An Oligopolistic Theory of Regional Trade Agreements

Christian Soegaard

No 1007

WARWICK ECONOMIC RESEARCH PAPERS

DEPARTMENT OF ECONOMICS

An Oligopolistic Theory of Regional Trade Agreements

Christian Soegaard*

21st May 2013

Abstract

Why are trade agreements regional? I address this question in a model of oligopoly featuring product variety. Tariffs have the effect of manipulating a country's terms of trade and shifting profits towards the domestic market at the expense of foreign trade partners. Countries endogenously form into regional trade agreements or global free trade in a framework where any agreement must be sustained by repeated interaction. A crucial parameter determining the degree of regionalism is product variety. I demonstrate that for a given trade cost and discount factor, increases in product variety leads to greater scope for global free trade relative to regional trade agreements.

Keywords: trade policy, self-enforceability, trade costs, regional trade agreements.
JEL codes: F13, F15.

1 Introduction

The history of trade liberalisation in the post-war era is intimately related with the expansion of the GATT/WTO, and to the signing of a countless number of bilateral and regional trade agreements. Since World War II, average ad valorem import tariffs have been reduced from over 40 percent to less than 4 percent, and the average WTO member has now signed regional or bilateral trade agreements with fifteen countries (Freund and Ornelas, 2010). As such, it is important for economists and political scientists alike to understand the nature and causes of the desire to engage in cooperative trade policy. Why do countries sign trade agreements, and what determines the extent of trade liberalisation?

The trade policy literature abounds with explanations for the occurrence and/or desirability of preferential trade agreements (PTA). In fact, these issues have been at the very heart of the debate on trade policy in the last three decades, a period which has been characterised by a rapid proliferation of PTAs. A dimension of preferentialism which has received relatively little attention in the literature, however, is the regional bias of PTAs. This is puzzling given that almost all PTAs as of today are

*Department of Economics, University of Warwick, UK. Email: C.Soegaard@warwick.ac.uk. The author is grateful to several people for helpful comments and feedback. Thanks are especially due to Bouwe Dijkstra, Daniel Bernhofen and Allan Sørensen who have provided substantial feedback on earlier drafts of this paper. In addition, the author would like to thank Inger Sommerfelt Ervik, Dennis Novy, Natalie Chen, Jordi Vidal-Robert, Amrita Dhillon, Magdalene Silberberger, Ron Davies, Peter Neary, Monika Mrazova, Daniel Etzel, Sebastian Benz, Per Svejstrup Hansen, Rodney Ludema, Laura Rovegno and Francesca Jensenius.

regional.[1] In a broader context, regionalism is discussed within the framework of natural trading blocs. Krugman (1991) constructs an example with several countries on different continents. If the bulk of trade, he argues, is intra-regional due to near-prohibitive inter-continental natural trade costs, intra-regional trade agreements will be welfare enhancing. In fact, in the extreme case where inter-continental transport costs prohibit inter-continental trade, intra-regional trade blocs liberalise all trade which is possible to liberalise, while leaving inter-continental trade unaffected.[2]

Ludema (2002) remarks, however, that in the discussion surrounding natural trading blocks, it may not be assumed that the political forces underpinning the signing of PTAs are so benign as to ensure that only the most welfare-enhancing trade agreements are actually signed in practice. For this reason, there is a need for an endogenous theory of the formation of PTAs.

The present paper aims to contribute to this literature by demonstrating the existence of a regional bias of trade agreements based on oligopoly and product variety. Its main prediction is that greater product variety increases the scope for global free trade, thus making it more likely the world abandons preferentialism in favour of global free trade. The key driver behind this finding is a trade-off, central to oligopoly, between pro-competitive gains from free trade and losses in transit due to natural trade costs,[3] a trade-off first identified in Brander and Krugman (1983). In particular, they show that when natural trade costs are reduced by a negligible amount from their prohibitive levels, the welfare loss due to cross-hauling outweigh the pro-competitive gains. As trade costs are reduced below a certain cut-off this is reversed such that the pro-competitive effect dominates. The addition of product variety, such as in the present paper, introduces another gain from trade, and as this gain from trade increases the pro-competition versus transit-loss trade-off diminishes.

In a first step towards studying regionalism, this paper sets up a two-country model based on repeated games,[4] where the sustainability of a trade agreement is determined by governments' weighting of the one-shot benefits from defection against the long run cost. It is shown that there is a discontinuity in the relationship between the sustainability of trade agreements and trade costs. A critical threshold of trade costs must be crossed before free trade agreements can be supported at all. Anywhere above this threshold, the two countries derive higher welfare by imposing unilaterally optimal tariffs against each other that optimally exploit their market power over terms of trade[5] and shift profits towards their respective domestic markets. As trade costs fall, both the cost and benefits of defection increase, but as the pro-competitive gains from trade begin to dominate losses due to transit, the benefits will increase proportionally less than the costs, paving the way for sustaining trade agreements. As product variety increases, however, and the trade-off becomes less important, the relationship between trade

[1] An exception to this rule includes the recent trade agreement signed between the US and South Korea.

[2] Empirically, the natural trading bloc view receives support in Baier and Bergstrand (2004). Using a sample of 54 countries in the first systematic attempt to empirically uncover the predictors of PTAs, they find that distance between a country pair and their remoteness with respect to the rest of the world are very good predictors of membership in a PTA. These findings are confirmed using a larger sample in Egger and Larch (2008).

[3] Natural, as opposed to politically induced trade barriers, include such things as transport costs, communication costs, distance, language barriers and so on.

[4] Models of repeated games are popular as a building bloc for the study of international trade agreements. This strand of literature include: Collie (1993), Bond and Syropoulos (1996), Bagwell and Staiger (1997a), Bagwell and Staiger (1997b), Bond (2001), Bond et al. (2001), Saggi (2006) and Limao and Saggi (2008).

[5] Johnson (1954) is the first to identify terms-of-trade manipulations as and explicit motive for unilateral trade policy.

agreements and trade costs becomes less pronounced. In the special case where the two countries trade distinct varieties, the aforementioned trade-off vanishes and there is thus no relationship between trade costs and the sustainability of trade agreements (the costs and benefits of defection increase in the same proportion as trade costs are reduced). The model is extended to a three-country setting where the regional dimension is examined. A threshold level of extra-regional trade costs is identified above which there is scope for regionalism. Increases in product variety have the effect of reducing the scope for regionalism in favour of global free trade for a given discount factor and a given extra-regional trade cost.[6] The notion of natural trading blocs, where only the most welfare enhancing trade agreements are signed, does not hold for all parameter ranges in this model, however, as it is possible to identify discount factors for which only a regional PTA can be sustained even though global free trade yields higher welfare.

Endogenous formation of regional PTAs has also been studied in perfectly competitive environments. Bond (2001) sets up a four-country, four-good endowment economy to analyse the sustainability of multilateral versus regional trade agreements in a repeated games framework. He finds that higher discount factors are required to sustain global free trade when inter-continental trade costs are positive.

In the repeated games framework and under perfect competition, however, it may not be possible to establish a general result regarding the sustainability of trade agreements in the presence of transport costs. The intuition for this can be visualised using a simple example with two countries, call them countries 1 and 2. Suppose these countries are able to use import tariffs to distort terms of trade in their favour at the expense of trading partners. If transport costs are high, it would be expected that both the costs and benefits from deviating from free trade are low due to low trade volumes. If, on the other hand, transport costs are low which would imply high volumes of trade, both the costs and benefits from deviation are high. Hence, if the sustainability of a trade agreement between the two countries is determined by their weighting of the one-shot benefits of defection against the long run costs of such deviation, it is unclear whether lower natural trade costs increase or decrease the sustainability of a trade agreement. It can therefore be argued that the repeated games framework generates an ambiguity regarding the relationship between natural trade costs and the sustainability of free trade. It is precisely this ambiguity which does not arise in oligopoly due to the trade-off between pro-competitive gains from trade and losses in cross-hauling (the benefits from defection rise proportionally less than the costs in oligopoly in response to falling trade costs).

In a related paper, Ludema (2002) constructs a model of economic geography that generates a similar regional bias to the present model. In his model, however, the bias comes from economic geography where firms face a trade-off between being close to their markets and concentrating production

[6]Unlike earlier models examining the endogenous formation of regional PTAs, the present paper makes an explicit distinction between Customs Unions, where members set a common external tariff, and Free Trade Agreements, where members are free to choose their own optimal external tariffs. It is found that when the alternative to global free trade is an exclusive regional Customs Unions, increases in product variety unambiguously increase the scope for global free trade, whereas if the alternative is an exclusive regional Free Trade Agreement, there are intermediate values of product variety for which the relationship between product variety and global free trade is not monotonic. This is because increases in product variety will increase the sustainability of a regional PTA in addition to global free trade. Since preferential Free Trade Agreements set lower external tariffs, this could induce a distant country to exit to take advantage of this.

to reap the benefits of economies of scale. Zissimos (2011) develops a similar theory of endogenous formation of regional PTAs in an oligopolistic model of trade based on Brander and Spencer (1984) and Yi (1996). In his framework, transport costs may be used to coordinate on a unique equilibrium in which trade agreements are regional. The absence of transport costs give rise to a coordination failure where any one of many possible trade agreements can form. Unlike the present paper, however, Zissimos (2011) does not consider the variety component. Papers that are also closely related to the present one include Collie (1993) and Saggi (2006). In the first paper, the sustainability of trade agreements is analysed in the presence of trade costs. It is shown that free trade can be sustained if countries are sufficiently similar and sufficiently patient. No explicit distinction, however, is made between political and natural trade costs, a distinction which is central to the model presented in this paper. The second paper studies the sustainability of trade agreements in the presence of asymmetric production costs, but unlike the present paper, no distinction is made between production costs and trade costs.

The remainder of this paper is organised as follows. Section 2 presents the oligopolistic model with product variety which will be used throughout the paper. Section 3 presents some trade policy preliminaries in addition to defining the repeated game. Section 4 introduces a simple two-country case before Section 5 analyses the full triangular model. Finally, Section 6 offers some extensions while Section 7 concludes with a summary and ideas for future research.

2 The model

This section presents a version of Yi's (1996) extension of the Brander (1981) model of trade with oligopoly. I choose a simple setup with a world of $n \geq 2$ countries with one firm in each. There are an infinite number of discrete time periods, and each firm produces one good. Preferences are identical across countries and can be represented by the following quasilinear-quadratic utility function in each period:[7]

$$U(\mathbf{q_i}, q_{i0}) = aQ_i - \frac{\gamma}{2}Q_i^2 - \frac{1-\gamma}{2}\sum_{j=1}^{n} q_{ij}^2 + q_{i0}, \quad i = 1..n, \tag{1}$$

where q_{ij} is country i's consumption of country j's product, $\mathbf{q_i} \equiv (q_{i1}, q_{i2}, ..., q_{in})$ is country i's consumption vector, $Q_i \equiv \sum_{j=1}^{n} q_{ij}$ and q_{i0} is country i's consumption of the numéraire good. The numéraire is freely traded across countries to settle the balance of trade, and its price is normalised to 1. Labour is the only factor of production in this model and its marginal product is constant and normalised to unity. The labour endowment in each country is the same, and I assume that these endowments are large enough to guarantee a positive consumption of the numéraire good in equilibrium. These assumptions ensure that the wage rate is equal to one in equilibrium. The parameter $\gamma \in [0; 1]$ represents a substitution index: when $\gamma = 0$ goods are independent and each firm is a monopolist in its own market. As γ increases goods become closer substitutes. Assuming $\gamma < 1$ consumers have a taste for variety. Notice that γ can be thought of as a measure of the degree of strategic interaction between firms, such that a higher γ implies a more direct competition among firms. Country i's inverse

[7] Time subscripts are omitted where it does not cause confusion.

demand for country j's good can be derived by maximising utility in (1):

$$p_{ij} = a - (1-\gamma)q_{ij} - \gamma Q_i = a - q_{ij} - \gamma \sum_{\substack{k=1 \\ k \neq j}}^{n} q_{ij}. \tag{2}$$

Trade is subject to natural trade costs of the iceberg form. In order for one unit of exports to arrive in country i, $1+\alpha_{ij}$ units must be produced. I assume there are no internal natural trade costs, $\alpha_{ii} = 0$, and that trade costs between any country pair i and j are symmetric, such that $\alpha_{ij} = \alpha_{ji}$. In addition to natural trade costs, the governments of each country are able to impose political trade costs in the form of a specific import tariff. I assume that tariffs are country-specific such that country i sets a tariff equal to τ_{ij} on imports from country j. I also assume there are no internal political trade barriers, $\tau_{ii} = 0$.

All firms produce at the same marginal cost in terms of units of labour, w, in their respective domestic markets, but due to trade costs (both political and natural) the effective marginal cost of exporting to country i becomes $w_{ij} = w + \alpha_{ij} + \tau_{ij}$ for the firm in country j. Markets are segmented and firms compete in a Cournot fashion by choosing quantities in each country. In country i, firm j solves the following problem, $\max_{q_{ij}} \pi_{ij} = (p_{ij} - w_{ij})\, q_{ij}$. This yields the first-order conditions:

$$p_{ij} - w_{ij} - q_{ij} = 0 \tag{3}$$

Using (2) these conditions can be rewritten as:

$$a - w - (2-\gamma)q_{ij} - \gamma Q_i = 0 \tag{4}$$

Summing the first-order conditions in (4) gives the following per-period quantities in Cournot equilibrium:

$$q_{ij} = \frac{\Gamma(0,\gamma) + \gamma(T_i + A_i) - \Gamma(n,\gamma)(\tau_{ij} + \alpha_{ij})}{\Gamma(0,\gamma)\,\Gamma(n,\gamma)}; \qquad Q_i = \frac{n - T_i - A_i}{\Gamma(n,\gamma)}, \tag{5}$$

where,

$$T_i \equiv \sum_{j=1}^{n} \tau_{ij} \quad \text{and} \quad A_i \equiv \sum_{j=1}^{n} \alpha_{ij}, \tag{6}$$

and I have normalised such that $a - w = 1$. The function $\Gamma(\cdot)$ is defined as:

$$\Gamma(k,\gamma) \equiv 2 - \gamma + k\gamma. \tag{7}$$

The equilibrium quantities have the following properties:

$$\begin{aligned} \frac{dq_{ij}}{d\tau_{ij}} &= \frac{dq_{ij}}{d\alpha_{ij}} = \frac{\gamma - \Gamma(n,\gamma)}{\Gamma(0,\gamma)\Gamma(n,\gamma)} < 0; \quad \frac{dq_{ih}}{d\tau_{ij}} = \frac{dq_{ih}}{d\alpha_{ij}} = \frac{\gamma}{\Gamma(0,\gamma)\Gamma(n,\gamma)} > 0 \quad \text{for} \quad h \neq j; \\ \frac{dQ_i}{d\tau_{ij}} &= \frac{dQ_i}{d\alpha_{ij}} = -\frac{1}{\Gamma(n,\gamma)} < 0. \end{aligned} \tag{8}$$

If country i raises its tariff on imports from country j, the consumption of good j falls, but the consumption of all other goods increases. Total consumption, however, falls. Exogenous increases in natural trade costs, α_{ij}, have the same effect on quantities. In fact, what matters for the equilibrium quantities are *total* trade costs whether political or natural.

Using the first-order condition in (3) I obtain an expression for the per-period equilibrium profits of firm j in country i:

$$\pi_{ij} = (p_{ij} - w_{ij})q_{ij} = q_{ij}^2.$$

The equilibrium profits have the following properties:

$$\frac{d\pi_{ij}}{d\tau_{ij}} = \frac{d\pi_{ij}}{d\alpha_{ij}} = \frac{2(\gamma - \Gamma(n,\gamma))q_{ij}}{\Gamma(0,\gamma)\Gamma(n,\gamma)} < 0; \quad \frac{d\pi_{ih}}{d\tau_{ij}} = \frac{d\pi_{ih}}{d\alpha_{ij}} = \frac{2\gamma q_{ih}}{\Gamma(0,\gamma)\Gamma(n,\gamma)} > 0 \quad \text{for} \quad h \neq j.$$

If country i raises its tariff (or there is an exogenous rise in natural trade costs) on imports from country j, the export profits of firm j fall, but country i's firm's profits increase along with the profits of all other firms exporting to country i.

There are two sources of gains from trade in the model: an increased variety of goods and decreased market power of the domestic industry. When the substitution index γ is lower, consumers value variety whereas the pro-competitive effect is higher when γ is higher. Whether the gains from trade are of the pro-competitive type or of the variety type have important implications for the arguments that follow in this paper.

The welfare of each country consists of consumer surplus, tariff revenue, the sum of domestic and export profits and labour income. The expression for per-period consumer surplus takes the following form:

$$CS_i = V(Q_i) - \sum_{j=0}^{n} p_{ij}q_{ij}, \tag{9}$$

where $V(\cdot)$ is the indirect utility function obtained from the consumer's optimisation problem. The per-period tariff revenue which is redistributed back to individuals in a lump-sum fashion is given as:

$$TR_i = \sum_{\substack{j=1 \\ j\neq i}}^{n} \tau_{ij}q_{ij}. \tag{10}$$

The sum of domestic and export profits of firm i is:

$$\Pi_i = \pi_{ii} + \sum_{\substack{j=1 \\ j\neq i}}^{n} \pi_{ji} = (p_{ii} - w)q_{ii} + \sum_{\substack{j=1 \\ j\neq i}}^{n} (p_{ji} - w - \tau_{ji} - \alpha_{ji})q_{ji}, \tag{11}$$

and finally, labour income is:

$$\ell_i = wL_i, \tag{12}$$

where L_i is the total number of workers per country, which is assumed to be the same across every country $L_i = L$. The per-period welfare of country i can thus be expressed by adding up (9)-(12):

$$\begin{aligned} W_i &= CS_i + TR_i + \Pi_i + \ell_i \\ &= V(Q_i) - q_{i0} - wQ_i - \sum_{\substack{j=1 \\ j \neq i}}^{n} (p_{ij} - w - \tau_{ij}) q_{ij} + \sum_{\substack{j=1 \\ j \neq i}}^{n} (p_{ji} - w - \tau_{ji} - \alpha_{ji}) q_{ji} + wL_i \\ &= V(Q_i) - q_{i0} - wQ_i - \sum_{\substack{j=1 \\ j \neq i}}^{n} \alpha_{ij} q_{ij} + \sum_{\substack{j=1 \\ j \neq i}}^{n} \pi_{ji} + wL_i - \sum_{\substack{j=1 \\ j \neq i}}^{n} \pi_{ij} \end{aligned} \tag{13}$$

Hence, welfare in country i is total surplus in country i less profits accruing to foreign firms.

3 Trade policy

In this section, I present some preliminaries of trade policy which will serve as a point of departure for the discussion that follows. What drives countries to impose import tariffs unilaterally, and why do they wish to cooperate? To answer these questions, I follow the literature on trade policy (see for example Bagwell and Staiger (2010) for an overview), and discuss how natural trade barriers affect the objectives.

3.1 Unilateral trade policy

When acting non-cooperatively, it is assumed that the governments of each country set tariffs so as to maximise their individual welfare. The governments move first by setting optimal tariffs and firms then set Cournot quantities subject to the tariffs chosen by the governments in each market. As discussed in Baldwin and Venables (1995) and Mrazova (2009), it is possible to decompose the welfare effects of import tariffs into a terms-of-trade effect (ToT), a volume-of-trade effect (VoT), and a profit-shifting (PS) effect. Differentiating (13) with respect to the tariff imposed on imports from country l, τ_{il}, yields $\forall\ l \neq i$,[8]

$$\frac{dW_i}{d\tau_{il}} = \underbrace{-\sum_{\substack{j=1 \\ j \neq i}}^{n} q_{ij} \frac{dp_{ij}^*}{d\tau_{il}}}_{ToT \geq 0} + \underbrace{\sum_{\substack{j=1 \\ j \neq i}}^{n} \tau_{ij} \frac{dq_{ij}}{d\tau_{il}}}_{VoT \leq 0} + \underbrace{(p_{ii} - w) \frac{dq_{ii}}{d\tau_{il}}}_{PS \geq 0}, \tag{14}$$

where p_{ij}^* is the net-of-tariff price of country j's good sold in country i, or $p_{ij}^* = p_{ij} - \tau_{ij}$. The ToT effect is the variation in the net-of-tariff price which country j's firm receive for their exports to country i. In this model, the ToT effect is positive such that an increase in country i's import tariff improves its terms of trade. The tariff reduces country i's volume of trade ($VoT \leq 0$) due to a higher consumer price of imports, but it shifts profits from foreign exporters to domestic producers by reducing market access ($PS \geq 0$). This last effect is due to the oligopolistic distortion where the import tariff moves the domestic firm towards the Stackelberg leader output level. This effect would be absent under perfect competition where prices equal marginal costs. Moreover, if there were no strategic interaction

[8] This derivation uses the well known condition that price equal marginal utility, $\frac{dV(Q_i)}{d\tau_{il}} = \sum_{j=1}^{n} p_{ij} \frac{dq_{ij}}{d\tau_{il}}$.

between firms ($\gamma = 0$), then $\frac{dq_{ii}}{d\tau_{ij}} = 0$, such that there would be no profit-shifting incentive for imposing import tariffs. In this case, the only motive for country i to unilaterally impose tariffs is to switch the terms of trade in its favour. Substituting the Cournot quantities (5) and the inverse demand function (2) into (14), I can solve for the optimal non-cooperative tariff of country i on imports from country l:[9]

$$\tau_{il}^N = \frac{\Gamma(0,\gamma)\Gamma(2,\gamma)[\Gamma(0,\gamma)+1] + \gamma\Gamma(0,\gamma)\Gamma(2,\gamma)A_i - D(1,n,\gamma)\alpha_{il}}{D(1,n,\gamma)[\Gamma(0,\gamma)+1]} > 0 \quad l \neq i, \tag{15}$$

where the $D(\cdot)$ is defined as:

$$D(k,n,\gamma) \equiv \Psi(k,\gamma)\Gamma(n,\gamma) + \Gamma(k,\gamma)\Gamma(2k,\gamma) \quad \text{and} \quad \Psi(k,\gamma) \equiv (\Gamma(0,\gamma)+1)\Gamma(k,\gamma) - \Gamma(2k,\gamma). \tag{16}$$

The superscript N in (15) stands for Nash, and is there to illustrate the prisoner's dilemma nature of non-cooperative trade policy. Due to the assumption of market segmentation, the two countries do not set Nash tariffs strategically such that Nash tariffs in country i are independent of the Nash tariffs in other countries (see Equation (55) in Appendix A).

