The Likelihood of Regional and Multilateral Trade Agreements*

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Abstract

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1 INTRODUCTION

In earlier work (Abrego, Riezman and Whalley (2001a, 2001b)) we investigated, using numerical methods, whether certain propositions in customs union theory are likely to hold. The general approach used considers a three-country, three-good, pure exchange model with CES preferences. To generate our sample set we use both random draws and a grid search over the space defining preference parameters and endowments. We compare both free trade and three-country non-cooperative (Nash) equilibria to partial cooperation regional agreement equilibria where two countries form a regional agreement and play non-cooperatively against the third country (CU).

We assume a uniform prior over the parameter space (admittedly a strong assumption) and then calculate the percentage of cases for which certain results hold. The uniform prior assumption means that we do not take a stand about which parameters are more likely to occur than others. We think this is appropriate because we view our work as a substitute for theory. In theoretical research there are no presumptions about parameter values. While we think that it would be interesting to try and run simulations based on actual field data that is not our purpose here. Thus, the sample frequencies we obtain can be interpreted as the probability of particular propositions holding conditional on both the model and the assumed uniform prior.

We obtain results about the effects of customs unions on tariffs, prices, trade volumes and welfare. For example, our computations suggest that in 72.2% of the cases, customs unions raise common external tariff rates relative to three-country Nash levels. Customs unions improve the terms of trade with respect to the non-member countries in 88.6% of cases when the comparison is with Nash equilibrium and trade volume increases most of the time (86.9% of cases.) In terms of welfare results we show, for example, that about one-half the time (47.6%) both members of a potential customs union would prefer the customs union to three-country Nash equilibrium.[1]

Our results show that numerical simulation can be an important and useful adjunct to theory in economics. Our point of departure in this paper is to study a further and complementary set of considerations, namely the ease of negotiation and the durability of agreements once negotiated. At the time of the Canada-US Free Trade Agreement (FTA) in the mid 1980s, it was argued in Canada that changing their focus in trade policy negotiation from then GATT arrangements to negotiating a bilateral FTA made sense on the grounds it was possible to go "further and faster down the bilateral route" (Canada (1984). Coneybeare (1986) discusses the stability of trade agreements in his historical survey of such agreements. There is a widely held intuition that the number of players makes multilateral arrangements harder to negotiate, but once in place they are more

[1] See Abrego , Riezman, and Whalley (2001a,2001b) for a complete analysis.

likely to endure both because joint (and foregone under termination) gains are larger, and that the ability of members to enforce the agreement on potential departees is larger.

We both formalize these notions, and use a series of numerical simulations to explore the considerations involved. Specifically, we use our simple three-country three-good trade model to evaluate the negotiability and durability of both multilateral and regional agreements. We do this by first considering randomly generated proposals for both types of agreements and assessing the probability they will be accepted by all parties to them compared to a non-cooperative three country Nash outcome. Intuition suggests that with three rather than two countries involved in any multilateral agreement, and the absence of joint two country terms of trade gains from an optimal tariff against third countries, multilateral agreements are less likely to be accepted than bilateral agreements. Our purpose here is to see whether this intuition holds.

To do this we use the core solution concept. This concept has been used to study customs union formation (Riezman (1985), Konishi, Kowalczyk and Sjostrom (2003)) and is appropriate here since customs unons in the core require that both member countries prefer the customs union alternative to any other possible allocation. In the same way, if free trade is in the core it means that no pair of countries find a customs union more appealing and in addition, no country finds non-cooperation better for them. In this sense, allocations in the core represent negotiatable and durable trade arrangements.

We begin with a development of the basic model and discussion of the equilibrium concepts. We then discuss computational procedures followed by the results on blocking coaltions and the core. Finally, we discuss sensitivity analysis and concluding comments.

2 Model Structure

Each country has a single representative consumer with endowments of three goods, and a utility function of the form

$$U^i = U^i(X_1^i, X_2^i, X_3^i) \qquad (i = 1, ..., 3) \tag{1}$$

where X_1^i, X_2^i, X_3^i represent consumption of goods 1, 2 and 3 in country i and U^i is country i's utility. Endowments are given by $\overline{E}_1^i, \overline{E}_2^i, \overline{E}_3^i$, where i denotes the country, and 1, 2 and 3 denote the goods.

