ISSN 2042-2695

CENTRE *for* ECONOMIC PERFORMANCE

CEP Discussion Paper No 1021

November 2010

Is the WTO Article XXIV Bad?

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Abstract
This paper shows that the WTO's Article XXIV increases the likelihood of free trade, but may worsen world welfare when free trade is not reached and customs unions (CUs) form. We consider a model of many countries. Article XXIV prevents a CU from raising its common external tariff, which makes CU formation less attractive and explains why free trade is more likely. In an equilibrium where two CUs do form, one is necessarily larger than the other. We show that Article XXIV has a 'composition effect' on CU formation, whereby CUs are (endogenously) more symmetric in size so more goods are subject to tariff distortions as they move between CUs; thus Article XXIV may be 'bad' for world welfare.

Keywords: Coalition formation game, customs union, protection, trade block, trade liberalization
JEL Classifications: F02, F13, F15

This paper was produced as part of the Centre's Globalisation Programme. The Centre for Economic Performance is financed by the Economic and Social Research Council.

Acknowledgements
Special thanks are due to Christopher Bliss, Rick Bond, and Peter Neary for extensive conversations about this paper. We are also grateful for comments from seminar participants at Michigan State University, the University of Oxford, Vanderbilt University, and the 50th Midwest International Trade Meeting at Purdue University. The work of Monika Mrázová has been supported by the Economic and Social Research Council [grant numbers PTA-026-27-2479, PTA-030-2005-00825]. Financial support for travel from the George Webb Medley Fund, Balliol College, and Oriel College is also gratefully acknowledged.

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Published by
Centre for Economic Performance
London School of Economics and Political Science
Houghton Street
London WC2A 2AE

1 Introduction

Article XXIV of the World Trade Organization (WTO) allows countries to form customs unions (CUs) or free trade agreements (FTAs) under the following two conditions: first, any internal barriers to trade inside the union must be removed; second, trade barriers on non-members must not be increased on average.[1,2] Intuition might suggest that, compared to a world where bloc formation is allowed without any constraints, Article XXIV must increase world welfare, since it precludes (average) tariff increases on non-members by countries that form preferential trade agreements while requiring tariff removal between members. Thus, aggregate world trade distortions through the formation of trade agreements should be reduced compared to a world in which trade agreements are not constrained by Article XXIV, and world welfare should be enhanced. This paper shows, in a many-country framework, how the conditions imposed by Article XXIV do increase the likelihood of free trade over the formation of CUs, hence increasing world welfare. But the paper also shows that when free trade does not arise in equilibrium under Article XXIV, the constraints that it imposes may actually lead to a reduction of world welfare.

The paper adopts the model of Yi (1996) as a benchmark. A key feature of the benchmark model is that there can be any number of countries. This is not standard in the literature: the most common approach is to assume that there are just three countries, two of which form a CU. By allowing for many countries, Yi is able to model CU formation as a coalition formation game in which the number of countries in any of the CUs that form is endogenously determined. The benchmark model also has the standard feature that countries can form a CU under the first condition of Article XXIV set out above but the second condition is not imposed.

In this paper we formally introduce into the benchmark model the second condition, that trade barriers cannot be raised on average when a CU forms or expands, and we analyze its implications. We will refer to the second condition as the *Article XXIV constraint*. This constraint has been considered in previous literature but not, to our knowledge, in a many-country framework. It is the extension to many countries coupled with the underlying structure of our benchmark model that makes possible the new insights regarding the implications of Article XXIV that we obtain.

In the benchmark model, when goods are independent, members of any CU always become better off when the CU expands, driving CU expansion all the way to free trade.

[1] A third condition of Article XXIV, which will not have a bearing on our analysis, is that all agreements must be notified to the WTO.

[2] The common feature of CUs and FTAs is that both types of agreement coordinate on the removal of internal tariffs; the difference is that CUs coordinate on the setting of a common external tariff whereas each member of an FTA undertakes external tariff setting independently. In studying Article XXIV, our focus on CUs seems legitimate since CU members internalize any terms-of-trade externality between themselves through coordination and thus tend to set higher tariffs than FTAs. Indeed, Bond, Riezman, and Syropoulos (2004) and Ornelas (2005a) have shown, in different settings, that FTAs tend to compete external tariffs down through their bids for third markets, in which case the Article XXIV constraint would not bind.

There are two reasons for this. First, free trade is preferred by consumers: they are more hurt by the static efficiency losses arising through the reduced trade volume in goods from non-member countries than they are helped by the terms-of-trade gain associated with a CU. Second, free trade is also preferred by firms: if the substitutability between varieties is low then competition between firms in any given market is less intense; each firm gains more (in terms of profits) from access to a larger number of markets and loses less from greater access by other firms to its domestic market. However, when goods are closer substitutes, in the unique equilibrium CU structure there is one large CU and one small CU.[3] For the countries in the large CU, the terms-of-trade gains outweigh the static efficiency losses and they obtain a higher level of welfare than they would under free trade. The countries in the small CU suffer an adverse terms-of-trade effect as well as static efficiency losses, and these leave them significantly worse off than under free trade. Overall world welfare is worsened relative to free trade.[4]

We will show that, if the CU structure is held constant, the introduction of the Article XXIV constraint into the benchmark model must increase world welfare (or at worst have no effect). This is because, if there is an incentive for a CU to increase its common external tariff (CET) when it forms, then the Article XXIV constraint, by preventing this increase, will prevent a rise in aggregate trade distortions. That will bring about a higher level of world welfare. (If there is no incentive to raise the CET then the Article XXIV constraint does not bind and thus has no effect.) As a result, we will show that any negative effects on world welfare of the Article XXIV constraint cannot be observed when the equilibrium CU structure is held constant. Instead, they derive from a *composition effect* of Article XXIV on the CU structure that arises in equilibrium.

The composition effect works as follows. When the Article XXIV constraint is introduced, the CU formation leads to the same equilibrium CU structure, but with the two key differences. When goods are independent, it is the large bloc that is more constrained by Article XXIV (it would want to impose a higher CET), because it uses its market power to shift rents from outsiders. In this case, the Article XXIV constraint makes the equilibrium CU structure weakly more asymmetric, i.e. the large bloc is larger under the Article XXIV constraint. This is because, being constrained, the large bloc is not able to use its market power to shift rents as much as it would like, and the gain from freer trade with more countries is relatively greater. Thus the large bloc accepts more members. A consequence of this

[3]It appears that there is a threshold number of countries in the model above which the number of CUs in equilibrium is three, where the threshold lies in the hundreds-of-thousands. Our analysis will focus on a 'practical' number of countries that lies below this threshold.

[4]Perhaps the aspect of Yi's (1996) paper that is best known is his characterization of CU formation under rules of 'open regionalism'; no country is allowed to exclude another from a CU that it wishes to join. In that setting, he shows that free trade is the unique equilibrium coalition structure. However, he also characterizes the equilibrium CU structure under conditions of 'unanimous regionalism' in which members can exclude potential entrants if they wish. It is his analysis of 'unanimous regionalism' that forms our benchmark case here.

effect is that free trade becomes the equilibrium outcome of the bloc formation game for a wider range of parameters. Without Article XXIV, it may be beneficial for the large bloc to leave some countries outside its own bloc, whereas Article XXIV, by limiting terms-of-trade gains and profit shifting, makes it beneficial to accept them in the bloc.

When goods are more homogeneous, the large bloc tends to decrease its CET to avoid an excessive trade diversion harming its consumers. Therefore, it is the small bloc that is more constrained by Article XXIV. In the absence of the Article XXIV constraint, the small bloc would raise its CET in order to exploit the increased monopoly/monopsony power afforded by the CU. This in turn would give the larger CU an incentive to invite some of the countries from the small CU to join, in order to avoid having the higher tariff levied on their exports. The countries from the smaller CU would accept this offer since member welfare is higher in the larger CU. Thus the equilibrium CU structure is more asymmetric without the Article XXIV constraint: the larger CU is larger and the smaller CU is smaller without the Article XXIV constraint than with it. It is this which gives rise to the possibility of negative effects. Since all varieties of goods in the model are consumed by consumers in all countries, more varieties are subject to a tariff distortion as they move between CUs in the more symmetric outcome. Thus world welfare is reduced.[5]

The most comprehensive previous analysis of Article XXIV is by Syropoulos (1999), using a model of CU formation between two countries in a three-country model. He shows that CU formation can damage the rest of the world even under Article XXIV. But he does not compute the effects of CU formation on world welfare - either with or without Article XXIV.[6] Furthermore, since Syropoulos' analysis is carried out in a three-country model, the composition effect of Article XXIV, which is crucial to our claim that world welfare may be lower under Article XXIV, cannot be discussed in his framework.[7] On the other hand,

[5]To see this composition effect most clearly, think of two CUs with CETs fixed at the same rate. The 'most asymmetric' CU structure is one in which all countries are in one CU with none in the other. This corresponds to free trade, with no goods being subject to a tariff distortion and world welfare being maximized. Now consider the 'least asymmetric' CU structure, wherein half of the countries are in one CU and half are in the other. This maximizes the number of goods that are subject to a trade distortion and hence minimizes world welfare (all else equal). Thus, in general, the more symmetric the outcome the lower is world welfare. Note that this composition effect of Article XXIV cannot be observed in a conventional three-country model. The constraint in a three-country model, which is relaxed in our model, is that once two countries have formed a CU the best reply by the rest of the world in terms of CU formation cannot be analyzed; it is ruled out by the fact that the rest of the world is characterized by a single country.

[6]Indeed, the standard basis for criticism of Article XXIV is that it is not sufficient to prevent third countries being harmed when two countries form a trade agreement. As far as we are aware, ours is the first paper to evaluate Article XXIV from the perspective of its implications for world welfare.

[7]Article XXIV was originally formulated as part of the General Agreement on Tariffs and Trade (GATT), and has now been formally adopted into the Charter of the WTO (GATT 1994). The historical events through which Article XXIV came into being are nicely explained by Snape (1993). Its implementation in practice is documented by McMillan (1993). Bagwell and Staiger (1998, 1999, 2002) relate Article XXIV to the most favored nation (MFN) principle. They identify the MFN principle as one of the two 'pillars of the GATT,' showing that (in the absence of other distortions) it guides countries to an efficient trade agreement. Since the MFN principle stipulates that any trade concession granted to one country is automatically granted to all, Article XXIV allows an exception to MFN and hence may preclude an efficient trade agreement. Note that Article XXIV is not the focus of Bagwell and Staiger's analysis and they do not

Goto and Hamada (1999) study Article XXIV in a many-country model, but because they consider exogenous CU formation only, the composition effect, that we identify, cannot be observed in their framework either.