It is useful to see how changes in trade costs between a pair i and l affect country i's welfare gain from imposing a tariff on imports from country l. Taking the derivative with respect to α_{il} in (14) yields:[10]

$$\frac{d^2 W_i}{d\tau_{il} d\alpha_{il}} = \frac{\gamma[\Gamma(2,\gamma) + \Gamma(n,\gamma)] - \Gamma(n,\gamma)^2}{[\Gamma(0,\gamma)\Gamma(n,\gamma)]^2} < 0. \tag{17}$$

Hence, when the cost of importing from country l, α_{il}, falls, the gain from a tariff on imports from country l increases. This is because when natural trade costs are lower, the natural distortion of profits and consumer prices is lower, making import tariffs more effective at switching the terms of trade in country i's favour and shifting profits towards the domestic firm in the domestic market. The exact relationship between τ_{il} and α_{il} can be found by differentiating (15) with respect to α_{il}:

$$\frac{d\tau_{il}^N}{d\alpha_{il}} = \frac{\gamma\Gamma(0,\gamma)\Gamma(2,\gamma) - D(1,n,\gamma)}{D(1,n,\gamma)[\Gamma(0,\gamma)+1]} < 0.$$

The effect of natural trade costs from any other country than l on country i's tariff on country l is either zero or positive. In fact, differentiating (15) with respect to trade cost from any other country, α_{ih}, yields:

$$\frac{d\tau_{il}^N}{d\alpha_{ih}} = \frac{\gamma\Gamma(0,\gamma)\Gamma(2,\gamma)}{[\Gamma(0,\gamma)+1]D(1,n,\gamma)} \geq 0, \qquad h \neq l.$$

The intuition is that the optimal import tariff on country l compensates for trade diversion which results from increases in natural trade costs from other countries. However, when goods are independent of each other, $\gamma = 0$, there is no such diversion, and the relationship vanishes.

[9] See Appendix A for the derivation.

[10] See Appendix A for the derivation.

3.2 Cooperative trade policy

Unilateral trade policy is inefficient, however, as one country's welfare gain comes at the expense of the other. By taking the derivative of country i's welfare with respect to country l's tariff on imports from country i, τ_{li}, it is similarly possible to decompose the welfare effect into a terms-of-trade (ToT), a volume-of-trade (VoT) and a profit-shifting (PS) component:

$$\frac{dW_i}{d\tau_{li}} = \underbrace{q_{li}\frac{dp^*_{li}}{d\tau_{li}}}_{ToT\leq 0} - \underbrace{\tau_{li}\frac{dq_{li}}{d\tau_{li}}}_{VoT\geq 0} + \underbrace{(p_{li} - w - \alpha_{li})\frac{dq_{li}}{d\tau_{li}}}_{PS\leq 0}, \tag{18}$$

where p^*_{li} is the net-of-tariff price of firm i's good sold in country l. Notice that country l's import tariff only affects country i's welfare through its export profits to that country. This is because of the assumption of market segmentation. As is clear from Appendix B, the derivative in (18) depends on country l's Nash tariff on country i as well as the sum of its tariffs imposed on all other countries, $T_l = \sum_{j=1}^{n} \tau_{lj}$. Evaluating (18) at country l's Nash tariffs yields:[11]

$$\left.\frac{dW_i}{d\tau_{li}}\right|_{\tau^N_{li},T_l} = \frac{\Gamma(1,\gamma)[\Gamma(n,\gamma)-\gamma]\Gamma(n,\gamma)\Gamma(0,\gamma)\gamma\Psi(1,\gamma)A_l + [\Gamma(0,\gamma)+1]\Psi(1,\gamma) - D(1,n,\gamma)\alpha_{li}]}{[\Gamma\left(0,\gamma\right)\Gamma\left(2,\gamma\right)]^2[\Gamma(0,\gamma)+1]D(1,n,\gamma)} < 0, \tag{19}$$

where $\Psi(\cdot)$ and $D(\cdot)$ are defined in (16). Hence, by acting non-cooperatively, international trade policy produces a terms-of-trade and a profit-shifting externality. It is also clear from (19) that this externality becomes more severe when trade costs are lower:

$$\left.\frac{d^2W_i}{d\tau_{li}d\alpha_{li}}\right|_{\tau^N_{li},T_l} = \frac{\Gamma(1,\gamma)[\Gamma(n,\gamma)-\gamma][\Psi(1,\gamma)\Gamma(0,\gamma)(\Gamma(n,\gamma)-\gamma) - \Gamma(1,\gamma)\Gamma(0,\gamma)\Gamma(2,\gamma)]}{[\Gamma\left(0,\gamma\right)\Gamma\left(2,\gamma\right)]^2[\Gamma(0,\gamma)+1]D(1,n,\gamma)} > 0. \tag{20}$$

When trade costs fall, the unilateral gain from import tariffs is larger, and the Nash tariffs are therefore higher. This, in turn produces larger international externalities.

Under what circumstances would it improve global welfare to abandon import tariffs among all countries or a subset of countries? This is the question which will be addressed in the next two sections. For now, I will define what form cooperative trade policy takes. The countries in the world may decide to abandon import tariffs all together, and let trade flow freely amongst each other. Alternatively, a subset of the countries may form a trade agreement, while keeping positive Nash tariffs on all other countries not part of the agreement. Such a trade agreement may take the form of an FTA in which each country sets their own individually optimal external tariffs, or alternatively, they may form a CU in which they set common external tariffs. In the first case, assume that a subset of countries, $k \geq 2$, sign an FTA. Hence, if country i is in k it abolishes tariffs on all countries $1, ..., k$ but for any country $j = k+1, ..., n$ it sets the tariff which maximises its individual welfare. Each country i in the FTA thus maximises the following:

$$\max_{\{\tau_{ij}\}^N_{j=k+1}} W_i = CS_i + TR_i + \Pi_i + \ell_i \tag{21}$$

[11] See Appendix B for the derivation.

Differentiating (21) with respect to the tariff imposed on imports from country l, τ_{il}, yields $\forall\ l \notin k$,

$$\frac{dW_i}{d\tau_{il}} = \underbrace{-\sum_{j=k+1}^{n} q_{ij}\frac{dp^*_{ij}}{d\tau_{il}}}_{ToT^{er}\geq 0} \underbrace{-\sum_{\substack{j=1\\ j\neq i}}^{k} q_{ij}\frac{dp_{ij}}{d\tau_{il}}}_{ToT^{ir}\leq 0} + \underbrace{\sum_{j=k+1}^{n}\tau_{ij}\frac{dq_{ij}}{d\tau_{il}}}_{VoT\leq 0} + \underbrace{(p_{ii}-w)\frac{dq_{ii}}{d\tau_{il}}}_{PS\geq 0}, \tag{22}$$

The optimal tariff balances country i's *extra-regional* (er) terms of trade gain, ToT^{er}, against its *intra-regional* (ir) loss, ToT^{ir}. Substituting the Cournot quantities (5) and the inverse demand function (2) into (22), I can solve for the optimal extra-regional non-cooperative tariff of country i on imports from country l:[12]

$$\tau_{il}^{FTA} = \frac{[\Gamma(0,\gamma)+1]\{\Gamma(0,\gamma)\Gamma(2,\gamma)+\gamma[\Gamma(2,\gamma)+\Gamma(n,\gamma)]A_i^{ir}\} + \gamma\Gamma(0,\gamma)\Gamma(2,\gamma)A_i^{er} - \Xi(k,n,\gamma)\alpha_{il}}{\Xi(k,n,\gamma)[\Gamma(0,\gamma)+1]} \quad l\neq i, \tag{23}$$

where,

$$A_i^{ir} \equiv \sum_{j=1}^{k}\alpha_{ij} \quad \text{and} \quad A_i^{er} \equiv \sum_{j=k+1}^{n}\alpha_{ij}, \tag{24}$$

are, respectively, country i's *intra-regional* and *extra-regional* trade costs. The function $B(\cdot)$ is defined as:

$$\Xi(k,n,\gamma) = D(k,n,\gamma) + B(k,n,\gamma) \quad \text{and} \quad B(k,n,\gamma) \equiv \Gamma(1,\gamma)[\Gamma(n,\gamma)-\Gamma(k,\gamma)][\Gamma(k,\gamma)-\Gamma(1,\gamma)]. \tag{25}$$

It is clear from (23) that for $k = 1$ the optimal external tariff collapses into (15). The sign of the relationship between bilateral trade costs between i and l and country i's import tariff on country l, that is $\frac{d\tau_{il}^{FTA}}{d\alpha_{il}}$, is negative, and the intuition is the same as for the case without the FTA above.

The relationship between the aggregate *intra-regional* trade costs and the tariff is non-negative. If goods are not distinct, $\gamma > 0$, then following higher intra-regional natural trade diversion, country i will compensate by levying higher external political trade barriers. Also, country i will raise the tariff on country l following an increase in trade costs from any outsider which is not l if $\gamma > 0$. In Appendix C, I prove that the optimal external tariff is strictly smaller than the Nash tariff when $\gamma > 0$ and equal to the Nash tariff when $\gamma = 0$. The intuition is that because of the FTA, trade is diverted away from outsiders due to zero internal tariffs, and each country individually compensates by setting lower external tariffs. This is commonly referred to as the tariff complementarity effect in the trade policy literature. Since this paper allows for product variety, however, tariff complementarity holds (only) weakly.

In the case of a CU, the countries within the union $1, ..., k$ set the external tariff which maximises their joint welfare:

$$\max_{\{\tau_j\}_{j=k+1}^{N}} W_{CU} = \sum_{i=1}^{k} W_i = \sum_{i=1}^{k}\{CS_i + TR_i + \Pi_i + \ell_i\} \tag{26}$$

[12] See Appendix A for the derivation.

Differentiating (26) with respect to the import tariff of country l yields:

$$\frac{dW_{CU}}{d\tau_l} = \underbrace{-\sum_{i=1}^{k}\sum_{j=k+1}^{n} q_{ij}\frac{dp^*_{ij}}{d\tau_l}}_{ToT\geq 0} + \underbrace{\sum_{i=1}^{k}\sum_{j=k+1}^{n} \tau_{ij}\frac{dq_{ij}}{d\tau_l}}_{VoT\leq 0} + \underbrace{\sum_{i=1}^{k}\sum_{j=1}^{k}(p_{ji}-w-\alpha_{ji})\frac{dq_{ji}}{d\tau_l}}_{PS\geq 0}. \tag{27}$$

Members of the CU coordinate their internal terms of trade and profits, and effectively act as if they were one country. Substituting the Cournot quantities (5) and the inverse demand function (2) into (27), I can solve for the optimal extra-regional tariff the members of the CU impose on imports from (outside) country l:[13]

$$\tau_l^{CU} = \frac{\gamma^2(2k-n)[\Gamma(0,\gamma)+1]A^{ir}_{CU} + \Gamma(0,\gamma)\Gamma(2k,\gamma)\{[\Gamma(0,\gamma)+1]k + \gamma A^{er}_{CU}\} - D(k,n,\gamma)A^{ir}_l}{D(k,n,\gamma)[\Gamma(0,\gamma)+1]k}, \tag{28}$$

where,

$$A^{ir}_{CU} \equiv \sum_{i=1}^{k} A^{ir}_i \quad , \quad A^{er}_{CU} \equiv \sum_{i=1}^{k} A^{er}_i \quad \text{and} \quad A^{ir}_l \equiv \sum_{i=1}^{k} \alpha_{li}, \tag{29}$$

are, respectively, the aggregate *intra-regional*, the aggregate *extra-regional* trade costs of the members of the CU, and the sum of country l's bilateral trade costs with each member.

The effect of A^{ir}_l on the common external tariff is unambiguously negative, and the intuition for this is similar to the one-country Nash tariff described above: when natural trade costs fall, an import tariff becomes more effective as a tool to manipulate the terms of trade and switch profits towards the CU market. The effect of the aggregate *extra-regional* trade costs on the import tariff depends on the degree of substitution. The optimal external tariff simply compensates for any trade diversion on other countries than l if the substitutability between the goods is positive, $\gamma > 0$. The sign of the relationship between the aggregate *intra-regional* trade costs, A^{ir}_{CU} depends on the size of the CU relative to the rest of the world. From (28) it is clear that A^{ir}_{CU} affects the tariff on country l non-negatively whenever:

$$k > \frac{1}{2}n,$$

and when $\gamma = 0$ there is no relationship. Hence, when the CU comprises more than half of the countries in the world, external tariffs will rise in response to increases in aggregate intra-regional trade costs. The intuition comes from the market size effect: when the CU is large, there is greater trade diversion within the CU when intra-regional trade costs rise. If the CU is small relative to the rest of the world this trade diversion is not very large.

The optimal external CU tariff is weakly greater than the optimal external FTA tariff. The intuition for this is that the CU is able to coordinate their internal profit-shifting and terms-of-trade manipulations as well as exploiting their increase monopoly power on the world market. The optimal external CU tariff, however, may be greater or smaller than the individual Nash tariff depending on the number of countries in the world, n, and the size of the CU relative to the world, that is k relative to n. If for example, n is very large and k very small, the volume of trade flows between the CU and

[13] See Appendix A for the derivation.

the rest of the world will be greater than intra-regional trade. In this case, the optimal external CU tariff will be greater than the Nash tariff because the CU is larger than the individual country and has greater market power. If the CU is large relative to the rest of the world, the trade flows between it and the rest of the world are smaller than the intra-regional trade flows. In this case, there is smaller scope for using the CUs' increased market power on world markets and consequently, the CU tariffs will be lower than the individual Nash tariffs.

The tariffs in (15), (23) and (28) are ranked in the following lemma.

Lemma 1 *The Nash tariff set by an individual country is greater than or equal to the optimal external tariff set by an individual country in an FTA, that is* $\tau_{il}^{N} > (=)\ \tau_{il}^{FTA}$ *for* $\gamma > 0$ $(\gamma = 0)$. *The optimal external tariff as set by a CU is greater than or equal to that set by an FTA, that is,* $\tau_{il}^{CU} > (=)\ \tau_{il}^{FTA}$ *for* $\gamma > 0$ $(\gamma = 0)$. *The Nash tariff may be larger or smaller than the optimal external CU tariff depending on the number of countries in the world (n), and the size of the CU relative to the rest of the world (k relative to n).*
Proof. See Appendix C ■

3.3 Self-enforcing trade policy

Following the convention in the trade policy literature, I model trade policy cooperation as a stationary repeated game, where cooperation is sustained only where it is incentive compatible for all countries. In this framework, each country weighs the benefit of defection against the future cost of such defection. I assume that countries can sustain cooperation through trigger strategies, where a defection by any country is followed by a permanent trade war.

In what follows it will be useful to define country i's welfare expression in terms of two components, one which depends on surplus in the domestic market (i.e. consumer surplus, tariff revenue and local profits), and one which depends on producer surplus in all other countries. Denote the former by $S_i(T_i, A_i) = CS_i(T_i, A_i) + TR_i(T_i, A_i) + \pi_{ii}(T_i, A_i)$, which depends only on country i's tariffs imposed on the rest of the world. The latter is given by $\sum_{\substack{j=1 \\ j\neq i}}^{n} \pi_{ji}(T_{-i}, A_{-i})$ which depends on the aggregate bilateral natural as well as political trade costs of the rest of the world less those of country i,

$$T_{-i} \equiv \sum_{\substack{j=1 \\ j\neq i}}^{n} T_j \quad \text{and} \quad A_{-i} \equiv \sum_{\substack{j=1 \\ j\neq i}}^{n} A_j.$$

Country i's per-period welfare is thus:

$$W_i(T_i, T_{-i}, A_i, A_{-i}) = S_i(T_i, A_i) + \sum_{\substack{j=1 \\ j\neq i}}^{n} \pi_{ji}(T_{-i}, A_{-i}). \tag{30}$$

Assume that k countries sign a trade agreement (TA) with one another, leaving aside the question of whether this is an FTA or a CU for the moment. Hence, k countries abolish their tariffs on each other and if $k < n$ they will set external tariffs on the $n - k$ outsiders. Assume that country $i \in k$ and let $T_i^{TA} \equiv \sum_{j=1}^{n} \tau_{ij}^{TA}$ denote the sum of tariffs it imposes on other countries when it signs a TA, where $TA = FTA, CU$. This sum can be broken into its *intra-regional* and *extra-regional* components such that $T_i^{TA} = T_i^{ir} + T_i^{er} = \sum_{j=1}^{k} \tau_{ij} + \sum_{j=k+1}^{n} \tau_{ij}^{E} = \sum_{j=k+1}^{n} \tau_{ij}^{E}$, where $E = FTA, CU$. The per-period welfare from adhering to the trade agreement is:

$$\begin{aligned} W_i^{TA} =& \sum_{j=1}^{k} S_i(T_i^{TA}, A_i, \tau_{ij}^{TA}, \alpha_{ij}) + \sum_{j=k+1}^{n} S_i(T_i^{TA}, A_i, \tau_{ij}^{E}, \alpha_{ij}) + \sum_{\substack{j=1 \\ j\neq i}}^{k} \pi_{ji}(T_j^{TA}, A_j, \tau_{ji}^{TA}, \alpha_{ji}) \\ &+ \sum_{j=k+1}^{n} \pi_{ji}(T_j^{N}, A_j, \tau_{ji}^{N}, \alpha_{ji}), \end{aligned} \tag{31}$$

where T_j^N is the sum of Nash tariffs imposed by non-members. If country i defects from the agreement, and reverts to its Nash tariff, it enjoys temporary benefits in the form of improved terms of trade and higher domestic profits at the expense of the members of the TA. In this case, its per-period welfare becomes:

$$W_i^{D} = \sum_{j=1}^{n} S_i(T_i^{N}, A_i, \tau_{ij}^{N}, \alpha_{ij}) + \sum_{\substack{j=1 \\ j\neq i}}^{k} \pi_{ji}(T_j^{TA}, A_j, \tau_{ji}^{TA}, \alpha_{ji}) + \sum_{j=k+1}^{n} \pi_{ji}(T_j^{N}, A_j, \tau_{ji}^{N}, \alpha_{ji}). \tag{32}$$

Notice that the one-shot defection welfare affects country i's welfare only through domestic surplus, leaving its export profits unchanged. One period after defection, however, the other members of the agreement will punish the cheating nation by increasing their tariffs. It is not clear what this punishment might entail and in this paper I will consider two cases: one where deviation by one country implies contagion, such that every country in the agreement would revert to Nash against all members, and another where deviation does not imply contagion, such that only the cheating nation is punished and the rest of the countries would remain in a trade agreement. The per-period welfare of country i following punishment by trading partners is:

$$W_i^{P} = \sum_{j=1}^{n} S_i(T_i^{N}, \tau_{ij}^{N}, \alpha_{ij}) + \sum_{\substack{j=1 \\ j\neq i}}^{k} \pi_{ji}(T_j^{P}, \tau_{ji}^{P}, \alpha_{ji}) + \sum_{j=k+1}^{n} \pi_{ji}(T_j^{N}, A_j, \tau_{ji}^{N}, \alpha_{ji}), \tag{33}$$

where $P = N, FTA, CU$. Country i will stay in the agreement provided that the present discounted value of doing so is greater than or equal to the present discount value of deviation. It is then possible to define the following self-enforcement constraint:

$$\frac{1}{1+\delta} W_i^{TA} \geq W_i^{D} + \frac{\delta}{1+\delta} W_i^{P} \tag{34}$$

This constraint can be solved in terms of a critical discount factor above which the trade agreement can be sustained:

$$\delta_i^c \geq \frac{W_i^D - W_i^{TA}}{W_i^D - W_i^P} \tag{35}$$

The numerator of this expression is the one-shot gain in welfare from deviation whereas the denominator is the long-run cost. It will be convenient to define the one-shot benefit as:

$$\begin{aligned} B_i^D = W_i^D - W_i^{TA} =& \sum_{j=1}^{n} S_i(T_i^{N}, A_i, \tau_{ij}^{N}, \alpha_{ij}) - \sum_{j=1}^{k} S_i(T_i^{TA}, A_i, \tau_{ij}^{TA}, \alpha_{ij}) \\ &- \sum_{j=k+1}^{n} S_i(T_i^{TA}, A_i, \tau_{ij}^{E}, \alpha_{ij}). \end{aligned} \tag{36}$$

This benefit depends only on the change in domestic surplus. Similarly, I define the long-run cost of deviation as:

$$C_i^D = W_i^D - W_i^P = \sum_{\substack{j=1 \\ j\neq i}}^{k} \pi_{ji}(T_j^{TA}, A_j, \tau_{ji}^{TA}, \alpha_{ji}) - \sum_{\substack{j=1 \\ j\neq i}}^{k} \pi_{ji}(T_j^{P}, \tau_{ji}^{P}, \alpha_{ji}), \tag{37}$$

which depends on the change in country i's surplus in other countries.

