{j \in N} t_{ij} x_{ij}$ and $\pi_{ij} = (x_{ij})^2$. Because the transport sector is perfectly competitive, goods are delivered at cost and there is no surplus associated with that sector; $D_i = 0$.[13]

[12] This is firm j's reaction function for market i.

[13] This specification makes 'iceberg' transportation costs consistent with a general equilibrium setting.

2.3. The Structure and Tariffs of Trade Agreements

If a group of countries forms a TA, they abolish mutual tariffs and jointly choose their external tariffs to maximize the aggregate welfare of members. There are no side-payments among members, so each country in a TA keeps its own tariff revenue.

Two remarks are in order. First, this is exactly the approach taken in the previous literature to formalize CU formation. But a key additional requirement of a CU is that all members set common external tariffs. In the previous literature, the approach stated here does induce members to form a CU, setting a common external tariff, because all countries are ex ante symmetrical. In the present setting, countries are asymmetrical because we have introduced a regional structure to the model. So the approach does not necessarily induce all members to set a common external tariff. In this sense the stipulations of TA formation are in fact weaker than the requirement that countries form a CU. Countries may choose to form a CU, but this outcome would be a feature of the equilibrium rather than a rule of TA formation.

Second, there is nothing in our formalization to stop members from raising their external tariffs when they form a TA. This could put TA formation in violation of Article XXIV of the GATT, adopted in the Charter of the WTO (GATT 1994), which requires that levels of protectionism against non-members be no higher (on average) than prior to the agreement. (Our formalization does satisfy the other key requirement of Article XXIV, that tariffs among members be abolished.) However, since the approach we will take here has been adopted in past research, its adoption here facilitates comparison with results in the literature.[14]

2.3.1. Trade Agreement Structure

The structure of TAs in the world economy is defined as follows. A *TA structure* $B = (B_1, B_2, ..., B_m)$ is a partition of the set of countries N, where B_1, B_2, ... , B_m are TAs; $B_i \cap B_j = \emptyset$ for $i \neq j$, and $\cup_{i=1}^{m} B_i = N$. If B_i has only one element then it is referred to as a *singleton*; a country that does not coordinate trade policy with others and simply optimizes

[14] Mrazova, Vines and Zissimos (2006) show in a related model that imposing an 'Article XXIV constraint,' which prevents members from raising common external tariffs, does not dramatically alter the structure of the TAs that form in equilibrium.

tariffs on a unilateral basis.[15]

Recall that the location of each country is fixed either in R_1 or in R_2. Therefore, $(B_k \cap R_1) \cup (B_k \cap R_2) = B_k$. Let b_{ir} be the number of country i's TA partners that are in the same region as country i, and let b_{inr} be the number of country i's TA partners that are in the "other" region.[16] In the present simple regional set-up, $b_{ir} \in \{1, 2, 3\}$ and $b_{inr} \in \{0, 1, 2, 3\}$.

2.3.2. Optimal tariffs

The members of a TA coordinate on setting external tariffs exactly as they would in a CU:

$$\underset{\{t_{ij}\}_{i \in B_k, j \notin B_k}}{\text{Max}} \sum_{i \in B_k} w_i = \sum_{i \in B_k} \left(C_i + \pi_{ii} + \sum_{j \in N \setminus i} \pi_{ji} + T_i + D_i \right), \tag{2.8}$$

where $t_{ij} = 0$ for all $i, j \in B_k$.

We now determine optimal tariffs; let r stand for regional and nr stands for non-regional. Then t_{ir} is the tariff that country i sets on imports from non-members in the same region and t_{inr} is the tariff set on imports from non-members in the other region. The following notation will be helpful with writing down the optimal tariff:

$$\Delta (b_{ir}, b_{inr}) \equiv 7 + (1 + (b_{ir} + b_{nr})) (3 + 2 (b_{ir} + b_{inr})) .$$

Optimal tariffs are derived in the next result.

Proposition 1. *Assume that country i belongs to a TA of b_{ir} regional members and b_{inr} non-regional members. Country i's unique optimal external tariff on imports from a non-member in the same region as country i is*

$$\begin{aligned} t_{ir}^* (b_{ir}, b_{inr}; d) &= \frac{(1 + 2 (b_{ir} + b_{inr})) (e - c)}{\Delta (b_{ir}, b_{inr})} \\ &+ \frac{3 + 6b_{ir} + b_{inr} (2 (b_{ir} + b_{inr}) - 7)}{2\Delta (b_{ir}, b_{inr})} d. \end{aligned}$$

[15] In coalition formation, relations between countries are transitive; if Countries 1 and 2 have an agreement and 2 and 3 have an agreement then 1 and 3 *must* have an agreement. In network formation, by contrast, relations may be intransitive; it does not follow that 1 and 3 must have an agreement. Because TA formation involves coordination over external and internal tariffs, it implies a transitive relationship between members. Almost all the literature on stable equilibrium TA structures focuses on transitive trade agreements, as we do here. Goyal and Joshi (2005) is one exception, in which FTAs are modelled as a network.

[16] Formally, if $i \in B_k$ and $i \in R_l$ then let b_{ir} be the cardinality of the set $B_k \cap R_l$ and let b_{inr} be the cardinality of the set $B_k \cap R_m$, $l \neq m$.

The unique optimal external tariff imposed by country i on non-members who are not in the same region as country i is

$$\begin{aligned} t_{inr}^{*}\left(b_{ir}, b_{inr}; d\right) &= \frac{\left(1+2\left(b_{ir}+b_{inr}\right)\right)(e-c)}{\Delta\left(b_{ir}, b_{inr}\right)} \\ &\quad -\frac{5+b_{ir}\left(2b_{ir}-3\right)+2b_{inr}\left(5+b_{ir}\right)}{2\Delta\left(b_{ir}, b_{inr}\right)} d. \end{aligned}$$

The most important thing to notice about $t_{ir}^{*}\left(b_{ir}, b_{inr}; d\right)$ and $t_{inr}^{*}\left(b_{ir}, b_{inr}; d\right)$ is that the difference between them depends on d. That is, if $d=0$ then $t_{ir}^{*}\left(b_{ir}, b_{inr}; d\right)=t_{inr}^{*}\left(b_{ir}, b_{inr}; d\right)$. And $t_{ir}^{*}\left(b_{ir}, b_{inr}; d\right)-t_{inr}^{*}\left(b_{ir}, b_{inr}; d\right)$ is increasing in $d>0$. Also notice that if $d=0$ then $t_{ir}^{*}=t_{inr}^{*}$ corresponds exactly to the optimal tariff found in previous literature.[17]

2.4. Demand functions by region and TA membership

We can now write down expressions for equilibrium output produced by country j for country i along two dimensions; whether or not country j is a member of country i's TA and whether or not country j is in the same region as country i. These expressions are obtained from (2.6) by appropriate substitution of distance $d_{ij}=0$ or $d_{ij}=d$ and optimal tariffs $t_{ir}^{*}\left(b_{ir}, b_{inr}; d\right)$ and $t_{inr}^{*}\left(b_{ir}, b_{inr}; d\right)$.[18]

Let m stand for TA member and let nm stand for non-member. Write x_{irm} for output produced for country i by a country that is in the same region as country i *and* is a member of country i's TA:

$$x_{irm}\left(b_{ir}, b_{inr}; d\right)=\frac{2\left(1+b_{ir}+b_{inr}\right)(e-c)+\left(3\left(1+b_{ir}\right)+2b_{inr}\left(\left(b_{ir}+b_{inr}-1\right)\right)\right) d}{\Delta\left(b_{ir}, b_{inr}\right)}. \quad (2.9)$$

Write x_{inrm} for output produced for country i by a country not in the same region but which is a member of country i's TA:

$$x_{inrm}\left(b_{ir}, b_{inr}; d\right)=\frac{2\left(1+b_{ir}+b_{inr}\right)(e-c)-\left(5+2b_{ir}^{2}+b_{inr}\left(5+2b_{ir}\right)\right) d}{\Delta\left(b_{ir}, b_{inr}\right)}. \quad (2.10)$$

[17] Under a particular specification, Yi's preference function replicates the expression for u_i in the present paper, (2.2). In the model of the present paper, if we let $d=0$ and $k=b_{ir}+b_{inr}$ then $t_{ir}^{*}=t_{inr}^{*}=(1+2k)(e-c)/\left(8+3k+2k^{2}\right)$. If we set $n=6$ in Yi's expression for the optimal tariff, presented in *his* Proposition 1, we obtain $\tau(k)=(1+2k)/\left(8+3k+2k^{2}\right)$, where $\tau(k)$ is Yi's notation for the optimal tariff. Note that Yi assumes $e-c=1$ (expressed in our notation).

[18] The intermediate step of solving for equilibrium output based on the model's regional structure but for arbitrary tariffs is presented in the appendix.

Write x_{irnm} for output produced for country i by a country that is in the same region but *not* a member of country i's TA:

$$x_{irnm}(b_{ir}, b_{inr}; d) = \frac{2(e-c) + (3 + b_{inr}(3 + 2(b_{ir} + b_{inr})))d}{2\Delta(b_{ir}, b_{inr})}. \tag{2.11}$$

Finally, write x_{inrnm} for output produced for country i by a country that is not in the same region and is not a of country i's TA:

$$x_{inrnm}(b_{ir}, b_{inr}; d) = \frac{2(e-c) - (5 + b_{ir}(3 + 2(b_{ir} + b_{inr})))d}{2\Delta(b_{ir}, b_{inr})}. \tag{2.12}$$

From these expressions, total output is given by

$$X_i = b_{ir}x_{irm} + (3 - b_{ir})x_{irnm} + b_{inr}x_{inrm} + (3 - b_{inr})x_{inrnm}.$$

2.5. TA Expansion and Welfare

In this subsection, we shall examine the effect on welfare of TA formation and expansion. We will want to focus on a situation where TA formation does not lead to a complete severing of trade relations, since otherwise the effects are rather obvious. So we will derive conditions under which we can restrict attention to a situation where firms in all countries produce positive quantities for all markets. Output levels and hence trade flows are positive even between countries that are in different regions and not members of the same TA.

It can be seen by inspection that trade flows are lowest between countries that are not members of the same TA and are not in the same region; $x_{inrnm}(b_{ir}, b_{inr})$ is the smallest of the quantities given by (2.9)-(2.12).[19] Also, by (2.12), $x_{inrnm}(b_{ir}, b_{inr})$ is decreasing in d. It follows that placing an upper bound on d ensures that $x_{inrnm}(b_{ir}, b_{inr}) > 0$ and that in turn all trade flows are positive. The next result identifies the upper bound on d.[20]

Lemma 1. *Fix* $e > c$. *If* $d \in (0, (e-c)/22)$ *then, for* $b_{ir} \in \{1, 2, 3\}$, $b_{inr} \in \{0, 1, 2, 3\}$ *and* $b_{ir} + b_{inr} \leq 5$ *we have that* $x_{irm}(b_{ir}, b_{inr}) > x_{inrm}(b_{ir}, b_{inr}) > x_{irnm}(b_{ir}, b_{inr}) > x_{inrnm}(b_{ir}, b_{inr}) > 0$ *and* $t^*_{ir}(b_{ir}, b_{inr}) > t^*_{inr}(b_{ir}, b_{inr}) > 0$.