Overall, the literature on preferential trade agreements has addressed two issues. The first of these issues, which was the focus of Viner (1950), Krugman (1991), Syropoulos (1999) etc., concerns the welfare implications of trade agreements in which the structure of the agreement is taken to be exogenous. The second issue is the stability of trade-agreement structures. Given endogenous trade-agreement formation, what structures are stable? Is the process of trade-agreement formation one which will, or will not, lead to free trade? (See Bhagwati (1993), although the roots of this question are found in Viner (1950).) Recent literature has focused on the interaction between these issues: on the welfare implications of stable structures. The present paper is a contribution to this work. It examines the impact of Article XXIV on the stable structures and on the resulting welfare outcomes.[8]

The paper proceeds as follows. The economic model is presented in Section 2. In Section 3, we analyze the effects on welfare of exogenously mandated CU formation and expansion. Section 4 explores the linkages between CU structures and welfare, sets out the CU formation game and determines stable CU structures of this game. The main results of this paper showing the effect of Article XXIV on the equilibrium CU structure and world welfare are derived in Section 5. Conclusions are drawn in Section 6.

2 The model and the Article XXIV constraint

2.1 Benchmark model of unconstrained CU formation

In this subsection, we summarize the key characteristics and results of Yi's (1996) model, which we adopt as our benchmark. In the following subsection, we will introduce the Article XXIV constraint into the model.

2.1.1 Preferences and technology

There are N countries in the model. Each country i has a representative consumer, firm, and government. There are two goods in the model, denoted M and Q. Good M is chosen as the

actually study equilibrium under its conditions.

[8]The literature on the dynamics of trade liberalization examines the possibility that trade agreements give way to world free trade at a later stage; see Riezman (1999), Aghion, Antras, and Helpman (2007), Seidmann (2009) and Saggi, Woodland, and Yildiz (2010) for recent contributions. Building on Baldwin (1996), Krishna (1998) shows how political interests can undermine the progression from regionalism. Ornelas (2005b) shows that trade agreements may create problems for multilateral trade liberalization 'through their own success'; if governments can adjust tariffs then they only support trade-creating TAs, but then non-member countries may prefer to free-ride on such agreements, blocking a subsequent move to free trade. Ethier (1998) considers how multilateral liberalization may give way to regionalism. See Bhagwati, Greenaway, and Panagariya (1998) for a literature review on the dynamics of regionalism.

numeraire. It is transferred internationally to settle the balance of trade. By assumption, each country is endowed with a sufficient quantity of M to ensure that it consumes a positive quantity in equilibrium. The term M_i measures consumption of M in country i.

Each firm, one in every country, produces a different variety of the horizontally differentiated product Q, at a constant marginal cost c in terms of the numeraire good. Consumers have quasilinear-quadratic preferences of the form

$$u(\mathbf{q}_i, M_i) = v(\mathbf{q}_i) + M_i = aQ_i - \frac{\gamma}{2}Q_i^2 - \frac{1-\gamma}{2}\sum_{j=1}^{N} q_{ij}^2 + M_i \tag{1}$$

where q_{ij} is country i's consumption of country j's variety of Q, $\mathbf{q}_i = (q_{i1}, q_{i2}, ..., q_{iN})$ is country i's consumption profile, and $Q_i \equiv \sum_{j=1}^{N} q_{ij}$. The parameter γ is a substitution index between varieties which ranges from 0 (varieties are independent) to 1 (the good is homogeneous); as γ increases, the varieties become closer substitutes. The parameter γ determines consumers' love for variety: for low values of γ, variety is highly valued; for higher values of γ, variety does not matter so much; and when $\gamma = 1$, variety is completely unimportant.

There are no transportation costs in this model. Countries impose specific tariffs on imports from other countries. τ_{ij} denotes country i's tariff on imports from country j. Firms perceive markets as being segmented, and so they compete by choosing quantities in each country.[9] In equilibrium,

$$Q_i = \frac{N - T_i}{\Gamma(N)} \quad \text{and} \quad q_{ij} = \frac{\Gamma(0) + \gamma T_i - \Gamma(N)\tau_{ij}}{\Gamma(0)\Gamma(N)} \tag{2}$$

where $T_i \equiv \sum_{j=1}^{N} \tau_{ij}$ is the sum of tariffs; $\Gamma(k) \equiv 2 - \gamma + k\gamma$, $k = 0, ..., N$; and where we have normalised $a - c = 1$. Notice that the parameter γ also determines the degree of competition between firms: when $\gamma = 0$, firms do not compete with each other, but as γ increases so does the strategic interaction between firms.

There will be two sources of gains from trade: access to a wider variety of goods and increased competition in the domestic market. The importance of each of these gains will depend on the substitution index γ.

2.1.2 CUs and optimal tariffs

Country i's welfare is the sum of four components: domestic consumer surplus CS^i; domestic firm's profit in the home market π^{ii}; tariff revenue TR^i; and domestic firm's export profits π^{ji}, $j \neq i$. When forming a CU, countries are assumed to abolish tariffs among union

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

members and jointly set a common external tariff (CET) to maximize the aggregate welfare of members. Thus, if countries $1, ..., k$ belong to a CU of size k, to set their CET, they will solve

$$\max_{\substack{\{\tau_{ij}\} \\ i=1,k;j=k+1,N}} \sum_{i=1}^{k} W^i = \sum_{i=1}^{k} \left\{ CS^i + \pi^{ii} + TR^i + \sum_{\substack{j=1 \\ j \neq i}}^{N} \pi^{ji} \right\}$$

where $\tau_{ij} = 0$, for $i = 1, ..., k$ and $j = 1, ..., k$. As Yi (1996) shows, the unique optimal CET of a CU of size k is

$$\tau(k) = \frac{\Gamma(0)\Gamma(2k)}{D(k)} \tag{3}$$

with $D(k) \equiv \Psi(k)\Gamma(N) + \Gamma(k)\Gamma(2k)$ and $\Psi(k) \equiv (\Gamma(0) + 1)\Gamma(k) - \Gamma(2k)$. Note that in this model, the CET of a CU of size k depends *only* on the size of the CU and the parameters of the model N and γ. It does not depend on the tariffs set by the rest of the world. This property is driven by the assumptions of segmented markets, a quasilinear utility function and constant marginal cost, and will play an important role in the subsequent analysis of the welfare effects of CU formation.

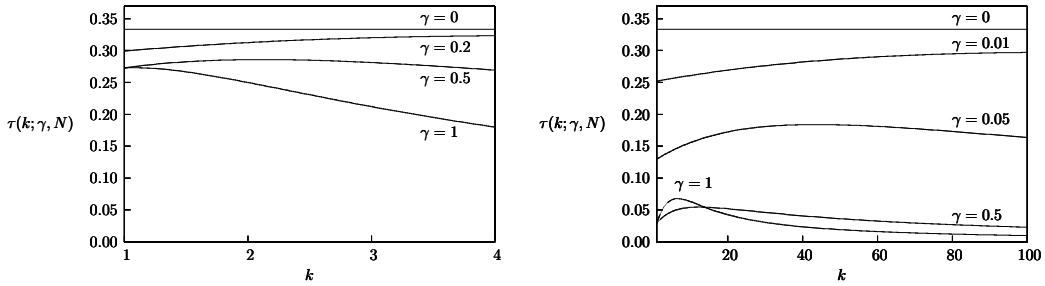
2.2 The Article XXIV constraint

As a CU expands, its CET varies with size of the union k in a non-monotonic way depending on the parameters γ and N. The numerator of $\tau(k)$ is linear in k while the denominator is a quadratic in k and $\tau(k)$ has only one positive turning point: $\tau(k)$ increases with k if and only if

$$k < k^* = k^*(N, \gamma) = \frac{\sqrt{\Gamma(0)[\Gamma(0) + 1]\Gamma(N)} - \Gamma(0)}{2\gamma} \tag{4}$$

So an expanding CU will raise its CET until it reaches the critical size of k^* members. If it expands beyond this size, its CET will decrease. This non-monotonicity of $\tau(k)$ is the result of two opposing effects of CU formation on the CET: a market-power effect and a trade-diversion effect. When members of a CU coordinate over tariff setting, each member internalizes the external benefit to the profits of firms in other member countries of an increase in its own tariff, which tends to put upward pressure on the CET. On the other hand, when members of a CU remove internal tariffs there is trade diversion towards goods produced by members and away from the rest of the world. Since, all else equal, consumers prefer a more balanced consumption bundle, there is an incentive to lower the CET in order to offset this trade diversion. Which of these effects dominates depends on the parameters γ and N. For low values of γ, when goods are not substitutable, CU expansion does not divert trade much. The market-power effect dominates and $\tau(k)$ is an increasing function in the relevant range $k \in [1, N]$. (k^* is large and outside the relevant range.) For high values of γ, CU expansion diverts trade in a significant way and when the expanding CU reaches the

critical size k^* (within the relevant range for high values of γ), the trade-diversion effect starts to dominate and $\tau(k)$ is a decreasing function beyond k^*. These variations are illustrated in Figure 1. Panel 1(a) shows the case of small N. Note that for $\gamma = 1$, $k^*(N,1) = \frac{\sqrt{2(N+1)}-1}{2}$. So for small N and $\gamma = 1$, $k^*(N,1) \leq 1$ and $\tau(k)$ is a monotonically decreasing function in the relevant range $k \in [1, N]$. This case occurs only for a very limited range of parameters, when N is very small and γ close to 1, when the trade diversion effect is the strongest. (For small N, adding one more country into a CU represents a large proportion of world trade and so trade diversion dominates from the start.) For larger values of N and high values of γ, $\tau(k)$ initially increases but eventually decreases in k as shown in panel 1(b). For any N and a sufficiently small γ, $k^* > N$ and $\tau(k)$ is a monotonically increasing function of k in the relevant range $[1, N]$ as can be seen in both panels 1(a) and 1(b). When $\gamma = 0$, the CET is constant and equal to 1/3.



(a) $N = 4$ (b) $N = 100$

Figure 1: External tariff $\tau(k)$ as a function of the CU size for different values of N and γ.

Given the properties of the CET, the Article XXIV constraint can be formalized in a simple way. To set the level of the Article XXIV constraint we will assume that initially there are no CUs. Since all countries are symmetric, they all initially impose the same Nash tariff $\tau(1)$. Then, if a set of countries forms a CU, but is obliged to abide by Article XXIV, their external tariff is constrained to be less than or equal to $\tau(1)$. The effect of the Article XXIV constraint depends on the form of the function $\tau(k)$. If, for example, $\tau(k)$ is a decreasing function in the relevant range, then the Article XXIV constraint is not binding and has no effect. On the other hand, if $\tau(k)$ is initially an increasing function and becomes a decreasing function only for higher values of k, then there will be a range of k for which the Article XXIV constraint will bind. The following proposition identifies when the Article XXIV constraint binds and when it does not.