4 The two-country case

In this section, I develop a simple model of two countries, call them country 1 and country 2. While this model does not address the issue of preferential trade agreements, it will develop the basic intuition which will serve as a starting point for the full triangular model presented in the next section. The purpose is to take an intermediate step towards establishing how reductions in natural trade costs may facilitate trade policy cooperation.

I choose country 1 as the home country, and due to symmetry of trade costs, $\alpha_{12} = \alpha_{21} = \alpha$ the analogous analysis for country 2 is a mirror image. Setting $n = 2$ in (15), it is easy to see that in a world with just two countries, Nash tariffs are given as:

$$\begin{aligned}\tau_{12}^N = \tau_{21}^N &= \frac{\Gamma(0,\gamma)\Gamma(2,\gamma)[\Gamma(0,\gamma)+1] + \gamma\Gamma(0,\gamma)\Gamma(2,\gamma)\alpha - D(1,2,\gamma)\alpha}{[\Gamma(0,\gamma)+1]D(1,2,\gamma)} \\ &= \frac{1-\alpha}{3}.\end{aligned} \tag{38}$$

Due to the assumed linear demand functions it is possible that the Nash tariffs prohibit trade in the non-numéraire goods. To rule this out I make the following assumption for the two-country case:

Assumption 1 $\alpha < \overline{\alpha} \equiv \frac{\Psi(1,\gamma)}{\Gamma(1,\gamma)^2} = 1 - \frac{3}{4}\gamma$.[14]

I establish this assumption more formally in the following lemma:

Lemma 2 *If and only if* $\alpha < \overline{\alpha} \equiv \frac{\Psi(\gamma)}{\Gamma(1,\gamma)^2}$, *there exists a unique non-prohibitive Nash tariff for both countries.*
Proof. See Appendix D ■

The two countries would enjoy benefits from deviation from a trade agreement[15] in the form of improved terms of trade and higher profits in the domestic market. It was established in the previous section that this benefit is higher when natural trade costs are lower. Internationally, however, this implies that the externalities that tariffs impose are also larger when trade costs are lower. Hence, when trade costs fall the conflict between unilateral and cooperative trade policy increases. As such, it

[14] Notice that when the firms' monopoly power increases (a fall in γ), a larger trade cost can support a positive trade flow in equilibrium, that is, $\frac{d\overline{\alpha}}{d\gamma} = -\frac{3}{4} < 0$. This is because increased monopoly power allows the firms to produce at a higher mark-up, which in turn allows them to operate at higher marginal trade costs.

[15] In this section, I use the word trade agreement to describe an agreement that abolishes import tariffs between the two countries. This is to distinguish it from a regional free trade agreement in the triangular model.

may appear ambiguous whether decreases in trade costs increase or decrease the scope for a trade agreement. It turns out, however, that decreases in trade costs unambiguously increases the scope for a trade agreement for $\gamma > 0$.

In order to see this, it is necessary to examine whether free trade is the optimal joint trade policy. Whenever goods are substitutable ($\gamma > 0$) this question is not certain. There are two effects that work in opposite directions: on the one hand, free trade brings joint benefits in the form of increased competition, while on the other, free trade implies greater losses in transit.[16] This trade-off, however, is smaller when there is more variety (a lower γ). When γ falls the gains from trade are to a larger extent of the variety type, and thus the trade-off between pro-competition and trade diversion is smaller. When goods are independent of each other ($\gamma = 0$), there is no such trade off. In this case, the gain from trade arises exclusively from the increased variety, and therefore, free trade is always the jointly optimal trade policy.

When $\gamma > 0$ such that the trade-off exists, the pro-competitive gain from trade dominates transit losses for low trade costs, but as α exceeds a critical threshold, world welfare can be raised by increasing tariffs above zero to deal with the losses due to cross-hauling. Let this critical threshold be denoted $\widehat{\alpha}$, such that from a bilateral perspective, tariffs should be raised above zero whenever:

$$\alpha > \widehat{\alpha} \equiv \frac{\Gamma(0,\gamma)^2}{\Gamma(2,\gamma)^2 - \gamma\Gamma(1,\gamma)^2} = \frac{(2-\gamma)^2}{4+\gamma^2}. \tag{39}$$

In the following lemma I state this result formally:

Lemma 3 *If and only if* $\alpha > \widehat{\alpha} \equiv \frac{\Gamma(0,\gamma)^2}{\Gamma(2,\gamma)^2 - \gamma\Gamma(1,\gamma)^2}$ *and* $\gamma > 0$*, bilateral welfare can be improved by raising tariffs above their free trade levels. For* $\gamma = 0$ *free trade always raises welfare relative to any positive tariff for any non-prohibitive trade cost.*
Proof. See Appendix D ■

Due to symmetry, this implies that it is in each country's long term interest to enter a trade agreement when $\alpha < \widehat{\alpha}$. Comparing the threshold from Assumption 1, $\overline{\alpha}$, with (39) it can readily be established that $\overline{\alpha} > \widehat{\alpha}$ whenever $\gamma > 0$, whereas for $\gamma = 0$ they are equal, $\overline{\alpha} = \widehat{\alpha}$. This result leads to the following lemma:

Lemma 4 *For* $\gamma > 0$*, when trade costs are reduced by a negligible amount from their prohibitive levels, the welfare loss in transit dominates the pro-competitive gain from free trade. In the case where* $\gamma = 0$*, free trade always involves higher bilateral welfare than any positive tariff.*

In the simple two-country model it is easy to obtain an expression for the benefit from defection by evaluating (36) for $n = 2$. For country 1, this boils down to:[17]

$$B_1^D = W_1^D - W_1^{TA} = S_1(\tau_{12}^N, \alpha) - S_1(\tau_{12}^{TA}, \alpha) = \frac{1 - \alpha(2-\alpha)}{6\Gamma(0,\gamma)\Gamma(2,\gamma)}. \tag{40}$$

[16] This trade-off between pro-competition and trade diversion in the presence of trade costs was first established in Brander and Krugman (1983).

[17] Country 1's welfare can be found by evaluating (13) for $n = 2$ and $i = 1$.

It is similarly possible to derive an expression for the long-run costs of defection by setting $n = 2$ in (37):

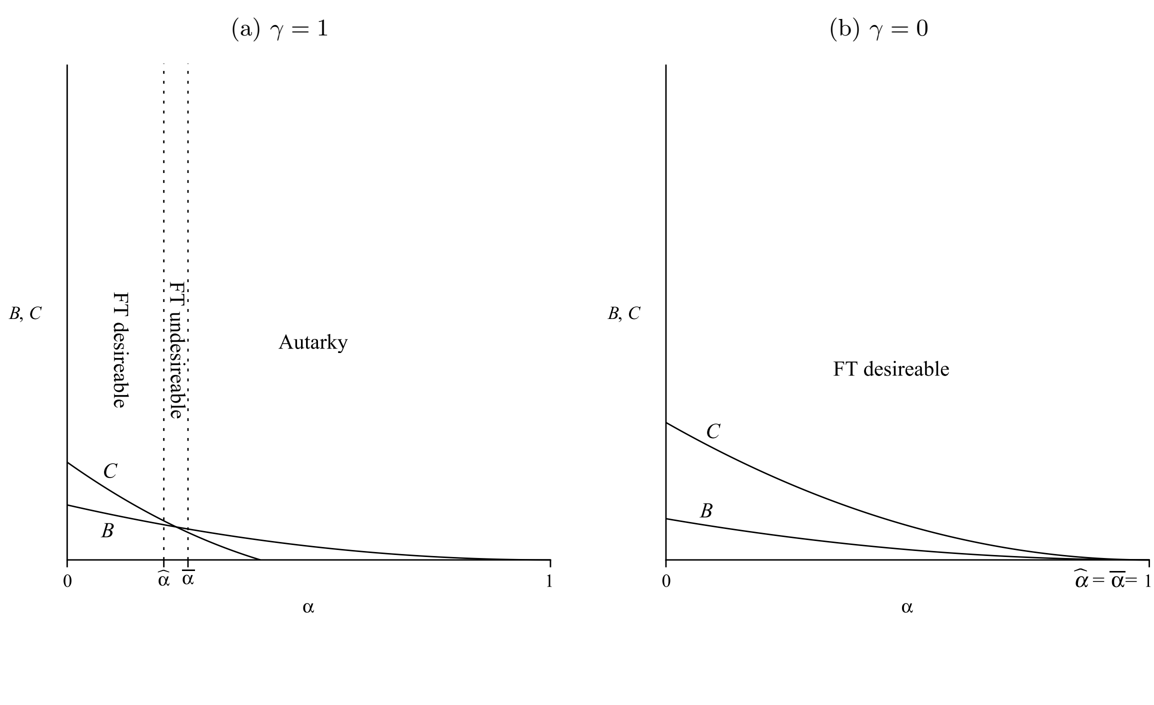
$$C_1^D = W_1^D - W_1^P = \pi_{21}(\tau_{21}^{TA}, \alpha) - \pi_{21}(\tau_{21}^{N}, \alpha) = \frac{5[1-\alpha(2-\alpha)] - 3\gamma(1-\alpha)}{[\Gamma(0,\gamma)\Gamma(2,\gamma)]^2}. \quad (41)$$

The relationship between the cost and benefits from defection and trade costs is established in the following proposition:

Proposition 1 *The benefit and cost of defection, respectively B_1^D and C_1^D, are decreasing in α but positive for any non-prohibitive trade cost.*

The intuition is that when trade costs decrease the natural distortion of consumer prices and profits is lower, making political trade costs more effective at doing the job. This implies that the unilateral incentive to deviate from an agreement increases. The cost of deviation also increases when α declines. This is because when trade cost decrease, the pro-competitive gains from free trade become greater relative to the losses in transit. Hence, the Nash equilibrium becomes less attractive relative to free trade as trade costs decrease. The fact that the benefit from deviation increases in response to falling trade costs makes the trade agreement less self-enforceable. However, since the cost of deviation also increases, this makes the trade agreement more self-enforceable. It is therefore necessary to analyse how the costs and benefits vary proportionally in response to changes in trade costs.

Figure 1: The costs and benefits of defection



In Figure 1, I depict the costs and benefits of defection for the two extreme cases in which $\gamma = 1$ and $\gamma = 0$, respectively, in panels (a) and (b). In panel (a) it is clear that several thresholds of trade costs need to be crossed before free trade is desirable and sustainable. First, as trade costs fall below the prohibitive level, the benefit from defection exceed the cost. In this case, the Nash equilibrium, where each country optimally exploits its market power over terms of trade and profits, is simply preferred to free trade. As trade costs fall further, the costs and benefits intersect. This critical level of trade costs that marks this intersection can be solved for from (40) and (41), such that there will be permissible discount factors to sustain free trade if and only if:

$$\alpha \leq \tilde{\alpha} \equiv \frac{28 - 24\gamma + 3\gamma^2}{28 + 3\gamma^2}. \tag{42}$$

As trade costs decline further below $\widehat{\alpha}$, free trade becomes desirable in addition to being sustainable for some discount factors. The ranking of the critical levels of trade cost is addressed in the following lemma:

Lemma 5 *For the case $\gamma > 0$, the critical level above which a trade agreement cannot be sustained due to the benefits exceeding the costs, $\tilde{\alpha}$, is smaller than the prohibitive level of trade costs, $\overline{\alpha}$, but greater than the level above which free trade is no longer the desired bilateral trade policy, $\widehat{\alpha}$. Hence, the critical level of trade costs have the following ranking, $\overline{\alpha} > \tilde{\alpha} > \widehat{\alpha}$. For the case where $\gamma = 0$, they are equal such that $\overline{\alpha} = \tilde{\alpha} = \widehat{\alpha} = 1$.*

As trade costs decline, the increase in the cost of defection will be proportionally greater than the benefit for $\gamma > 0$. The intuition for this is due to the trade-off between pro-competition and losses in transit: as trade costs decline, the pro-competitive gain from trade begins to dominate the losses in transit, thus increasing the cost of deviation proportionally more than the benefit. For $\gamma = 0$, this trade-off is absent, such that the cost and benefits of defection increase in the same proportion following decreases in trade costs. The critical discount factor above which a trade agreement is sustainable can be solved by diving the benefits of deviation in (40) by the costs in (41). This yields:

$$\delta_1^c = \frac{3(\Gamma(0,\gamma)\Gamma(2,\gamma)(1-\alpha)}{8(5(1-\alpha) - 3\gamma)} \tag{43}$$

Differentiating δ_1^c with respect to α:

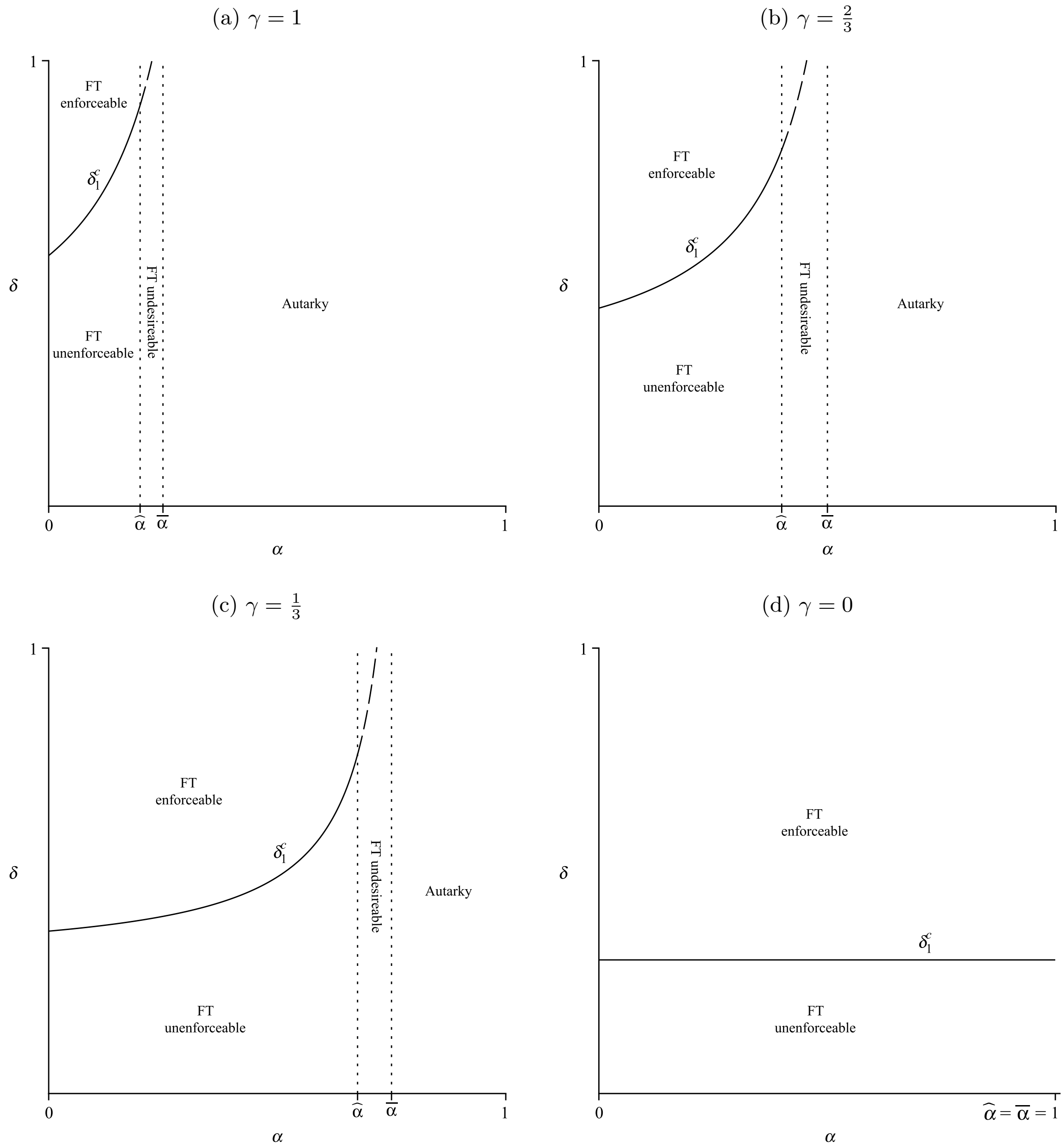
$$\frac{d\delta_1^c}{d\alpha} = \frac{9\gamma\Gamma(0,\gamma)\Gamma(2,\gamma)}{8(5(1-\alpha) - 3\gamma)^2} \geq 0. \tag{44}$$

On the basis of (44) I can state the following proposition.

Proposition 2 *For the case $\gamma > 0$, decreases in trade costs increase the self-enforceability of a trade agreement by lowering the critical discount factor above which a trade agreement can be sustained, $\frac{d\delta_1^c}{d\alpha} > 0$. However, when $\gamma = 0$, the critical discount factor is unaffected by trade costs, $\frac{d\delta_1^c}{d\alpha} = 0$.*

In Figure 2, I depict the relationship between the critical discount factor and trade costs for four different values of γ. In panel (a) where goods are homogeneous, the range of non-prohibitive trade costs is smaller since greater competition reduces the markups of the two firms. Free trade is enforceable and desirable for points in the diagram that satisfy: $\delta > \delta_1^c$ and $\alpha \in [0; \widehat{\alpha}]$. There is also a grey area in which free trade is enforceable but undesirable; This occurs for points where $\delta > \delta_1^c$ and $\alpha > \widehat{\alpha}$. This is the range where $\alpha \in [\widehat{\alpha}; \tilde{\alpha}]$. In this range the δ_1^c-line is dashed. It can be seen from (44) that the

Figure 2: The critical discount factors for different values of γ



relationship between δ_1^c and α becomes less steep when γ is lower. Taking the derivative of (44) with respect to γ yields,

$$\frac{d^2\delta_1^c(\alpha)}{d\alpha d\gamma} = \frac{3\left(20(1-\alpha) - 15\gamma^2(1-\alpha) + 12\gamma + 3\gamma^2\right)}{8\left(5(1-\alpha) - 3\gamma\right)^3} > 0.$$

This is also clear from Figure 2. When γ falls, free trade can be supported for a larger range of discount factors, and the relationship between trade costs and the critical discount factor is less steep for every value of α. The intuition is that when the competition between firms is less intense, the variety gains from trade are greater, implying that the pro-competition versus transit loss trade-off is less pronounced. This, in turn, means that free trade can be supported for a larger range of discount factors as well as a larger range of trade costs. The case $\gamma = 0$ is depicted in panel (d), where trade costs are irrelevant for the sustainability of a trade agreement. When the gains from trade arise exclusively from increased variety there is no trade-off between competition and losses in transit.

5 The full triangular model

This section augments the simple two-country model with a third country, call this country 3. For convenience, I assume that the three countries are located on the corners of an isosceles triangle, with country 3 being farthest away in terms of trade costs but equidistant from its two trading partners. The purpose of the model is to examine how natural trade barriers affect the incentives of the three countries to engage in cooperative trade policy, whether this takes the form of global free trade or a regional PTA. I assume that the trade costs between the two close partners are $\alpha_{12} = \alpha_{21} = \alpha^{ir}$ where the superscript *ir* stands for *intra-regional.* The trade cost between country 3 and 1, and that between country 3 and 2 are equal and given as $\alpha_{31} = \alpha_{13} = \alpha_{32} = \alpha_{23} = \alpha^{er}$ where the superscript *er* stands for *extra-regional.* For convenience I assume that intra-regional trade costs are zero, $\alpha^{ir} = 0$.

With the additional structure of three countries, the Nash tariffs differ across countries. Due to symmetry of trade costs between country 1 and country 2, and the fact that they face the same extra-regional trade costs, the Nash tariffs which country 1 and 2 impose on each other are identical as are the tariffs they impose on the third country in equilibrium. Country 3 faces the same trade costs regardless of its export destination, and so it will impose the same tariff on its two trading partners. All Nash tariffs can be found from (15), and the exact expressions are produced in Appendix E. The external tariffs imposed by any pair of countries forming a preferential trade agreement are also produced in the same appendix for $n = 3$ and $k = 2$.

It is possible that natural trade costs are so high that import tariffs prohibit trade in the non-numéraire goods between the two geographically close countries and country 3. However, since the two close countries impose different tariffs on country 3 than country 3 imposes on them, the critical level of α^{er} which prohibits exports of the non-numéraire goods from the region to the outsider is different from the critical level of α^{er} which prohibits exports of the non-numéraire good from the outsider to the region. Denote by $\overline{\alpha}^{er}_{r3}$, where $r = 1, 2$ is any of the two countries inside the region, the critical level of trade costs below which country 3's non-numéraire export flows to the region, that is q_{13} and q_{23}, are positive, and denote by $\overline{\alpha}^{er}_{3r}$ the critical levels of trade costs below which the non-numéraire export flows to the outsider, that is q_{31} and q_{32}, are positive. The critical levels can be solved as:

$$\overline{\alpha}^{er}_{r3} \equiv \frac{\Psi(1,\gamma)[\Gamma(0,\gamma)+1]}{3\Gamma(0,\gamma)\Gamma(2,\gamma)} = \frac{(4-3\gamma)(3-\gamma)}{3(4-\gamma^2)}; \tag{45}$$

$$\overline{\alpha}^{er}_{3r} \equiv \frac{\Psi(1,\gamma)}{\Gamma(1,\gamma)^2} = 1 - \frac{3}{4}\gamma = 1 - \frac{3}{4}\gamma. \tag{46}$$

In the following lemma, I state this formally:

Lemma 6 *If and only if* $\alpha < \overline{\alpha}^{er}_{r3} \equiv \frac{\Psi(1,\gamma)[\Gamma(0,\gamma)+1]}{3\Gamma(0,\gamma)\Gamma(2,\gamma)}$, *there exists unique and non-prohibitive tariffs (unilaterally optimal Nash tariff, optimal external FTA tariff or optimal external CU tariff) imposed* *by country $r = 1, 2$ on imports of the non-numéraire goods from country 3. Further, if and only if $\alpha < \overline{\alpha}_{3r}^{er} \equiv \frac{\Psi(1,\gamma)}{\Gamma(1,\gamma)^2}$, there exists a unique and non-prohibitive Nash tariff imposed by country 3 on imports from country $r = 1, 2$.*

Proof. See Appendix E ■

From inspection of (45) and (46), it is clear that $\overline{\alpha}_{r3}^{er} \leq \overline{\alpha}_{3r}^{er}$. Exports to the region are prohibitive at a lower level of trade costs for $\gamma > 0$, since consumers in country 1 and 2 are able to substitute for goods produced inside the region at a lower trade cost. In the event that trade costs take a value between the two thresholds, $\overline{\alpha}_{r3}^{er}$ and $\overline{\alpha}_{3r}^{er}$, the two countries inside the region will trade non-numéraire goods in exchange for units of the numéraire good from country 3. Trade costs above the threshold $\overline{\alpha}_{3r}^{er}$ correspond to autarky. When $\gamma = 0$ substitution cannot occur and the two critical thresholds are equal. In this paper, I restrict attention to situations with trade of the non-numéraire goods in both directions, and hence, the following assumption is made:

Assumption 2 $\alpha < \overline{\alpha}_{r3}^{er} \equiv \frac{\Psi(1,\gamma)[\Gamma(0,\gamma)+1]}{3\Gamma(0,\gamma)\Gamma(2,\gamma)} = \frac{(4-3\gamma)(3-\gamma)}{3(4-\gamma^2)}$.