[19] Henceforth, the parameter d will be dropped from functional notation so that, for example, $t_{ir}(b_{ir}, b_{inr}; d)$ will be written $t_{ir}(b_{ir}, b_{inr})$ and $x_{inrnm}(b_{ir}, b_{inr}; d)$ will be written $x_{inrnm}(b_{ir}, b_{inr})$.

[20] The reason for restricting attention to $b_{ir} + b_{inr} = 5$ in the result is because there are no non-regional non-members under free trade ($b_{ir} = 3$, $b_{inr} = 3$), and so it does not make sense to calculate a quantity for $x_{inrnm}(3, 3)$.

To restrict attention to positive output levels and positive optimal tariffs, the following standing assumption will be imposed throughout.

Assumption 1. $d \in [0, (e-c)/22)$.

Thus, TA formation always entails the removal of positive tariffs.

We now turn to look at the effect of TA formation on member and non-member welfare. We will follow Yi (1996) by looking first at the effect of TA formation on non-member countries. Yi shows (in his Proposition 3) that if a TA forms or expands, then non-member countries are adversely affected. We will now show that Yi's result extends directly to the present model.

TA expansion may occur within a region (in which case b_{ir} increases) or across regions (in which case b_{inr} increases). Thus, define *TA expansion* as an increase in b_{ir} and/or b_{inr}.[21] *TA formation* is just a special case of TA expansion in which all members of the TA that forms start as singletons.

Also note that TA expansion only affects non-members through the demand for exports. This is because optimal tariff setting of non-members is unaffected by TA formation. Thus we can evaluate the effect of TA formation on non-members entirely in terms of the effect on non-member exports to the TA, x_{irnm} and x_{inrnm}, and hence export profits. The next result shows that both x_{irnm} and x_{inrnm} are globally decreasing in b_{ir} and b_{inr}.

Proposition 2. *For $b_{ir} \in \{1, 2, 3\}$, $b_{inr} \in \{0, 1, 2\}$, it is the case that $dx_{irnm}/db_{ir} < 0$, $dx_{inrnm}/db_{ir} < 0$, $dx_{irnm}/db_{inr} < 0$, $dx_{inrnm}/db_{inr} < 0$. A non-member country's volume of exports and export profits to a TA of size b_{ir}, b_{inr} is decreasing in b_{ir} and decreasing in b_{inr}. The expansion or formation of a TA reduces the welfare of non-member countries.*

As a TA expands, and removes internal trade barriers, demand for X by consumers in member countries turns towards TA members and away from non-members, hurting the export profits of non-members.

Let us now examine the effect of TA formation on the welfare of members. Yi shows for

[21] Say that a TA initially has two members, one in each region. Then say that one member breaks up with its partner and instead forms a TA with two countries from its own region. Although a new larger TA is created, this is not allowable under our definition of TA expansion since it involves cessation/contraction of membership of the initial TA.

his model that the *joint* welfare of countries involved in TA expansion increases (where 'joint' implies the welfare of existing members and new members). And more generally, if several TAs merge to form a larger TA the aggregate welfare of the member countries increases. Yi remarks that consumer surplus displays a non-monotonicity that is present in underlying optimal external tariffs; the consumer surplus in member countries may first decrease and then increases as a TA expands. A country's export profits, on the other hand, may initially increase but ultimately decreases as the TA expands. The present model introduces a further ambiguity because there are two common external tariffs; the one levied on countries in the same region and the one levied on countries in the other region.

Even though the economic environment is made more complicated by the regional dimension of the model, the next result shows that Yi's Proposition 4 extends to the present setting as well.

Proposition 3. *The expansion or formation of a TA increases the aggregate welfare of member countries.*

Despite the levying of different external tariffs across regions, the same logic that underpins Yi's Proposition 4 may be applied here too. If a set of countries abolishes tariffs internally and sets external tariffs to maximize aggregate welfare then their joint welfare must improve. Proposition 3 shows that the formation of a TA improves joint welfare of member countries even if non-negative tariffs on imports are the only policy tools and even though members and non-members may be in different regions.

So far, we have seen that Yi's results concerning TA expansion in an environment where all countries are ex ante symmetric extend to the present setting where countries are ex ante asymmetric. When a TA expands, this increases the aggregate welfare of the countries in the TA and harms countries that are not members of the TA. Just as in the world where countries are ex ante symmetric, this implies that the effect of TA expansion on global welfare is ambiguous. The single case in which this ambiguity disappears is the case where TA expansion goes all the way to the grand coalition, which is equivalent to world free trade. Thus, Yi's Proposition 5 carries over to the present setting and is reproduced here for completeness.

Proposition 4. *The effects on global welfare of the formation or expansion of TAs are ambiguous, except when the grand TA forms. World welfare is higher under the grand TA (world free trade) than under any other TA structure.*

All of Yi's results that we have examined so far extend to the present setting. These results have focused on the welfare effects of TA expansion on non-members and on the aggregate welfare of members.

Let us now focus explicitly on the welfare of individual member countries in the TA formation process. In doing so, we will show that a key property of Yi's homogeneous-country model *fails* to hold when transport costs are sufficiently large but still in the range where trade flows between all countries are positive. Of course, Yi's result continues to hold when transport costs are sufficiently small.[22]

Proposition 5. *There exists a unique value $d' \in (0, (e-c)/22)$ such that for $d \in [0, d')$, a country is better off in a (4-country) TA consisting of itself and all 3 countries* in the other region *than in a (3-country) regional TA* in its own region. *For $d \in [d', (e-c)/22)$, a country is better off in a (3-country) regional TA in its own region than in a (4-country) TA consisting of itself and all 3 countries in the other region.*

For $d \in [0, d')$ this result is consistent with Yi's Proposition 8, which says that a member of a TA becomes better off if it leaves its TA to join another TA of equal or larger size. But for $d \in [d', (e-c)/22)$, the result says that a country is better off remaining in a 3-country TA within its own region than it would be if it left its regional TA to form a 4-country TA with all three countries in the other region.

To understand the intuition behind this result, let us consider a member of a regional TA (in its own region), and ask whether it could gain by joining a regional TA in the other region. Say that Country 1 is initially in a regional TA; $1 \in B_1 = R_1$. And say that the countries in the other region form another regional TA, $B_2 = R_2$. Country 1 considers whether it could gain by leaving B_1 and joining B_2. Decompose the process into three steps: (i) Original members of B_2 abolish tariffs on imports from Country 1 and change tariffs on the other countries in R_1 from $t^*_{inr}(3,0)$ to $t^*_{inr}(3,1)$; (ii) Country 1 abolishes tariffs on

[22] We will assume that if a country is just indifferent between forming a regional agreement or a non-regional agreement then it exhibits a preference for the regional agreement. This assumption is trivial, and could be reversed without consequence.

all countries in B_2, and levies tariffs at $t^*_{ir}(1,3)$ on its two former TA partners in B_1; (iii) The remaining two members of B_1 change tariffs on the (original) members of B_2 (who are located in R_2) from $t^*_{inr}(3,0)$ to $t^*_{inr}(2,0)$ and levy a tariff $t^*_{ir}(2,0)$ on Country 1.

Consider the effect of each of these steps on the welfare of Country 1 for $d \in [0, d')$ and $d \in (d', (e-c)/22]$ respectively. Take $d \in [0, d')$ first. (i) The abolition of tariffs by the members of B_2 has a positive impact on the welfare of Country 1, because Country 1 enjoys greater openness in three markets. (ii) Country 1's abolition of tariffs on all three countries in B_2 also improves welfare but the implementation of tariffs on its two former TA partners in B_1 reduces welfare; the net effect is *positive* because access is increased to three markets while it is reduced in only two. (iii) Finally, the implementation of tariffs by its two former TA partners in B_1 reduces export profits and hence welfare in Country 1. But the effect on exports of access to its three new partners in B_2 (in step (i)) more than compensates. The positive effect on consumer surplus from net tariff removal in moving to the larger TA is greater than the negative effect on tariff revenue and the loss of domestic profits from greater competition in the domestic market.

Now take $d \in (d', (e-c)/22]$. The impact on welfare for Country 1 of moving from B_1 to B_2 is reversed. (i) As before, the removal of tariffs by Country 1's three new partners in B_2 has a positive impact on export profits. (ii) And once again, Country 1's abolition of tariffs on all three countries in B_2 improves welfare while the implementation of tariffs on its two former TA partners in B_1 reduces welfare. But in the presence of transport costs, the net effect is *negative* because the implementation of tariffs by two nearby partners has a larger negative effect on export profits than the removal of tariffs by the three new distant partners in the other region. (iii) Again, the implementation of tariffs by its two former TA partners in B_1 reduces export profits and hence welfare in Country 1. And now, the effect on exports of access to its three new partners in B_2 (in step (i)) is not sufficient to compensate. The positive effect on consumer surplus from net tariff removal in moving to the larger TA is smaller than the negative effect on tariff revenue and the loss of domestic profits from greater competition in the domestic market.

Thus, a key result of Yi's is overturned in the present model with the introduction of transport costs. This is significant because it shows that a country will not leave a TA in its own region to form or join a TA in the other region, even if the new TA that forms is larger.

In Yi's characterization of an equilibrium TA structure, the first TA to form is the largest. Our result calls into question whether, in a regional setting, a country would always agree to join a larger TA.

One is bound to ask whether the tendency towards regionalism presented in this result is specific to the model we are using here. Interestingly, Egger and Larch (2006) show that exactly the same effect prevails in a generalization of Krugman's (1991) constant-elasticity-of-substitution model of regionalism. Egger and Larch (2006) have three regions, each of which has two countries. They present simulations in Figure 4 of their paper to show that, with relatively high intercontinental transport costs, a country would rather form a (two country) regional TA than form a (three country) TA by joining a TA with two countries from another region. This suggests that the tendencies towards regionalism derived in the present model extend to other settings as well.[23]

A natural question to ask next is whether the members of a regional TA would invite a country from the other region to join them. The next result shows that, once again, the answer depends on the size of transport costs.