Proposition 1. *For any number of countries in the world N and any substitution index γ, the Article XXIV constraint is binding for any size-k CU, $k \leq k^{**}$, where k^{**} is the non-trivial root of $\tau(k) = \tau(1)$:*

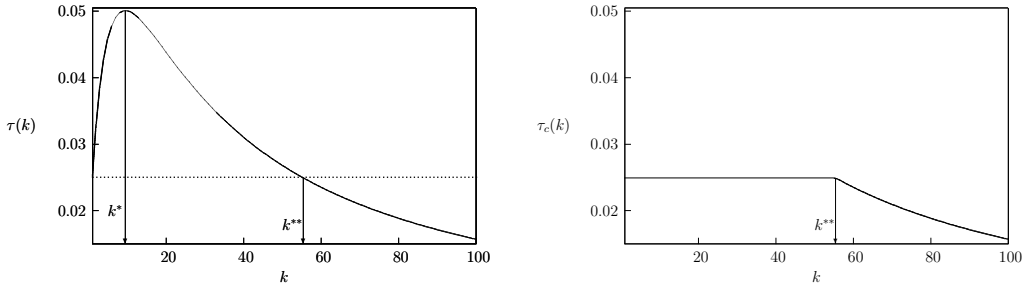
$$k^{**} = \frac{\Gamma(0)\left\{\Gamma(N)\left[\Gamma(0)+1\right] - \Gamma(2)\right\}}{2\gamma\Gamma(2)} \tag{5}$$

The Article XIV constraint imposes

$$\tau_c(k) = \begin{cases} \tau(1) & \text{for } k \leq k^{**} \\ \tau(k) & \text{for } k^{**} < k < N \text{ and} \\ 0 & \text{for } k = N \end{cases}$$

Proof. See Appendix A page 24.

Figure 2 illustrates $\tau_c(k)$ as a function of CU size. Note that $\tau_c(k)$ is a non-increasing function of k.



(a) $\tau(k)$ with $k^* \approx 9.5$ and $k^{**} \approx 55.5$ (b) $\tau_c(k)$

Figure 2: $\tau(k)$ and $\tau_c(k)$ for $N = 100$ and $\gamma = 0.7$.

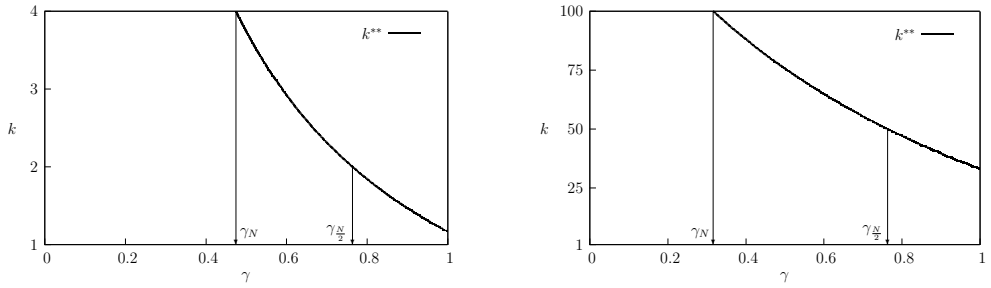
The proof in the appendix derives the existence and uniqueness of k^{**} and studies its properties in detail. It is however useful to point out some of the key characteristics that will be crucial for the derivation of the main results in later sections: k^{**} is a linear (monotonically increasing) function of N (when $\gamma \neq 0$) and a monotonically decreasing function of γ with $k^{**}(\gamma = 1) = \frac{2N-1}{6}$. Hence we know that *any CU of size smaller than* $\frac{2N-1}{6}$ *will always* (for any N and γ) *be bound* by the Article XXIV constraint. Furthermore, when $\gamma = 0$, k^{**} is infinite, and when $\gamma = 1$, k^{**} is strictly positive and smaller than N. Thus, by the intermediate value theorem, there exists a unique value of γ, denoted γ_N, such that $k^{**} = N$. Hence we know that for $\gamma \in [0, \gamma_N]$, Article XXIV *binds for any possible* CU. It can be shown that γ_N is a monotonically decreasing function of N with $\gamma_N(N = 1) = 7 - \sqrt{41} \approx 0.597$ and approaches a horizontal asymptote when N tends to infinity: $\lim_{N \to +\infty} \gamma_N = \frac{1}{2}(7 - \sqrt{41}) \approx 0.298$. Table 1 shows values of γ_N for selected values of N.

N	10	30	50	100	200	500	1000	10^4	10^5	10^6
γ_N	0.406	0.349	0.332	0.317	0.308	0.302	0.300	0.299	0.298	0.298

Table 1: Values of γ_N (rounded to three decimal places).

Similarly, we can also find the unique value of γ, denoted $\gamma_{\frac{N}{2}}$, such that $k^{**} = \frac{N}{2}$: $\gamma_{\frac{N}{2}} = 3 - \sqrt{5} \approx 0.764$. Note that $\gamma_{\frac{N}{2}}$ is a constant, independent of N. We know that for any N

and $\gamma \in [3-\sqrt{5}, 1]$, the Article XXIV constraint *does not* bind for CUs containing more than half of the countries in the world. These features are illustrated in Figure 3: CUs of size smaller than k^{**} (k below the k^{**} curve) are constrained by Article XXIV while CUs of size larger than k^{**} (k above the k^{**} curve) are not. For $\gamma \leq \gamma_N$, all CUs are constrained. For $\gamma > \gamma_{\frac{N}{2}}$, any CUs containing more than $N/2$ countries are not constrained.



(a) $N = 4$ (b) $N = 100$

Figure 3: k^{**} as a function of γ.

3 CU formation and welfare

In this section, we briefly analyse the impact of exogenous CU formation under the Article XXIV constraint on the welfare of individual countries and on global welfare before determining stable CU structures in the next section. Our analysis proceeds along the same lines as Yi (1996) but with the key difference that all CUs have to abide by Article XXIV. We show that the Article XXIV constraint slightly attenuates the negative effects of CU formation, but does not prevent them altogether.

3.1 Preliminaries

The impact of CU formation and expansion on members' and non-members' welfare can be studied through the following quantities which can be derived from (2): sales of a member nation (*Insider*) $q_I(k)$ and sales of a non-member nation (*Outsider*) $q_O(k)$ in a country belonging to a size-k CU

$$q_I(k) = \frac{\Gamma(0) + [\Gamma(N) - \Gamma(k)]\,\tau_c(k)}{\Gamma(0)\Gamma(N)} \text{ and } q_O(k) = \frac{\Gamma(0) - \Gamma(k)\tau_c(k)}{\Gamma(0)\Gamma(N)} \tag{6}$$

and total consumption $Q(k)$ in a country belonging to a size$-k$ CU

$$Q(k) = \frac{N - (N-k)\tau_c(k)}{\Gamma(N)} \tag{7}$$

3.2 Non-members' welfare

We can see by inspection of (6) that $q_I(k)$ exceeds $q_O(k)$; i.e. a member country always sells a higher volume of exports in a member country than a non-member country. Since the expression for export profits is the square of the expression for export volume, a member country makes higher export profits in any member country than a non-member country. Furthermore, as noted above, a non-member country is affected by CU formation or expansion only through its export profits to the CUs that form. So from (6), we can show that non-member countries become worse off if a CU expands. Yi (1996) shows this result without the Article XXIV constraint, reflecting a standard property in the literature that CU formation and expansion tend to hurt non-members through trade diversion. We show that the Article XXIV constraint is not sufficient to prevent the harmful trade diversion effect, but attenuates it slightly.

Lemma 1. *1. A non-member country's exports $q_O(k)$ are a decreasing function of k and so a non-member country becomes worse off if a CU expands.*

2. When the Article XXIV constraint binds, a non-member country's exports $q_O(k)$ decrease less in k compared to the situation without the Article XXIV constraint.

Proof. See Appendix B page 25.

3.3 Members' welfare

How does an expansion of a CU affect the welfare of member countries? Without Article XXIV, all the components of welfare (consumer surplus, tariff revenue and producer surplus) are affected in an ambiguous way. As a CU expands, there are two effects on the consumer surplus of a member country: consumer surplus tends to increase through the increased consumption of products from member countries, but it tends to decrease through the diminished consumption of non-member countries' products. Tariff revenue may also increase or decrease as the CET may increase as a CU expands while the number of taxed importers decreases. Finally, the home firm's export profits increase as it gets tariff-free access to more countries, but its home profits may either increase or decrease: it faces more competition from other member countries' firms, but, at the same time, it may face less competition from outsiders' firms when the CET rises. So the effect on home firm's total profit is also ambiguous. As shown in the following lemma, Article XXIV changes somewhat how a CU expansion affects the different components of members' welfare.

Lemma 2. *As a CU expands, a representative member's*

1. consumer surplus unambiguously increases,

2. tariff revenue unambiguously falls,

3. *home firm's export profits increase, but domestic profit decreases and so the total profits are affected in an ambiguous way.*

Thus the effect of a CU expansion on welfare of member countries is ambiguous.

Proof. See Appendix B page 25.

The proof in the Appendix shows analytically that consumer surplus is an increasing function of the size of the CU when Article XXIV is in place. The intuition for this result is that consumers will still benefit from the increased consumption of products from member countries and they will still be harmed by the diminished consumption of non-member countries' products, but the Article XXIV constraint, by preventing member countries from raising the external tariff above the initial level, makes the second effect less important (Lemma 1). The tariff revenue necessarily decreases as the CU expands, because countries are not allowed to raise their external tariffs, and as the CU expands they can thus levy at most the same level of tariff on fewer countries. Finally, the effect of CU expansion on domestic firm's total profits is still ambiguous, however, with Article XXIV, the profit made at home unambiguously decreases as the domestic firm faces more competition from other members' firms and is less protected from the competition of non-members' firms. On the whole, the effect of CU expansion on the welfare of a member country is ambiguous.

While we are not able to obtain a general prediction about how CU expansion will affect the welfare of an individual member, we can show that the joint welfare of the member countries (existing members plus any new members) improves when a CU expands. (In the case where existing members lose, new members gain by more than enough to compensate.) This implies that, if several CUs merge, the aggregate welfare of members of the newly formed CU increases. While this result is established by Yi (1996) for the case without Article XXIV, we show that it continues to hold under the Article XXIV constraint.

Lemma 3. *Under the Article XXIV constraint, the formation or expansion of CUs increases the aggregate welfare of member countries.*

Proof. See Appendix B page 27.

3.4 World welfare

What is the effect of CU formation and expansion on world welfare? As Yi (1996) points out, without the Article XXIV constraint, as a CU expands, its members are on average better off, but non-members are made worse off, so the effect on world welfare is ambiguous, except when global free trade is reached where world welfare is maximised. As we have shown above, the presence of Article XXIV does not reverse any of these effects. In particular, Article XXIV is not sufficient to prevent the harmful effects of CU formation on non-members, and so the effect on world welfare also appears ambiguous except for the global free trade case.

However, Article XXIV affects the magnitude of these effects, namely it reduces the harm to non-members, so it may be possible that on the whole CU expansion with the Article XXIV constraint increases world welfare. We cannot conclude at this stage. To evaluate the effects of CU formation on world welfare we need to examine the link between CU structures and welfare which we do in the next section.

4 CU structures, welfare and CU formation equilibria

4.1 CU structures and individual members' welfare

In the previous subsection, we showed that the formation and expansion of a CU has an ambiguous impact on individual-member welfare. In fact circumstances do exist under which we can clearly predict that member welfare will increase under CU expansion. In order to determine these conditions, we need to make explicit the link between welfare and CU structures.

Definition 1. Let $\mathcal{P}$ be the set of countries: $\mathcal{P} = \{P_1, P_2, ..., P_N\}$. A CU structure $C = \{B_1, B_2, ..., B_m\}$ is a partition of the set of countries $\mathcal{P}$ into m CUs. $B_i \cap B_j = \varnothing$ for $i \neq j$ and $\cup_{i=1}^{m} B_i = \mathcal{P}$.