Due to the trade-off between pro-competition and losses in transit, it will not necessarily be the case that it is in the three countries' long term interest to abolish political trade barriers between the region and the outsider. As in the two-country model, it is possible to derive critical levels of natural trade costs below which free trade raises welfare relative to positive import tariffs. However, those levels are different for a country inside the region relative to the outsider. Denote by $\widehat{\alpha}_3^{er}$ the critical level of trade costs below which free trade raises welfare for the outsider relative to a positive import tariff. This critical level can be solved as:

$$\widehat{\alpha}_3^{er} \equiv \frac{\Gamma(0,\gamma)^2}{\Gamma(1,\gamma)[\Gamma(3,\gamma)+\gamma^2]} = \frac{1}{2}\left[\frac{4-4\gamma+\gamma^2}{2+2\gamma+\gamma^2}\right] \tag{47}$$

It is slightly more complicated to solve this for an insider, since such a country may derive a higher welfare from signing a PTA with the other insider and leaving country 3 out. The question is: under what circumstances would it raise country r's welfare to include the more distant country in a trade agreement? The critical level of trade costs for an insider below which welfare can be raised by including country 3 in a trade agreement relative to imposing a positive import tariff can be solved as:

$$\widehat{\alpha}_r^{er} \equiv \frac{\Gamma(0,\gamma)^2}{\Gamma(1,\gamma)[1-\gamma]+\gamma^2} = \frac{4-4\gamma+\gamma^2}{2-2\gamma+\gamma^2} \tag{48}$$

The fact that intra-regional trade costs are assumed to be zero implies that it always raises welfare for one inside country to sign a preferential trade agreement with the other. In addition, if $\alpha < \widehat{\alpha}_r^{er}$ it would raise welfare for the insiders to include country 3 in an agreement. The following lemma formalises these critical trade costs:

Lemma 7 *If and only if $\alpha < \widehat{\alpha}_3^{er} \equiv \frac{\Gamma(0,\gamma)^2}{\Gamma(1,\gamma)[\Gamma(3,\gamma)+\gamma^2]}$, global free trade improves welfare for country 3. Further, if and only if $\alpha < \widehat{\alpha}_r^{er} \equiv \frac{\Gamma(0,\gamma)^2}{\Gamma(1,\gamma)[1-\gamma]+\gamma^2}$, it improves welfare for any of the two insiders to include country 3 in a global free trade agreement.*

Proof. See Appendix E ■

It is clear from (47) and (48) that global free trade raises welfare for an insider for a larger range of natural trade costs, $\widehat{\alpha}_3 < \widehat{\alpha}_r$ for $\gamma > 0$. This is not surprising; free trade entails larger benefits for an insider since it is able to trade with its other inside partner at lower trade costs under global free trade. When $\gamma = 0$ the two thresholds are equal; in this case, it always raises welfare to include country 3 in an agreement for every non-prohibitive trade cost, and likewise it always raises welfare for country 3 to be part of a global trade agreement.

Each country has three options: (i) to remain in the Nash equilibrium, (ii) to sign a preferential trade agreement, or (iii) to sign a global free trade agreement. In this paper I allow two types of preferential trade agreements, a Free Trade Agreement (FTA) and a Customs Union (CU). The next two subsections will carry out a welfare analysis of these two types.

5.1 The sustainability of a Free Trade Agreement versus global free trade

In order to determine the sustainability of preferential FTAs, it is necessary to examine whether such an agreement can occur in the presence of an alternative such as global free trade. The analysis of global free trade, however, poses further challenges since in this three country model; following deviation by one country, it is not clear what happens to the two remaining trading partners. In this paper I consider two scenarios. In the first, deviation by one country implies contagion such that in the following period all countries return to the Nash equilibrium. In the second scenario the two countries that did not deviate continue as a preferential trade agreement, leaving the defecting country out. I consider each scenario in turn.

5.1.1 Contagion

To evaluate the sustainability of global free trade there are two constraints to consider: the critical discount factor required for any of the insiders to participate, and that which is required for country 3. Denote by $\delta_r^{GFT,C}$ the critical discount required to sustain global free trade for an insider, such that global free trade is incentive-compatible for an insider if and only if:

$$\begin{aligned}\delta_r \geq \delta_r^{GFT,C} &\equiv \frac{W_r^D - W_r^{FTA}}{W_r^D - W_r^N} \\ &= \frac{\sum_{j=1}^3 S_r(T_r^N, A_r, \tau_{rj}^N, \alpha_{rj}) - \sum_{j=1}^3 S_r(T_r^{FT}, A_r, \tau_{rj}^{FT}, \alpha_{rj})}{\sum_{\substack{j=1\\ j\neq r}}^3 \pi_{jr}(T_j^{FT}, A_j, \tau_{jr}^{FT}, \alpha_{jr}) - \sum_{\substack{j=1\\ j\neq r}}^3 \pi_{jr}(T_j^N, \tau_{jr}^N, \alpha_{jr})}, \quad r = 1, 2. \end{aligned} \tag{49}$$

GFT stands for global free trade, and C is for contagion. Similarly, global free trade is incentive-compatible for country 3 if and only if:

$$\begin{aligned}\delta_3 \geq \delta_3^{GFT,C} &\equiv \frac{W_3^D - W_3^{FTA}}{W_3^D - W_3^P} \\ &= \frac{\sum_{j=1}^3 S_3(T_3^N, A_3, \tau_{3j}^N, \alpha_{3j}) - \sum_{j=1}^3 S_3(T_3^{FT}, A_3, \tau_{3j}^{FT}, \alpha_{3j})}{\sum_{j=1}^2 \pi_{j3}(T_j^{FT}, A_j, \tau_{j3}^{FT}, \alpha_{j3}) - \sum_{j=1}^2 \pi_{j3}(T_j^N, \tau_{j3}^N, \alpha_{j3})}. \end{aligned} \tag{50}$$

The relative magnitudes of these two critical values is established in the following lemma:

Lemma 8 *For the case $\gamma > 0$ and $\alpha^{er} > 0$, the critical discount factor required to sustain global free trade for the outsider is strictly greater than that for an insider, $\delta_3^{GFT,C} > \delta_r^{GFT,C}$, $r = 1, 2$. For the case where either $\gamma = 0$ or $\alpha^{er} = 0$ they are equal, $\delta_3^{GFT,C} = \delta_r^{GFT,C}$, $r = 1, 2$.*
Proof. See Appendix E ■

This lemma is not surprising since, if $\alpha^{er} > 0$ the inside countries are facing lower average trade costs with respect to their trading partners, and hence, their benefit of global free trade are higher and their cost lower, permitting a larger range of discount factors to sustain free trade. If goods are independent of each other, however, the two proximate countries are unable to substitute for goods inside the region, and hence, the discount factors coincide. The implication of the lemma is that the relevant constraint for the sustainability of global free trade is that facing the outside country, namely $\delta_3^{GFT,C}$. Hence, country 3 is pivotal to global free trade.[18]

I next examine the sustainability of a preferential trade agreement. There are two ways for such an agreements to occur: (i) the two insiders sign a trade agreement, leaving country 3 out, or (ii) the distant country signs a preferential trade agreement with one of the insiders, leaving the other out. To conserve space, I do not formally analyse the second case. It is possible to prove that for country 3, the critical discount required to sustain a FTA with an insider is greater than or equal to that required to sustain global free trade.[19] Hence, if global free trade fails to be an equilibrium, so does a preferential FTA between country 3 and any of the insiders. It is therefore only necessary to compare the sustainability of a preferential FTA between the geographically proximate countries to that of global free trade.

The critical discount factor above which a preferential FTA between the close partners is sustainable can be found by setting $n = 3$ and $k = 2$ in (36) and (37) and plugging into (35). An exclusive FTA between countries 1 and 2 is incentive-compatible if and only if:

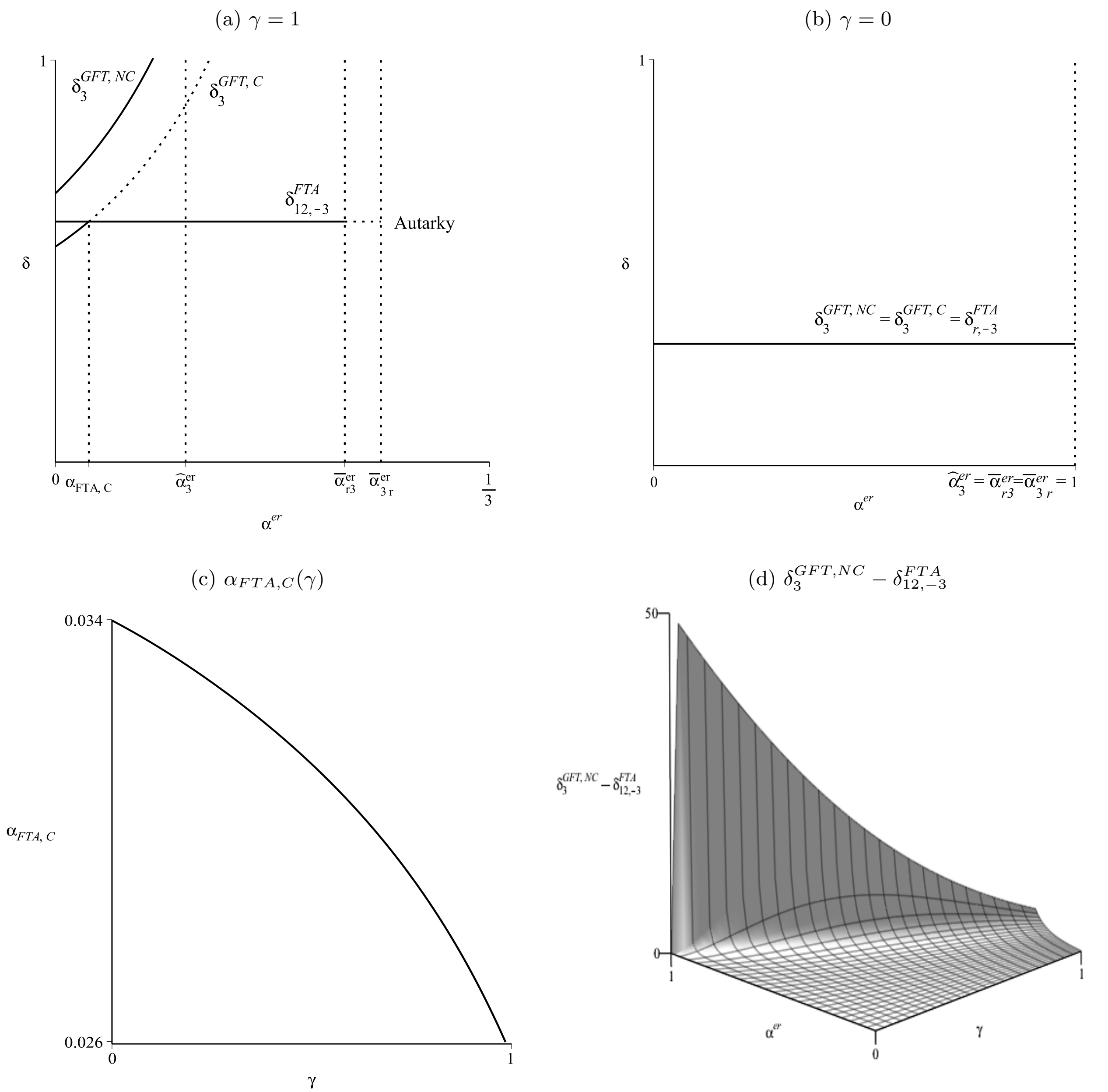
$$\delta \geq \delta_{12,-3}^{FTA} \equiv \frac{\sum_{j=1}^{3} S_1(T_1^N, \tau_{1j}^N, \alpha^{er}) - \sum_{j=1}^{3} S_1(T_1^{FTA}, \tau_{1j}^{FTA}, \alpha^{er})}{\pi_{21}(T_2^{FTA}, \alpha^{er}) - \pi_{21}(T_2^N, \tau_{21}^N \alpha^{er})}, \tag{51}$$

and by symmetry this is equal to $\delta_{21,-3}^{FTA}$. In Figure 3, I plot these critical values as a function of trade costs. Where defection implies contagion, global free trade is enforceable anywhere above the $\delta_3^{GFT,C}$-line, and the two extreme cases of perfect substitutes ($\gamma = 1$) and independent goods ($\gamma = 0$) are drawn in, respectively, panels (a) and (b). As in the two-country case, for $\gamma = 1$ there are ranges of non-prohibitive trade costs and discount factors for which global free trade is not desirable nor enforceable, namely points below $\delta_3^{GFT,C}$ and to the right of $\widehat{\alpha}_3^{er}$. There is also an area of the graph where global free trade is enforceable but undesirable, points above $\delta_3^{GFT,C}$ and to the right of $\widehat{\alpha}_3^{er}$. Points above $\delta_3^{GFT,C}$ and to the left of $\widehat{\alpha}_3^{er}$ represent areas for which global free trade is enforceable and desirable. For the contagion case, there is also an area for which global free trade is desirable but unenforceable,

[18] Lemma 8 relies on Assumption 2 and $\gamma \in [0; 1]$. If any of these constraints are relaxed the lemma may not hold. For example, for $\overline{\alpha}_{r3}^{er} < \alpha < \overline{\alpha}_{3r}^{er}$, exports to the insiders are prohibited by Nash tariffs. Country 3 may then not be the pivotal country. Moreover, if goods are strategic complements, $\gamma \in [-1; 0]$, the benefit on the part of any of the insiders from including the distant country in a global trade agreement is substantially higher, to the point where the insiders may become pivotal to global free trade.

[19] A formal proof is available from the author upon request.

Figure 3: The critical discount factors for different values of γ



anywhere below $\delta_3^{GFT,C}$ and above $\delta_{12,-3}^{FTA}$. In this area, a FTA between country 1 and country 2 occurs, even though it would raise world welfare to include country 3: this contradicts the notion of natural trading blocs. There is also a range of trade costs and discount factors for which global free trade is more sustainable than a preferential FTA, namely anywhere below $\delta_{12,-3}^{FTA}$ and above $\delta_3^{GFT,C}$. This is because for very low extra-regional trade costs a preferential agreement diverts trade away from the 'not so distant' country 3. Notice from Figure 3a that at some critical level of trade costs, $\alpha_{FTA,C}$, the discount factors $\delta_3^{GFT,C}$ and $\delta_{12,-3}^{FTA}$ intersect. Anywhere to the right of that intersection there is scope for regionalism since there are ranges of discount factors where global free trade is unsustainable, but where an FTA between the proximate countries can be sustained. Anywhere to the left of this intersection, there is no scope for a PTA if deviation does not imply contagion, since if global free trade can be sustained ($\delta > \delta_3^{GFT,C}$) it is also desirable ($\alpha_{FTA,C} < \widehat{\alpha}_3^{er}$). This is not so when $\gamma = 0$; in this case the critical discount factors coincide, $\delta_3^{GFT,C} = \delta_{12,-3}^{FTA}$, and any agreement which is enforceable is also desirable ($\widehat{\alpha}_3^{er} = \overline{\alpha}_{r3}^{er}$), see Figure 3b. In panel (c) of Figure 3, I graph the relationship between $\alpha_{FTA,C}$ and γ. On the basis of the relationship depicted in this figure, the following proposition is stated:

Proposition 3 *The critical level of trade costs, $\alpha_{FTA,C}$, above which there is scope for regionalism is decreasing in γ, $\frac{\alpha_{FTA,C}}{d\gamma} < 0$.*

The implication of this proposition is that when products are more differentiated, and when the gains from trade to a larger extent are variety-driven, there is a larger range of extra-regional trade costs between 0 and $\alpha_{FTA,C}$ for which there is no scope for regionalism. In the special case where $\gamma = 0$ there is no scope for regionalism as any type of trade agreement, whether preferential or global, are equally sustainable. In this case global free trade is desirable and if the world is patient enough, this will occur in equilibrium. When variety increases, the critical discount factors $\delta_3^{GFT,C}$ and $\delta_{12,-3}^{FTA}$ shift downwards. This is established in the following proposition:

Proposition 4 *For every non-prohibitive level of extra-regional trade costs, $\frac{d\delta_3^{GFT,C}(\alpha^{er},\gamma)}{d\gamma} > 0$ and $\frac{d\delta_{12,-3}^{FTA}(\alpha^{er},\gamma)}{d\gamma} > 0$.*

Proof. *See Appendix E* ■

The implication of this proposition is that when defection implies contagion, more variety (a decrease in γ) increases the range of discount factors which can sustain free trade. Notice, however, from Figure 3a, the critical discount factor for the sustainability of global free trade, $\delta_3^{GFT,C}$, is a dotted line anywhere above the $\delta_{12,-3}^{FTA}$-line. This is because for every point on that line above $\delta_{12,-3}^{FTA}$, a preferential FTA between countries 1 and 2 can be sustained, such that deviation by country 3 from global free trade does not imply contagion. This case is considered next.

5.1.2 No contagion

With no contagion, deviation by country 3 from global free trade will be followed by a preferential FTA between the two proximate countries. This does not alter the sustainability of a preferential FTA for a given value of γ in this three-country framework but it will alter the incentive-compatibility of the pivotal country 3 in a global FTA.[20] Without contagion, global free trade is incentive-compatible if and only if:

$$\delta \geq \delta_3^{GFT,NC} \equiv \frac{S_3(\tau_{31}^N, \tau_{32}^N, \alpha^{er}) - S_3(\tau_{31}^{FT}, \tau_{32}^{FT}, \alpha^{er})}{\pi_{13}(\tau_{13}^{FT}, \alpha^{er}) + \pi_{23}(\tau_{23}^{FT}, \alpha^{er}) - \pi_{13}(\tau_{13}^{FTA}, \alpha^{er}) - \pi_{23}(\tau_{23}^{FTA}, \alpha^{er})}. \tag{52}$$

[20]Since the possibility of a preferential FTA between the distant country and one of the insiders is ruled out, country 3 will be pivotal to global free trade also for the case of no contagion.

There is only one difference between (50) and (52), which is that country 3 is punished by the optimal external FTA tariff, that is τ^{FTA}, rather than the Nash tariff. In lemma 1, I proved that the common external tariff chosen by member countries in a FTA is weakly less than the Nash tariffs as set by countries individually due to the well-known tariff complementarity effect whereby each member compensates for the trade-diverting effects of the FTA by reducing tariffs on outsiders. Hence, for the case without contagion, country 3's punishment of defection is lower for every trade cost. The next proposition establishes the relationship between the sustainability of global free trade relative to a preferential FTA:

Proposition 5 *For $\gamma > 0$ and with no contagion, the critical discount factor which sustains global free trade for the pivotal country 3 is strictly above that which sustains a preferential FTA between country 1 and country 2 for every non-prohibitive trade cost, $\delta_3^{GFT,NC} > \delta_{12,-3}^{FTA}$. For the case $\gamma = 0$ they are equal, $\delta_3^{GFT,NC} = \delta_{12,-3}^{FTA}$.*
Proof. See Appendix E ■

The implication of this proposition is that without contagion there is scope for regionalism for every level of trade costs. This finding is depicted in Figure 3. Where $\gamma = 1$, $\delta_3^{GFT,NC}$ is strictly above $\delta_{12,-3}^{FTA}$ in panel (a) whereas in panel (b) for $\gamma = 0$, all critical discount factors are the same. The exact nature of the difference between $\delta_3^{GFT,NC}$ and $\delta_{12,-3}^{FTA}$ is depicted in 3-dimensional space in Figure 3d. This leads to the rather dismal conclusion that when deviation from global free trade does not lead to contagion, there is even greater scope for regionalism, even when global free trade can improve global welfare ($\alpha^{er} < \widehat{\alpha}_3^{er}$).