Proposition 6. *There exists a value $d'' \in (d', (e-c)/22)$ such that for $d \in [0, d'')$ the highest feasible level of welfare is achieved when a country is a member of a TA with all of its regional partners and one country from the other region while non-members are singletons. For $d \in [d'', (e-c)/22)$, the highest feasible level of welfare is achieved when a country is a member of a regional TA (with all members from its own regional and no members from the other region) while non-members are singletons.*

This result is again in keeping with Yi (1996). A group of countries can obtain a higher level of welfare than under free trade by forming a TA while non-members remain as singletons. In Yi's model, the highest level of welfare is achieved by a country when it forms a TA of four members. This continues to be true in our model for $d \in [0, d'')$, i.e. when transport costs are small. When transport costs are larger, that is $d \in [d'', (e-c)/22)$, a country does better by forming a regional TA (only with members from its own region). The reason is that the terms-of-trade benefits of TA formation increase with transport costs, and these benefits are increasing in the number of countries left outside the TA. In either case,

[23] Egger and Larch (2006) identify these effects to make sense of their empirical investigation of tendencies towards regional TAs.

to maximize national welfare, the TA of which a country is a member must include all of its regional partners.

We are now in a position to see that existence of equilibrium would not have been guaranteed in our model if we had adopted the Bloch (1996) 'size announcement' game (used by Yi 1996) as our game of TA formation. The application of that game to the present framework would be the following. All countries are placed on a list, say 1, 2, ... , 6. Country 1 would be asked to announce the size of the agreement that it would like to form. Then, all proposed partners (following subsequently from Country 1) would be asked to agree or disagree. If a proposed partner disagrees then it is asked to make its own proposal of a TA and, again, each subsequent proposed partner is asked whether or not it agrees. If all agree then those countries withdraw from the game, and the next country on the list is asked to announce the size of the TA that it wants to form. If the end of the list of countries is reached then there is a return to the first country on the list that has not already formed an agreement and withdrawn from the game.

Now consider what would happen if the size announcement game were played based on our model for $d \in (d', d'')$. In that case since $d \in (0, d'')$, by Proposition 6, Country 1 would announce that it wants to form a 4-country TA consisting of itself and Countries 2, 3 and 4. But since $d \in (d', (e-c)/22]$, by Proposition 5, Country 4 would do better in its own regional TA so it refuses (while Countries 2 and 3 accept). When Country 4 is asked to make an alternative proposal, by Proposition 6, it proposes a TA consisting of itself and Countries 5, 6 and 1. This is a mirror of Country 1's original proposal. It is now clear that no equilibrium would exist in this situation.[24] In addition to providing a way to capture the coordination problem in TA formation, the TA formation game presented in the next section also provides a way around this existence problem.

3. The TA Formation Game

As argued in the Introduction, a country has many potential options for partners when seeking a TA, and this creates potential for coordination failure. We will capture this problem formally by basing the TA formation process on the $\delta -$ coalition formation game of Hart

[24]A similar argument establishes that no equilibrium exists for $d \in [0, d']$. For $d \in [d'', (e-c)/22]$, an equilibrium does exist for the size announcement game in which two regional TAs form, one in each region.

and Kurz (1983). Within that setting, once a country had chosen which potential partners it would approach to form a TA, a reasonable assumption would be that countries who had approached each other would have more information about the prospective membership of their agreement than countries who had not approached each other. In the TA formation game, we will adopt a particularly tractable form of this assumption; within a period, each country only knows about the prospective TA membership of its own TA partners. We adopt this approach from Arnold and Wooders (2005), who impose this essential restriction on the flow of information in their general formalization of club formation.

The game lasts three periods; $t = 0, 1, 2$. The process is initialized at $t = 0$ with a TA structure in which there are *no TAs*; initially the TA structure, B, is the set of singletons. Within each period $t \geq 1$, the sequence of events is as follows. At the start of the period, each country observes the TA structure of the previous period. Then, each country i chooses a *strategy* s_i, where each s_i contains a list of countries in N with which country i would like to form a TA; this list includes country i itself. The purpose of including i in s_i is that then we can view B_k as the intersecting set of all the elements of strategies s_i for all $i \in N$. The *strategy space* S_i for country i is the set of all subsets of N i.e. the set of all possible TAs that could include country i. Strategies are chosen simultaneously. During the TA formation process, a country only observes whether or not it ends up in a TA and, if so, it sees which other countries are its TA partners. A country does not observe the strategies of other countries. We will say that, during the TA formation process, if a country does not observe another country as its TA partner, it maintains the assumption that the trade policy of that other country is described by the TA structure B of the previous period.

A *bilateral trade accord* (i, j) is formed if and only if $i \in s_j$ and $j \in s_i$. A subset of countries B_k is a *TA* if and only if all pairs of countries in B_k have a bilateral trade accord. This assumption ensures that a TA forms if and only if there is unanimous support for its membership. If a country finds itself in the position of being in two or more otherwise exclusive and otherwise unanimous TAs, it chooses the TA that maximizes its payoff under the assumption that the memberships of the TA it joins and the TA that it leaves remain otherwise constant.[25] When a country chooses one TA over another one, it assumes that the

[25] Pushing this one step further, any two countries caught between two TAs will assume that each behaves in the same way as the other in the TA that they choose. This assumption is the same as that of Hart and Kurz, that if any player is caught between two coalitions then it chooses the biggest one under the assumption that all other players caught in the same situation do the same. In a symmetrical world this

other goes ahead without it. If a new TA forms by the merger of more than one existing TA, then all members of all merging TAs must agree to the new one.

Under the assumption that countries observe the TA structure given by B in the previous period and take this as given, it is not possible to break up an existing TA in the process of forming a new one. Therefore, the assumption introduces a degree of inertia into the formal characterization of existing TAs. Countries are unable to force out existing TA partners once a TA has formed. In one sense this is theoretically restrictive, but it reflects actual practical restrictions on the cessation arrangements of existing TAs. For example, with regard to the EU, any member of the Council of Ministers has the power to veto membership of a country that would like to join, but there is no way to force out a country that is already a member. The present formalization reflects perfectly this type of arrangement.

Each strategy vector $s = (s_1, ..., s_N)$ *induces* a unique TA structure, B, and so we can now write B as a function of s; $B(s)$:

$$B(s) = \{ (i, j) | \, i \in s_j, j \in s_i \} .$$

Since a TA structure implies a unique value of b_{ir} and b_{inr} for each country i, and since these in turn imply values of $t^*_{ir}(b_{ir}, b_{inr})$ and $t^*_{inr}(b_{ir}, b_{inr})$, the payoff to country i associated with s can be represented simply as $w_i = w_i(t_{ir}(B(s)), t_{inr}(B(s)))$; the payoff for country i from the TA structure *induced by* s. For compactness, we may write $w_i = w_i(s)$.

The notion of equilibrium is adapted from Arnold and Wooders (2005). For any given TA structure $B = (B_1, ..., B_k, ..., B_m)$, a strategy vector $s^* \in S$ is a *Nash club equilibrium* of the TA formation game if for any given $B_k \in B$ there is no $Z \subseteq B_k$ and $s \in S$ such that

1. $s_i = s^*_i$ for all $i \notin Z$.
2. $w_i(s) \geq w_i(s^*)$ for all $i \in Z$ and $w_i(s) > w_i(s^*)$ for some $i \in Z$.

By definition, an equilibrium exists if no group of countries Z in some TA, B_k, can do better by deviating. By contrast, Hart and Kurz allow deviations to be undertaken by *any* coalition $Z \subseteq N$. If we were to allow deviations by any coalition of countries $Z \subseteq N$, then equilibrium may fail to exist, for reasons that shall become clear. Our definition weakens

assumption is innocuous. In principle this assumption could lead to mistakes in an asymmetrical world but this potential problem will not be an issue for any of the situations that we will study.

the notion of equilibrium relative to Hart and Kurz, admitting a relatively large number of equilibria. In particular, it does not exclude from the equilibrium set candidates that arise as a result of coordination failure - in the present context, where countries could all benefit from moving to free trade but fail to do so due to the restrictions placed on the flow of information. It remains to be shown how the problem of coordination arises when all countries are symmetric and is resolved when a degree of asymmetry is introduced between countries.

4. The Problem of Coordination Failure

We will now show how the problem of coordination arises in a world where all countries are symmetrical. To do so, fix $d = 0$. By Proposition 6, we know that a TA of four countries maximizes the welfare of its members (if the other two countries are singletons). The problem of coordination failure arises because, even if each country writes down a strategy s_i with four elements, in the absence of communication there are many possible TA structures that may arise in equilibrium as a result of all countries playing this strategy. An equilibrium may arise in which there is a TA with four countries, which is the desired outcome of each of the members. But of course the two countries excluded from the four-country TA do not achieve their desired outcome. Moreover, this is not the only TA structure that can be sustained in equilibrium. We will first consider an equilibrium in which there is a four-country TA, but then consider one of many possible alternative TA structures that may arise.

4.1. Various equilibria with coordination failure

An example of a strategy vector that gives rise to an equilibrium in which there is a four-country agreement is as follows:

$$\begin{aligned} s_1 &= \{1,2,3,4\} \\ s_2 &= \{1,2,3,4\} \\ s_3 &= \{1,2,3,4\} \\ s_4 &= \{1,2,3,4\} \\ s_5 &= \{1,2,5,6\} \\ s_6 &= \{1,2,5,6\}. \end{aligned}$$

Notice that the strategies $s_1...s_4$ form an intersecting set of elements $\{1,2,3,4\}$ while 5 is only listed in s_6 (and s_5 of course) and 6 is only listed in s_5 (and s_6). Thus, the resulting trade agreement structure is $\{\{1,2,3,4\},\{5,6\}\}$. It is easy to check that no country can gain by deviating from this agreement structure and so therefore this must be an equilibrium. Consider the allowable deviations. If a member of the four-country TA were to veto membership of another single member then the TA structure would become one of a three-country TA, a singleton and a two-country TA, for example $\{\{1,2,3\},\{4\},\{5,6\}\}$. Then, by Proposition 6, the payoff to the country that undertook the veto would fall, as would the payoff of the ejected member. The welfare of 5 and 6 actually increases. If more than one country's membership is vetoed, it is easy to check that the payoff of remaining members falls even further. No member of the four-country TA has an incentive to deviate. The same is true for the two-country TA. Thus we have a Nash club equilibrium.

We have already discussed above the reasons why the welfare of members to an agreement changes when one or more countries are ejected. Let us briefly review why non-member welfare changes. We just noted that, from an initial trade agreement structure of $\{\{1,2,3,4\},\{5,6\}\}$, if Country 4 is ejected, leaving a trade agreement structure of $\{\{1,2,3\},\{4\},\{5,6\}\}$, then the welfare of 5 and 6 increases. Why does this happen? Tariffs set by 5 and 6 do not change because these depend only on their own trade agreement structure, which has not changed. When 4 is ejected, Countries 1, 2 and 3 restore tariffs against it, and as a result demand less of X from 4, shifting some of their demand towards 5 and 6. This increases profits in 5 and 6. In addition, 4 restores tariffs against Countries 1, 2 and 3, shifting its demand for X towards 5 and 6. Both of these effects combine to shift profits towards 5 and 6, thus increasing welfare.