Since countries are symmetric, we can identify each CU with the number of its members. In what follows, we will use the same notation as Yi (1996) and write $C = \{n_1, n_2, ..., n_m\}$, where n_i is the number of countries in the ith CU in $C = \{B_1, B_2, ..., B_m\}$. Both with and without the Article XXIV constraint, the tariff equilibrium is unique for any given CU structure and so the welfare of a CU of size k in any CU structure is well defined. Following Yi (1996), we will denote the welfare of a member country of a CU of size k in a given CU structure C as $W(k; C)$, $k = n_1, n_2, ..., n_m$. For example, in a CU structure $C = \{2, 3, 4\}$, $W(3; \{2, 3, 4\})$ is the level of welfare of a country belonging to the three-country CU.

Lemma 4. *The welfare of a member of the size-n_i CU in $C = \{n_1, n_2, ..., n_m\}$ is given by*

$$W(n_i; C) = NS(n_i) + PB(n_i; C) \tag{8}$$

where $NS(n_i) = Q(n_i) - \frac{\gamma}{2} Q(n_i)^2 - \frac{1-\gamma}{2} \left\{ n_i \left[q_I(n_i) \right]^2 + (N - n_i) \left[q_O(n_i) \right]^2 \right\}$ *is the net benefit from consumption and* $PB(n_i; C) = \sum_{\substack{j=1 \\ j \neq i}}^{m} n_j q_O(n_j)^2 - (N - n_i) \left[q_O(n_i) \right]^2$ *is the profit balance.*

Proof. See Appendix C page 31.

The following results illustrate how the CU structure affects individual member welfare under the Article XXIV constraint. These results are analogous to the propositions derived by Yi (1996). We prove that Yi's results (his propositions 6–8) continue to hold under the

Article XXIV constraint and discuss what the differences are with respect to the situation without the Article XXIV constraint. These results will be crucial in determining the stable CU structures of the CU formation game below.

Lemma 5. *1. If $n_i \in C$, C', and $C - \{n_i\}$ can be derived from $C' - \{n_i\}$ by merging CUs in $C' - \{n_i\}$, then $W(n_i; C) < W(n_i; C')$.*

2. If $n_i > n_j$, then $W(n_i; C) > W(n_j, C)$.

3. The members of a CU that merges with another CU of equal or larger size become better off.

4. A member of a CU becomes better off if it leaves its CU to join another CU of equal or larger size.

Proof. The qualitative properties of the welfare components $q_O(k)$ and $NS(k)$ are the same as in Yi (1996) and so Yi's proofs of his propositions 6–8 (pages 163–164) apply with the appropriate amendments (the Nash CET function $\tau(k)$ is replaced by the Article XXIV-constrained CET $\tau_c(k)$). □

Although the proofs of these results are identical to the equivalent results of Yi except that ours replace the general tariff, $\tau(k)$, with our tariff on which the Article XXIV constraint may be binding $\tau_c(n_i)$, it may be helpful to provide some brief intuition. The first point of Lemma 5 says that if CUs merge to form a larger CU, non-member countries not involved in the merger are made worse off. This result is a consequence of Lemma 1: as any CU expands, the export profits made by non-members unambiguously fall, and this is the only effect of CU expansion on nonmembers. Also from Lemma 1 we know that the Article XXIV constraint will attenuate the adverse effect of a CU merger on non-members.

The second point ranks the per-member welfare of CUs in a given CU structure: in any given CU structure, a member of a large CU has a higher level of welfare than does a member of a small CU. This result holds both under the Article XXIV constraint and without it, but the impact of Article XXIV is ambiguous and will depend on the given CU structure. If the Article XXIV constraint binds for small CUs but not for large ones (which is the case if γ is relatively large), the difference in welfare of a member of a large CU and a member of a small CU will be exacerbated. However, if the Article XXIV constraint binds for both large and small CUs, this difference may be attenuated.

The final two points show how changes in the CU structure affect the welfare of countries involved in the change. When CUs merge, the welfare of members increases on average. Before the merger, the members of the smallest CU involved have the lowest welfare among the CUs involved, and thus their welfare must have necessarily increased by the merger.[10]

[10]Note that given the fact that two CUs of the same size are always better off by merging, if countries were allowed to form only symmetric blocs as in Krugman (1991), they would always want to form one large bloc containing all countries, i.e. go to free trade. Thus in our model, free trade would be the stable

Imposition of the Article XXIV constraint does not reverse any of Yi's equivalent results. It only modifies the magnitude of the effect of CU formation on welfare. This will in turn have important implications for the final equilibrium CU structure with and without the Article XXIV constraint and for world welfare as we will show in Section 5.

4.2 CU structures and world welfare

Having understood the link between CU structures and welfare, we can now return to the question how does CU formation and expansion affect world welfare under Article XXIV? As we have mentioned, Yi (1996) shows that, without the Article XXIV constraint, the effect of CU expansion on world welfare is ambiguous (except when free trade is reached). The following lemma derives the conditions under which, when Article XXIV binds, CU expansion increases world welfare.

Lemma 6. *Assume a given CU structure. When the Article XXIV constraint binds, a mean-preserving spread of the distribution of the number of countries per CU, increasing the size of one union by moving countries from a smaller or equal-sized union, increases world welfare if and only if the two CUs involved represent a sufficiently large proportion of the countries in the world.*

Proof. See Appendix C page 31.

The intuition behind this result is that CU expansion increases members' welfare while hurting outsiders. So if there are not many outsiders and if the Article XXIV constraint binds on the small union such that the expanding union is even better off than when it expands in the absence of Article XXIV, world welfare increases on average. Note an important consequence of this lemma: if the world is divided into only two blocs, an increase in the asymmetry between these blocs increases world welfare (with free trade being the extreme case that maximises world welfare). This is not necessarily true in the absence of Article XXIV because the smaller union when becoming smaller could raise its CET and thus reduce the benefits to the members of the larger expanding union.

4.3 CU formation game

We follow Yi (1996) in using an infinite-horizon sequential-move 'coalition unanimity game' to model the CU formation process. In this game, a coalition forms if and only if all potential members agree to form the coalition.[11] Bloch (1996) shows that this game yields

equilibrium outcome if only symmetric blocs were allowed. This result is shown by Oladi and Beladi (2008) in a different setting using the Krugman (1991) model. The difference of this paper is that we do not impose the symmetry constraint on the CU structure, and as we will show in Subsection 4.4, symmetric blocs are not an equilibrium outcome of the CU formation game considered in this paper.

[11]The country P_1 starts the game by proposing the formation of a CU, e.g. $\{P_1, P_3, P_7, P_8\}$. Then all proposed partners (following subsequently from country P_1) are asked to agree or disagree. If a proposed CU

the same stationary subgame perfect equilibrium coalition structure as the following 'size announcement game'. All countries are placed on a list, say $P_1, P_2, ..., P_N$. Country P_1 is asked to announce the size of the CU that it would like to form, e.g. k. Then the first k countries form a size-k CU, and then country P_{k+1} announces the size of the CU it would like to form, and so on until P_N is reached. Bloch (1996) shows that this size announcement game has a (generically) unique subgame perfect equilibrium coalition structure. We will now use this size announcement game to determine stable CU structures of the CU formation process.[12]

4.4 Characterisation of stable CU structures

In this subsection, we will characterize stable CU structures when countries play the size announcement game characterised above. In order to do so, let us introduce the notation k_0 as *the largest integer such that any size-k CU becomes better off by merging with a single-country CU*. Formally:

Definition 2. For all CU structures C and C', $C' = C - \{k\} \cup \{k-1, 1\}$, and all k, $1 \leq k \leq k_0$, k_0 is the largest integer which satisfies $W(k; C) \geq W(k-1; C')$.

Lemma 7. *1. Under the Article XXIV constraint, the unique subgame perfect equilibrium CU structure of the size announcement game has a unique smallest CU, which is the last CU to form.*

2. Under the Article XXIV constraint, the unique subgame perfect equilibrium CU structure of the size announcement game has a unique second-smallest CU, which is the second-to-last CU to form and which has at least k_0 members.

3. Under the Article XXIV constraint, the number of equilibrium CUs in the size announcement game is not greater than three.

Proof. See Appendix C page 32.

The intuition for these results is simple: from Lemma 5, we know that two CUs of equal size would be better off by merging and so the CU equilibrium structure cannot be symmetric. Also, the last CU to form must be the smallest since it implies the lowest level of welfare for each of its members. If its members had the option to form a larger CU earlier in the process then they would have done so. By the same reasoning, the second-to-last CU to form must be the unique second-smallest CU. Furthermore, it has to have at least

partner disagrees then it is asked to make its own proposal of a CU and, again, each subsequent proposed partner of the CU is asked whether or not it agrees. If all agree then the CU forms and those countries withdraw from the game. Then the first country among the remaining countries makes a proposal.

[12]Note that side-payments between countries are not allowed in the CU formation process. If they were, then it would be possible to reach free trade under any set of parameter values. While they do occur in practice, it appears that political constraints coupled with credit market imperfections mean that side-payments between countries are not large enough to facilitate free trade.

k_0 members, because if it did not, it would be better off by admitting at least one more member. Thus we are able to put a lower bound on the size of the second-to-last CU to form and of all the other larger CUs that form before the second-to-last union. Therefore we can conclude that there will be at most three CUs in equilibrium.

It is hard to solve for the equilibrium CU structure in general. The fact that Article XXIV binds only on a certain range of parameters introduces a kink to the tariff function and finding the equilibrium structure requires solving a series of p^{th} degree polynomial equations with $p \geq 5$ and with two parameters. It is however possible to solve for the equilibrium structure numerically by constructively using the integer characteristic of the CU formation game: we conduct a grid-search over the possible sizes of the CUs to find the equilibrium CU structure. The algorithm of the grid-search is detailed in Appendix D page 34. The numerical analysis shows that for $N \leq 10^5$, there will be *at most two* CUs in equilibrium both with and without the Article XXIV constraint in place, but the sizes of the CUs will be affected by the presence of the Article XXIV constraint. The following section examines the consequences of the Article XXIV constraint for the equilibrium CU structure.

5 The effect of the WTO Article XXIV constraint

The previous sections showed that the Article XXIV constraint slightly attenuates the negative effects on outsiders of CU formation, but does not reverse them, and it does not affect the number of CUs that emerge in equilibrium. These intermediate results might suggest that Article XXIV is relatively unimportant. This section will show however, that the Article XXIV constraint affects the incentives for CU formation and thus affects the final equilibrium CU structure, with important implications for world welfare.

To disentangle the different effects of Article XXIV, we start by determining the impact of Article XXIV on world welfare for a given CU structure.

Proposition 2. *For a given CU structure, the Article XXIV constraint increases world welfare.*

Proof. See Appendix E page 35.

The intuition for this result is clear: Article XXIV lowers CETs of CUs when it binds (and has no effect when it does not bind) and so for a given CU structure, Article XXIV reduces barriers to trade and so improves world welfare. But the reduction of trade barriers is not the only effect that Article XXIV has on CU formation: by affecting the CET that CUs may impose, it affects the incentives of countries to form CUs. The following proposition shows how these incentives are affected locally.