Because each country can impose non-negative tariffs at rate t_j^i on good j imported by country i, for any good j we define the sellers prices (i.e. net of tariff prices) as P_j for any good j. This implies that internal (gross of tariff) prices in any country are

$$P_j^i = (1 + t_j^i)P_j \tag{2}$$

Tariffs are set to zero on any good exported by country i. Countries (or regions) set optimal tariffs on all imported goods. Tariff revenues collected by country i are

$$T^i = \sum_{j=1}^{3} t_j^i P_j \max\left\{(X_j^i - \overline{E}_j^i), 0\right\} \tag{3}$$

The income of country i is thus given by

$$I^i = \sum_{j=1}^{3} P\overline{E}_j^i + T^i \tag{4}$$

It is easily shown that (2), (3) and (4) imply that the balance of trade for each country is zero.

We use constant elasticity of substitution (CES) (and in special cases Cobb-Douglas) preferences to represent the utility functions (1), for which (in the CES case) utility maximizing demands are given by

$$X_j^i = \frac{a_j^i I}{(P_j^i)^{\sigma_i} \sum_{j=1}^{3} \alpha_j^i P_j^{i(1-\sigma_i)}} \tag{5}$$

Where the α_j^i are CES preference shares on good j in country i,and σ_i are country i CES substitution elasticities in preferences. Equation (2) presumes knowledge of the direction of trade for any country in any commodity. In the theoretical literature this is assumed to be given and unchanging as we move between alternative equilibria (free trade; three-country Nash; with regional trade agreements). In the model we use, the direction of trade is endogenously determined as part of the equilibrium solution. This endogeneity of trade patterns is an important feature of this model and differentiates it from previous work in this area. We achieve endogeneity by performing sequential equilibrium calculations in which the direction of trade is given by the previous iteration and then checked for consistency with the resulting model solution[2]. Only when full consistency is achieved do we accept this as a bonafide equilibrium solution. We find that changes in the direction of trade across equilibria occur surprisingly frequently (see Abrego, Riezman and Whalley, 2001a), calling into question the use of this assumption in theoretical work.

3 Equilibrium Solution Concepts

We examine a range of solution concepts for our model. Denote demands for commodities in country i by x_j^i, which in turn depend on prices for goods in the country and country incomes. Purchase prices within countries are sellers (world)

[2]Initially, we use the base case trade pattern.

prices gross of tariffs; i.e. $P^i_j = P_j(1 + t^i_j)$. In the presence of tariffs, country incomes include tariff revenues.

3.1 *Competitive Free Trade Equilibria*

In free trade, tariff rates are all set to zero on all products in all countries, and equilibrium prices clear markets globally, i.e. equilibrium prices (P_1^*, P_2^*, P_3^*) are determined such that

$$\sum_{j=1}^{3} X^i_j - \sum_{j=1}^{3} \overline{E}^i_j = 0 \tag{6}$$

and global excess demands are all zero for all three commodities. Given that only relative prices matter in such a structure; we can normalize prices to sum to unity i.e.

$$\sum_{j=1}^{3} P_j = 1; \qquad P_j \geq 0. \tag{7}$$

3.2 *Three-Country Non-Cooperative Nash Equilibria*

We also compute 3-country non-cooperative Nash equilibria. Here, each country takes other countries' tariffs as given and computes their own optimal tariffs. In equilibrium, country computations of optimal tariffs are mutually consistent. The t^i_j are thus endogenously determined for country i.

Specifically, each country determines their own optimal tariff vector $(t^i_j)^*$ by maximizing U^i subject to the constraint that their balance of trade equals zero. Equilibrium occurs where global markets clear and each country charges optimal tariffs given the tariffs of other countries. Tariff revenues, T^i, enter this version of the model, and affect demands since they are redistributed to the country's representative consumer in lump sum fashion.