Anywhere below $\delta_{12,-3}^{FTA}$, the boundaries for the sustainability of global free trade lie within $0 \leq \alpha \leq \alpha_{FTA,C}$ and $\delta_3^{GFT,C} \leq \delta \leq \delta_{12,-3}^{FTA}$. Anywhere above $\delta_{12,-3}^{FTA}$, the lower boundary is defined by $\delta_3^{GFT,NC}$. When γ decreases, all of the critical discount factors, $\delta_3^{GFT,C}$, $\delta_3^{GFT,NC}$ and $\delta_{12,-3}^{FTA}$ decrease, and $\alpha_{FTA,C}$ increases. In the case where defection from global free trade does not imply contagion, increases in variety (decreases in γ), shifts the $\delta_3^{GFT,NC}$ curve downwards for every value of trade costs. This is established in the following proposition:

Proposition 6 *For every non-prohibitive level of extra-regional trade costs, $\frac{d\delta_3^{GFT,NC}(\alpha^{er},\gamma)}{d\gamma} > 0$.*
Proof. See Appendix E ■

The Implication of this proposition is that the range of discount factors which can sustain global free trade is increasing with greater variety when defection does not imply contagion.

Analysed separately, the two cases of "contagion" and "no contagion", respectively, leads to the unambiguous conclusion that increases in product variety increases the scope for global free trade for a given value of a common world discount factor, and a given value of extra-regional trade cost. However, putting these together, it is necessary to include the cut-off level of the discount factor that determines whether deviation by country 3 implies contagion or not, that is $\delta_{12,-3}^{FTA}$. There may be ranges of discount factors and trade costs for which greater variety actually induces regionalism. Assume, for example, that the common world discount factor, denote this δ^W, lies in the range $\delta^W \in [\delta_3^{GFT,C}; \delta_{12,-3}^{FTA}]$ and trade costs lie in the range $\alpha^{er} \in [0; \alpha_{FTA,C}]$. In this case, global free trade can be sustained whereas a regional FTA between countries 1 and 2 cannot. Increases in product variety will reduce all three discount factors, that is $\delta_{12,-3}^{FTA}$, $\delta_3^{GFT,C}$ and $\delta_3^{GFT,NC}$, for a fixed level of trade costs. Hence, it may be that following a decrease in γ, $\delta_{12,-3}^{FTA}$ falls below δ^W, prompting country 3 to take advantage, in the short run, of the lower external tariffs of the FTA. Thus, the overall conclusion from the analysis of FTAs is that while there is less scope for global free trade in the extreme case of $\gamma = 1$ relative to the other extreme of $\gamma = 0$, there may be intermediate values of γ for which non-monotonicities in the relationship between variety and global free trade occur.

5.2 The sustainability of a Customs Union

In Customs Unions (CU), member countries set a common external tariff on imports from outside. In so doing they coordinate their internal terms-of-trade and profit shifting effects, and together they exert a larger market power on the outsider. Also, in this case it is necessary to assess whether a customs union can occur in the presence of an alternative such as global free trade. In the case of contagion, the critical discount factors for sustaining a global free trade agreement for any of the two close trading partners and for the distant country are the same as in (49) and (50). In the no contagion case, however, the fact that the non-deviating countries would remain as a customs union rather than a free trade agreement has important implications for the incentives to cooperate. Consider this from the point of view of the outsider. Global free trade is incentive-compatible when the alternative to global free trade is a CU if and only if:

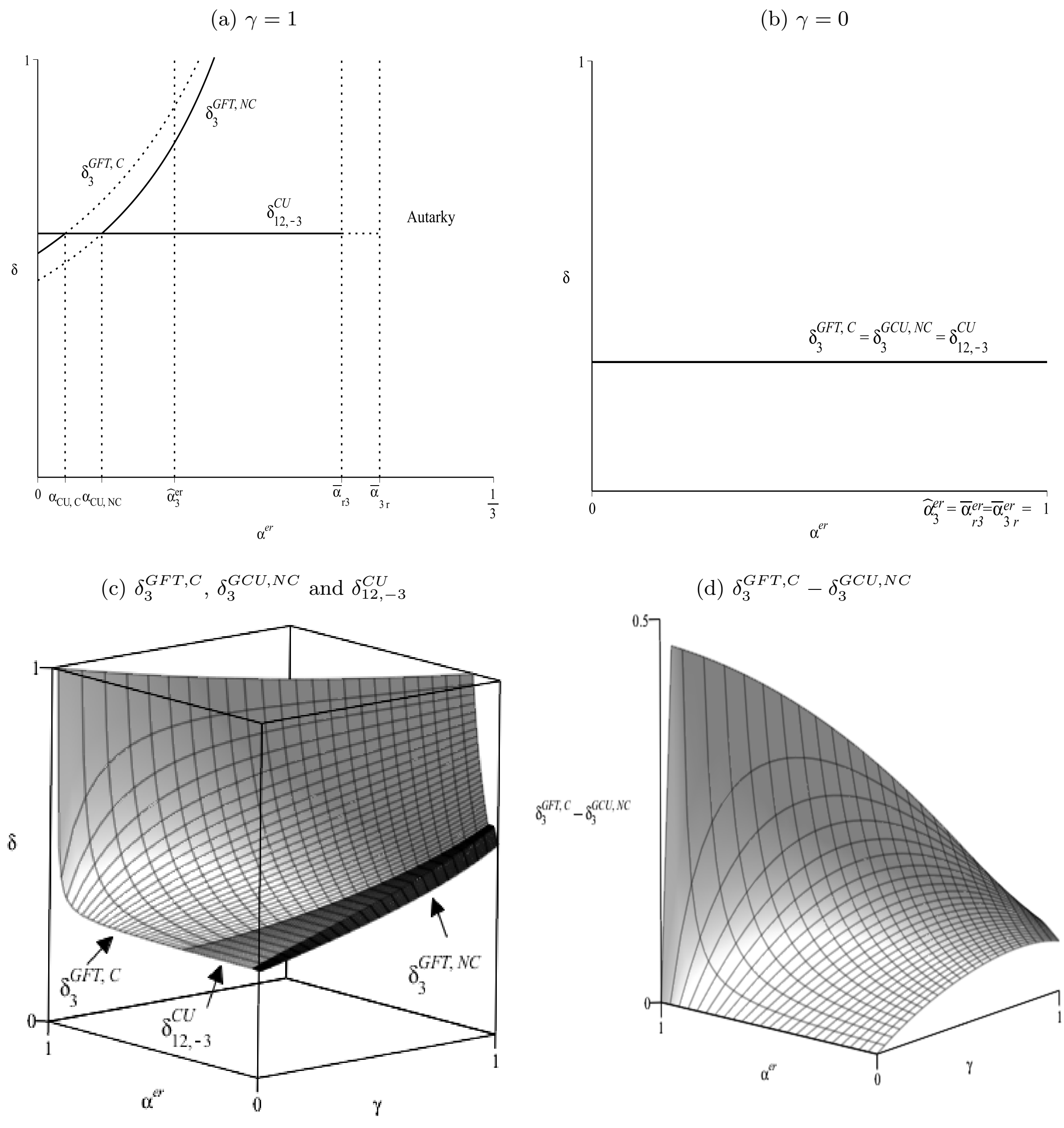
$$\delta \geq \delta_3^{GCU,NC} \equiv \frac{S_3(\tau_{31}^N, \tau_{32}^N, \alpha^{er}) - S_3(\tau_{31}^{FT}, \tau_{32}^{FT}, \alpha^{er})}{\pi_{13}(\tau_{13}^{FT}, \alpha^{er}) + \pi_{23}(\tau_{23}^{FT}, \alpha^{er}) - \pi_{13}(\tau_{13}^{CU}, \alpha^{er}) - \pi_{23}(\tau_{23}^{CU}, \alpha^{er})}. \tag{53}$$

Notice that the numerator of this expression is the same as in (52) but the denominator depends on the optimal external CU tariff rather than the optimal FTA tariff. This implies that the punishment of deviation is substantially larger than if the two non-defecting countries had punished the defecting nation by the FTA tariff. The punishment for the outsider when country 1 and country 2 impose external CU tariffs is also harsher than if they had applied their individually optimal Nash tariffs due to the internal coordination of a CU. Hence, while the benefit of deviation remains unchanged the costs are higher. The critical discount factor above which a CU between the close partners is sustainable can be found by setting $n = 3$ and $k = 2$ in (36) and (37) and plugging into (35). A preferential CU is incentive-compatible if and only if:

$$\delta \geq \delta_{12,-3}^{CU} \equiv \frac{\sum_{j=1}^{3} S_1(T_1^N, \tau_{1j}^N, \alpha^{er}) - \sum_{j=1}^{3} S_1(T_1^{FTA}, \tau_{1j}^{FTA}, \alpha^{er})}{\pi_{21}(T_2^{CU}, \alpha^{er}) - \pi_{21}(T_2^N, \tau_{21}^N \alpha^{er})}, \tag{54}$$

In Figure 4, I depict the critical discount factors for the sustainability of global free trade and of a preferential CU. Panel (a) depicts the case where goods are perfect substitutes ($\gamma = 1$). For the range of trade costs $\alpha^{er} \in [0 : \alpha_{CU,C}]$ and below $\delta_{12,-3}^{CU}$, the relevant constraint is $\delta_3^{GFT,C}$ for sustaining global free trade. As α^{er} exceeds a critical threshold, $\alpha_{CU,C}$, however, the critical discount factor $\delta_3^{GFT,C}$ intersects $\delta_{12,-3}$. Anywhere above $\delta_{12,-3}$, $\delta_3^{GFT,C}$ is no longer the relevant lower boundary for the sustainability of global free trade. In fact, in the range $\alpha^{er} \in [\alpha_{CU,C} : \alpha_{CU,NC}]$, the relevant constraint is $\delta_{12,-3}$, and above $\alpha_{CU,NC}$, it is $\delta_3^{GFT,NC}$. There are ranges of discount factors and trade costs for which global free trade cannot be sustained although it would improve world welfare. This occurs in the range $\alpha^{er} \in [\alpha_{CU,NC} : \widehat{\alpha}_3^{er}]$, if the common world discount factor is between $\delta_3^{GFT,NC}$ and $\delta_{12,-3}^{CU}$. In the other extreme case where $\gamma = 0$, which is depicted in panel (b) of Figure 4, all three critical

Figure 4: The critical discount factors for different values of γ



(a) $\gamma = 1$ (b) $\gamma = 0$ (c) $\delta_3^{GFT,C}$, $\delta_3^{GCU,NC}$ and $\delta_{12,-3}^{CU}$ (d) $\delta_3^{GFT,C} - \delta_3^{GCU,NC}$

discount factors coincide, such that there is no scope for regionalism when goods are independent of each other.

The relationship between product variety and the scope for global free trade when the alternative is an exclusive CU is monotonic, as opposed to the case in the previous subsection that considered an exclusive FTA as an alternative to free trade. The case where deviation implies contagion always represents a tougher punishment for country 3 if it chooses to deviate from global free trade. Because of this $\delta_3^{GCU,NC}$ always lies below $\delta_3^{GFT,C}$. The difference between the two discount factors is depicted in three-dimensional space in panel (d) of Figure 4. Greater variety decreases all discount factors that define the boundaries for global free trade, $\delta_3^{GFT,C}$, δ_3^{GCU} and $\delta_{12,-3}$, in the relevant ranges of trade costs, such that for a given common world discount factor and for a given extra-regional trade cost, greater variety unambiguously increases the scope for global free trade relative to a preferential CU. This is established in the following proposition:

Proposition 7 $\frac{d\delta_3^{GFT,C}(\alpha^{er},\gamma)}{d\gamma} > 0$, $\frac{d\delta_3^{GCU,NC}(\alpha^{er},\gamma)}{d\gamma} > 0$ *and* $\frac{d\delta_{12,-3}^{CU}(\alpha^{er},\gamma)}{d\gamma} > 0$, *for every non-prohibitive level of extra-regional trade costs.*
Proof. *See Appendix E* ■

In panel (c) of Figure 4, I depict the boundaries for the sustainability of global free trade for all α^{er} and γ.[21]

5.3 Comparing FTAs and CUs

The scope for sustaining global free trade when the alternative is a CU is always greater than or equal to the scope for global free trade when the alternative is a FTA. The boundary for the sustainability of global free trade when deviation implies contagion is given by $\delta_3^{GFT,C}$ whereas when deviation implies no contagion they are given by $\delta_3^{GFT,NC}$ and $\delta_3^{GCU,NC}$, respectively, for a FTA- and a CU-alternative. In the no contagion case, a larger range of parameter values can support free trade when the alternative to free trade is a CU.

6 Extensions

The model presented in this paper can be extended in several interesting ways. First, the variety parameter γ has been restricted to take values between 0 and 1. Allowing goods to be complements such that $\gamma \in]-1:0[$ would actually reverse the results of this paper. In fact, PTAs would become anti-regional in nature. This is because if distant trade partners trade goods that complement domestic ones, abolishing political barriers with distant rather than close trading partners have much larger welfare benefits to the domestic economy.

Second, while the present model assumes quantity competition, it is not difficult to derive all of its results in price competition. Since price competition is a fiercer form of competition, however, this presents some challenges. For example, price competition reduces the range of non-prohibitive trade costs. In the special case of homogeneous goods ($\gamma = 1$), the permitted range of trade costs is zero. For positive trade costs, importers will not be able to compete and any positive trade costs (whether natural or political) will eliminate trade, in which case it does not make sense to study regionalism. For the general case where $\gamma < 1$, the permitted range of trade costs is positive but smaller than

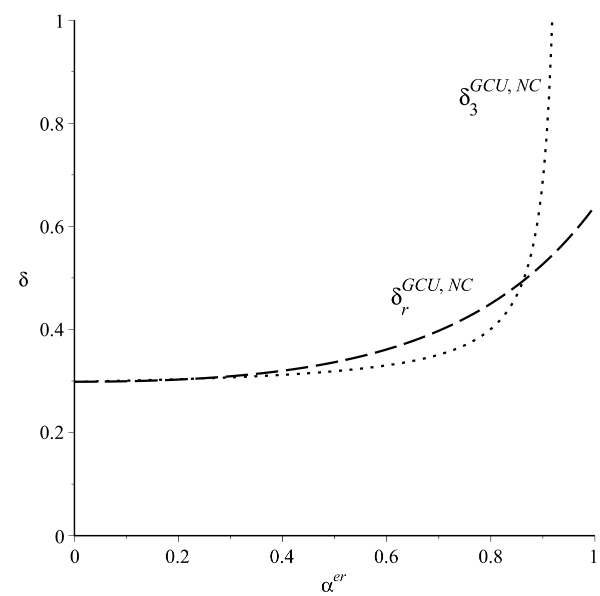
[21] $\delta_3^{GFT,C}$ is drawn in the range $\alpha \in [0 : \alpha_{CU,C}]$, $\delta_{12,-3}^{CU}$ for $\alpha \in [\alpha_{CU,C} : \alpha_{CU,NC}]$, and $\delta_3^{GFT,NC}$ in the remaining range.

that permitted under quantity competition. Price competition, however, does not alter the general conclusion that there is greater scope for free trade when variety increases.

Third, the present model assumes iceberg trade costs. The driving force behind the finding on regionalism is that the economy endures welfare-reducing transit losses, and these welfare reductions outweigh the pro-competitive benefits from free trade when trade costs are high. Things might change, however, if the revenue from transportation was earned by a specific transport sector, or if the revenue was simply distributed back to consumers in a lump sum fashion. While the results from such an extension are not derived in this paper, one could easily speculate on what might happen. If the revenue from transport is distributed unevenly between the two countries, the country that earns the higher revenue would be more likely to favour the agreement. However, assuming that each country earns all transport revenue from either exporting or importing to or from the foreign trading partner, that is, a more equal distribution, this might have the effect of increasing the benefit of including more distant countries in an agreement without necessarily affecting the general result that agreements have scope for regionalism. How product variety might affect the scope for global free trade versus regionalism in the presence of non-iceberg costs, however, is beyond the scope of the present paper.

Fourth, the present paper has only considered grim trigger strategies to deter deviation from agreements. This is a simplification, and a large variety of commitment devices could be analysed. It cannot be excluded that some of these strategies may actually overturn the findings of this paper. However, the fundamental aspect of the current oligopolistic model, namely that free trade is not in any country's long term interest if trade costs are close to prohibitive for $\gamma > 0$ would hold regardless of the commitment device. Trade agreements, thus, are most likely to have scope for regionalism under any commitment device.

Figure 5: $\delta_3^{GCU,NC}$ and $\delta_r^{GCU,NC}$, where $r = 1, 2$ and $\gamma = 0.05$



Fifth, the present paper has assumed away the possibility of a trade agreement between the distant country and one of the proximate countries. In the case where the alternative to global free trade is a preferential FTA such as in Section 5.1, this will not change the analysis because when it comes to global free trade, the distant country 3 is pivotal. Also the discount factor required to sustain a preferential FTA between country 3 and any of the other two countries is larger than any other discount factor, such that if global free trade cannot be sustained, then neither can such a preferential agreement. When the analysis turns to trade integration in the presence of CUs, however, things change under some circumstances. In fact, it can be shown that when deviation from global free trade implies no contagion and when there is a high degree of variety (low γ), there are ranges of trade costs for which country 3 is no longer pivotal. This is illustrated in Figure 5. The variety parameter γ has been set to a very low value of 0.05. In this case, any of the two proximate countries, $r = 1, 2$, are pivotal to global free trade for low and intermediate levels of trade costs α^{er}. However, for high trade costs the distant country 3 is pivotal. The explanation lies in the fact that external CU tariffs are larger than FTA tariffs, and this can be particularly harmful for one of the proximate countries to face large tariffs with respect to its close neighbour. As evidenced in Figure 5 this cost can be so high that country r, where $r = 1, 2$, becomes pivotal.

Finally, In this paper I have followed the closely related literature on regional trade agreements by assuming a relatively simple preference structure. As remarked by Ludema (2002), adding more non-linearities to the preference structure, external FTA tariffs may not be smaller than individual Nash tariffs. This may work to reduce the regional bias of trade agreements when the alternative to global free trade is a FTA.

7 Concluding remarks

The present paper has contributed to a research question which given its empirical unambiguity has received surprisingly little attention in the literature on preferential trade agreements: out of all the various factors that may determine the nature of preferentialism in the world trading system, regionalism stands out, and few economists even bother making an explicit distinction between the two. This research has made this distinction in an oligopolistic framework, where product variety has been put to the forefront as a determinant of regionalism.

The punchline from this research is fundamentally that increases in product variety reduces the scope for regionalism, and thus, for greater product variety it is more likely that the world trading system abandons preferentialism in favour of global free trade. The present paper draws on earlier findings in Ludema (2002), where a theoretical foundation for endogenous regionalism was made. These findings have been strengthened in this paper by showing that a regional bias of trade agreements is robust to alternative model specifications. While Ludema (2002) constructs a model of horizontal FDI, where the home market effect drives the regional bias, in this paper the bias is driven by a trade-off between pro-competition and transit losses as identified in Brander and Krugman (1983); as trade costs are reduced, the pro-competitive gains from trade become larger relative to losses in transit. The variety component of the present model, thus, serves to reduce this trade-off and the regional bias is lower when the gains from trade are more variety driven.

The role of variety in predicting regionalism lends itself to curious potential future empirical investigations. To the best of my knowledge, this key prediction of the paper has not been scrutinised by the data. Casual observation, however, lends support to such a relationship since multilateral trade liberalisation has been deeper in the developed world, where natural trade barriers are lower and where there is greater variety of traded goods.

The findings of the paper, however, have been derived in an oligopolistic framework with quantity competition. It would therefore be useful to extend this to other modes of competition to examine the validity of the prediction on variety in different environments. In the real world, the size of countries and their regional structure is far more complex, and the simple model presented in this paper is not able to capture such aspects. A promising way to address such short-comings is to incorporate more sophisticated simulations-based models.

Many papers on preferentialism explicitly incorporate political-economy features where tariffs are used for redistributive purposes in addition to the motives accounted for in the present study. It would be possible that a higher weight on profits in the objective function, which comes about due to lobbying, might have an impact on the results of this paper. A recent strand of research extends the standard models of oligopoly to incorporate general equilibrium effects, see for example Neary (2009). This paper has assumed a numéraire sector which eliminates cross-price effects on demand and income effects. Future research could be directed towards examining the implications of such income effects on preferentialism, although given the complexity of such effects it is unlikely that simple analytical results can be achieved.