Proposition 3. *In an equilibrium CU structure with one large bloc and one small bloc,*

1. *when Article XXIV binds on the large bloc, it makes the large bloc want to accept more members;*

2. *when Article XXIV binds on the small bloc, it makes the large bloc want to accept fewer members.*

3. *For $\gamma \geq \gamma_{\frac{N}{2}} = 3 - \sqrt{5}$, effect 1. of Article XXIV cannot be present.*

Proof. See Appendix E page 35.

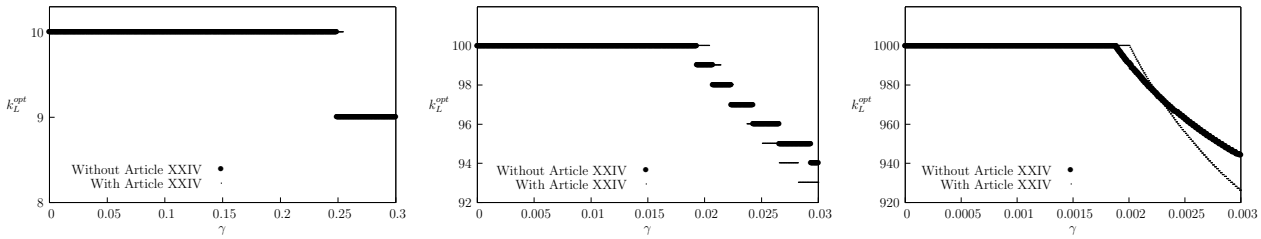
Proposition 3 derives local effects of Article XXIV: at the equilibrium point where the large bloc has chosen its size optimally in the presence of Article XXIV, how would its choice be affected if we were to remove Article XXIV and allow CUs to increase their CET slightly? The intuition for these results is simple: when the large bloc is constrained, it is less able to exploit terms-of-trade and profit-shifting gains from outsiders. Hence gains from free trade with more countries become relatively larger and so the large bloc would want to expand. For the second part of the result, assume that Article XXIV binds on the small bloc. If this constraint is lifted, the small bloc would raise its CET and thus hurt the members of the large bloc. To mitigate this effect, the members of the large bloc would want to accept more members so that they suffer the import tariff rise from fewer countries. Thus, when the small bloc is constrained, the large bloc would want to accept fewer members. Finally, we know that for $\gamma \geq \gamma_{\frac{N}{2}}$, the large bloc will never be constrained and thus the effect of Article XXIV, if any, would make the large bloc want to accept fewer members.

The next question is: do these local effects translate into a global change in the CU structure when Article XXIV is imposed? And if yes, how is the equilibrium CU structure affected by Article XXIV? We can see for example that when γ is small and both blocs are constrained by Article XXIV, the two effects of Article XXIV work in opposite directions. Which effect dominates? In other words, we want to compare the equilibrium CU structures with and without Article XXIV. To do so, we use our CU formation algorithm (see Appendix D) to determine equilibrium CU structures both with and without the Article XXIV constraint. Our numerical analysis shows that the results of Proposition 3 correctly predict the global effects of Article XXIV on the equilibrium CU structure.

Result 1. *For low values of γ, Article XXIV leads to a weakly more asymmetric equilibrium CU structure (i.e. the large CU is larger) and makes free trade arise for a wider range of γ.*

Result 1 is illustrated in Figure 4 which shows k_L^{opt}, the size of the large CU in the equilibrium CU structure consisting of two asymmetric CUs, with and without Article XXIV. We can see that for low values of γ, the large CU is weakly larger with Article XXIV than without. Intuitively, for low γ, the equilibrium CU structure is weakly more asymmetric with the Article XXIV constraint, because, for low γ, given the shape of the CET function which is increasing in the size of the bloc, it is the large CUs that are more constrained than small ones, and thus the first effect from Proposition 3 dominates.[13]

[13]Note that the range of γ for which Result 1 arises becomes smaller as N increases. This is because an increase in N affects the shape of the CET and thus the way in which Article XXIV binds. We know that for $\gamma \leq \gamma_N$, all CUs are constrained by Article XXIV, but as N increases, small CUs become more constrained than large ones as $k^*/N \to 0$ (the maximum of the function τ is shifting to the left).



(a) $N = 10$, $0 \leq \gamma \leq 0.3$ (b) $N = 100$, $0 \leq \gamma \leq 0.03$ (c) $N = 1000$, $0 \leq \gamma \leq 0.003$

Figure 4: Size of the large bloc in the equilibrium two CU structure for low values of γ.

Figure 4 also confirms the result of Yi (1996) that, for sufficiently low γ, the equilibrium CU structure is one large union containing all the countries, i.e. free trade. This is because, when goods are independent, the static efficiency gains of free trade outweigh the terms-of-trade benefits that would arise under CU formation even for a large CU. Thus there is a strong incentive for countries to go to free trade. For higher values of γ, gains from free trade are relatively smaller than benefits from foreign-rent extraction and so it is beneficial for the large union to leave some countries out of the union. Yi (1996) shows that there is a unique threshold value of γ, below which the equilibrium is free trade and above which the equilibrium CU structure consists of one large and one small bloc. As explained in the Appendix page 39, we determine this threshold value of γ numerically both with and without the Article XXIV constraint (γ_c^{FT} and γ_u^{FT} respectively) and we find that with Article XXIV, the critical threshold value of γ is higher: $\gamma_c^{FT} \geq \gamma_u^{FT}$. This is because Article XXIV limits foreign rent extraction and so the benefits from free trade outweigh the benefits from foreign rent extraction for a larger range of parameters.[14] Table 2 shows the threshold value of γ with and without Article XXIV for selected values of N.

N	10	20	30	50	100	150	200	500	1000
γ_u^{FT}	0.2488	0.1072	0.0683	0.0396	0.0193	0.0128	0.0095	0.0038	0.0019
γ_c^{FT}	0.2543	0.1117	0.0717	0.0417	0.0204	0.0135	0.0101	0.0040	0.0020

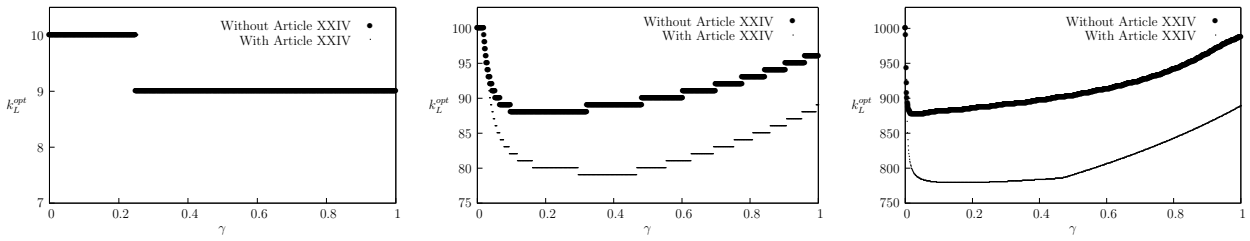
Table 2: Values of γ_u^{FT} and γ_c^{FT} (rounded to four decimal places).

Result 2. *For higher values of γ, Article XXIV leads to a weakly more symmetric equilib-*

[14] Syropoulos (1999) obtains a similar result in a very different setting. He considers CU formation in a three-country model with perfect competition and studies the equilibrium outcome of CU formation in a different parameter space: his parameter of interest is countries comparative advantage and he shows that under Article XXIV, free trade may be reached for a larger range of this parameter. In our case, we have an oligopolistic model of international trade among N countries and our parameter of interest to determine whether the equilibrium outcome will or not be free trade is the substitution index between goods (or the total number of countries in the world). What our models have in common is that we both find that Article XXIV makes free trade the equilibrium outcome for a wider range of parameters.

rium CU structure (i.e. the large CU is smaller).

For higher values of γ, the large CU is less constrained than the small CU (or not at all if the Article XXIV constraint does not bind on the large union which is the case for $\gamma \geq \gamma_{\frac{N}{2}}$) and so the second effect from Proposition 3 dominates (or is the only present). Result 3 is illustrated in Figure 5 which shows again the equilibrium size of the large bloc k_L^{opt} with and without Article XXIV, but this time for the whole range of γ.



(a) $N = 10$ (b) $N = 100$ (c) $N = 1000$

Figure 5: Size of the large bloc in the equilibrium two CU structure for all γ.

Finally, we are interested in determining the impact of Article XXIV on world welfare. We know from Proposition 2, that for a given CU, Article XXIV increases world welfare, but Proposition 3 tells us that Article XXIV affects the incentives of countries to form CUs and our numerical analysis shows that indeed, Article XXIV affects the equilibrium CU structure. The total effect on world welfare of Article XXIV depends on how the equilibrium CU structure is affected.

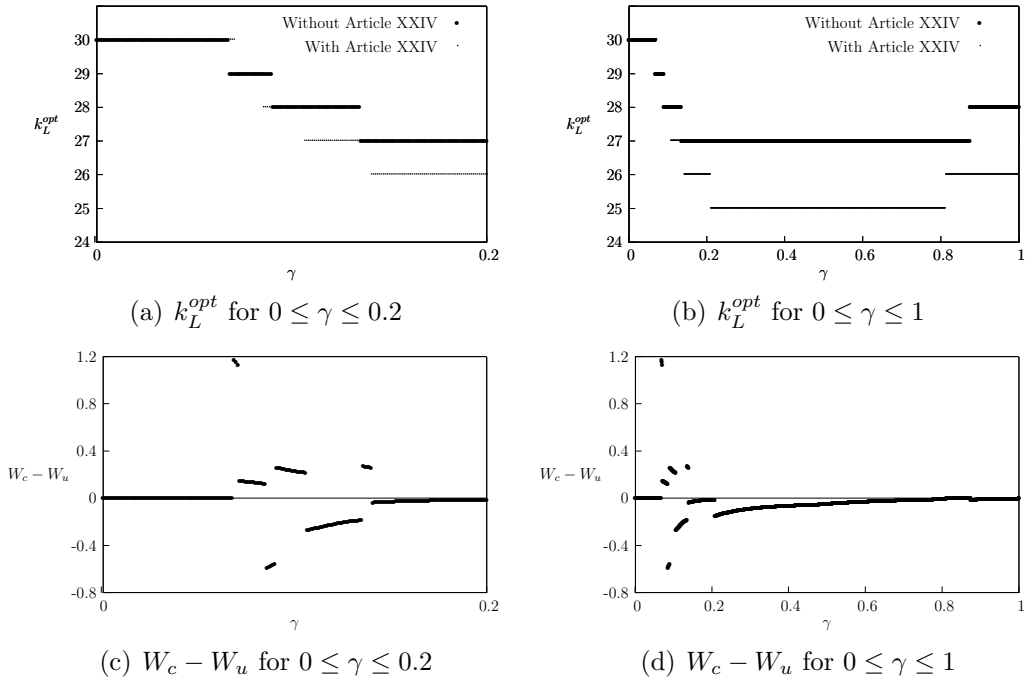
Proposition 4. *When Article XXIV leads to a more asymmetric equilibrium CU structure (or leaves the CU structure unchanged), it unambiguously increases world welfare. When Article XXIV leads to a more symmetric equilibrium CU structure, its effect on world welfare is ambiguous.*

Proof. Follows from Proposition 2 and Lemma 6. □

Article XXIV affects world welfare in two ways: it reduces barriers to trade and so for a given CU structure increases world welfare, and it affects the equilibrium CU structure. From Lemma 6, we know that when Article XXIV binds, an increase in the asymmetry of the CU structure increases world welfare. Thus, for low values of γ, when Article XXIV makes the equilibrium CU structure more asymmetric, world welfare unambiguously increases, because the two effects of Article XXIV work in the same direction. On the other hand, when Article XXIV makes the equilibrium CU structure more symmetric, the two effects work in opposite directions. Our numerical analysis confirms that either effect can dominate and shows that for a wide range of parameters world welfare may fall. This is particularly important in light of our earlier result that, for a given CU structure, Article XXIV must increase world welfare.