In equilibrium, consistent optimizing behavior on tariffs by country, market clearing and government budget balance in each country define equilibria. Thus each country i solves an optimization problem

$$\max U^i$$

subject to

$$\sum_{j=1}^{3} P_j(X^i_j - \overline{E}^i_j) = 0. \tag{8}$$

In the problem (8), t^i_j for $j \neq i$ are taken as given and denoted by $\widehat{t}^i_j$. In a

Nash equilibrium, optimal tariff rates $t_j^{i*} = \hat{t}_j^i$ for all i, j and markets clear, i.e.

$$\sum_{j=1}^{3} X_j^i - \sum_{j=1}^{3} \overline{E}_j^i = 0 \quad \forall i \tag{9}$$

3.3 *Customs Union Equilibria*

We also compute customs union equilibria for this model. In these, we assume that country 1 and country 2 form a customs union with zero tariffs between them, and set a common external tariff against country 3[3]. Thus, countries 1 and 2 jointly set an optimal tariff against country 3, and country 3 sets an optimal tariff against the other two countries. Members of the Union receive the tariff revenues collected on their own imports.

In this mixed cooperative, non-cooperative case, countries 1 and 2 set zero tariffs against each other, i.e. $t_j^1 = t_j^2 = 0$ if the supplying country is 1 or 2, but jointly set optimal tariffs against country 3. Since countries 1 and 2 typically have a conflict of interest over how their joint external tariff is set, we assume that this tariff is set to maximize the sum of country 1 and 2's utilities. We then use different weights on country utilities in this joint sum in subsequent sensitivity analyses.

The customs union optimization problem is given by

$$\max U^1 + U^2$$

subject to

$$\sum_{i=1}^{2} \sum_{j=1}^{3} P_j (X_j^i - \overline{E}_j^i) = 0. \tag{10}$$

In this case, the computation of tariff revenues requires that bilateral trade flows be accounted for in the model, unlike for free trade and Nash. We do this by taking bilateral flows in any good to be given by the difference in the sum of country 1 and 2 imports of good j and the exports of good j by country 3. Such a calculation is only necessary for the goods that country 3 exports, and the direction of trade in such goods at any point in model calculations is given by the directional assumption in force at that point.

[3]see Woodland, A. D. and M. Melatos (2002) for a discussion of the issue of how a customs union goes about selecting the optimal tariff.

4 Computational Procedures

Table 1 sets out the key features of the model structure we use in our calculations. We have a three country, three good, pure exchange economy. Countries set optimal tariffs unless they are involved in a cooperative trade agreement. As indicated above, countries involved in a customs union agree to have free trade between themselves and they set the optimal tariff against the non-member that maximizes the sum of their utilities.

Table 1

Model Structure and Other Details of Experiments used to Assess the Frequency of Trade Pattern Changes

Dimensionality:	3 countries, 3 goods
Preferences:	CES, with parameter values generated by random draws, One consumer per country
Endowments:	Endowments are randomly drawn from a unit interval
Other Features:	Ad valorem tariffs on imports in each country Tariff revenues redistributed in lump sum form to country consumers
Number of cases:	We consider 2000 different model specifications in our central case, with an equilibrium computed for each
Equilibria computed for each case:	Competitive equilibria, three-country Nash equilibria, Customs Union equilibria (the sum of member utilities is maximized)

We next discuss how these calculations are made. The first step is to randomly draw endowments and CES preference parameters. For each draw we calculate all possible equilibria. That would include free trade, non-cooperative Nash equilibrium, and three customs unions involving each pair of countries. The next step in the process is to use these calculations to determine the viability of the various possible trade agreement possibilities. To do this we introduce the concept of Blocking. We need some additional notation to discuss blocking. Let the utility of country i at free trade be given by U^i_{FT}, let the utility of country i when a customs union between countries j and k forms be given by U^i_{jk}, and let the utility of country i at Nash equilibrium be given by U^i_{NE}.