Appendix A

Derivation of Eq. (15) and (17)

Substituting the inverse demand function in (2), the Cournot quantities in (5) and their derivatives in (8) into (14) yields the following import-tariff first-order condition:

$$\frac{dW_i}{d\tau_{il}} = [\Gamma(0,\gamma)\Gamma(2,\gamma) + \gamma\{\Gamma(2,\gamma) + \Gamma(n,\gamma)[\Gamma(0,\gamma)+1]\}T_i - \Gamma(n,\gamma)^2[\Gamma(0,\gamma)+1]\tau_{il} + \gamma[\Gamma(2,\gamma)+\Gamma(n,\gamma)]A_i - \Gamma(n,\gamma)^2\alpha_{il}]/[\Gamma(0,\gamma)\Gamma(n,\gamma)]^2 = 0, \quad (55)$$

Summing this equation over all $n-1$ tariffs and multiplying out $(\Gamma(0,\gamma)\Gamma(n,\gamma))^2$ yield:

$$(n-1)\Gamma(0,\gamma)\Gamma(2,\gamma) - [\Psi(1,\gamma)\Gamma(n,\gamma) + \Gamma(1,\gamma)\Gamma(2,\gamma)]T_i + [\gamma\Gamma(n,\gamma) - \Gamma(1,\gamma)\Gamma(2,\gamma)]A_i = 0, \quad (56)$$

Solving (56) in terms of T_i yields:

$$T_i = \frac{(n-1)\Gamma(0,\gamma)\Gamma(2,\gamma) + [\gamma\Gamma(n,\gamma) - \Gamma(1,\gamma)\Gamma(2,\gamma)]A_i}{D(1,n,\gamma)}, \quad (57)$$

where $D(\cdot)$ and $\Psi(\cdot)$ are defined in (16). Now substituting (57) into (55) and solving for τ_{il} yield the solution in (15).
Finally, differentiating (55) wrt. α_{il} using (57) to get $\frac{dT_i}{d\alpha_{il}}$, yields the expression in (17). **q.e.d.**

Derivation of Eq. (23)

Substituting the inverse demand function in (2), the Cournot quantities in (5) and their derivatives in (8) into (22) yields the following import-tariff first-order condition:

$$\frac{dW_i}{d\tau_{il}} = \Gamma(0,\gamma)\Gamma(2,\gamma) + \gamma\{\Gamma(2,\gamma) + \Gamma(n,\gamma)[\Gamma(0,\gamma)+1]\}T_i - \Gamma(n,\gamma)^2[\Gamma(0,\gamma)+1]\tau_{il} \\ +\gamma[\Gamma(2,\gamma) + \Gamma(n,\gamma)]A_i - \Gamma(n,\gamma)^2\alpha_{il} = 0, \quad (58)$$

Summing this equation over all $n-k$ tariffs yield:

$$(n-k)\Gamma(0,\gamma)\Gamma(2,\gamma) - [\Psi(k,\gamma)\Gamma(n,\gamma) + \Gamma(k,\gamma)\Gamma(2k,\gamma) + B(k,n,\gamma)]T_i \\ +[\Gamma(n,\gamma) - \Gamma(k,\gamma)][\Gamma(2,\gamma) + \Gamma(n,\gamma)]A_i - \Gamma(n,\gamma)^2 A_i^{er} = 0, \quad (59)$$

Solving (59) in terms of T_i yields:

$$T_i = \frac{(n-k)\Gamma(0,\gamma)\Gamma(2,\gamma) + [\Gamma(n,\gamma) - \Gamma(k,\gamma)][\Gamma(2,\gamma) + \Gamma(n,\gamma)]A_i - \Gamma(n,\gamma)^2 A_i^{er}}{D(k,n,\gamma) + B(k,n,\gamma)}, \quad (60)$$

where $D(\cdot)$ and $\Psi(\cdot)$ are defined in (16) and $B(\cdot)$ is defined in (25). Now substituting (60) into (58) and solving for τ_{il} yield the solution in (23).

Derivation of Eq. (28)

Substituting the inverse demand function in (2), the Cournot quantities in (5) and their derivatives in (8) into (27) yields the following import-tariff first-order condition for the CU:

$$\frac{dW_{CU}}{d\tau_l} = k\Gamma(0,\gamma)\Gamma(2k,\gamma) + k\gamma\{\Gamma(2k,\gamma) + \Gamma(n,\gamma)[\Gamma(0,\gamma)+1]\}T_{CU} - k\Gamma(n,\gamma)^2[\Gamma(0,\gamma)+1]\tau_l \\ +\gamma\{\Gamma(2k,\gamma) + \Gamma(n,\gamma)\}A_{CU}^{er} + \gamma[\Gamma(2k,\gamma) - \Gamma(n,\gamma)]A_{CU}^{ir} - \Gamma(n,\gamma)^2 A_l^{ir} = 0, \quad (61)$$

Summing this equation over all $n-k$ tariffs yield:

$$(n-k)k\Gamma(0,\gamma)\Gamma(2k,\gamma) - k[\Psi(k,\gamma)\Gamma(n,\gamma) + \Gamma(k,\gamma)\Gamma(2k,\gamma)]T_{CU} + [k\gamma\Gamma(n,\gamma) - \Gamma(k,\gamma)\Gamma(2k,\gamma)]A_{CU}^{er} \\ +\gamma(n-k)[\Gamma(2k,\gamma) - \Gamma(n,\gamma)]A_{CU}^{ir} = 0, \quad (62)$$

Solving (62) in terms of T_{CU} yields:

$$T_{CU} = \frac{(n-k)k\Gamma(0,\gamma)\Gamma(2k,\gamma) + [k\gamma\Gamma(n,\gamma) - \Gamma(k,\gamma)\Gamma(2k,\gamma)]A_{CU}^{er} + \gamma(n-k)[\Gamma(2k,\gamma) - \Gamma(n,\gamma)]A_{CU}^{ir}}{kD(k,n,\gamma)}, \quad (63)$$

where $D(\cdot)$ and $\Psi(\cdot)$ are defined in (16). Now substituting (63) into (61) and solving for τ_l yield the solution in (28). **q.e.d.**

Appendix B

Derivation of Eq. (19)

Plugging the inverse demand function in (2), the Cournot quantites in (5) and their derivatives in (8) into (18) yield the following expression for the effect of country l's import tariff on country i's welfare:

$$\frac{dW_i}{d\tau_{li}} = \frac{\Gamma(1,\gamma)[\gamma - \Gamma(n,\gamma)][\Gamma(0,\gamma) + \gamma(T_l + A_l) - \Gamma(n,\gamma)(\tau_{li} + \alpha_{li})]}{[\Gamma(0,\gamma)\Gamma(n,\gamma)]^2}. \quad (64)$$

Evaluating this expression at country l's specific Nash tariff on country i in (15) and the sum of its Nash tariffs in (57) yield the expression in (19).[22] **q.e.d.**

Appendix C

Proof of Lemma 1

Subtract τ_{il}^N in Eq. (15) from τ_{il}^{FTA} in (23):

$$\begin{aligned}\tau_{il}^N - \tau_{il}^{FTA} &= \frac{\Gamma(0,\gamma)\Gamma(2,\gamma)}{[\Gamma(0,\gamma)+1]}\left[\frac{[D(k,n,\gamma)+B(k,n,\gamma)] - D(1,n,\gamma)}{D(1,n,\gamma)[D(k,n,\gamma)+B(k,n,\gamma)]}\right][\Gamma(0,\gamma)+1+\gamma A_i] \\ &\quad - \frac{\gamma D(1,n,\gamma)\{\Gamma(2,0)+\Gamma(n,\gamma)[\Gamma(0,\gamma)+1]\}}{[\Gamma(0,\gamma)+1][D(1,n,\gamma)[D(k,n,\gamma)+B(k,n,\gamma)]}A_i^{ir} \end{aligned} \quad (65)$$

Since $D(k,n,\gamma)+B(k,n,\gamma)] - D(1,n,\gamma) = (k-1)\gamma\{\Gamma(2,0)+\Gamma(n,\gamma)[\Gamma(0,\gamma)+1]\}$, Eq. (65) rearranges as:

$$\tau_{il}^N - \tau_{il}^{FTA} = \frac{\gamma\{\Gamma(2,0)+\Gamma(n,\gamma)[\Gamma(0,\gamma)+1]\}\{(k-1)\Gamma(0,\gamma)\Gamma(2,\gamma)[\Gamma(0,\gamma)+1+\gamma A_i] - D(1,n,\gamma)A_i^{ir}\}}{D(1,n,\gamma)[D(k,n,\gamma)+B(k,n,\gamma)][\Gamma(0,\gamma)+1]} \quad (66)$$

It is easy to see that if there are no intra-regional trade costs, $A_i^{ir} = 0$, the Nash tariff is greater than the optimal external FTA tariff for $\gamma > 0$ and equal to the optimal external FTA tariff when $\gamma = 0$. For the case $A_i^{ir} > 0$, it is necessary to evaluate A_i^{ir} at its maximal value. This value is given as the maximal value that permits positive intra-regional trade flows, $\overline{A}_i^{ir}$. Assume then that extra-regional trade costs are zero, $A_i^{er} = 0$, then the highest permitted value for aggregate intra-regional trade cost is the one that guarantees positive intra-regional trade when country i implements Nash tariffs (if country i's imports are positive under the Nash tariffs they will also be positive for free trade which is the case if it enters a trade agreement). The value can thus be solved from the following equation:

$$\sum_{\substack{j=1\\ j\neq i}}^{k} q_{ij} = \frac{\Gamma(0,\gamma) + \gamma(T_i^N + A_i^{ir}) - \Gamma(n,\gamma)(\tau_{ij}^N + \alpha_{ij})}{\Gamma(0,\gamma)\Gamma(n,\gamma)} > 0. \quad (67)$$

where I have used $A_i^{er} = 0 \Rightarrow A_i = A_i^{ir}$. Summing yields:

$$\frac{(k-1)\Gamma(0,\gamma) + [\Gamma(k,\gamma) - \Gamma(1,\gamma)][T_i^N + A_i^{ir}] - \Gamma(n,\gamma)[T_i^{ir} + A_i^{ir}]}{\Gamma(0,\gamma)\Gamma(n,\gamma)} > 0, \quad (68)$$

[22] Country l's Nash tariff and the sum of its Nash tariffs can be found by exchanging i and l in, respectively, (15) and (57)

where $T_i^{ir} = \sum_{\substack{j=1 \\ j \neq i}}^{k} \tau_{ij}$. Rearranging yields:

$$\frac{(k-1)\Gamma(0,\gamma) + [\Gamma(k,\gamma) - \Gamma(1,\gamma) - \Gamma(n,\gamma)][T_i^N + A_i^{ir}] + \Gamma(n,\gamma)T_i^{er}}{\Gamma(0,\gamma)\Gamma(n,\gamma)} > 0, \tag{69}$$

where $T_i^{er} = \sum_{j=k}^{n} \tau_{ij}$. An expression for T_i^N can be obtained in (57) and T_i^{er} can be found be summing (15) over the $n-k$ extra-regional tariffs. Plugging the resulting expressions into (69) and solving for A_i^{ir} yields:

$$A_i^{ir} < \overline{A}_i^{ir} \equiv \frac{[\Gamma(k,\gamma) - \Gamma(1,\gamma)]\Psi(1,\gamma)[\Gamma(0,\gamma)+1]}{\gamma[\Gamma(n,\gamma) - \Gamma(k,\gamma)]\Psi(1,\gamma) + \gamma\Gamma(1,\gamma)^2[\Gamma(0,\gamma)+1]}. \tag{70}$$

Now plugging $\overline{A}_i^{ir}$ into (66) gives:

$$\tau_{il}^N - \tau_{il}^{FTA} = \frac{\gamma\{\Gamma(2,\gamma) + \Gamma(n,\gamma)[\Gamma(0,\gamma)+1]\}\{[\Gamma(k,\gamma) - \Gamma(1,\gamma)][\Gamma(0,\gamma)+1]^2\}}{[D(k,n,\gamma) + B(k,n,\gamma)][\Gamma(0,\gamma)+1]} \geq 0. \tag{71}$$

This expression is positive for $\gamma > 0$ and equal to zero for $\gamma = 0$.

Assume now symmetry of aggregate and country-specific trade costs of the members of the CU, that is, $A_i = \frac{A_{CU}}{k}$, $A_i^{ir} = \frac{A_{CU}^{ir}}{k}$ and $\alpha_l = \frac{A_l^{ir}}{k}$. Then $\tau_l^{CU} - \tau_{il}^N$ becomes:

$$\begin{aligned}
\tau_l^{CU} - \tau_{il}^N \quad &= \frac{\gamma(k-1)\Gamma(0,\gamma)[\Gamma(0,\gamma)+1]}{[\Gamma(0,\gamma)+1]} \left[\frac{\{\Gamma(0,\gamma)\Gamma(n,\gamma)[\Gamma(0,\gamma)+1] - \Gamma(2,\gamma)\Gamma(2k,\gamma)\}}{D(k,n,\gamma)D(1,n,\gamma)}\right] \\
&+ \frac{\gamma^2(k-1)\Gamma(0,\gamma)}{[\Gamma(0,\gamma)+1]} \left[\frac{\{\Gamma(0,\gamma)\Gamma(n,\gamma)[\Gamma(0,\gamma)+1] - \Gamma(2,\gamma)\Gamma(2k,\gamma)\}}{D(k,n,\gamma)D(1,n,\gamma)}\right] \frac{A_{CU}}{k} \\
&+ \frac{\gamma D(1,n,\gamma)}{[\Gamma(0,\gamma)+1]} \left[\frac{\{\Gamma(2k,\gamma) - \Gamma(n,\gamma)[\Gamma(0,\gamma)+1]\}}{D(k,n,\gamma)D(1,n,\gamma)}\right] \frac{A_{CU}^{ir}}{k}
\end{aligned} \tag{72}$$

It is clear from this expression that $\tau_l^{CU} - \tau_{il}^N = 0$ when $\gamma = 0$. However, for $\gamma > 0$, the sign can be positive or negative depending on the size of the CU relative to the rest of the world and the level of intra-regional and extra-regional trade costs.

$\tau_l^{CU} - \tau_{il}^{FTA}$ can be expressed as:

$$\begin{aligned}
\tau_l^{CU} - \tau_{il}^{FTA} \quad &= \frac{\Gamma(0,\gamma)[\Gamma(0,\gamma)+1]}{[\Gamma(0,\gamma)+1]} \left[\frac{\Gamma(2k,\gamma)[D(k,n,\gamma) + B(k,n,\gamma)] - \Gamma(2,\gamma)D(k,n,\gamma)}{D(k,n,\gamma)[D(k,n,\gamma) + B(k,n,\gamma)]}\right] \\
&+ \frac{\gamma\Gamma(0,\gamma)}{[\Gamma(0,\gamma)+1]} \left[\frac{\Gamma(2k,\gamma)[D(k,n,\gamma) + B(k,n,\gamma)] - \Gamma(2,\gamma)D(k,n,\gamma)}{D(k,n,\gamma)[D(k,n,\gamma) + B(k,n,\gamma)]}\right] \frac{A_{CU}}{k} \\
&+ \frac{\gamma}{[\Gamma(0,\gamma)+1]} \left[\frac{\Gamma(2k,\gamma)[D(k,n,\gamma) + B(k,n,\gamma)] - \Gamma(2,\gamma)D(k,n,\gamma)}{D(k,n,\gamma)[D(k,n,\gamma) + B(k,n,\gamma)]}\right] \frac{A_{CU}^{ir}}{k} \\
&- \frac{\gamma}{[\Gamma(0,\gamma)+1]} \left[\frac{\Gamma(n,\gamma)[\Gamma(0,\gamma)+1][\Gamma(1,\gamma)D(k,n,\gamma) + B(k,n,\gamma)]}{D(k,n,\gamma)[D(k,n,\gamma) + B(k,n,\gamma)]}\right] \frac{A_{CU}^{ir}}{k}
\end{aligned} \tag{73}$$

It is easy to verify that $\Gamma(2k,\gamma)[D(k,n,\gamma) + B(k,n,\gamma)] - \Gamma(2,\gamma)D(k,n,\gamma) > (=)\ 0$ for $\gamma > (=)\ 0$. This implies that the first three terms in (73) are non-negative. What is left to show is that fourth term cannot be larger than the first three at its maximal value? The maximum value of this expression is found as the largest possible value for trade costs, $\frac{A_{CU}^{ir}}{k}$. By symmetry this must take the same value as in (70). Plugging (70) into (73), noting that it is assumed $A_{CU}^{er} = 0$, yields:

$$\tau_l^{CU} - \tau_{il}^{FTA} \quad = \frac{\gamma\Gamma(1,\gamma)[\Gamma(0,\gamma)+1][\Gamma(k,\gamma) - \Gamma(1,\gamma)]\Gamma(n,\gamma)[\Gamma(n,\gamma)\Psi(1,\gamma) + \Gamma(2,\gamma)\Gamma(k,\gamma)]}{D(k,n,\gamma)[D(k,n,\gamma) + B(k,n,\gamma)]\{[\Gamma(n,\gamma) - \Gamma(k,\gamma)]\Psi(1,\gamma) + \Gamma(1,\gamma)^2[\Gamma(0,\gamma)+1]\}} \geq 0, \tag{74}$$

which is positive for $\gamma > 0$ and equal to zero for $\gamma = 0$. **q.e.d.**

Appendix D

Proof of Lemma 2

For the two-country-case, the symmetric trade cost, α, is non-prohibitive if the imported trade flow is positive. The trade flow for the two-country case can be found by setting $n = 2$ in (5):

$$\frac{\Gamma(0,\gamma) + \Gamma(1,\gamma)[\tau_{12} + \alpha]}{\Gamma(0,\gamma)\Gamma(2,\gamma)} > 0. \tag{75}$$

Substituting the Nash tariff (38) for the two-country case into this expression yields:

$$\frac{\Gamma(0,\gamma) - \Gamma(1,\gamma)[\frac{\Gamma(0,\gamma)\Gamma(2,\gamma)[\Gamma(0,\gamma)+1]+\gamma\Gamma(0,\gamma)\Gamma(2,\gamma)\alpha - D(1,2,\gamma)\alpha}{[\Gamma(0,\gamma)+1]D(1,2,\gamma)} + \alpha]}{\Gamma(0,\gamma)\Gamma(2,\gamma)} > 0. \tag{76}$$

Solving this for α gives the non-prohibitive trade cost, $\overline{\alpha}$, in Lemma 2. **q.e.d.**

Proof of Lemma 3

The critical threshold of trade costs below which bilateral welfare can be increased by implementing free trade over positive import tariffs, can be solved by maximising joint welfare wrt. the import tariffs. Hence, the following problem is solved:

$$\max_{\tau_{12},\tau_{21}} W_1 + W_2. \tag{77}$$

Due to symmetry, it is only necessary to solve this for one country, thus country 1 is chosen. Setting $i = 1$ and $n = 2$ in (13), and differentiating wrt. τ_12 gives the following first-order condition:

$$\sum_{j=1}^{2}(p_{1j} - w - \alpha_{1j})\frac{dq_{1j}}{d\tau_{12}} = 0. \tag{78}$$

This condition shows that it is jointly optimal to increase or decrease the quantities produced to the point where there is marginal cost pricing. Substituting the inverse demand functions in (2) and the derivatives of the Cournot quantities in (8) into (78) yields the following import tariff first-order conditions:

$$\left[\frac{\Gamma(0,\gamma) + \gamma(\tau_{12} + \alpha)}{\Gamma(0,\gamma)\Gamma(2,\gamma)}\right]\left(\frac{\gamma}{\Gamma(0,\gamma)\Gamma(2,\gamma)}\right) - \left[\frac{\Gamma(0,\gamma) + (\Gamma(1,\gamma) - \gamma^2)\tau_{12} - \Gamma(1,\gamma)\alpha}{\Gamma(0,\gamma)\Gamma(2,\gamma)}\right]\left(\frac{\Gamma(1,\gamma)}{\Gamma(0,\gamma)\Gamma(2,\gamma)}\right) = 0. \tag{79}$$

The jointly optimal import tariff now becomes:

$$\tau_{12} = \tau_{21} = \frac{-\Gamma(0,\gamma)^2 + (\Gamma(2,\gamma)^2 - \gamma\Gamma(1,\gamma)^2)\alpha}{\Gamma(1,\gamma)^2 - 3\gamma^2}. \tag{80}$$

This tariff is negative when $\alpha = 0$, but increases monotonically in α. Setting equal to zero yields the expression in Lemma 3. **q.e.d.**

Appendix E

Import tariffs in the three-country world

The Nash tariffs country 1 and country 2 impose on each other can be found by setting $n = 3$ in (15):

$$\tau_{12}^N = \tau_{21}^N = \frac{\Gamma(0,\gamma)\Gamma(2,\gamma)[\Gamma(0,\gamma)+1] + \gamma\Gamma(0,\gamma)\Gamma(2,\gamma)(\alpha^{ir}+\alpha^{er}) - D(1,3,\gamma)\alpha^{ir}}{[\Gamma(0,\gamma)+1]D(1,3,\gamma)}$$
$$= \frac{[\Gamma(0,\gamma)\Gamma(2,\gamma)][\Gamma(0,\gamma)+1] + \gamma[\Gamma(0,\gamma)\Gamma(2,\gamma)]\alpha^{er}}{[\Psi(1,\gamma)\Gamma(3,\gamma)+\Gamma(1,\gamma)\Gamma(2,\gamma)][\Gamma(0,\gamma)+1]}. \tag{81}$$

The Nash tariffs they impose on country 3 are:

$$\tau_{13}^N = \tau_{23}^N = \frac{\Gamma(0,\gamma)\Gamma(2,\gamma)[\Gamma(0,\gamma)+1] + \gamma\Gamma(0,\gamma)\Gamma(2,\gamma)(\alpha^{ir}+\alpha^{er}) - D(1,3,\gamma)\alpha^{er}}{[\Gamma(0,\gamma)+1]D(1,3,\gamma)}$$
$$= \frac{[\Gamma(0,\gamma)\Gamma(2,\gamma)][\Gamma(0,\gamma)+1] + [\gamma[\Gamma(0,\gamma)\Gamma(2,\gamma)] - D(1,3,\gamma)]\alpha^{er}}{[\Psi(1,\gamma)\Gamma(3,\gamma)+\Gamma(1,\gamma)\Gamma(2,\gamma)][\Gamma(0,\gamma)+1]}. \tag{82}$$

The Nash tariffs country 3 imposes on country 1 and country 2 are:

$$\tau_{31}^N = \tau_{32}^N = \frac{\Gamma(0,\gamma)\Gamma(2,\gamma)[\Gamma(0,\gamma)+1] + \gamma\Gamma(0,\gamma)\Gamma(2,\gamma)(\alpha^{er}+\alpha^{er}) - D(1,3,\gamma)\alpha^{er}}{[\Gamma(0,\gamma)+1]D(1,3,\gamma)}$$
$$= \frac{\Gamma(0,\gamma)\Gamma(2,\gamma) - \Gamma(1,\gamma)[\Gamma(0,\gamma)\Gamma(2,\gamma) - \Gamma(1,\gamma)]\alpha^{er}}{2(3\Gamma(0,\gamma)[\Gamma(0,\gamma)-1]-\gamma)}, \tag{83}$$

where the second lines in (82)-(83) use $\alpha^{ir} = 0$. The external tariffs country 1 or 2 impose on country 3 in a FTA are:

$$\tau_{13}^{FTA} = \tau_{23}^{FTA} = \frac{[\Gamma(0,\gamma)+1]\{\Gamma(0,\gamma)\Gamma(2,\gamma) + \gamma[\Gamma(2,\gamma)+\Gamma(3,\gamma)]\alpha^{ir}\} - \Gamma(2,\gamma)^2[\Gamma(0,\gamma)+1]\alpha^{er}}{[D(2,3,\gamma)+B(2,3,\gamma)][\Gamma(0,\gamma)+1]}$$
$$= \frac{\Gamma(0,\gamma)\Gamma(2,\gamma) - \Gamma(2,\gamma)^2\alpha^{er}}{[D(2,3,\gamma)+B(2,3,\gamma)]}. \tag{84}$$

The external tariff of a CU consisting of country 1 and country 2 is:

$$\tau_3^{CU} = \frac{\gamma^2[\Gamma(0,\gamma)+1]\alpha^{ir} + \Gamma(0,\gamma)\Gamma(4,\gamma)\{[\Gamma(0,\gamma)+1]+\gamma\alpha^{er}\} - D(2,3,\gamma)\alpha^{er}}{D(2,3,\gamma)[\Gamma(0,\gamma)+1]}$$
$$= \frac{\Gamma(0,\gamma)\Gamma(4,\gamma)\{[\Gamma(0,\gamma)+1]+\gamma\alpha^{er}\} - D(2,3,\gamma)\alpha^{er}}{D(2,3,\gamma)[\Gamma(0,\gamma)+1]}, \tag{85}$$

where the second lines in (84)-(85) use $\alpha^{ir} = 0$.