Result 3. *When Article XXIV leads to a more symmetric CU structure, world welfare falls for a wide range of parameters.*

This result is illustrated in Figure 6 which shows the change in world welfare between the equilibria with and without Article XXIV related to the change in equilibrium CU structures. Figure 6(a) shows k_L^{opt}, the size of the large bloc in the two-bloc equilibrium CU



(a) k_L^{opt} for $0 \leq \gamma \leq 0.2$

(b) k_L^{opt} for $0 \leq \gamma \leq 1$

(c) $W_c - W_u$ for $0 \leq \gamma \leq 0.2$

(d) $W_c - W_u$ for $0 \leq \gamma \leq 1$

Figure 6: Size of the large bloc in the equilibrium two CU structure and difference in world welfare with and without Article XXIV as a function of γ for $N = 30$.

structure, for a world with $N = 30$ as a function of γ when γ is low, and Figure 6(b) shows this size for the full range $0 \leq \gamma \leq 1$. Notice again from Figure 6(a) that, for low γ, the equilibrium size of the large bloc is weakly larger with Article XXIV and free trade is reached for a slightly broader range of parameters than without the Article XXIV constraint. For higher values of γ, as shown in Figure 6(b), the equilibrium size of the large bloc becomes weakly smaller with Article XXIV than without. Figures 6(c) and 6(d) show the difference in world welfare with and without the Article XXIV constraint for the same ranges of γ as figures 6(a) and 6(b) respectively. When free trade is reached, both with and without Article XXIV, world welfare is identical in both situations and the difference is zero. When free trade is reached under the Article XXIV constraint, but not without it (which is the case for $\gamma_u^{FT} = 0.0683 < \gamma < \gamma_c^{FT} = 0.0717$), there is a significant improvement in world welfare as world welfare is maximised under free trade. When the equilibrium structure is the same in both cases, the large bloc is of the same size in figures 6(a) and 6(b), and world welfare is improved under the Article XXIV constraint, because, as we showed in Proposition 2, Article XXIV increases world welfare for a given CU structure. But when the equilibrium

structure is more symmetric under the Article XXIV constraint, the large bloc is smaller in figures 6(a) and 6(b), and world welfare is lower. This is the case for the entire range of $\gamma \geq 0.141$ with the exception of $\gamma \in [0.811, 0.874]$ where the welfare increasing effect coming from the reduction in trade barriers dominates.[15] This is the crucial possibility highlighted in this paper.

6 Conclusion

This paper has examined the effect of the WTO's Article XXIV on CU formation, the equilibrium CU structure, the welfare of individual countries and the welfare of the world as a whole. We introduced an Article XXIV constraint to the model of Yi (1996), which formed our benchmark. The Article XXIV constraint essentially prevents a CU from raising its CET. This makes CU formation less attractive and hence increases the likelihood that free trade will arise in equilibrium. This in turn increases the range of γ for which free trade would arise, making free trade more likely. But if free trade does not arise in equilibrium, the Article XXIV constraint may reduce world welfare. Our analysis showed that if free trade did not occur in equilibrium then (for a practical number of countries) an equilibrium CU structure would arise in which there are two CUs, one necessarily larger than the other. If the Article XXIV constraint binds on the smaller CU, the terms-of-trade externality imposed on the large CU is not as great, so the larger CU does not have an incentive to include as many countries as without the Article XXIV constraint. Consequently, the equilibrium CU structure is almost always more symmetric, and a larger number of varieties are subject to the tariff distortion as they pass between CUs; hence Article XXIV may indeed be bad for world welfare.

Inevitably, the theoretical framework developed here simplifies the situation in a number of key respects. In future work, it would be useful to check the robustness of our results to alternative economic and policy-making environments. To check robustness to alternative economic environments, one could begin by examining the introduction of an Article XXIV constraint to other models of CU formation, such as that of Bond and Syropoulos (1996). These authors study CU formation in an endowment economy with C.E.S. preferences which in all other respects is the same as ours. A key difference between the behavior of their model and ours is that in their model the CET is monotonically increasing in CU size while in ours, as we have seen, it is non-monotonic. So while in the equilibrium CU structure of our model the Article XXIV constraint may bind only on the small CU, in theirs it would have to bind on both simultaneously. Further analysis is needed to determine which of the effects examined in this paper would dominate, but we conjecture that the monotonic feature of the CET in their model would rule out the reduced asymmetry of CUs under Article XXIV

[15] Note that world welfare appears here to be a discontinuous function of γ because of the integer constraint on the CU structure.

that drives a reduction of world welfare in ours.

To check the robustness of our results to alternative policy-making environments, a useful starting point would be to follow recent research on regionalism where tariffs are used for political or redistributive purposes.[16] Such considerations could be incorporated in the model of the present paper by putting a higher weight on producers' profits. It seems likely that the basic insights of the present paper about the application of Article XXIV would remain robust to the inclusion of distributional/political concerns of the government.

Since our paper suggests that Article XXIV may worsen world welfare, the question naturally arises as to what an appropriate revision of Article XXIV would be. A follow-up paper by Mrázová (2010) examines this question and determines by how much it is necessary to reduce the CET of a CU in this framework to eliminate the harmful effects of CU formation.

While the analysis that we have undertaken reveals a surprising implication of Article XXIV, it does not go on to consider the effects of Article XXIV on multilateral liberalization and so on GATT/WTO rules. Snape (1993) suggests that the six countries which originally formed the EC might not have joined the GATT unless its rules were sufficiently indulgent towards the bloc formed by the EC-6. By contrast, Bhagwati (2008) has suggested that there are now so many blocs in existence, and this number is increasing, that this undermines negotiations directed at further liberalisation of the WTO. Baldwin (2006) argues the opposite. Dinopoulos and Syropoulos (2008) argue that Article XXIV may lessen the impediments to multilateralism created by the existence of CUs, because it reduces the gains from CU formation, but alternatively may prevent the progression from regionalism to multilateralism because it makes regionalism more palatable to some parties. It would be interesting to examine how Article XXIV's composition effect that we have identified operates in a dynamic setting.

[16] In addition to Ornelas (2005a,b), see for examples Krishna (1998), Grossman and Helpman (1994) and Maggi and Rodriguez-Clare (1998).

Appendix

For all the derivations, we assume that the parameters of the model lie within the relevant ranges for the analysis, namely $\gamma \in [0,1]$, $N > 1$ and $k \in [1, N]$.

A Proofs from Section 2

Proof of Proposition 1. The numerator of $\tau(k)$ is linear in k while the denominator is a quadratic of k and $\tau(k)$ has only one positive turning point:

$$\frac{\partial \tau(k)}{\partial k} = \frac{\gamma \Gamma(0)}{D(k)^2} \left\{ \Gamma(0)\Gamma(N)\left[\Gamma(0)+1\right] - \Gamma(2k)^2 \right\} \geq 0 \text{ if and only if } k \leq k^* \text{ given by (4)}$$

So $\tau(k)$ is an initially increasing and then decreasing function of k with a maximum at $k^* > 0$. Note that $\tau(0) < \tau(1)$ for $\gamma > 0$ (for $\gamma = 0$, $\tau(k)$ is a constant function) and that $\lim_{k \to +\infty} \tau(k) = 0 < \tau(1)$ and so using the intermediate value theorem, we know that the second degree polynomial equation $\tau(k) = \tau(1)$ will have two positive roots: a trivial root $k = 1$ and another strictly positive root k^{**}. If $k^* = 1$, 1 will be a double root (and $k^{**} = 1$), if $k^* \neq 1$, k^{**} will be different from 1. Factorising the equation

$$\tau(k) - \tau(1) = 0 \Leftrightarrow (k-1)\gamma \left\{ \Gamma(0)\Gamma(N)\left[\Gamma(0)+1\right] - \Gamma(0)\Gamma(2) - 2\gamma\Gamma(2)k \right\} = 0$$

yields k^{**} given by (5). When $k^* \leq 1$, we will have $k^{**} \leq 1$, the CET will be a monotonically decreasing function on the relevant range $1 \leq k \leq N$, and thus the Article XXIV constraint will not bind and $\tau_c(k) = \tau(k)$. When $k^* > 1$, we will have $k^{**} > 1$ and the Article XXIV will be binding for $k \leq k^{**}$. It will impose $\tau_c(k) = \tau(1)$ for $k \leq k^{**}$ and $\tau_c(k) = \tau(k)$ for $k \geq k^{**}$. □

Properties of k^* and k^{**}: To get an idea for which range of parameters the Article XXIV constraint binds, namely where $k^{**} > 1$, it is useful to study the variations of k^* and k^{**} with γ and N. It is immediate to see that both k^* and k^{**} are increasing functions of N. The following shows that they are decreasing functions of γ:

$$\frac{\partial k^*(N,\gamma)}{\partial \gamma} = \frac{\Phi}{4\gamma^2 \sqrt{\Gamma(0)\left[\Gamma(0)+1\right]\Gamma(N)}}$$

with $\Phi \equiv 4\sqrt{\Gamma(0)\left[\Gamma(0)+1\right]\Gamma(N)} + \gamma^3(N-1) + 2\gamma(8-3N) - 24$. The denominator being strictly positive, the derivative of k^* is of the same sign as its numerator Φ. Furthermore, $\frac{\partial \Phi}{\partial N} = \gamma\left(-6 + \gamma^2 + 2\sqrt{\frac{\Gamma(0)[\Gamma(0)+1]}{\Gamma(N)}}\right)$ which is strictly negative for $0 \leq \gamma \leq 1$ and $N \geq 1$. So Φ is a decreasing function of N and $\Phi(N=1) = 4\sqrt{2(2-\gamma)(3-\gamma)} + 10\gamma - 24 < 4\sqrt{12} + 10 - 24 < 0$ and so Φ is always negative and k^* is a monotonically decreasing function of γ. When $\gamma = 0$, k^* is infinite, when $\gamma = 1$, $k^* = \frac{\sqrt{2(N+1)}-1}{2} > 0$. So $k^* > 1$ for

any γ and $N \geq 4$. Furthermore

$$\frac{\partial k^{**}(N,\gamma)}{\partial \gamma} = \frac{\Psi}{2\gamma^2\Gamma(2)^2}$$

with $\Psi = -16 - 16\gamma - 16(N-2)\gamma^2 + 4(N-1)\gamma^3 + (N-1)\gamma^4$. The denominator being strictly positive, the derivative of k^{**} is of the same sign as its numerator Ψ. Note that

$$\begin{aligned}\Psi \leq & -16 - 16\gamma - 16(N-2)\gamma^2 + 4(N-1)\gamma^2 + (N-1)\gamma^2 \\ \leq & -\left[16 + 16\gamma + (11N-27)\gamma^2\right] \leq -16\left[1 + \gamma - \gamma^2\right] < 0\end{aligned}$$

and so k^{**} is a decreasing function of γ. When $\gamma = 0$, k^{**} is infinite, when $\gamma = 1$, $k^{**} = \frac{2N-1}{6} > 0$. So $k^{**} > 1$ for any γ and $N \geq 4$, $k^{**} > 2$ for any γ and $N \geq 7$.