Notice that, because $d = 0$, the partition of countries into regions has no relevance to this equilibrium. As specified, the equilibrium contains three countries from R_1 and one country from R_2. But under an equivalent characterization of equilibrium we could permute the countries in such a way that two countries were in R_1 (say 1 and 2), and two countries were in R_2 (say 3 and 4). This is due to the fact that all countries are symmetrical. We shall see that the partition of countries into regions does become relevant for equilibrium when $d > 0$.

Now let us consider another possible equilibrium, in which there are three agreements, each with two members. This equilibrium arises if each country proposes to form a TA with the three countries 'next to it':

$$\begin{aligned} s_1 &= \{1,2,3,4\} \\ s_2 &= \{2,3,4,5\} \\ s_3 &= \{3,4,5,6\} \\ s_4 &= \{4,5,6,1\} \\ s_5 &= \{5,6,1,2\} \\ s_6 &= \{6,1,2,3\}. \end{aligned}$$

By inspection of the strategy vector, the agreements that form are $\{1,4\}$, $\{2,5\}$ and $\{3,6\}$. Again, it is straight-forward to check that this is an equilibrium strategy vector. If any member of a two-country agreement vetoes membership of the other, splitting the agreement into two singleton agreements, then its payoff falls by Proposition 3. This is the only feasible deviation. Consequently, the strategy vector shown above must be an equilibrium. And again, notice that the partition of countries into regions has no relevance to this equilibrium.

5. Transport Costs and Coordination

The problem of coordination failure identified in the previous section is resolved in the presence of transport cost $d \in (0, (e-c)/22)$. It follows from Proposition 6 that in period $t = 1$ each country has an incentive to form a trade agreement with all other countries in the same region.

Proposition 7. *Assume $d \in (0, (e-c)/22)$. At $t = 1$ there is a unique equilibrium with two regional TAs; $B_1 = R_1$, $B_2 = R_2$. The payoff to each country is the same and is lower than free trade.*

There are two cases to consider, although the outcome is the same in both; one where $d \in (0, d'')$ and one is where $d \in (d'', (e-c)/22)$. The second case is easier so we consider that first. Recall that for $d = 0$ each country wants to be in a TA with four other countries. For $d \in (d'', (e-c)/22)$, due to higher transport costs, each country obtains the highest level of welfare from a regional TA with only the two other countries in its own region. Thus, it is immediate that the intersecting sets formed by countries' strategies is two regional TAs; $B_1 = R_1$ and $B_2 = R_2$.

The case where $d \in (0, d'')$ is slightly more subtle. In that case, each country's welfare is maximized by a 4-member TA with three members from its own region and one member from the other region. But even if all countries write down a strategy containing four countries, three from its own region and one from the other region, the intersecting sets of countries formed by these strategies give rise to two regional TAs; $B_1 = R_1$ and $B_2 = R_2$. To see why, consider the following strategy vector:

$$\begin{aligned} s_1 &= \{1,2,3,4\} \\ s_2 &= \{1,2,3,4\} \\ s_3 &= \{1,2,3,4\} \\ s_4 &= \{1,4,5,6\} \\ s_5 &= \{1,4,5,6\} \\ s_6 &= \{1,4,5,6\}. \end{aligned}$$

The strategies $s_1 ... s_3$ form an intersecting set of elements $\{1,2,3\}$ and the strategies $s_4 ... s_6$ form an intersecting set of elements $\{4,5,6\}$. Thus, the resulting trade agreement structure is $\{\{1,2,3\},\{4,5,6\}\}$. Even though, for this example, all countries that end up in B_1 list Country 4, Country 4 only names Country 1 and *not* 2 and 3. Only the membership of 1, 2 and 3 is unanimous among all members. It is straight forward to check that the same is true for all other possible strategy vectors.

No country can gain by deviating from this agreement structure and so therefore this must be an equilibrium. Consider the allowable deviations. If a member of one of the regional agreements were to veto membership of another single member then the agreement structure would become one of a two-country agreement, a singleton and a three-country agreement; for example $\{\{1,2,3\},\{4,5\},\{6\}\}$. Then the payoff to the country that undertook the veto, in this example Country 4 or 5, would fall. The welfare of countries in the regional trade agreement that remains $\{1,2,3\}$ actually increases. As before, if more than one country's membership is vetoed, it is easy to check that the payoff of the remaining member falls even further. Thus, no member of a regional agreement has an incentive to deviate. No deviation is available to the singleton. Thus we have a Nash club equilibrium. Providing play proceeds in the manner described, this is the only possible equilibrium that can arise for transport costs in the interval $d \in (0,(e-c)/22))$. In equilibrium the trade agreement structure is symmetrical, so each country receives the same payoff. By Proposition 4, the payoff that each country receives must be lower than under free trade.

Clearly, the assumption that agents hold constant the strategies of other countries when forming a trade agreement is crucial for this outcome. If countries were far-sighted then each would obviously anticipate that the countries of the other region would form a trade agreement as well. Then each country would be able to see that a move to free trade would be more beneficial. But we can also see how the present assumption of naivete captures aspects of uncertainty that are likely to be present in the actual process of trade agreement formation across regions.

6. Do Regional TAs Facilitate Free Trade?

We have seen how, for $d \in (0,(e-c)/22)$, two regional TAs emerge at stage $t=1$. We now proceed to stage $t=2$ and ask whether free trade can emerge at this point. We find that it does. The thinking is as follows. Each country observes the regional trading arrangements described by B from period $t=1$. At $t=1$, there are two regional trade agreements; $B_1 = R_1$, $B_2 = R_2$. At $t=2$, countries are able to secure this same payoff as at $t=1$ by maintaining the existing structure. However, each is able to obtain a higher payoff by moving to free trade. Thus every country is potentially able to gain by moving to free trade. In the next result, the reference to $t=1$ replicates Proposition 1 and is included for completeness.

Proposition 8. *Assume $d \in \{0,(e-c)/22\}$. There is a unique equilibrium path. At $t=1$ there are two regional TAs; $B_1 = R_1$, $B_2 = R_2$. At $t=2$ there is world free trade.*

How can free trade be an equilibrium at $t=2$ but not at $t=1$? At $t=1$ a country has an incentive to veto the membership of one or more countries in the other region. The payoff to such a deviation rests on the assumption that all the excluded members return to the trade agreement structure given by the network B at $t=0$. That is, all excluded countries were assumed to return to singleton status. At $t=2$ the outcome is different. All excluded countries are assumed to return to the trade agreement structure given by B at $t=1$. By Proposition 7, the payoff to such a deviation is not profitable as it is lower than free trade.

Also recall that, by assumption, it is not possible to break apart an existing trade agreement by ejecting a subset of countries from the other region. If a deviation from free trade were allowed in which only one of the countries were ejected, for example bringing about a trade agreement structure of $\{\{1,2,3,4,5\},\{6\}\}$, then countries 1, 2 and 3 may be able to gain over free trade. For the same reason, $s_i = \{1,2,3,4,5\}$ is not an allowable strategy at $t = 2$, given the equilibrium $\{\{1,2,3\},\{4,5,6\}\}$ at $t = 1$. Indeed, the only profitable strategy is free trade, since it includes all the countries from the two agreements of period $t = 1$. Thus, we have shown that free trade is a Nash club equilibrium at $t = 2$. Regional trade agreements do ultimately facilitate free trade.

7. Conclusions

The purpose of this paper has been to show that problems of coordination failure in the formation of TAs may be resolved when countries are organized into regions. Costs of shipping goods between regions must be significant, but no so high as to eliminate trade between regions. With no transport costs, there is a problem of multiple equilibria due to coordination failure familiar from the theory of coalition formation. Positive transport costs are enough to bring about a unique equilibrium in the first period of the TA formation game. Starting from a situation where there are no TAs, in the first period two regional TAs form simultaneously. In the second period the two regional TAs merge to bring about free trade. The attainment of free trade only after a period of regionalism rests on a restriction in the flow of information through the TA formation process. Members can only communicate about their agreement once they have simultaneously and independently chosen their trade agreement partners. Best responses are made naively, based only on information about the TA structure of the previous period.

Inevitably, the theoretical framework developed here simplifies the situation in a number of key respects. The underlying economic structure of the model is one of Cournot competition in a homogeneous product. In practice, the forces of competition are more subtle and complex. Future research could take steps to see whether the insights of the present model extend to alternative settings. It seems reasonable to argue that the features of the model exhibited in the examples would extend to other forms of competition. It is widely appreciated that Bertrand competition behaves like Cournot competition when firms must pre-commit to quantities. A more elaborate modelling of perfect competition should also exhibit the same features, as suggested by Bond (2001). The key motivating feature of the model is that import substitution elasticities are declining in distance in the model, and this motivates higher rents in trade and hence higher tariffs between close neighbors in the absence of an agreement. This feature of the model should be robust to alternative assumptions about competition.

It also seems reasonable to argue that the features of the model would extend to a more elaborate model of production. A direct way to do this would be to assume that X is horizontally differentiated, extending preferences and production accordingly. Alternatively, Syropoulos (1999) offers a way to investigate whether the insights of the model developed in the present paper could be extended to a Heckscher-Ohlin framework.

One question that should be addressed in future research on this topic is whether the model predictions are robust to more elaborate and realistic country and regional structures. How big must the asymmetries across countries and regions get before problems of multiple equilibria re-emerge? When will asymmetries preclude the eventual move to free trade? It would also be desirable to see whether the basic insights of the present model could be extended to alternative model specifications.

A focus of recent research on regionalism is on situations where tariffs are used for political or redistributive purposes and particularly with the interests of producers.[26] Such considerations could be incorporated in the model of the present paper by using the national welfare function for government objectives but putting a heavier weight on producers profits in the or by incorporating a term to reflect political contributions into the function. It seems possible that producer interests that span regions, as between the UK and the US for example, could counteract the forces towards regionalism identified in the basic framework.

Another interesting line of research is to investigate how variation in the assumptions over the flow of information and expectations between countries through the agreement formation process changes the outcome. It appears that perfect information and perfect foresight facilitate an immediate move to free trade. But it would be interesting to ask in which ways weakening information flows in various ways would vary the outcome away from

[26]See for example Grossman and Helpman (1995), Krishna (1998), Maggi and Rodriguez-Clare (1998) and Ornelas (2005).

free trade, and under what alternative assumptions about information flows and expectations regional trade block formation would be the result.