Proof of Lemma 6

The extra-regional trade cost α^{er} does not prohibit exports from country 3 to country $r = 1, 2$ if and only if the trade flow from country 3 to country $r = 1, 2$ is positive. This trade flow can be found by setting $n = 3$ in (5):

$$\sum_{r=1}^{2} q_{r3} = \sum_{r=1}^{2} \frac{\Gamma(0,\gamma) + \gamma(T_r + A_r) - \Gamma(3,\gamma)(\tau_{r3}+\alpha_{r3})}{\Gamma(0,\gamma)\Gamma(3,\gamma)}$$
$$= \frac{\Gamma(1,\gamma)\Gamma(0,\gamma) + \gamma(T_1 + T_2 + \Gamma(1,\gamma)\alpha^{er}) - \Gamma(3,\gamma)(\tau_{13}+\tau_{23}+\Gamma(1,\gamma)\alpha^{er})}{\Gamma(0,\gamma)\Gamma(3,\gamma)} > 0. \tag{86}$$

This expression can be evaluated when country $r = 1, 2$ imposes unilaterally optimal Nash tariffs from (82), optimal external FTA tariffs in (84), or the optimal external CU tariff in (85). In either case, the solution for the upper boundary becomes:

$$\overline{\alpha}_{r3} \equiv \frac{\Psi(1,\gamma)[\Gamma(0,\gamma)+1]}{3\Gamma(0,\gamma)\Gamma(2,\gamma)}. \tag{87}$$

The extra-regional trade cost, α^{er} does not prohibit exports from country $r = 1, 2$ to country 3 if and only if:

$$\begin{aligned}\sum_{r=1}^{2} q_{3r} &= \frac{\Gamma(0,\gamma)+\gamma(T_3+A_3)-\Gamma(3,\gamma)(\tau_{3r}+\alpha_{3r})}{\Gamma(0,\gamma)\Gamma(3,\gamma)} \\ &= \frac{\Gamma(1,\gamma)\Gamma(0,\gamma)+\gamma\Gamma(1,\gamma)(\tau_{31}+\tau_{32}+\Gamma(1,\gamma)\alpha^{er})-\Gamma(3,\gamma)(\tau_{3r}+\alpha_{3r})}{\Gamma(0,\gamma)\Gamma(3,\gamma)} > 0. \end{aligned} \tag{88}$$

Evaluating this expression at country 3's Nash tariff, which can be found from (83), and solving for α^{er} gives the upper boundary for α^{er} as:

$$\overline{\alpha}_{3r} \equiv \frac{\Psi(1,\gamma)}{\Gamma(1,\gamma)^2}. \tag{89}$$

q.e.d.

Proof of Lemma 7

An expression for country 3's welfare can be found from (13):

$$W_3 = V(Q_3) - wQ_3 - \sum_{j=1}^{2}(p_{3j} - w - \tau^W)q_{3j} + \sum_{j=1}^{2}(p_{j3} - w - \tau^W - \alpha^{er})q_{j3} + wL_3, \tag{90}$$

where τ^W is a uniform world tariff. Country 3 would prefer a world of free trade if and only if:

$$\left.\frac{dW_3}{d\tau^W}\right|_{\tau^W=0} > 0. \tag{91}$$

Differentiating (90) wrt. τ^W yields:

$$\begin{aligned}\frac{dW_3}{d\tau^W} &= -\sum_{j=1}^{2}\left(\frac{dp_{3j}}{d\tau^W}-1\right)q_{3j} + \sum_{j=1}^{2}\tau^W\frac{dq_{3j}}{d\tau^W} + (p_{33}-w)\frac{dq_{33}}{d\tau^W} \\ &+ \sum_{j=1}^{2}(p_{j3}-w-\tau^W-\alpha^{er})\frac{dq_{j3}}{d\tau^W} + \sum_{j=1}^{2}\left(\frac{dp_{j3}}{d\tau^W}-1\right)q_{j3}. \end{aligned} \tag{92}$$

Substituting the inverse demand function in (2), the Cournot quantities in (5) and their derivatives in (8) into (92) yields:

$$\begin{aligned}\frac{dW_3}{d\tau^W} &= \left[\frac{\Gamma(1,\gamma)^2}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right]\left[\frac{\Gamma(0,\gamma)-\Gamma(1,\gamma)(\tau^W+\alpha^{er})}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right] \\ &- \left[\frac{1}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right]\left[\frac{\Gamma(1,\gamma)^2\Gamma(0,\gamma)\Gamma(3,\gamma)}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right]\tau^W \\ &+ \left[\frac{\gamma\Gamma(1,\gamma)}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right]\left[\frac{\Gamma(0,\gamma)+\gamma\Gamma(1,\gamma)[\tau^W+\alpha^{er}]}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right] \\ &- \left[\frac{\Gamma(1,\gamma)^2}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right]\left[\frac{\Gamma(0,\gamma)-\Gamma(1,\gamma)\tau^W-\Gamma(2,\gamma)\alpha^{er}}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right] \\ &- \left[\frac{\Gamma(1,\gamma)^2}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right]\left[\frac{\Gamma(0,\gamma)-\Gamma(1,\gamma)\tau^W-\Gamma(2,\gamma)\alpha^{er}}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right]. \end{aligned} \tag{93}$$

Setting $\tau^W = 0$ in (93) and solving for α^{er} gives the expression for $\widehat{\alpha}_3^{er}$ in Lemma 7.

An expression for any of the two insiders' welfare can be found from (13):

$$W_r = V(Q_r) - wQ_r - \sum_{\substack{j=1\\j\neq r}}^{3}(p_{rj} - w - \tau^W)q_{rj} + \sum_{\substack{j=1\\j\neq r}}^{3}(p_{jr} - w - \tau^W - \alpha_{jr})q_{jr} + wL_r, \quad r = 1,2. \tag{94}$$

Country r prefers free trade if and only if:

$$\left.\frac{dW_r}{d\tau^W}\right|_{\tau^W=0} > 0. \tag{95}$$

Differentiating (94) wrt. τ^W yields:

$$\begin{aligned}\frac{dW_r}{d\tau^W} &= -\sum_{\substack{j=1\\j\neq r}}^{3}\left(\frac{dp_{rj}}{d\tau^W}-1\right)q_{rj} + \sum_{\substack{j=1\\j\neq r}}^{3}\tau^W\frac{dq_{rj}}{d\tau^W} + (p_{rr}-w)\frac{dq_{rr}}{d\tau^W} \\ &+ \sum_{\substack{j=1\\j\neq r}}^{3}(p_{jr}-w-\tau^W-\alpha_{jr})\frac{dq_{jr}}{d\tau^W} + \sum_{\substack{j=1\\j\neq r}}^{3}\left(\frac{dp_{jr}}{d\tau^W}-1\right)q_{jr}, \quad r=1,2. \end{aligned}\tag{96}$$

Substituting the inverse demand function in (2), the Cournot quantities in (5) and their derivatives in (8) into (96) yields:

$$\begin{aligned}\frac{dW_r}{d\tau^W} &= \left[\frac{\Gamma(1,\gamma)^2}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right]\left[\frac{\Gamma(0,\gamma)-\Gamma(1,\gamma)\tau^W-\alpha^{er}}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right] \\ &- \left[\frac{1}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right]\left[\frac{\Gamma(1,\gamma)^2\Gamma(0,\gamma)\Gamma(3,\gamma)}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right]\tau^W \\ &+ \left[\frac{\gamma\Gamma(1,\gamma)}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right]\left[\frac{\Gamma(0,\gamma)+\gamma[\Gamma(1,\gamma)\tau^W+\alpha^{er}]}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right] \\ &- \left[\frac{\Gamma(1,\gamma)}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right]\left[\frac{\Gamma(1,\gamma)\Gamma(0,\gamma)-\Gamma(1,\gamma)^2\tau^W-\Gamma(0,\gamma)\alpha^{er}}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right] \\ &- \left[\frac{\Gamma(1,\gamma)}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right]\left[\frac{\Gamma(1,\gamma)\Gamma(0,\gamma)-\Gamma(1,\gamma)^2\tau^W-\Gamma(0,\gamma)\alpha^{er}}{\Gamma(0,\gamma)\Gamma(3,\gamma)}\right], \quad r=1,2. \end{aligned}\tag{97}$$

Setting $\tau^W = 0$ in (97) and solving for α^{er} gives the expression for $\widehat{\alpha}_r^{er}$ in Lemma 7. **q.e.d.**

Proof of Lemma 8

Subtracting $\delta_3^{GFT,C}$ from $\delta_r^{GFT,C}$:

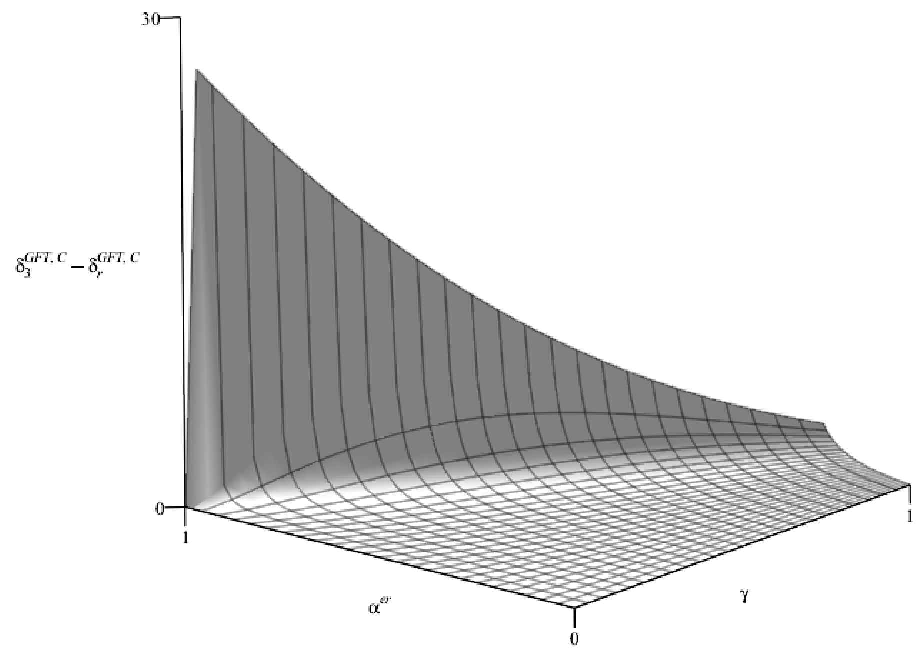
$$\delta_3^{GFT,C} - \delta_r^{GFT,C} = \frac{\sum_{j=1}^{3} S_3(T_3^N, A_3, \tau_{3j}^N, \alpha_{3j}) - \sum_{j=1}^{3} S_3(T_3^{FT}, A_3, \tau_{3j}^{FT}, \alpha_{3j})}{\sum_{j=1}^{2} \pi_{j3}(T_j^{FT}, A_j, \tau_{j3}^{FT}, \alpha_{j3}) - \sum_{j=1}^{2} \pi_{j3}(T_j^N, \tau_{j3}^N, \alpha_{j3})}$$
$$- \frac{\sum_{j=1}^{3} S_r(T_r^N, A_r, \tau_{rj}^N, \alpha_{rj}) - \sum_{j=1}^{3} S_r(T_r^{FT}, A_r, \tau_{rj}^{FT}, \alpha_{rj})}{\sum_{j=1, j\neq r}^{3} \pi_{jr}(T_j^{FT}, A_j, \tau_{jr}^{FT}, \alpha_{jr}) - \sum_{j=1, j\neq r}^{3} \pi_{jr}(T_j^N, \tau_{jr}^N, \alpha_{jr})}, \quad r = 1, 2. \tag{98}$$

Using the individual components of welfare of country i in (9)-(12) for $i = 3$ and $i = r$, evaluated at free trade and the Nash tariffs in (81)-(83), yields:

$$\begin{aligned}
&\delta_3^{GFT,C} - \delta_r^{GFT,C} \\
&= 1/4(-456192 + 131328\gamma - 2348736\gamma^2\alpha^{er} - 474816\gamma^3 + 988416\alpha^{er} + 269568(\alpha^{er})^3 \\
&- 379664\gamma^3(\alpha^{er})^3 + 5528\gamma^{10}(\alpha^{er})^3 + 2724\gamma^{11}(\alpha^{er})^3 + 5348\gamma^8(\alpha^{er})^3 + 14788\gamma^7(\alpha^{er})^3 \\
&+ 137328\gamma^5(\alpha^{er})^3 - 81152\gamma^6(\alpha^{er})^3 + 241264\gamma^4(\alpha^{er})^3 - 18740\gamma^9(\alpha^{er})^3 - 380928\gamma^2(\alpha^{er})^3 \\
&+ 301248\gamma(\alpha^{er})^3 + 108\gamma^{13}(\alpha^{er})^3 - 1260\gamma^{12}(\alpha^{er})^3 - 93312\gamma\alpha^{er} + 1018368\gamma^2 - 249984\gamma(\alpha^{er})^2 \\
&- 143032\gamma^8(\alpha^{er})^2 + 104360\gamma^9(\alpha^{er})^2 - 5874\gamma^{10}(\alpha^{er})^2 - 11238\gamma^{11}(\alpha^{er})^2 - 4425\gamma^{12}\alpha^{er} \\
&+ 3690\gamma^{12}(\alpha^{er})^2 + 414\gamma^{13}\alpha^{er} - 378\gamma^{13}(\alpha^{er})^2 + 782952\gamma^6\alpha^{er2} + 275136\gamma^5(\alpha^{er})^2 \\
&+ 125408\gamma^3(\alpha^{er})^2 - 1717600\gamma^4(\alpha^{er})^2 + 1822848\gamma^2(\alpha^{er})^2 - 298656\gamma^7(\alpha^{er})^2 + 106678\gamma^8\alpha^{er} \\
&- 154717\gamma^9\alpha^{er} + 19931\gamma^{10}\alpha^{er} + 12753\gamma^{11}\alpha^{er} + 595682\gamma^7\alpha^{er} + 663840\gamma^3\alpha^{er} - 801792(\alpha^{er})^2 \\
&- 7054\gamma^8 + 55418\gamma^9 - 11323\gamma^{10} - 3425\gamma^{11} + 1509\gamma^{12} - 153\gamma^{13} - 826944\gamma^4 + 543568\gamma^5 \\
&+ 263024\gamma^6 - 265348\gamma^7 + 2148656\gamma^4\alpha^{er} - 989560\gamma^5\alpha^{er} - 868220\gamma^6\alpha^{er})\alpha^{er}\gamma\,(\gamma - 3)\,/ \\
&([6\gamma^7 - 21\gamma^7\alpha^{er} + 12\gamma^7(\alpha^{er})^2 + 146\gamma^6\alpha^{er} - 51\gamma^6 - 52\gamma^6(\alpha^{er})^2 + 116\gamma^5 - 261\gamma^5\alpha^{er} + 52\gamma^5(\alpha^{er})^2 \\
&- 248\gamma^4\alpha^{er} + 113\gamma^4 + 46\gamma^4(\alpha^{er})^2 - 716\gamma^3 + 1096\gamma^3\alpha^{er} - 200\gamma^3(\alpha^{er})^2 - 524\gamma^2\alpha^{er} + 544\gamma^2 \\
&+ 286\gamma^2(\alpha^{er})^2 + 624\gamma - 864\gamma\alpha^{er} + 96\gamma(\alpha^{er})^2 + 720\alpha^{er} - 720 - 360(\alpha^{er})^2][12\gamma^7(\alpha^{er})^2 + 6\gamma^7 \\
&+ 18\gamma^7\alpha^{er} - 51\gamma^6 - 68\gamma^6\alpha^{er} + 8\gamma^6(\alpha^{er})^2 - 126\gamma^5\alpha^{er} + 116\gamma^5 - 148\gamma^5(\alpha^{er})^2 + 113\gamma^4 + 608\gamma^4\alpha^{er} \\
&- 124\gamma^4(\alpha^{er})^2 - 716\gamma^3 + 576\gamma^3(\alpha^{er})^2 + 192\gamma^3\alpha^{er} + 540\gamma^2(\alpha^{er})^2 + 544\gamma^2 - 1704\gamma^2\alpha^{er} + 624\gamma \\
&+ 96\gamma\alpha^{er} - 720\gamma(\alpha^{er})^2 + 1440\alpha^{er} - 720 - 720(\alpha^{er})^2]) \geq 0
\end{aligned} \tag{99}$$

The above expression attains a minimum at zero when $\gamma = 0$ or $\alpha^{er} = 0$, and is strictly positive when $\gamma > 0$ and $\alpha^{er} > 0$. The interested reader may wish to study the exact relationship between α^{er}, γ and $\delta_3^{GFT,C} - \delta_r^{GFT,C}$, which is depicted in 3-dimensional space in Figure A.1. **q.e.d.** The interested reader may wish to study the exact relationship between α^{er}, γ and $\delta_3^{GFT,C} - \delta_r^{GFT,C}$, which is depicted in 3-dimensional space in Figure A.1.

Figure A.1: $\delta_3^{GFT,C} - \delta_r^{GFT,C}$



Proof of Proposition 5

Subtracting $\delta_3^{GFT,NC}$ from $\delta_{12,-3}^{FTA}$:

$$\delta_3^{GFT,NC} - \delta_{12,-3}^{FTA} = \frac{S_3(\tau_{31}^N, \tau_{32}^N, \alpha^{er}) - S_3(\tau_{31}^{FT}, \tau_{32}^{FT}, \alpha^{er})}{\pi_{13}(\tau_{13}^{FT}, \alpha^{er}) + \pi_{23}(\tau_{23}^{FT}, \alpha^{er}) - \pi_{13}(\tau_{13}^{FTA}, \alpha^{er}) - \pi_{23}(\tau_{23}^{FTA}, \alpha^{er})} - \frac{\sum_{j=1}^{3} S_1(T_1^N, \tau_{1j}^N, \alpha^{er}) - \sum_{j=1}^{3} S_1(T_1^{FTA}, \tau_{1j}^{FTA}, \alpha^{er})}{\pi_{21}(T_2^{FTA}, \alpha^{er}) - \pi_{21}(T_2^N, \tau_{21}^N \alpha^{er})} \tag{100}$$

Using the individual components of welfare of country i in (9)-(12) for $i = 3$ and $i = 1$, evaluated at free trade, the Nash tariffs in (81)-(83), the common external tariffs in (84), and setting $\alpha^{er} = 0$ yield:

$$\begin{aligned}\delta_3^{GFT,NC} - \delta_{12,-3}^{FTA} = &\{\gamma(48\gamma^9 - 156\gamma^8 - 532\gamma^7 + 1455\gamma^6 + 2798\gamma^5 - 4120\gamma^4 - 7968\gamma^3 \\ &+ 2064\gamma^2 + 8352\gamma + 3456)\}/\{12\left(240 - 20\gamma^5 + 89\gamma^4 - 20\gamma^3 - 268\gamma^2 + 96\gamma\right) \\ &\times \left(6 - 3\gamma^2 + 2\gamma\right)\left(10 - 4\gamma^2 + 5\gamma\right)\} \geq 0.\end{aligned} \tag{101}$$

It is easy to see that this expression is positive for all $\gamma > 0$ and zero for $\gamma = 0$. Using the individual components of welfare of country i in (13) for $i = 1$ evaluated at free trade, the Nash tariffs in (81)-(83) and the common external tariffs in (84), the critical discount factor, $\delta_{12,-3}^{FTA}$ can be written:

$$\delta_{12,-3}^{FTA} = \frac{(2+\gamma)\left(6 - 2\gamma^2 + 3\gamma\right)\left(3\gamma^3 - 11\gamma^2 + 18\right)}{720 - 60\gamma^5 + 267\gamma^4 - 60\gamma^3 - 804\gamma^2 + 288\gamma}. \tag{102}$$

Notice that this discount factor is independent of α^{er}. Hence, it suffices to check the first derivative of $\delta_3^{GFT,NC}$ with respect to α^{er}. Using the individual components of welfare of country i in (9)-(12) for

$i = 3$, evaluated at free trade and the Nash tariffs in (81)-(83) yield:

$$\frac{d\delta_3^{GFT,NC}}{d\alpha^{er}} = \{\gamma(2-\gamma)\left(6-2\gamma^2+3\gamma\right)^2 (6\gamma^3\alpha^{er} - 3\gamma^3 + 8\gamma^2\alpha^{er} - 4\gamma^2 + 12\gamma\,(1-\alpha^{er}) - 16\alpha^{er} + 16)\}/\{2\,(\gamma+2)\,(40 - 4\gamma^4 - 4\gamma^4(\alpha^{er})^2 - 8\gamma^4\alpha^{er} - 11\gamma^3\alpha^{er2} + 21\gamma^3 + 10\gamma^3\alpha^{er} - 26\gamma^2 + 52\gamma^2\alpha^{er} + 14\gamma^2(\alpha^{er})^2 - 40\gamma\alpha^{er} + 60\gamma(\alpha^{er})^2 - 20\gamma - 80\alpha^{er} + 40(\alpha^{er})^2)\,(2-\gamma-\alpha^{er}\,(\gamma+2))\left(6-3\gamma^2+2\gamma\right)\} \geq 0. \tag{103}$$

This expression is non-negative for $\alpha \in [0;\alpha_{r3}^{er}]$, and hence $\delta_3^{GFT,NC}$ is greater than $\delta_{12,-3}^{FTA}$ for $\gamma > 0$ in the permitted range.