B Proofs from Section 3

Proof of Lemma 1. $q_O(k)$ **decreasing in** k**:**

$$q_O(k) = \begin{cases} \frac{\Gamma(0)-\Gamma(k)\tau(1)}{\Gamma(0)\Gamma(N)} & \text{for } k \leq k^{**} \\ \frac{\Gamma(0)-\Gamma(k)\tau(k)}{\Gamma(0)\Gamma(N)} & \text{for } k^{**} < k < N \text{ and} \end{cases}$$

So

$$\frac{dq_O(k)}{dk} = \begin{cases} -\frac{\gamma\tau(1)}{\Gamma(0)\Gamma(N)} < 0 & \text{for } k \leq k^{**} \\ -\frac{\gamma}{D(k)^2}\left\{\left[2(2-\gamma)+1+4k\gamma\right](2-\gamma)^2 + 2(1-\gamma)k^2\gamma^2\right\} < 0 & \text{for } k^{**} < k < N \end{cases}$$

Effect of Article XXIV: Note that $\Gamma(0)\Gamma(N)\frac{dq_O(k)}{dk} = -\gamma\tau(k) - \Gamma(k)\frac{d\tau_c(k)}{dk}$. When the Article XXIV constraint binds, $\tau_c(k) \leq \tau(k)$, so the first term on the right hand-side is negative, but greater under the Article XXIV constraint than without. The second term on the right hand-side is 0 under the Article XXIV constraint when it binds. For $1 \leq k < k^*$, $\tau(k)$ is an increasing function of k, so the second term is negative without the Article XXIV constraint. So on the whole, under the Article XXIV constraint, the derivative of $q_O(k)$ is negative, but greater than without the Article XXIV constraint. So $q_O(k)$ is decreasing at a slower rate under the Article XXIV constraint for $1 \leq k < k^*$. For $k = k^*$, the second term on the right hand-side becomes also 0 without the Article XXIV constraint (from the variations of $\tau(k)$). This is the point where the difference in the rate of decrease in $q_O(k)$ is the largest between the situations with and without the Article XXIV constraint. For $k^* < k < k^{**}$, the second term on the right hand-side becomes positive and so the difference in the rates of decrease starts to diminish until it disappears at k^{**}. □

Proof of Lemma 2. 1. Consumer surplus: The consumer surplus of a country belonging

to a k-size CU is

$$CS\left[k,\tau_c(k)\right]=\frac{\gamma}{2}Q\left[k,\tau_c(k)\right]^2+\frac{1-\gamma}{2}\left\{kq_I\left[k,\tau_c(k)\right]^2+(N-k)q_O\left[k,\tau_c(k)\right]^2\right\}$$

The goal of this proof is to determine the sign of the derivative of CS with respect to k. Note that

$$\frac{d}{dk}CS\left[k,\tau_c(k)\right]=\left.\frac{\partial CS}{\partial k}\right|_{\tau_c(k)}+\frac{\partial CS}{\partial\tau_c}\frac{\partial\tau_c}{\partial k} \tag{9}$$

we will thus proceed in three steps and sign each of the three terms of the derivative separately. We already know from the properties of $\tau_c(k)$ that $\frac{\partial\tau_c}{\partial k}\leq 0$. Furthermore,

$$\frac{\partial CS}{\partial\tau}=\frac{(N-k)}{\Gamma(0)^2\Gamma(N)^2}(-\lambda_{CS}+\mu_{CS}\tau)$$

with

$$\begin{aligned}&\lambda_{CS}\equiv\Gamma(0)^2(1-\gamma+\gamma N)>0\\&\mu_{CS}\equiv\gamma(N-k)\Gamma(0)^2+(1-\gamma)k\gamma^2(N-k)+\Gamma(k)^2(1-\gamma)=D(k)-2\Gamma(k)^2>0\end{aligned}$$

so the derivative of consumer surplus is a linear increasing function of the tariff. We now show that for any tariff smaller or equal to the Nash optimal tariff, $\tau\leq\tau(k)$, the derivative of consumer surplus is negative. Set τ_{CSmin} the tariff at which the derivative of consumer surplus is zero (and consumer surplus is minimum).

$$\tau_{CSmin}=\frac{\lambda_{CS}}{\mu_{CS}}=\frac{\Gamma(0)^2(1-\gamma+\gamma N)}{D(k)-2\Gamma(k)^2}\text{ and }\tau_{CSmin}-\tau(k)=\frac{\Gamma(0)Num}{D(k)\left[D(k)-2\Gamma(k)^2\right]}$$

with $Num=D(k)\left[\Gamma(0)(1-\gamma+\gamma N)-\Gamma(2k)\right]+2\Gamma(k)^2\Gamma(2k)$. The denominator being strictly positive, $\tau_{CSmin}-\tau(k)$ is of the same sign as Num. To determine the sign of Num, we study its variations with k. $\frac{d^2}{dk^2}Num=4\gamma^2\Gamma(N)\geq 0$ and so the derivative of Num with respect to k is a monotonically increasing function of k. Furthermore, we have $\frac{d}{dk}Num(k=1)=\gamma\Gamma(N)\left[\gamma(1-\gamma)(2-\gamma)N+4-2\gamma+4\gamma^2-\gamma^3\right]\geq 0$ and so for any number of firms k, $\frac{d}{dk}Num$ is positive. Hence Num is a monotonically increasing function of k. Finally, $Num(k=1)=\Gamma(N)\left[\gamma\Gamma(0)(4-3\gamma)N+\underbrace{8-16\gamma+14\gamma^2-3\gamma^3}_{\geq 0}\right]\geq 0$ and so we have $\tau_{CSmin}\geq\tau(k)$ and $\frac{\partial CS}{\partial\tau}\leq 0$ for any tariff between 0 and $\tau(k)$. Hence the second term in (9) is positive. Moreover,

$$\begin{aligned}\frac{\partial CS}{\partial k}&=\gamma Q(k)\frac{\partial Q(k)}{\partial k}+\frac{1-2}{2}\left[q_I(k)^2+2kq_I(k)\frac{\partial q_I(k)}{\partial k}-q_O(k)^2+2(N-k)q_O(k)\frac{\partial q_O(k)}{\partial k}\right]\\&=\frac{\tau}{\Gamma(0)^2\Gamma(N)^2}\Phi\end{aligned}$$

with $\Phi = 2\Gamma(0)^2\left[\gamma N + (1-\gamma)\right] - \tau\left[2\gamma(N-k)\Gamma(0) + (1-\gamma)\Gamma(N)\Gamma(2k-N)\right]$. The Article XXIV constraint imposes $\tau_c(k) \leq \tau(1)$ and so

$$\begin{aligned}\Phi &\geq 2\Gamma(0)^2\left[\gamma N + (1-\gamma)\right] - \tau(1)\left[2\gamma(N-k)\Gamma(0) + (1-\gamma)\Gamma(N)\Gamma(2k-N)\right] \\ &= \frac{1}{D(1)}\left\{\Gamma(0)\Gamma(N)\left[\Gamma(0)(1-\gamma)\left[6+\gamma(9N-2k-7)\right] + 2\gamma^2\left[N+2(1-\gamma)(N-k)\right]\right]\right. \\ &\quad \left. +2\Gamma(0)^2\Gamma(2)\left[\gamma(N+k)+2(1-\gamma)\right]\right\} \geq 0\end{aligned}$$

and so $\frac{\partial CS}{\partial k}\big|_{\tau_c(k)} \geq 0$ and hence the result. □

2. Tariff revenue: trivial. □

3. Home firm's domestic profits:

$$\frac{dq_I(k)}{dk} = \frac{1}{\Gamma(0)\Gamma(N)}\left[(\Gamma(N)-\Gamma(k))\frac{d\tau_c(k)}{dk} - \gamma\tau_c(k)\right] < 0$$

given that $\frac{d\tau_c(k)}{dk} \leq 0$ and $\tau_c(k) \geq 0$. □

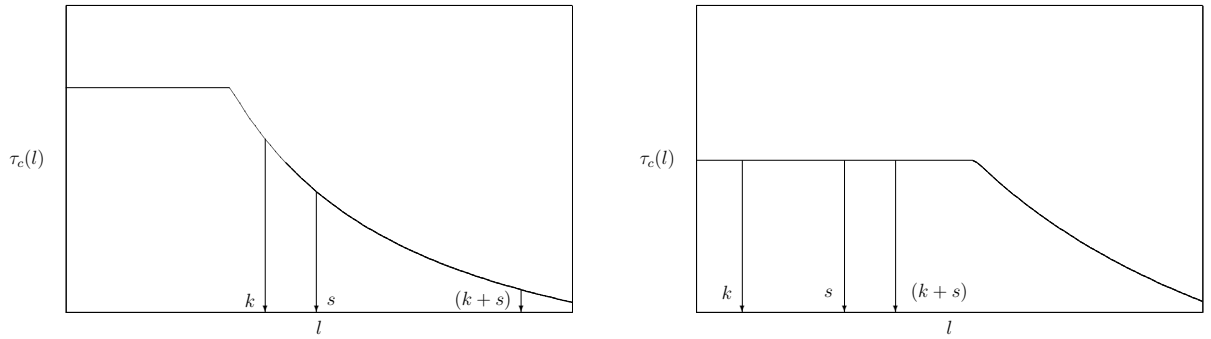
Proof of Lemma 3. We want to prove that formation or expansion of CUs under the Article XXIV constraint increases the aggregate welfare of member countries. To do so, we suppose that CUs of size$-k$, size$-l$, size$-m$, ..., size$-r$ merge and we show that the aggregate welfare of the countries involved in the merger increases in each member country. Without loss of generality, we consider the merger of a size$-k$ CU and a size$-s$ CU where $s = l + m + \ldots + r$.

The proof consists of three steps: First, to prove the case where the Article XXIV constraint does not bind on the CUs involved in the merger, we invoke the proof of Yi's (1996) Proposition 3; the case shown in Figure 7(a). Note that it is valid to consider a group of CUs for whom the Article XXIV constraint does not bind even though it might bind on other CUs not involved in the merger. Second, we prove the proposition for CUs on which the Article XXIV constraint is binding as shown in Figure 7(b). Finally, we will show how the first two subcases generalise for any CU merger.