The assumption of naive best responses gives a convenient and tractable way to define payoffs under the TA formation game. Naive best responses are also believed to capture the process by which agents learn about their environment when they do not have full information about, or cannot communicate perfectly with, the actions of all of the other players (see Bala and Goyal 2000). Such an assumption seems reasonable in the present international policy making environment where policy makers are not able to perfectly observe each others' actions. An alternative approach would be to assume that countries are far sighted. Page, Wooders and Kamat (2004) provide a basic general framework which could be used to incorporate farsightedness into the present model.

A. Appendix

A.1. Demand functions by region and agreement membership

Based on (2.6), the basic expressions for equilibrium output produced by country j for country i can be written as follows. The output functions (2.9)-(2.12) are obtained by substituting optimal tariffs $t^*_{ir}(b_{ir}, b_{inr})$ and $t^*_{inr}(b_{ir}, b_{inr})$ into the following functions:

$$x_{irm} = \frac{(e-c) + 3d + (3-b_{ir})\, t_{ir} + (3-b_{inr})\, t_{inr}}{7};$$

$$x_{inrm} = \frac{(e-c) - 4d + (3-b_{ir})\, t_{ir} + (3-b_{inr})\, t_{inr}}{7};$$

$$x_{irnm} = \frac{(e-c) + 3d - (4+b_{ir})\, t_{ir} + (3-b_{inr})\, t_{inr}}{7};$$

$$x_{inrnm} = \frac{(e-c) - 4d + (3-b_{ir})\, t_{ir} - (4+b_{inr})\, t_{inr}}{7}.$$

A.2. Proofs

Proof of Proposition 1.

For country i, where $i \in B_k$ and $i \in R_l$, maximize $\sum_{i \in B_k} w_i$, given by (2.8), with respect to t_{ir} and t_{inr}. Use $C_i = X_i^2/2$, $T_i = \sum_{j \in N} t_{ij} x_{ij}$ and the fact that $\pi_{ij} = x_{ij}^2$. Since country i's tariffs do not affect consumption or production decisions in other countries, we may write country i's its tariff problem as

$$\underset{\{t_{ij}\}_{i \in B_k, j \notin B_k}}{\text{Max}} \; w_i + \sum_{j \in B_k \setminus \{i\}} \pi_{ij} = (e-c)\, X_i - \frac{1}{2} X_i^2 - \sum_{j \notin B_k} x_{ij}^2 - d \sum_{j \notin R_l} x_{ij}.$$

The first order condition with respect to t_{ir} is

$$(e-c-1)\,\frac{dX_i}{dt_{ir}} - 2\,(3-b_{ir})\, x_{irnm} \frac{dx_{irnm}}{dt_{ir}} - 2\,(3-b_{inr})\,\frac{dx_{inrnm}}{dt_{ir}} - \left(b_{inr} \frac{dx_{inrm}}{dt_{ir}} + (3-b_{inr})\,\frac{dx_{inrnm}}{dt_{ir}} \right) d = 0.$$

The first order condition with respect to t_{inr} is

$$(e-c-1)\,\frac{dX_i}{dt_{inr}} - 2\,(3-b_{ir})\, x_{irnm} \frac{dx_{irnm}}{dt_{inr}} - 2\,(3-b_{inr})\,\frac{dx_{inrnm}}{dt_{inr}} - \left(b_{inr} \frac{dx_{inrm}}{dt_{inr}} + (3-b_{inr})\,\frac{dx_{inrnm}}{dt_{inr}} \right) d = 0.$$

Then differentiate the expressions for x_{irm}, x_{irnm}, x_{inrm} and x_{inrnm} in Appenix A1 and substitute to obtain a reduced form for each first order condition. Since the objective function is globally concave in t_{ir} and in t_{inr}, there exists a unique symmetric solution for each:

$$\begin{aligned} t_{ir}^{*} &= \frac{(e-c)(1+b_{ir}+b_{inr})+(24+6b_{ir}-8b_{inr})d+(3-b_{inr})(15+2(b_{ir}+b_{inr}))t_{inr}}{2+2b_{ir}^{2}+b_{ir}(9+2b_{inr})+3(17-2b_{inr})}; \\ t_{inr}^{*} &= \frac{(e-c)(1+b_{ir}+b_{inr})-(25-6b_{ir}+8b_{inr})d+(3-b_{inr})(15+2(b_{ir}+b_{inr}))t_{ir}}{2+2b_{inr}^{2}+b_{inr}(9+2b_{ir})+3(17-2b_{ir})}. \end{aligned}$$

Solving simultaneously for t_{ir}^{*} and t_{inr}^{*} obtains the result. □

Proof of Lemma 1. That fact that $x_{irm}(b_{ir},b_{inr}) > x_{inrm}(b_{ir},b_{inr}) > x_{irnm}(b_{ir},b_{inr}) > x_{inrnm}(b_{ir},b_{inr})$ is established by inspection of (2.9)-(2.12). It remains to show that if $d \in (0,(e-c)/22)$ then $x_{inrnm}(b_{ir},b_{inr}) > 0$. Since $x_{inrnm}(b_{ir},b_{inr})$, as given by (2.12), is decreasing d, we can solve for the largest value of d at which $x_{inrnm}(b_{ir},b_{inr}) = 0$ ($b_{ir} \in \{1,2,3\}$, $b_{inr} \in \{0,1,2,3\}$ and $b_{ir}+b_{inr} \leq 5$; recall that there are no non-regional non-members for $b_{ir}=3$, $b_{inr}=3$.) The solution for the value of d at which $x_{inrnm}(b_{ir},b_{inr}) = 0$, denoted by $\widetilde{d}$, is

$$\widetilde{d} = \frac{2(e-c)}{5+3b_{ir}+2b_{ir}b_{inr}+2b_{ir}^{2}}.$$

The solution $\widetilde{d}$ is globally decreasing in b_{ir} and b_{inr}, so use $b_{ir}=3$, $b_{inr}=2$ in the solution to yield $\widetilde{d}=(e-c)/22$. It can be checked by substitution that $x_{inrnm}(b_{ir},b_{inr}) > 0$ for $b_{ir}=2$, $b_{inr}=3$. The result follows. □

Proof of Proposition 2. It must be established that $dx_{irnm}/db_{ir} < 0$, $dx_{inrnm}/db_{ir} < 0$, $dx_{irnm}/db_{inr} < 0$, and $dx_{inrnm}/db_{inr} < 0$. Each case will be taken in turn. Differentiating $x_{irnm}(b_{ir},b_{inr})$ with respect to b_{ir}, we obtainDifferentiating $x_{inrnm}(b_{ir},b_{inr})$ with respect to b_{ir}, we obtain

$$\begin{aligned} \frac{dx_{irnm}(b_{ir},b_{inr})}{db_{ir}} &= \frac{2b_{inr}d}{2\Delta(b_{ir},b_{inr})} \\ &\quad -\frac{(6+8(b_{ir}+b_{inr}))(2(e-c)+(3+b_{inr}(3+2(b_{ir}+b_{inr})))d)}{(2\Delta(b_{ir},b_{inr}))^{2}} \end{aligned}$$

$$= -\frac{2(3+4(b_{ir}+b_{inr}))(e-c)+(9+12b_{ir}+b_{inr}(1+2(b_{ir}+b_{inr}))(5+2(b_{ir}+b_{inr})))d}{2(\Delta(b_{ir},b_{inr}))^{2}}.$$

So $dx_{irnm}(b_{ir},b_{inr})/db_{ir} < 0$ for all $d \geq 0$.

Differentiating $x_{inrnm}(b_{ir}, b_{inr})$ with respect to b_{ir}, we obtain

$$\frac{dx_{inrnm}(b_{ir}, b_{inr})}{db_{ir}} = -\frac{(3+4b_{ir}+2b_{inr})\,d}{2\Delta(b_{ir}, b_{inr})} - \frac{(6+8(b_{ir}+b_{inr}))(2(e-c)-(5+b_{ir}(3+2(b_{ir}+b_{inr})))\,d)}{(2\Delta(b_{ir}, b_{inr}))^2}$$

$$= -\frac{2(3+4(b_{ir}+b_{inr}))(e-c)+(9+12b_{ir}+b_{inr}(1+2(b_{ir}+b_{inr}))(5+2(b_{ir}+b_{inr})))\,d}{2(\Delta(b_{ir}, b_{inr}))^2}.$$

So $dx_{inrnm}(b_{ir}, b_{inr})/db_{ir} < 0$ for all $d \geq 0$. (After simplification, we see that $dx_{irnm}(b_{ir}, b_{inr})/db_{ir} = dx_{inrnm}(b_{ir}, b_{inr})/db_{ir}$.)

Differentiating $x_{inrnm}(b_{ir}, b_{inr})$ with respect to b_{inr}, we obtain

$$\frac{dx_{irnm}(b_{ir}, b_{inr})}{db_{inr}} = \frac{(3+2b_{ir}+4b_{inr})\,d}{2\Delta(b_{ir}, b_{inr})} - \frac{(6+8(b_{ir}+b_{inr}))(2(e-c)+(3+b_{inr}(3+2(b_{ir}+b_{inr})))\,d)}{(2\Delta(b_{ir}, b_{inr}))^2}$$

$$= \frac{-2(3+4(b_{ir}+b_{inr}))(e-c)+(15+13b_{ir}+4(5b_{inr}+b_{ir}b_{inr}(3+b_{inr})+(3+2b_{inr})b_{ir}^2+b_{ir}^3))\,d}{2(\Delta(b_{ir}, b_{inr}))^2}.$$

The second term in the numerator is positive and increasing in b_{ir}, b_{inr} and d while the first term is negative. It is easily checked that overall the numerator is negative for $b_{ir} = 3$, $b_{inr} = 2$ and $d = (e-c)/22$. So $dx_{irnm}(b_{ir}, b_{inr})/db_{inr} < 0$ for all feasible $\{b_{ir}, b_{inr}\}$ pairs and $d \in (0, (e-c)/22)$.

Differentiating $x_{inrnm}(b_{ir}, b_{inr})$ with respect to b_{inr}, we obtain

$$\frac{dx_{inrnm}(b_{ir}, b_{inr})}{db_{inr}} = -\frac{2b_{inr}d}{2\Delta(b_{ir}, b_{inr})} - \frac{(6+8(b_{ir}+b_{inr}))(2(e-c)-(5+b_{ir}(3+2(b_{ir}+b_{inr})))\,d)}{(2\Delta(b_{ir}, b_{inr}))^2}$$

$$= \frac{-2(3+4(b_{ir}+b_{inr}))(e-c)+(15+13b_{ir}+4(5b_{inr}+b_{ir}b_{inr}(3+b_{inr})+(3+2b_{inr})b_{ir}^2+b_{ir}^3))\,d}{2(\Delta(b_{ir}, b_{inr}))^2}.$$

After simplification, we see that $dx_{inrnm}(b_{ir}, b_{inr})/db_{inr} = dx_{irnm}(b_{ir}, b_{inr})/db_{inr}$ So it must be the case that $dx_{inrnm}(b_{ir}, b_{inr})/db_{inr} < 0$ for all feasible $\{b_{ir}, b_{inr}\}$ pairs and $d \in (0, (e-c)/22)$.