5 Blocking

We determine viability of international trade equilibria by considering when a country or group of countries could block an existing agreement. This concept was first introduced in international trade equilibria by Riezman (1985). The general idea of blocking is that trade agreement A *blocks* trade agreement B if all members of A do better under A than they do under trade agreement B. This notion of blocking works well for customs unions and free trade. However, it is a bit problematic in the case in which a single country decides to set its optimal tariff and is not part of any cooperative trade agreement. The problem is, what does a single country obtain if it refuses to join in a customs union or a free trade agreement? It turns out that two things can happen in this case. All other countries might also refuse to cooperate in which case Nash equilibrium obtains. Alternatively, the other two countries might decide to form a customs union. How countries evaluate this situation is an interesting problem in itself. However, since we want to focus on other issues we simplify the analysis by assuming that countries are pessimistic in evaluating the payoff to going it alone. That is, they assume that they get the minimum of Nash equilibrium utility and the utility they would receive if the other two countries formed a customs union. Formally, if we let U_i^i be the utility country i receives from not being part of a customs union or a free trade agreement then

$$U_i^i = \min \left\{ U_{NE}^i, U_{jk}^i \right\} i \neq j, k$$

We next define blocking formally in Table 2. There is a slight asymmetry in blocking because of the problem, discussed above, that a single country acting alone cannot guarantee that non-cooperative Nash equilibrium in tariffs occurs. A country can refuse to cooperate with any other country, but it has no power to prevent the other countries from forming a customs union. This produces the following asymmetry. Three different types of equilibria can be blocked; free trade, a customs union, and non-cooperative Nash equilibrium in tariffs. However, these equilibria can be blocked by free trade, a customs union or a single country acting alone.

Table 2
Blocking Definitions

Free Trade *blocks* Nash equilibrium if:	$U^i_{FT} \geq U^i_{NE}$ for all i
Free Trade *blocks* Customs Union between countries j and k if:	$U^i_{FT} \geq U^i_{jk}$ for all i
Customs Union between countries j and k *blocks* Free Trade if:	$U^i_{jk} \geq U^i_{FT}$ for $i = j, k$
Customs Union between countries j and k *blocks* Nash equilibrium if:	$U^i_{jk} \geq U^i_{NE}$ for $i = j, k$
Customs Union between countries j and k *blocks* Customs Union between countries i and j if:	$U^m_{jk} \geq U^m_{ij}$ for $m = j, k$
Single Country i *blocks* Free Trade if:	$U^i_i \geq U^i_{FT}$ for country i
Single Country i *blocks* Customs Union between countries i and j if:	$U^i_i \geq U^i_{ij}$

Free trade blocks Nash equilibrium only if all countries do better at free trade than at the Nash equilibrium. Previous theoretical work suggests that this is likely to occur in cases when the endowments are relatively symmetric. Free trade blocks a particular customs union if both members of the customs union are better off at free trade than at the customs union equilibrium. A customs union blocks free trade or Nash equilibrium if both member countries do better under the customs union. A customs union can also block another customs union. This occurs if one member of the customs union can do better by joining in a customs union with the non-member. A single country can also block free trade if a country can guarantee themselves higher utility by going it alone than participating in a free trade agreement. Also, a single country can block a customs union of which it is a part if it does better by itself than as a member of the customs union.

Given these definitions of blocking the next step is to determine the likelihood that each of the three possible equilibria are blocked. For each draw of preferences and endowments we have calculated the welfare for each country under free trade, Nash equilibrium, and for any of the three possible customs unions. Using this information we apply the definitions in Table 2 and determine which equilibria are blocked. Keeping track of this information, we then repeat this process making new draws of preferences and endowments and record whether or not the equilibria are blocked. In this way can determine the probability that any of the three equilibria are blocked.[4]The results for free trade are in Table 3.

[4]We are assuming that all preference and endowment parameters are equally likely. Later we do sensitivity analysis and relax this assumption.

Table 3
Blocking Free Trade

	Percentage of Preference and Endowment Randomizations
Multilateral Free Trade Cannot be *blocked* by any option	17.4
Multilateral Free Trade Cannot be *blocked* by any Customs Union	45.0
Multilateral Free Trade Cannot be *blocked* by a Single Country	37.9

These results indicate that 45.0% of the time multilateral free trade cannot be blocked by any customs union. That is, almost half the time there does not exist any viable customs union that makes both members better off than they are at free trade. 37.9% of the time free trade cannot be blocked by a single country acting alone. The first entry in Table 3 combines these two measurements and tells us that in 17.4% of cases neither a customs union nor any country acting alone can block free trade. Putting together these numbers it means then, that 82.6% of the time free trade can be blocked by either a customs union or a single country acting alone. Since $45.0 + 37.9 = 82.9$ this implies that in .3% of cases *both* a customs union and a single country can block free trade. Another interesting implication of these results is that in the cases when free trade is blocked it is slightly more likely that it is blocked by a customs union than by a single country. We next turn to consideration of when customs unions can be blocked.