Proof of Proposition 4, Proposition 6, and Proposition 7

Using the individual components of welfare of country i in (9)-(12), evaluated at the appropriate tariffs in (81)-(85), yields:

$$\delta_3^{GFT,C} \equiv \frac{\sum_{j=1}^{3} S_3(T_3^N, A_3, \tau_{3j}^N, \alpha_{3j}) - \sum_{j=1}^{3} S_3(T_3^{FT}, A_3, \tau_{3j}^{FT}, \alpha_{3j})}{\sum_{j=1}^{2} \pi_{j3}(T_j^{FT}, A_j, \tau_{j3}^{FT}, \alpha_{j3}) - \sum_{j=1}^{2} \pi_{j3}(T_j^N, \tau_{j3}^N, \alpha_{j3})} \tag{104}$$

$$\Rightarrow$$

$$\frac{d\delta_3^{GFT,C}}{d\gamma} = 1/2(\gamma-3)(-55296 + 55296\gamma + 43008\gamma^2\alpha^{er} - 137920\gamma^3 + 27648\alpha^{er} - 2773\gamma^{11}\alpha^{er} - 69998\gamma^8\alpha^{er} + 4525\gamma^{10}\alpha^{er} + 18826\gamma^9\alpha^{er} - 211968\gamma\alpha^{er} + 86976\gamma^2 + 439040\gamma^3\alpha^{er} + 66\gamma^{12}(\alpha^{er})^2 + 3362\gamma^{11}(\alpha^{er})^2 - 54\gamma^{13}(\alpha^{er})^2 - 9\gamma^{13}\alpha^{er} - 13490\gamma^{10}(\alpha^{er})^2 - 15268\gamma^9(\alpha^{er})^2 + 142640\gamma^8(\alpha^{er})^2 + 381\gamma^{12}\alpha^{er} + 72\gamma^{13}\alpha^{er4} + 36\gamma^{13}(\alpha^{er})^3 + 312\gamma^{12}(\alpha^{er})^4 - 804\gamma^{12}(\alpha^{er})^3 - 2552\gamma^{11}(\alpha^{er})^4 + 628\gamma^{11}(\alpha^{er})^3 - 3496\gamma^{10}(\alpha^{er})^4 + 17260\gamma^{10}(\alpha^{er})^3 + 26416\gamma^9(\alpha^{er})^4 - 30520\gamma^9(\alpha^{er})^3 + 16272\gamma^8(\alpha^{er})^4 - 110856\gamma^8(\alpha^{er})^3 - 127120\gamma^7(\alpha^{er})^4 + 232928\gamma^7(\alpha^{er})^3 - 49232\gamma^6(\alpha^{er})^4 + 327040\gamma^6(\alpha^{er})^3 + 321632\gamma^5(\alpha^{er})^4 - 714176\gamma^5(\alpha^{er})^3 + 121728\gamma^4(\alpha^{er})^4 - 555072\gamma^4(\alpha^{er})^3 - 419904\gamma^3(\alpha^{er})^4 + 1003008\gamma^3(\alpha^{er})^3 - 199872\gamma^2(\alpha^{er})^4 + 616704\gamma^2(\alpha^{er})^3 + 224640\gamma(\alpha^{er})^4 - 550656\gamma(\alpha^{er})^3 + 138240(\alpha^{er})^4 - 359424(\alpha^{er})^3 + 702864\gamma^4(\alpha^{er})^2 - 884224\gamma^3(\alpha^{er})^2 - 546816\gamma^2(\alpha^{er})^2 + 482688\gamma(\alpha^{er})^2 + 248832(\alpha^{er})^2 + 536136\gamma^5(\alpha^{er})^2 + 5616\gamma^7\alpha^{er} - 479372\gamma^6(\alpha^{er})^2 - 88076\gamma^7(\alpha^{er})^2 + 15083\gamma^8 - 3756\gamma^9 - 829\gamma^{10} + 627\gamma^{11} - 126\gamma^{12} + 9\gamma^{13} + 5328\gamma^4 + 85664\gamma^5 - 44908\gamma^6 - 9244\gamma^7 - 274848\gamma^4\alpha^{er} - 240416\gamma^5\alpha^{er} + 248800\gamma^6\alpha^{er}))/((6\gamma^7 + 18\gamma^7\alpha^{er} + 12\gamma^7(\alpha^{er})^2 + 8\gamma^6(\alpha^{er})^2 - 68\gamma^6\alpha^{er} - 51\gamma^6 + 116\gamma^5 - 126\gamma^5\alpha^{er} - 148\gamma^5(\alpha^{er})^2 + 113\gamma^4 - 124\gamma^4(\alpha^{er})^2 + 608\gamma^4\alpha^{er} + 576\gamma^3(\alpha^{er})^2 - 716\gamma^3 + 192\gamma^3\alpha^{er} + 540\gamma^2(\alpha^{er})^2 - 1704\gamma^2\alpha^{er} + 544\gamma^2 + 624\gamma - 720\gamma(\alpha^{er})^2 + 96\gamma\alpha^{er} + 1440\alpha^{er} - 720 - 720(\alpha^{er})^2)^2 > 0 \quad \forall \quad \alpha^{er} \in [0:\overline{\alpha}_{r3}^{er}].$$

$$\delta_{12,-3}^{FTA} \equiv \frac{\sum_{j=1}^{3} S_1(T_1^N, \tau_{1j}^N, \alpha^{er}) - \sum_{j=1}^{3} S_1(T_1^{FTA}, \tau_{1j}^{FTA}, \alpha^{er})}{\pi_{21}(T_2^{FTA}, \alpha^{er}) - \pi_{21}(T_2^N, \tau_{21}^N \alpha^{er})} \tag{105}$$

$$\Rightarrow$$

$$\frac{d\delta_{12,-3}^{FTA}}{d\gamma} = 1/3((120\gamma^{10} - 1068\gamma^9 + 2991\gamma^8 + 392\gamma^7 - 16348\gamma^6 + 17444\gamma^5 + 32640\gamma^4 - 48480\gamma^3 - 38592\gamma^2 + 43776\gamma + 31104)/((20\gamma^5 - 89\gamma^4 + 20\gamma^3 + 268\gamma^2 - 96\gamma - 240)^2)) > 0 \quad \forall \quad \alpha^{er} \in [0 : \overline{\alpha}_{r3}^{er}].$$

$$\delta_3^{GFT,NC} \equiv \frac{S_3(\tau_{31}^N, \tau_{32}^N, \alpha^{er}) - S_3(\tau_{31}^{FT}, \tau_{32}^{FT}, \alpha^{er})}{\pi_{13}(\tau_{13}^{FT}, \alpha^{er}) + \pi_{23}(\tau_{23}^{FT}, \alpha^{er}) - \pi_{13}(\tau_{13}^{FTA}, \alpha^{er}) - \pi_{23}(\tau_{23}^{FTA}, \alpha^{er})} \tag{106}$$

$$\Rightarrow$$

$$\frac{d\delta_3^{GFT,NC}}{d\gamma} = 1/2(((2\gamma^2 - 3\gamma - 6)(7680 + 11136\gamma + 44736\gamma^2\alpha^{er} - 12576\gamma^3 - 36\gamma^{11}\alpha^{er} - 4041\gamma^8\alpha^{er} + 300\gamma^{10}\alpha^{er} + 154\gamma^9\alpha^{er} + 24192\gamma\alpha^{er} - 8256\gamma^2 - 10720\gamma^3\alpha^{er} - 576\gamma^{10}(\alpha^{er})^2 + 128\gamma^9(\alpha^{er})^2 + 8064\gamma^8(\alpha^{er})^2 + 48\gamma^{11}(\alpha^{er})^3 + 368\gamma^{10}(\alpha^{er})^3 - 568\gamma^9(\alpha^{er})^3 - 4628\gamma^8(\alpha^{er})^3 + 1288\gamma^7(\alpha^{er})^3 + 22336\gamma^6(\alpha^{er})^3 + 8032\gamma^5(\alpha^{er})^3 - 47056\gamma^4(\alpha^{er})^3 - 40672\gamma^3(\alpha^{er})^3 + 28224\gamma^2(\alpha^{er})^3 + 46464\gamma(\alpha^{er})^3 + 15360(\alpha^{er})^3 + 89200\gamma^4(\alpha^{er})^2 + 63968\gamma^3(\alpha^{er})^2 - 64704\gamma^2(\alpha^{er})^2 - 81792\gamma(\alpha^{er})^2 - 23040(\alpha^{er})^2 - 14080\gamma^5(\alpha^{er})^2 + 622\gamma^7\alpha^{er} - 40696\gamma^6(\alpha^{er})^2 + 88\gamma^7(\alpha^{er})^2 + 583\gamma^8 - 38\gamma^9 - 52\gamma^{10} + 12\gamma^{11} + 5360\gamma^4 + 5128\gamma^5 - 2444\gamma^6 - 710\gamma^7 - 48944\gamma^4\alpha^{er} - 1480\gamma^5\alpha^{er} + 20804\gamma^6\alpha^{er}))/((\gamma + 2)^2(4\gamma^4 + 8\gamma^4\alpha^{er} + 4\gamma^4(\alpha^{er})^2 + 11\gamma^3(\alpha^{er})^2 - 10\gamma^3\alpha^{er} - 21\gamma^3 + 26\gamma^2 - 52\gamma^2\alpha^{er} - 14\gamma^2(\alpha^{er})^2 + 20\gamma - 60\gamma(\alpha^{er})^2 + 40\gamma\alpha^{er} - 40 + 80\alpha^{er} - 40(\alpha^{er})^2)(4\gamma^3\alpha^{er} + 4\gamma^3 + 3\gamma^2\alpha^{er} - 13\gamma^2 - 20\gamma\alpha^{er} - 20\alpha^{er} + 20) \times (3\gamma^2 - 2\gamma - 6)^2)) > 0 \quad \forall \quad \alpha^{er} \in [0 : \overline{\alpha}_{r3}^{er}].$$

$$\delta_3^{GCU,NC} \equiv \frac{S_3(\tau_{31}^N,\tau_{32}^N,\alpha^{er}) - S_3(\tau_{31}^{FT},\tau_{32}^{FT},\alpha^{er})}{\pi_{13}(\tau_{13}^{FT},\alpha^{er}) + \pi_{23}(\tau_{23}^{FT},\alpha^{er}) - \pi_{13}(\tau_{13}^{CU},\alpha^{er}) - \pi_{23}(\tau_{23}^{CU},\alpha^{er})} \tag{107}$$

$$\Rightarrow$$

$$\begin{aligned}
\frac{d\delta_3^{GCU,NC}}{d\gamma} &= -1/2(((-24576 + 227328\gamma - 1685\gamma^{12} + 678\gamma^{13} + 247296\gamma^4\alpha^{er} \\
&- 607744\gamma^5\alpha^{er} - 436224\gamma^6\alpha^{er} + 516224\gamma^7\alpha^{er} - 13312\gamma^3\alpha^{er} - 71448\gamma^{10}\alpha^{er} \\
&+ 124908\gamma^{10}\alpha^{er2} + 3045888\gamma^4(\alpha^{er})^2 - 168960\gamma^3(\alpha^{er})^2 + 36684\gamma^{11}\alpha^{er} - 3096576\gamma^2(\alpha^{er})^2 \\
&- 69650\gamma^{11}(\alpha^{er})^2 + 8838\gamma^{12}\alpha^{er} - 20325\gamma^{12}(\alpha^{er})^2 - 3444\gamma^{13}\alpha^{er} + 264544\gamma^8\alpha^{er} \\
&- 241904\gamma^8(\alpha^{er})^2 - 1668768\gamma^7(\alpha^{er})^2 + 2561664\gamma^5(\alpha^{er})^2 - 588480\gamma^6(\alpha^{er})^2 - 191952\gamma^9\alpha^{er} \\
&+ 482712\gamma^9(\alpha^{er})^2 - 36\gamma^{15} + 36\gamma^{14} - 141312\gamma^2\alpha^{er} - 3904\gamma^7 - 139264\gamma^8 + 11224\gamma^9 \\
&+ 22628\gamma^{10} - 4506\gamma^{11} + 319488\alpha^{er} - 160256\gamma^3 + 454656\gamma\alpha^{er} + 513024\gamma^2 - 730368\gamma^4 \\
&+ 13568\gamma^5 + 444544\gamma^6 + 120\gamma^{15}\alpha^{er} - 400\gamma^{14}\alpha^{er} - 36\gamma^{15}(\alpha^{er})^2 + 1164\gamma^{14}(\alpha^{er})^2 \\
&+ 4326\gamma^{13}(\alpha^{er})^2 - 811008(\alpha^{er})^2 - 2727936(\alpha^{er})^2\gamma + 48\gamma^{15}(\alpha^{er})^4 - 144\gamma^{15}(\alpha^{er})^3 - 16\gamma^{14}(\alpha^{er})^4 \\
&- 1008\gamma^{14}(\alpha^{er})^3 - 2376\gamma^{13}(\alpha^{er})^4 + 888\gamma^{13}(\alpha^{er})^3 - 7812\gamma^{12}(\alpha^{er})^4 + 22684\gamma^{12}(\alpha^{er})^3 \\
&+ 10792\gamma^{11}(\alpha^{er})^4 + 27536\gamma^{11}(\alpha^{er})^3 + 91648\gamma^{10}(\alpha^{er})^4 - 174936\gamma^{10}(\alpha^{er})^3 + 81056\gamma^9(\alpha^{er})^4 \\
&- 388896\gamma^9(\alpha^{er})^3 - 333648\gamma^8(\alpha^{er})^4 + 464864\gamma^8(\alpha^{er})^3 - 716768\gamma^7(\alpha^{er})^4 + 1893952\gamma^7(\alpha^{er})^3 \\
&+ 131136\gamma^6(\alpha^{er})^4 + 455936\gamma^6(\alpha^{er})^3 + 1681792\gamma^5(\alpha^{er})^4 - 3649280\gamma^5(\alpha^{er})^3 + 1446144\gamma^4(\alpha^{er})^4 \\
&- 4008960\gamma^4(\alpha^{er})^3 - 676352\gamma^3(\alpha^{er})^4 + 1018880\gamma^3(\alpha^{er})^3 - 1840128\gamma^2(\alpha^{er})^4 + 4564992\gamma^2(\alpha^{er})^3 \\
&- 1136640\gamma(\alpha^{er})^4 + 3182592\gamma(\alpha^{er})^3 - 245760(\alpha^{er})^4 + 761856(\alpha^{er})^3)(2\gamma^3 + 3\gamma^2 - 12\gamma \\
&- 12))/((-12\gamma^7 - 8\gamma^7\alpha^{er} + 4\gamma^7(\alpha^{er})^2 + 5\gamma^6(\alpha^{er})^2 - 11\gamma^6 - 54\gamma^6\alpha^{er} - 32\gamma^5\alpha^{er} \\
&- 84\gamma^5(\alpha^{er})^2 + 148\gamma^5 + 424\gamma^4\alpha^{er} + 76\gamma^4 - 228\gamma^4(\alpha^{er})^2 + 96\gamma^3(\alpha^{er})^2 + 640\gamma^3\alpha^{er} \\
&- 544\gamma^3 + 880\gamma^2(\alpha^{er})^2 - 208\gamma^2 - 672\gamma^2\alpha^{er} + 960(\alpha^{er})^2\gamma - 1536\gamma\alpha^{er} + 576\gamma \\
&+ 320(\alpha^{er})^2 + 320 - 640\alpha^{er})^2(3\gamma^2 - 2\gamma - 6)^2)) > 0 \quad \forall \quad \alpha^{er} \in [0 : \overline{\alpha}_{r3}^{er}].
\end{aligned}$$

$$\delta_{12,-3}^{CU} \equiv \frac{\sum_{j=1}^3 S_1(T_1^N,\tau_{1j}^N,\alpha^{er}) - \sum_{j=1}^3 S_1(T_1^{FTA},\tau_{1j}^{FTA},\alpha^{er})}{\pi_{21}(T_2^{CU},\alpha^{er}) - \pi_{21}(T_2^N,\tau_{21}^N\alpha^{er})} \tag{108}$$

$$\Rightarrow$$

$$\begin{aligned}
\frac{d\delta_{12,-3}^{CU}}{d\gamma} &= ((792\gamma^{12} + 1404\gamma^{11} + 1869\gamma^{10} - 5692\gamma^9 - 12608\gamma^8 + 70620\gamma^7 + 218880\gamma^6 \\
&- 439152\gamma^5 - 1273536\gamma^4 + 643968\gamma^3 + 3072384\gamma^2 + 2142720\gamma + 373248)/((132\gamma^6 \\
&+ 117\gamma^5 - 1030\gamma^4 - 1236\gamma^3 + 1080\gamma^2 + 2736\gamma + 1440)^2)) > 0 \quad \forall \quad \alpha^{er} \in [0 : \overline{\alpha}_{r3}^{er}].
\end{aligned}$$

References

Bagwell, K. and Staiger, R. (1997a). Multilateral tariff cooperation during the formation of customs unions. *Journal of International Economics*, 42(1-2).

Bagwell, K. and Staiger, R. (1997b). Multilateral tariff cooperation during the formation of regional free trade areas. *International Economic Review*, 38(2).

Bagwell, K. and Staiger, R. W. (2010). The world trade organization: Theory and practice. *Annual Review of Economics*, 2(1):223–256.

Baier, S. L. and Bergstrand, J. H. (2004). Economic determinants of free trade agreements. *Journal of International Economics*, 64(1):29–63.

Baldwin, R. E. and Venables, A. J. (1995). Regional economic integration. In Grossman, G. M. and Rogoff, K., editors, *Handbook of International Economics*, volume 3, chapter 31, pages 1597–1644. Elsevier.

Bond, E. W. (2001). Multilateralism vs regionalism: Tariff cooperation and interregional transport costs. In Lahiri, S., editor, *Regionalism and Globalisation: theory and practice*, pages 16–38. Routledge.

Bond, E. W. and Syropoulos, C. (1996). Trading blocs and the sustainability of inter-regional cooperation. In Conzoneri, M. B., Ethier, W. J., and Grilli, V., editors, *The New Transatlantic Economy*, pages 118–140. Cambridge University Press.

Bond, E. W., Syropoulos, C., and Winters, L. A. (2001). Deepening of regional integration and multilateral trade agreements. *Journal of International Economics*, 53(2):335–361.

Brander, J. and Krugman, P. (1983). A 'reciprocal dumping' model of international trade. *Journal of International Economics*, 15(3-4):313–321.

Brander, J. A. (1981). Intra-industry trade in identical commodities. *Journal of International Economics*, 11(1):1–14.

Brander, J. A. and Spencer, B. (1984). Tariff protection and imperfect competition. In Kierkowski, H., editor, *Monopolistic Competition and International Trade*, pages 194–207. Oxford University Press.

Collie, D. (1993). Profit-shifting export subsidies and the sustainability of free trade. *Scottish Journal of Political Economy*, 40(4):408–19.

Egger, P. and Larch, M. (2008). Interdependent preferential trade agreement memberships: An empirical analysis. *Journal of International Economics*, 76(2):384–399.

Freund, C. and Ornelas, E. (2010). Regional trade agreements. *Annual Review of Economics*, 2(1):139–166.

Johnson, H. G. (1954). Optimum tariffs and retaliation. *The Review of Economic Studies*, 21(2):142–153.

Krugman, P. (1991). The move toward free trade zones. *Economic Review*, (Nov):5–25.

Limao, N. and Saggi, K. (2008). Tariff retaliation versus financial compensation in the enforcement of international trade agreements. *Journal of International Economics*, 76(1):48–60.

Ludema, R. D. (2002). Increasing returns, multinationals and geography of preferential trade agreements. *Journal of International Economics*, 56(2):329–358.

Mrazova, M. (2009). Trade negotiations when market access matters. Technical report.

Neary, J. P. (2009). Two and a half theories of trade. CEPR Discussion Papers 7600, C.E.P.R. Discussion Papers.

Saggi, K. (2006). Preferential trade agreements and multilateral tariff cooperation. *International Economic Review*, 47(1):29–57.

Yi, S.-S. (1996). Endogenous formation of customs unions under imperfect competition: open regionalism is good. *Journal of International Economics*, 41(1-2):153–177.

Zissimos, B. (2011). Why are trade agreements regional? *Review of International Economics*, 19(1):32–45.