□

Proposition 3. *The expansion or formation of a TA increases the aggregate welfare of member countries.*

Proof of Proposition 3. The strategy of proof follows Yi (1996). Assume that there exists a TA structure $B = (B_1, B_2, ..., B_m)$ and that two or more TAs B_1, B_2 ... B_r merge to create an enlarged TA. We will show that the total welfare of the members of the enlarged TA increases. To do this, we will show that the tariff changes required to implement TA enlargement undertaken by any one given member of the enlarged TA must increase the aggregate welfare of all members. Thinking of TA enlargement as a sequence of such tariff changes by each and every member then gives the result.

Claim. Initially, before the merger, country i has free trade with $b_{ir} - 1$ countries in its own region and b_{inr} countries in the other region. Country i levies a tariff $t_{ir}(b_{ir}, b_{inr})$ on each of the $3 - b_{ir}$ non-members in its own region and a tariff $t_{inr}(b_{ir}, b_{inr})$ on each of the $3 - b_{inr}$ countries in the other region. As a result of the merger, in the new enlarged TA, country i shares a TA with $b'_{ir} - 1$ countries in its own region and b'_{inr} countries in the other region. Let $s_{ir} = b'_{ir} - b_{ir} \geq 0$ and $s_{inr} = b'_{inr} - b_{inr} \geq 0$. Country i abolishes tariffs on s_{ir} countries in its own region and s_{inr} countries in the other region, and changes tariffs to $t'_{ir}(b'_{ir}, b'_{inr})$ on each of the $3 - b'_{ir}$ non-members in its own region and changes tariffs to $t'_{inr}(b'_{ir}, b'_{inr})$ on each of the $3 - b'_{inr}$ non-members in the other region. Then the aggregate welfare of the $b_{ir} + s_{ir} + b_{inr} + s_{inr}$ countries in the enlarged TA (which consists of country i, $b_{ir} + b_{inr} - 1$ countries who paid no tariffs initially and $s_{ir} + s_{inr}$ countries whose tariffs were abolished) improves.

Proof. Without loss of generality, consider the TA B_1, of which Country 1 is assumed to be a member. B_1 has b_{1r} members from R_1 and b_{1nr} members from R_2. Then let membership expand to create an enlarged TA, B'_1, consisting of b'_{1r} members in R_1 and b'_{1nr} members in R_2 (where all original members are also members of the enlarged TA). The comparative statics exercise that we will now carry out is as follows. We will calculate the effect on the aggregate welfare of all countries in B'_1 that results when Country 1 abolishes tariffs on s_{1r} countries in R_1 and s_{1nr} countries in R_2, and changes tariffs on $(3 - b_{1r} - s_{1r})$ non-members in R_1 from $t_{1r}(b_{1r}, b_{1nr})$ to $t_{1r}(b'_{1r}, b'_{1nr})$ and on $(3 - b_{1nr} - s_{1nr})$ non-members in R_2 from $t_{1nr}(b_{1r}, b_{1nr})$ to $t_{1nr}(b'_{1r}, b'_{1nr})$.

Define

$$\begin{aligned}\Delta t_{1r} &= t_{1r}(b_{1r}, b_{1nr}) - t_{1r}(b'_{1r}, b'_{1nr});\\ \Delta t_{1nr} &= t_{1nr}(b_{1r}, b_{1nr}) - t_{1nr}(b'_{1r}, b'_{1nr}).\end{aligned}$$

First consider infinitesimal changes in tariffs

$$d\mathbf{t} \equiv (0, ..., 0, dt, ..., dt, dt_r, ..., dt_r, 0, ..., 0, \phi dt, ..., \phi dt, dt_{nr}, ..., dt_{nr})$$

from a tariff vector

$$\mathbf{t} \equiv (0, ..., 0, t, ..., t, t_r, ..., t_r, 0, ..., 0, \phi t, ..., \phi t, t_{nr}, ..., t_{nr}),$$

where: dt appears from the $(b_{1r}+1)$th element to the $(b_{1r}+s_{1r})$th element and from the $(b_{1nr}+4)$th element to the $(b_{1nr}+s_{1nr}+4)$th element, unless $b_{1nr}=s_{1nr}=0$ in which case dt_{nr} appears from the 4th to the last elements; dt_r appears from the $(b_{1r}+s_{1r}+1)$th element to the 3rd element; dt_{nr} appears from the $(b_{1nr}+s_{1nr}+4)$th element to the last element. The tariff t is imposed on new TA members in the same region and is reduced to zero through the TA formation process. The tariff ϕt (i.e. $\phi \times t$) is imposed on new TA members from the other region, where $\phi = t_{1nr}/t_{1r}$ (see below for specification of t_{1nr} and t_{1r}). Also,

$$\begin{aligned}dt_r &\equiv \frac{\Delta t_{1r}}{t_{1r}(b_{1r}, b_{1nr})} dt;\\ dt_{nr} &\equiv \frac{\Delta t_{1nr}}{t_{1nr}(b_{1r}, b_{1nr})} \phi dt.\end{aligned}$$

Start from

$$\mathbf{t}(b'_{1r}, b'_{1nr}) \equiv (0, ..., 0, t_{1r}(b'_{1r}, b'_{1nr}), ..., t_{1r}(b'_{1r}, b'_{1nr}), 0, ..., 0, t_{1nr}(b'_{1r}, b'_{1nr}), ..., t_{1nr}(b'_{1r}, b'_{1nr}))$$

where 0 appears from the first to the $(b_{1r}+s_{1r})$th element and from the fourth to the $(b_{1nr}+s_{1nr}+4)$th element (unless $b_{1nr}=s_{1nr}=0$). We can move to

$$\mathbf{t}(b_{1r}, b_{1nr}) \equiv (0, ..., 0, t_{1r}(b_{1r}, b_{1nr}), ..., t_{1r}(b_{1r}, b_{1nr}), 0, ..., 0, t_{1nr}(b_{1r}, b_{1nr}), ..., t_{1nr}(b_{1r}, b_{1nr}))$$

where 0 appears from the first to the (b_{1r})th element and from the fourth to the $(b_{1nr}+4)$th element by integrating the infinitesimal changes $d\mathbf{t}$ from 0 to $\mathbf{t}(b_{1r}, b_{1nr})$. Below, we will show that $d\left(\sum_{j\in B'_1} w_j\right)/d\mathbf{t} < 0$ for all $\mathbf{t}$ along such a path of integration. The claim then follows.

Since changes in Country 1's tariffs do not affect sales in other countries,

$$d\left(\sum_{j\in B_1'} w_j\right)/d\mathbf{t} = d\left(\hat{w}_1 + \sum_{j\in B_1'\backslash\{1\}} \pi_{1j}\right)/d\mathbf{t},$$

where $\hat{w}_1$ is Country 1's welfare net of its exports. Since

$$\hat{w}_1 + \sum_{j\in N\backslash\{1\}} \pi_{1j} = v\left(X_1\right) - cX_1 - d\sum_{j\in R_2} x_{1j},$$

it follows that

$$\hat{w}_1 + \sum_{j\in B_1'\backslash\{1\}} \pi_{1j} = v\left(X_1\right) - cX_1 - \sum_{j\in N\backslash B_1'} \pi_{1j} - d\sum_{j\in R_2} x_{1j}.$$

The proportional relationship between $t_{1r}\left(b_{1r}, b_{1nr}\right)$ and $t_{1nr}\left(b_{1r}, b_{1nr}\right)$ is given by

$$\begin{aligned}\phi &= \frac{t_{1nr}\left(b_{1r}, b_{1nr}\right)}{t_{1r}\left(b_{1r}, b_{1nr}\right)} \\ &= 1 - \frac{2\left(4 + 5b_{1nr} + 2\left(b_{1nr} - 1\right)b_{1r} + 2b_{1r}^2\right)d}{\left(1 + 2\left(b_{1r} + b_{1nr}\right)\right)\left(e - c\right) + \left(3 + b_{1r}\left(2\left(b_{1r} + b_{1nr}\right) - 1\right)\right)d}.\end{aligned}$$

Note that $\phi = 1$ for $d = 0$ and $0 < \phi < 1$ for $d \in \left(0, \left(e - c\right)/22\right)$. The total tariff at the tariff vector $\mathbf{t}$ is

$$T_1 = \sum_{j\in N} t_{1j} = \left(s_{1r} + \phi s_{1nr}\right)t + \left(3 - b_{1r} - s_{1r}\right)t_r + \left(3 - b_{1nr} - s_{1nr}\right)t_{nr}.$$

The change in the total tariff is calculated from $d\mathbf{t}$ as follows:

$$\begin{aligned}dT_1 &= \left(s_{1r} + \phi s_{1nr}\right)dt + \left(3 - b_{1r} - s_{1r}\right)dt_r + \left(3 - b_{1nr} - s_{1nr}\right)dt_{nr} \\ &= \frac{s_{1r}t_{1r}\left(b_{1r}, b_{1nr}\right) + s_{1nr}t_{1nr}\left(b_{1r}, b_{1nr}\right) + \left(3 - b_{1r} - s_{1r}\right)\Delta t_{1r} + \left(3 - b_{1nr} - s_{1nr}\right)\Delta t_{1nr}}{t_{1r}\left(b_{1r}, b_{1nr}\right)}dt.\end{aligned}$$

The following notation will also be helpful:

$$\Delta T_1 = s_{1r}t_{1r}\left(b_{1r}, b_{1nr}\right) + s_{1nr}t_{1nr}\left(b_{1r}, b_{1nr}\right) + \left(3 - b_{1r} - s_{1r}\right)\Delta t_{1r} + \left(3 - b_{1nr} - s_{1nr}\right)\Delta t_{1nr}.$$

From (2.4) and the first-order-condition of (2.5), we have $p_i - c = x_{ij} + t_{ij} + d_{ij}$. Therefore, $\sum_{j\in N}\left(p_i - c\right) = X_i + T_i + D_i$, where $D_i = \sum_{j\in N} d_{ij} = 3d$.