The results from Table 4 indicate that customs unions are much less likely to be blocked than free trade. In more than forty percent of cases customs unions are unblocked compared to 17.4% for free trade. We have to be a bit careful here because there are three possible customs unions that could form. The numbers in the table hold for at least one customs union. So, the first entry in Table 4 means that for 40.4% of preference and endowment draws there is *at least one* customs union that cannot be blocked by any option (including the other two possible customs unions.)

Table 4
Blocking Customs Unions

	Percentage of Preference and Endowment Randomizations
Customs Unions Cannot be *blocked* by any option	40.4
Customs Unions Cannot be *blocked* by other Customs Unions	89.4
Customs Unions Cannot be *blocked* by Multilateral Free Trade	100.0
Customs Unions Cannot be *blocked* by a Single Country	67.5

For some of these 40.4% of cases there may be more than one customs union that is unblocked. The second entry in Table 4 tells us that most of the time, nearly ninety percent, a customs union cannot be blocked by one of the other two possible customs unions. Customs unions are never blocked by free trade, and they can be blocked by a single country 67.5% of the time. Here when customs unions are blocked it is more likely blocked by a single country (32.5%) than by another customs union (10.6%.) This implies that since customs unions are blocked 40.4% of the time then in 2.7% of cases both a single country *and* a customs unions block customs unions. Table 5 give us the results for Nash equilibrium. One can see that Nash equilibrium is much more likely to be blocked than a customs union and is more likely to be blocked than free trade.

Table 5
Blocking Nash Equilibrium

	Percentage of Preference and Endowment Randomizations
Nash Equilibrium Cannot be *blocked* by any option	12.4
Nash Equilibrium Cannot be *blocked* by any Customs Union	13.0
Nash Equilibrium Cannot be *blocked* by Multilateral Free Trade	73.3

Notice that a customs union blocks Nash equilibrium 87% of the time and Nash is blocked in total only 87.6% of the time. This means that in almost every case in which Nash equilibrium is blocked there is a customs union that blocks it. Free trade blocks Nash in 26.7% of cases but in all but .6% of those there is also a customs union which can block Nash equilibrium as well.

This completes our calculations of blocking. Given that we have all of this information on blocking the next step is to examine what occurs in equilibrium. This requires introducing the core solution concept and looking at which equilibria are in the core.

6 The Core

In the previous section we determined how likely it is that the various possible equilibria are unblocked. In this section we introduce the core solution concept in order to be able to determine which equilibria will be observed. We first formally define the core.

Definition 1 *An equilibrium is in the* **core** *if it is unblocked by any country acting alone or any group of countries in a customs union or a multilateral free trade agreement.*

This definition is slightly different than the standard core definition because equilibria are not blocked by other equilibria. Because of the ambiguity about what happens when one country decides not to cooperate with any other country, a single country can block an equilibrium. Groups of countries acting together in a trade agreement can block any of the three equilibria. The core is a natural solution concept to use because when a trade agreement is in the core it is stable in the following sense. There is no feasible alternative for any country participating in a trade agreement that would make that country better off. Thus, given that a free trade agrement is reached (i.e. in the core), there is no incentive for any participants to defect from that agreement.

Using the blocking data from Tables 3-5 we immediately know something about the properties of the core. Table 3 tells us that free trade is in the core 17.4% of the time. According to Table 4 there exists at least one customs union in the core 40.4% of the time and Table 5 indicates that Nash equilibrium will be in the core 12.4% of the time.

These results suggest that customs unions are the most likely to occur. For about forty percent of all endowment/preference draws there is a customs union in the core. Free trade agreements, on the other hand, only are feasible about seventeen percent of the time and Nash equilibrium (no trade agreement) is in the core about twelve percent of cases. To fully understand these results we have to determine one more thing. For any endowment/preference draw there could be multiple equilibria in the core. In Table 6 we summarize these results.