From (2.6), $dx_{ij} = \frac{dT_i - 7dt_{ij}}{7}$. Therefore we have:

$$\begin{aligned}
\frac{dx_{11}}{d\mathbf{t}} &= \frac{\Delta T_1}{7t_{1r}\left(b_{1r}, b_{1nr}\right)}; \\
\frac{dx_{1b_{1r}+1}}{d\mathbf{t}} &= \frac{\Delta T_1 - 7t_{1r}\left(b_{1r}, b_{1nr}\right)}{7t_{1r}\left(b_{1r}, b_{1nr}\right)}; \\
\frac{dx_{1b_{1r}+s_{1r}+1}}{d\mathbf{t}} &= \frac{\Delta T_1 - 7\Delta t_{1r}}{7t_{1r}\left(b_{1r}, b_{1nr}\right)}; \\
\frac{dx_{1b_{1nr}+4}}{d\mathbf{t}} &= \frac{\Delta T_1 - 7t_{1nr}\left(b_{1r}, b_{1nr}\right)}{7t_{1r}\left(b_{1r}, b_{1nr}\right)}; \\
\frac{dx_{1b_{1nr}+s_{1nr}+4}}{d\mathbf{t}} &= \frac{\Delta T_1 - 7\Delta t_{1nr}}{7t_{1r}\left(b_{1r}, b_{1nr}\right)}.
\end{aligned}$$

Using these results,

$$\begin{aligned}
\frac{d}{d\mathbf{t}}\left(\hat{w}_1 + \sum_{j \in B_1' \setminus \{1\}} \pi_{1j}\right) &= \frac{d}{d\mathbf{t}}\left(v\left(X_1\right) - cX_1\right) - \frac{d}{d\mathbf{t}} \sum_{j \in N \setminus B_1'} x_{1j}^2 - d\left(\frac{d}{d\mathbf{t}} \sum_{j \in R_2} x_{1j}\right) \\
&= \sum_{j \in N} \left(p_1 - c\right) \frac{dx_{1j}}{d\mathbf{t}} - \sum_{j \in N \setminus B_1'} 2x_{1j} \frac{dx_{1j}}{d\mathbf{t}} - d \sum_{j \in R_2} \frac{dx_{1j}}{d\mathbf{t}} \\
&= \frac{1}{7t_{1r}\left(b_{1r}, b_{1nr}\right)} \left\{s_{1r} t_{1r}\left(b_{1r}, b_{1nr}\right) \Xi_1 + s_{1nr} t_{1nr}\left(b_{1r}, b_{1nr}\right) \Phi_1 \right. \\
&\quad \left. + \left(3 - b_{1r} - s_{1r}\right) \Delta t_{1r} \Psi_1 + \left(3 - b_{1nr} - s_{1nr}\right) \Delta t_{1nr} \Omega_1 \right\},
\end{aligned}$$

where:

$$\begin{aligned}
\Xi_1 &= \left(X_1 + T_1\right) - 7\left(x_{1b_{1r}+1} + t\right) \\
&\quad -2\left(3 - b_{1r} - s_{1r}\right) x_{1b_{1r}+s_{1r}+1} - 2\left(3 - b_{1nr} - s_{1nr}\right) x_{1b_{1nr}+s_{1nr}+4}; \\
\Phi_1 &= \left(X_1 + T_1\right) - 7\left(x_{1b_{1nr}+4} + \phi t\right) \\
&\quad -2\left(3 - b_{1r} - s_{1r}\right) x_{1b_{1r}+s_{1r}+1} - 2\left(3 - b_{1nr} - s_{1nr}\right) x_{1b_{1nr}+s_{1nr}+4}; \\
\Psi_1 &= \left(X_1 + T_1\right) - 7\left(x_{1b_{1r}+s_{1r}+1} + t_r\right) + 2\left(4 + b_{1r} + s_{1r}\right) x_{1b_{1r}+s_{1r}+1}; \\
\Omega_1 &= \left(X_1 + T_1\right) - 7\left(x_{1b_{1nr}+s_{1nr}+4} + t_{nr}\right) + 2\left(4 + b_{1nr} + s_{1nr}\right) x_{1b_{1nr}+s_{1nr}+4}.
\end{aligned}$$

The proof that $\frac{d}{d\mathbf{t}}\left(\hat{w}_1 + \sum_{j \in B_1' \setminus \{1\}} \pi_{ij}\right) < 0$ proceeds in two steps. First we show that, at $\mathbf{t}\left(b_{1r}', b_{1nr}'\right)$, it is the case that $\frac{d}{d\mathbf{t}}\left(\hat{w}_1 + \sum_{j \in B_1' \setminus \{1\}} \pi_{ij}\right) < 0$. Second, we show that $\frac{d^2}{d\mathbf{t}^2}\left(\hat{w}_1 + \sum_{j \in B_1' \setminus \{1\}} \pi_{ij}\right) < 0$.

Step 1. At $\mathbf{t}\left(b_{1r}', b_{1nr}'\right)$, the optimal tariffs $t_{1r}\left(b_{1r}', b_{1nr}'\right)$ and $t_{1nr}\left(b_{1r}', b_{1nr}'\right)$ are chosen to satisfy $\Psi_1 = 0$ and $\Omega_1 = 0$ respectively. (Note that Ψ_1 and Ω_1 are the derivatives of

$\hat{w}_1 + \sum_{j \in B_1' \setminus \{1\}} \pi_{ij}$ with respect to t_{1r} and t_{1nr} respectively; $t_{1r}(b_{1r}', b_{1nr}')$ and $t_{1nr}(b_{1r}', b_{1nr}')$ are the optimal tariffs of the size $b_{1r}' + b_{1nr}'$ TA on $3 - b_{1r}'$ regional non-members and $3 - b_{1nr}$ non-regional non-members respectively, given free trade among the $b_{1r}' + b_{1nr}'$ members.) It remains to show that, at $\mathbf{t}(b_{1r}', b_{1nr}')$, the terms Ξ_1 and Φ_1 are both strictly negative. (Of course, due to oligopoly distortions, Ξ_1 and Φ_1 could only be zero if trade subsidies were allowed).

At $\mathbf{t}(b_{1r}', b_{1nr}')$, $x_{11} =, ..., = x_{1b_{1r}+s_{1r}}$, $x_{14} =, ..., x_{1b_{1nr}+s_{1nr}+3}$ (unless $b_{1nr} = s_{1nr} = 0$, in which case $x_{14} =, ..., x_{1b_{1nr}+s_{1nr}+4}$), and $t = 0$. Also,

$$\begin{aligned} X_1 &= b_{1r}' x_{11} + (3 - b_{1r}') x_{1b_{1r}+s_{1r}+1} + b_{1nr}' x_{1b_{1nr}+s_{1nr}+3} + (3 - b_{1nr}') x_{1b_{1nr}+s_{1nr}+4}; \\ T_1 &= (3 - b_{1r}') t_{1r}(b_{1r}', b_{1nr}') + (3 - b_{1nr}') t_{1nr}(b_{1r}', b_{1nr}'). \end{aligned}$$

Then we have

$$\begin{aligned} \Xi_1 &= -4x_{11} + b_{1nr}' x_{1b_{1nr}+s_{1nr}+3} \\ &\quad - (3 - b_{1r}') (x_{11} + x_{1b_{1r}+s_{1r}+1} - t_{1r}(b_{1r}', b_{1nr}')) \\ &\quad - (3 - b_{1nr}') (x_{1b_{1nr}+s_{1nr}+4} - t_{1nr}(b_{1r}', b_{1nr}')). \end{aligned}$$

Now, observing that $x_{11} = x_{1rm}$, $x_{1b_{1r}+s_{1r}+1} = x_{1rnm}$, $x_{1b_{1nr}+s_{1nr}+3} = x_{1nrm}$ and $x_{1b_{1nr}+s_{1nr}+4} = x_{1nrnm}$, we can use (2.9)-(2.12) to substitute for x_{11}, $x_{1b_{1r}+s_{1r}+1}$, $x_{1b_{1nr}+s_{1nr}+3}$ and $x_{1b_{1nr}+s_{1nr}+4}$, which obtains

$$\Xi_1 = -\frac{7(2(e-c) + (3 + b_{inr}(3 + 2(b_{ir} + b_{inr})))d)}{10 + b_{ir}(5 + 2b_{ir}) + b_{inr}(4 + b_{ir}) + b_{inr}^2} < 0.$$

Next observe that, after simplification,

$$\begin{aligned} \Phi_1 &= -4x_{1b_{1r}+s_{1r}+3} + b_{1r}' x_{11} \\ &\quad - (3 - b_{1nr}') (x_{1b_{1r}+s_{1r}+3} + x_{1b_{1nr}+s_{1nr}+4} - t_{1nr}(b_{1r}', b_{1nr}')) \\ &\quad - (3 - b_{1r}') (x_{1b_{1r}+s_{1r}+1} - t_{1r}(b_{1r}', b_{1nr}')). \end{aligned}$$

Adopting the same basic approach used to simplify Ξ_1, we then have

$$\Phi_1 = -\frac{7(2(e-c) - (5 + b_{inr}(3 + 2(b_{ir} + b_{inr})))d)}{10 + b_{ir}(5 + 2b_{ir}) + b_{inr}(4 + b_{ir}) + b_{inr}^2}$$

We can see straight away that for $d = 0$ it is the case that $\Phi_1 < 0$, and that Φ_1 is increasing in d. We then find by subsitution that for $d = (e-c)/22$, $b_{ir} = 3$ and $b_{inr} = 2$, it is the case that $\Phi_1 = 0$. It follows immediately that $\Phi_1 < 0$ for all $b_{1r} \in \{1, 2, 3\}$ and $b_{1nr} \in \{0, 1, 2\}$ and $d \in [0, (e-c)/22)$.

Step 2. We can write the second order condition directly as

$$\begin{aligned}
\frac{d^2}{d\mathbf{t}^2}\left(\hat{w}_1 + \sum_{j \in B_1' \setminus \{1\}} \pi_{ij}\right) = & \frac{1}{(7t_{1r})^2}\Big(-(3-b_{1r}')\left(35 + 15b_{1r}' + 2(b_{1r}')^2\right)\Delta t_{1r}^2 \\
& + (3-b_{1r}')(15 + 4b_{1r}' + 2b_{1nr}')(s_{1r}t_{1r} + s_{1nr}t_{1nr})\Delta t_{1r} \\
& - (3-b_{1nr}')\left(-14 + 15b_{1nr}' + 2(b_{1nr}')^2\right)\Delta t_{1nr}^2 \\
& + (3-b_{1nr}')(15 + 4b_{1nr}' + 2b_{1r}')(s_{1r}t_{1r} + s_{1nr}t_{1nr})\Delta t_{1nr} \\
& -2(3 - b_{1r}' - b_{1nr}')(s_{1r}t_{1r}' + s_{1nr}t_{1nr}')^2 \\
& - (3-b_{1nr}')\left(7 + 8b_{1r}' - 2b_{1nr}'(3-b_{1r}') + 2(b_{1r}')^2\right)\Delta t_{1r}\Delta t_{1nr}.
\end{aligned}$$

Using the functions for $t_{ir}(b_{ir}, b_{inr})$, $t_{ir}(b_{ir}', b_{inr}')$, $t_{inr}(b_{ir}, b_{inr})$ and $t_{inr}(b_{ir}', b_{inr}')$, substitution reveals that the second order condition is negative for all feasible values $b_{1r}' \in \{1, 2, 3\}$ and $b_{1nr}' \in \{0, 1, 2, 3\}$, given $d \in [0, (e-c)/22)$.

Proof of Proposition 5. Without loss of generality, take Country 1 as an example. (The cases for all other countries are analogous.) Write down two welfare functions for Country 1: $w_1\{\{1,2,3\},\{4,5,6\}\}$ and $w_1\{\{1,4,5,6\},\{2,3\}\}$. The first measures the welfare of Country 1 when it is in a regional TA and all countries in the other region are in a second regional TA. The second welfare function measures welfare when Country 1 joins a TA with the countries in the other region while Countries 2 and 3 form a TA. To calculate $w_1\{\{1,2,3\},\{4,5,6\}\}$, note that Country 1 sets a tariff $t_{inr}^*(3,0)$ on all imports from the other region, and Country 1's exports also face $t_{inr}^*(3,0)$ from all countries in the other region. Trade within regions is free. Using these tariffs in (2.9) and (2.12), and substituting the resulting expressions into (2.7), we obtain

$$w_1\{\{1,2,3\},\{4,5,6\}\} = \frac{3\left(387(e-c)^2 - 134(e-c)d + 1072d^2\right)}{2450}$$

For $w_1\{\{1,4,5,6\},\{2,3\}\}$, Country 1 sets $t_{ir}^*(1,3)$ on imports from non-members in its own region. Country 1's exports face tariffs $t_{ir}^*(2,0)$ from non-members in its own region. Trade between Country 1 and the countries in the other region is free. Substituting for tariffs in (2.9), (2.11) and (2.10), and substituting the resulting expressions into (2.7), we obtain

$$w_1\{\{1,4,5,6\},\{2,3\}\} = \frac{3\left(26442(e-c)^2 - 44336(e-c)d + 92225d^2\right)}{163592}.$$

We can now see that

$$w_1\{\{1,4,5,6\},\{2,3\}\} > w_1\{\{1,2,3\},\{4,5,6\}\} \text{ for } d=0;$$
$$w_1\{\{1,4,5,6\},\{2,3\}\} < w_1\{\{1,2,3\},\{4,5,6\}\} \text{ for } d=(e-c)/22.$$

We can also see that both $w_1\{\{1,2,3\},\{4,5,6\}\}$ and $w_1\{\{1,4,5,6\},\{2,3\}\}$ are decreasing in d for $d\in(0,(e-c)/22)$ but $w_1\{\{1,4,5,6\},\{2,3\}\}$ is decreasing more rapidly. So we can find a unique value of $d\in(0,(e-c)/22)$, called d', at which $w_1\{\{1,2,3\},\{4,5,6\}\} = w_1\{\{1,4,5,6\},\{2,3\}\}$;

$$d' = \frac{3\left(7225156-385\sqrt{338226178}\right)}{25290313}(e-c) \simeq 0.017\,(e-c)$$

□

Proof of Proposition 6. By Proposition 2, member welfare of a given TA is decreasing in the size of each of the other TAs that exist. Therefore, the highest feasible level of welfare is achieved when a country is a member of a TA and all non-members of its TA are singletons.

It remains to establish the TA structure that maximizes member welfare (given that all non-members are singletons). The result is seen clearly if we take each case in turn, starting with the smallest possible TA and increasing size. First, it follows from Proposition 3 that if two singletons form a two-member TA this must increase member welfare. We now establish that if both members are in the same region this yields a higher level of welfare than if each member is in a different region. Without loss of generality, assume that Country 1 forms a 2-country TA either with Country 2 in its own region or with Country 4 in the other region. Welfare is $w_1\{\{1,2\},\{3\},\{4\},\{5\},\{6\}\}$ or $w_1\{\{1,4\},\{2\},\{4\},\{5\},\{6\}\}$ respectively. To calculate $w_1\{\{1,2\},\{3\},\{4\},\{5\},\{6\}\}$, note that Country 1 levies a tariff $t^*_{ir}(2,0)$ and $t^*_{inr}(2,0)$ on imports from regional and non-regional non-members respectively. The non-member from R_1 levies a tariff $t^*_{ir}(1,0)$ on imports from Country 1, and non-members from R_2 levy a tariff $t^*_{inr}(1,0)$ on imports from Country 1. Substituting these tariffs into (2.9)-(2.12) and substituting appropriately into (2.7) yields

$$w_1\{\{1,2\},\{3\},\{4\},\{5\},\{6\}\} = \frac{889\,(e-c)^2-999\,(e-c)\,d+2205d^2}{1859}.$$

To calculate $w_1\{\{1,4\},\{2\},\{4\},\{5\},\{6\}\}$, note that Country 1 levies a tariff $t^*_{ir}(1,1)$ and $t^*_{inr}(1,1)$ on imports from regional and non-regional non-members respectively. The non-members from R_1 levy $t^*_{ir}(1,0)$ on imports from Country 1, and non-members from R_2

levy $t^*_{inr}(1,0)$ on imports from Country 1. Substituting these tariffs into (2.9)-(2.12) and substituting appropriately into (2.7) yields

$$w_1\left\{\{1,4\},\{2\},\{4\},\{5\},\{6\}\right\} = \frac{7112\,(e-c)^2 - 4404\,(e-c)\,d + 16431d^2}{14872}.$$

Welfare under the two TA configurations is equal for $d=0$ and the latter yields a lower level of welfare for $d>0$, with the difference increasing in the size of d.

The same basic approach can be used to establish that the 3-member TA that maximizes a member's welfare is where all members are in the same region, and that a 3-member regional TA yields a higher level of per-member welfare than a 2-member regional TA:

$$w_1\left(\{1,2,3\},\{4\},\{5\},\{6\}\right) = \frac{5787\,(e-c)^2 - 3114\,(e-c)\,d + 13362d^2}{11830}.$$

We can also calculate the level of welfare of Country 1 if a non-regional member is included; $w_1\left\{\{1,2,3,4\},\{5\},\{6\}\right\}$. In that case, Country 1 imposes a tariff $t^*_{inr}(3,1)$ on imports from non-member, and non-members impose a tariff $t^*_{inr}(1,0)$ on imports from Country 1. Substituting these tariffs into (2.9), (2.10) and (2.12), and making the appropriate substitution into (2.7), we have

$$w_1\left\{\{1,2,3,4\},\{5\},\{6\}\right\} = \frac{333\,(e-c)^2 - 262\,(e-c)\,d + 915d^2}{676}.$$

We can now see that

$$\begin{aligned} w_1\left\{\{1,2,3,4\},\{5\},\{6\}\right\} &> w_1\left\{\{1,2,3\},\{4\},\{5\},\{6\}\right\} \text{ for } d=0 \\ w_1\left\{\{1,2,3,4\},\{5\},\{6\}\right\} &< w_1\left\{\{1,2,3\},\{4\},\{5\},\{6\}\right\} \text{ for } d=(e-c)/22. \end{aligned}$$

We can also see that $w_1\left\{\{1,2,3,4\},\{5,6\}\right\}$ is declining in d for $d\in(0,(e-c)/22)$. So we can find a unique value of $d\in(0,(e-c)/22)$, called d'', at which $w_1\left\{\{1,2,3\},\{4,5,6\}\right\} = w_1\left\{\{1,2,3,4\},\{5,6\}\right\}$;

$$d'' = \frac{1471 - 2\sqrt{433615}}{5301}(e-c) \simeq 0.029\,(e-c).$$

Finally, we must check that a 5-member TA does not yield a higher level of welfare than either a 4-member TA or a 3-member TA. As for all previous cases, a member obtains a higher payoff if all countries in its own region are members of the TA. Thus

$$w_1\left\{\{1,2,3,4,5\},\{6\}\right\} = \frac{12145\,(e-c)^2 - 11262\,(e-c)\,d + 37450d^2}{24674}.$$

Since $w_1\{\{1,2,3,4\},\{5,6\}\} > w_1\{\{1,2,3,4,5\},\{6\}\}$ for $d=0$, and since $w_1\{\{1,2,3,4,5\},\{6\}\}$ has a steeper negative slope in d than $w_1\{\{1,2,3,4\},\{5,6\}\}$, it follows that $w_1\{\{1,2,3,4\},\{5,6\}\} > w_1\{\{1,2,3,4,5\},\{6\}\}$ for all $d \in [0,(e-c)/22]$. Similar calculations show that free trade yields a lower level of per-member welfare than $w_1\{\{1,2,3,4\},\{5,6\}\}$ and $w_1\{\{1,2,3\},\{4,5,6\}\}$.□

Proof of Proposition 7. There are two cases to consider; $d \in (0,d'')$ and $d \in (d'',(e-c)/22)$. Take $d \in (0,d'')$ first. Given that all countries are singletons in the previous period, by Proposition 5, each country i writes down a strategy s_i listing itself, the two other countries in its region, and one country from the other region. Thus, each country in R_1 names every other country in R_1 in its strategy plus one country from R_2. Symmetrically, again by Proposition 5, each country in R_2 names every other country in R_2 in its strategy plus one country from R_1. But no country in R_1 names every country in R_2 and no country in R_2 names every country in R_1. Therefore, the intersecting set of countries formed by the strategies of countries in R_1 is R_1 itself. So we have a regional TA, $B_1 = R_1$. Symmetrically, the intersecting set of countries formed by the strategies of countries in R_2 is R_2 itself. So we have a second regional TA, $B_2 = R_2$.

Now take $d \in (d'',(e-c)/22)$. The outcome is the same (but easier to establish). Given that all countries are singletons in the previous period, by Proposition 5, each country i writes down a strategy s_i listing itself and the two other countries in its region. Thus, each country in R_1 names every other country in R_1 in its strategy. Symmetrically, again by Proposition 5, each country in R_2 names every other country in R_2 in its strategy. Therefore, the intersecting set of countries formed by the strategies of countries in R_1 is R_1 itself. So we have a regional TA, $B_1 = R_1$. Symmetrically, the intersecting set of countries formed by the strategies of countries in R_2 is R_2 itself. So we have a second regional TA, $B_2 = R_2$.□

Proof of Proposition 8. By Proposition 4, aggregate member welfare increases when a TA expands from 3 members to 6 members (free trade). The two regional TAs, $B_1 = R_1$ and $B_2 = R_2$ are symmetrical, so each country has the same welfare. Thus, the welfare of every country must be increased by the merging of the two TAs to the grand 6 member coalition. Moreover, no country can gain by deviation because a veto of the grand coalition must result in a return to the TA structure of $B_1 = R_1$ and $B_2 = R_2$. □

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