Table 6
Core Allocations

	Percentage of Preference and Endowment Randomizations
Nash Equilibrium Only Core Allocation	
Free Trade Only Core Allocation	
Single Customs Union Only Core Allocation	...
Multiple Customs Unions in the Core	
Nash Equilibrium and a Customs Union in the Core	
Nash Equilibrium and Free Trade in the Core	
Empty Core	

Discussion of these results including a discussion of what the empty core results mean ....

7 Sensitivity Analysis

7.1 Restricting the Endowment Range

In the above calculations we adopt a uniform probability distribution over endowments and preferences. One might think that in fact all distributions are not equally likely. In particular, extreme endowments might be less likely to occur than more central ones. In this section we investigate what difference it makes if endowments are restricted. In the above calculations, the individual elements of the endowment matrix take on values that range from 0.005 to 1.0. Now we restrict the endowment range to be 0.25 to 0.75 and see if the results change.

These results are reported in Tables 7-9.

Table 7
Blocking Free Trade

	Percentage of Preference and Endowment Randomizations Central Case[5]	New Range[6]
Multilateral Free Trade Cannot be *blocked* by any option	17.4	21.2
Multilateral Free Trade Cannot be *blocked* by any Customs Union	45.0	40.0
Multilateral Free Trade Cannot be *blocked* by a Single Country	37.9	46.4

Table 7 shows that restricting the endowment range makes free trade more likely to occur. With restricted endowments a customs union is more likely to block free trade, but a single country is much less likely to block. This makes sense because extreme endowments are more likely to give rise to large countries that do very well at Nash equilibrium. The more even endowments of the restricted case are also more likely to lead to customs unions that can block free trade because to block *both* countries must be better off. With more even endowments this case is more probable. The results for customs unions, in Table 8 below are quite similar.

Table 8
Blocking Customs Unions

	Percentage of Preference and Endowment Randomizations Central Case	New Range
Customs Unions Cannot be *blocked* by any option	40.4	58.3
Customs Unions Cannot be *blocked* by other Customs Unions	89.4	90.1
Customs Unions Cannot be *blocked* by Multilateral Free Trade	100.0	100.0
Customs Unions Cannot be *blocked* by a Single Country	67.5	74.0

Restricted endowments mean that customs unions are more likely to occur. Customs unions and single countries are both less likely to block a customs union when endowments are more even. Free trade never blocks in either case. The case of Nash equilibrium is a bit different. Here restricting endowments to more

[5] Endowment range is (0.005,1.0)
[6] Endowment range is (0.25,0.75)

even endowment matrices makes Nash equilibrium less likely to occur. This is consistent with our earlier intuition. More even endowments mean large countries are less likely which means it is less likely that single countries can do well at Nash equilibrium.

Table 9
Blocking Nash Equilibrium

	Percentage of Preference and Endowment Randomizations	
	Central Case	New Range
Nash Equilibrium Cannot be *blocked* by any option	12.4	9.3
Nash Equilibrium Cannot be *blocked* by any Customs Union	13.0	9.3
Nash Equilibrium Cannot be *blocked* by Multilateral Free Trade	73.3	64.9

Overall, the results show that restricting endowments in a way that eliminates extreme endowments makes it less likely that an endowment configuration is drawn for which there are large countries. This in turn, means that free trade and customs unions are more probable while Nash equilibrium, the case in which no cooperation occurs, is less likely to occur. In addition, as a test of robustness, these results suggest that our unrestricted endowments results are robust. Restricting endowments effects the numerical results in ways consistent with theory, but the basic results change little. Customs unions are by far, the most likely outcome. Free trade is the next most likely and Nash equilibrium is the least likely to occur. Restricting endowments strengthens these basic results.

In Table 10 we see how the core results change when we restrict endowments......

Table 10
Core Allocations

	Percentage of Preference and Endowment Randomizations	
	Central Case	New Range
Nash Equilibrium Only Core Allocation		
Free Trade Only Core Allocation		
Single Customs Union Only Core Allocation		
Multiple Customs Unions in the Core		
Nash Equilibrium and a Customs Union in the Core		
Nash Equilibrium and Free Trade in the Core		
Empty Core		

7.2 Changing Preferences

7.3 Normal versus Uniform Randomizations

8 Concluding Comments

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