Step 1: merger of CUs that are not constrained by Article XXIV - see Yi (1996), Appendix B, pages 172–175

Step 2: merger of CUs that are constrained by Article XXIV

Here we consider the merger of size$-k$ and size$-s$ CUs such that the Article XXIV constraint is binding for both the two individual CUs and for the resulting size$-(k+s)$ CU. The proof proceeds similarly to Yi's case of unconstrained CUs. The goal of the proof is to show the following claim: suppose that country i has free trade with $k-1$ countries and levies equal tariffs $\tau(k)$ on $N-k$ countries. If country i abolishes tariffs on s countries, $s \leq N-k$, and changes tariffs on the remaining $N-k-s$ countries from $\tau(k)$ to $\tau(k+s)$, then the



(a) Article XXIV neither binding before nor after (b) Article XXIV both binding before and after

Figure 7: Two different merger situations: external tariffs of original and resulting CUs.

aggregate welfare of $k+s$ countries (which consist of country i, $k-1$ countries which pay no tariffs, and s countries whose tariffs are eliminated) improves.

Without loss of generality, take country 1 and suppose that it levies no tariffs on countries $2,\ldots,k$ and $\tau(k)$ on countries $k+1,\ldots,N$. We are interested in the following comparative statics exercise: what is the effect on the aggregate welfare of countries $1,\ldots,k+s$ of abolishing tariffs on countries $k+1,\ldots,k+s$ and changing tariffs on countries $k+s+1,\ldots,N$ from $\tau(k)$ to $\tau(k+s)$?

Using the same notation as Yi (1996), let $\Delta\tau \equiv \tau(k)-\tau(k+s)$. Consider a tariff vector

$$\mathbf{t} \equiv (0,\ldots,0,\tau,\ldots,\tau,\tau',\ldots,\tau') \tag{10}$$

where τ appears from the $(k+1)$th column to the $(k+s)$th column and τ' from the $(k+s+1)$th column to the last column. Consider the following two tariff vectors: $\mathbf{t}(k+s) \equiv (0,\ldots,0,\tau(k+s),\ldots,\tau(k+s))$ with 0 in the first $(k+s)$ columns and $\mathbf{t}(k) \equiv (0,\ldots,0,\tau(k),\ldots,\tau(k))$ with 0 from the first to the kth column. We can move from $\mathbf{t}(k+s)$ to $\mathbf{t}(k)$ by integrating from 0 to $\tau(k)$ the infinitesimal changes from the tariff vector defined by (10) $d\mathbf{t} \equiv (0,\ldots,0,d\tau,\ldots,d\tau,d\tau',\ldots,d\tau')$ with $d\tau' \equiv \frac{\Delta\tau}{\tau(k)}d\tau$: $\mathbf{t}(k) = \mathbf{t}(k+s) + \int_0^{\tau(k)} d\mathbf{t}$.

To prove our claim, similarly as Yi (1996), we show that $d(\sum_{j=1}^{k+s} W^j)/d\mathbf{t} < 0$ for all $\mathbf{t}$ along such a path of integration. To do so, we first show that $d(\sum_{j=1}^{k+s} W^j)/d\mathbf{t} < 0$ for $\mathbf{t}(k+s) \equiv (0,\ldots,0,\tau(k+s),\ldots,\tau(k+s))$. And second, we show that $d^2(\sum_{j=1}^{k+s} W^j)/d\mathbf{t}^2 < 0$.

Step 2a: Since changes in country 1's tariffs do not affect sales in other countries, $d(\sum_{j=1}^{k+s} W^j)/d\mathbf{t} = d(\hat{W}^1 + \sum_{j=2}^{k+s} \pi^{1j})/d\mathbf{t}$, where $\hat{W}^1$ is country 1's welfare net of its export profits. Since

$\hat{W}^1 + \sum_{j=2}^{N} \pi^{1j} = v(\mathbf{q}_1) - cQ_1$, which is the net total benefit from consumption of $\mathbf{q}_1$, $\hat{W}^1 + \sum_{j=2}^{k+s} \pi^{1j} = v(\mathbf{q}_1) - cQ_1 - \sum_{j=k+s+1}^{N} \pi^{1j}$. To save on notation, we can drop superscript 1.

The total tariff T at the tariff vector $\mathbf{t}$ is $T = \sum_{j=1}^{N} \tau_j = s\tau + (N-k-s)\tau'$ and $dT = sd\tau + (N-k-s)s\tau' = \frac{s\tau(k)+(N-k-s)\Delta\tau}{\tau(k)} d\tau$. From the first-order-condition of firms' profit maximisation, $p_j - c = q_j + \tau_j$. Then $\sum_{j=1}^{N} [p_j - c] = Q + T$. At $\mathbf{t}$, $q_1 = \ldots = q_k$, $q_{k+1} = \ldots = q_{k+s}$ and $q_{k+s+1} = \ldots = q_N$. From (2), $dq_j = \frac{\gamma dT - \Gamma(N) d\tau_j}{\Gamma(0)\Gamma(N)}$. Thus,

$$\begin{aligned}
\frac{dq_1}{d\mathbf{t}} &= \frac{\gamma\left[s\tau(k) + (N-k-s)\Delta\tau\right]}{\tau(k)\Gamma(0)\Gamma(N)} \\
\frac{dq_{k+1}}{d\mathbf{t}} &= \frac{\gamma\left[s\tau(k) + (N-k-s)\Delta\tau\right] - \Gamma(N)\tau(k)}{\tau(k)\Gamma(0)\Gamma(N)} \\
\frac{dq_N}{d\mathbf{t}} &= \frac{\gamma\left[s\tau(k) + (N-k-s)\Delta\tau\right] - \Gamma(N)\Delta\tau}{\tau(k)\Gamma(0)\Gamma(N)}
\end{aligned}$$

Using these results,

$$\begin{aligned}
\frac{d}{d\mathbf{t}}\left(\hat{W} + \sum_{j=2}^{k+s} \pi^j\right) &= \frac{d}{d\mathbf{t}}\left[v(\mathbf{q}) - cQ\right] - \frac{d}{d\mathbf{t}} \sum_{j=k+s+1}^{N} \pi^j = \sum_{j=1}^{N} \left[p_j - c\right] \frac{dq_j}{d\mathbf{t}} - \sum_{j=k+s+1}^{N} 2q_j \frac{dq_j}{d\mathbf{t}} \\
&= \frac{1}{\tau(k)\Gamma(0)\Gamma(N)} \left[s\tau(k)\Omega + (N-k-s)\Phi\Delta\tau\right]
\end{aligned}$$

where $\Omega \equiv \gamma(Q+T) - \Gamma(N)\left[q_{k+1} + \tau\right] - 2(N-k-s)\gamma q_N$ and $\Phi \equiv \gamma(Q+T) - \Gamma(N)\left[q_N + \tau'\right] + 2\Gamma(k+s)q_N$. As the Article XXIV constraint now imposes $\tau(k+s) = \tau(1)$, $\tau(k+s)$ is now not the optimal tariff of the size-$(k+s)$ customs union on $N-k-s$ non-members and Φ is not necessarily 0 as it is the case when CU are unconstrained. On the other hand, the Article XXIV now also imposes $\Delta\tau = \tau(k) - \tau(k+s) = \tau(1) - \tau(1) = 0$. It is therefore sufficient to show that $\Omega < 0$ at $\mathbf{t}(k+s)$. At $\mathbf{t}(k+s)$, $\Omega = -\Gamma(0)q_1 - (N-k-s)\gamma\left[q_1 + q_N - \tau(k+s)\right]$ and $q_1 + q_N - \tau(k+s) = \frac{1}{\Gamma(0)\Gamma(N)}\{2\Gamma(0) - \left[\Gamma(N)\left[\Gamma(0)+1\right] - 2(N-k-s)\gamma\right]\tau(k+s)\} = \frac{1}{D(1)\Gamma(N)}\Theta$ with

$$\begin{aligned}
\Theta &= \Gamma(N)\left[\Gamma(0)+1\right]\Gamma(0) + \Gamma(2)2\gamma(1-k-s) \\
&= (N-1)\gamma^3 + \left[9 - 5N - 2(k+s)\right]\gamma^2 + \left[6N - 4(k+s) - 12\right]\gamma + 12
\end{aligned}$$

If the Article XXIV is binding for the customs union of size-$(k+s)$, it must be that $k+s \leq k^{**}$. So $\Theta \geq (N-1)\gamma^3 + \left[9 - 5N - 2k^{**}\right]\gamma^2 + \left[6N - 4k^{**} - 12\right]\gamma + 12$. Using the expression of k^{**} given by (5), $\Theta \geq (2+\gamma)^2 > 0$.

Step 2b: Again following Yi (1996), we have

$$\begin{aligned}[\tau(k)\Gamma(0)\Gamma(N)]^2 \frac{d^2}{d\mathbf{t}^2}\left(\hat{W}+\sum_{j=2}^{k+s}\pi^j\right) = & -(N-k-s)\lambda(k+s)(\Delta\tau)^2 \\ & +2(N-k-s)s\gamma\tau(k)\zeta(k+s)\Delta\tau \\ & -s\tau(k)^2\{[\Gamma(0)-1]\,\Gamma(N)\Gamma(N-s) \\ & +s\gamma\,[\Gamma(0)+2(N-k-s)\gamma]\}\end{aligned}$$

with $\zeta(k) \equiv \Gamma(N)\,[\Gamma(0)-1] - \Gamma(0) + 2\Gamma(k)$ and $\lambda(k) \equiv \Gamma(k)\zeta(k) + \Gamma(0)\Gamma(N)$. In the constrained case considered, $\Delta\tau = 0$, so

$$\begin{aligned}[\tau(k)\Gamma(0)\Gamma(N)]^2 \frac{d^2}{d\mathbf{t}^2}\left(\hat{W}+\sum_{j=2}^{k+s}\pi^j\right) = & -s\tau(k)^2\{[\Gamma(0)-1]\,\Gamma(N)\Gamma(N-s) \\ & +s\gamma\,[\Gamma(0)+2(N-k-s)\gamma]\} < 0\end{aligned}$$

Step 3: generalisation

So far we have proved the proposition in two different situations: first, when the Article XXIV constraint is not binding (neither for the initial customs unions nor for the after-merger CU); second when the Article XXIV constraint is binding in both cases. We now have to show that the result still holds when the Article XXIV constraint is binding for (at least one of) the initial CUs but not for after-merger CU. (It is easy to deduce from Figures 3a and b that the converse cannot occur). This step is an easy comparative statics exercise. Consider the tariffs of the CUs not involved in the merger as given (could be constrained or unconstrained). The subscript u denotes an unconstrained CU and the subscript c denotes a constrained CU. By Yi's proof, we have $(k+s)W_u(k+s) \geq kW_u(k) + sW_u(s)$. Now given the tariffs of the CUs not involved in this merger, the CUs of size-k and size-s involved in this merger are better off when unconstrained compared to the constrained situation $kW_u(k) + sW_u(s) \geq kW_c(k) + sW_c(s)$. So, we have $(k+s)W_u(k+s) \geq kW_c(k) + sW_c(s)$. □

C Proofs from Section 4

Proof of Lemma 4. The welfare of Country i is by definition $W^i = CS^i + \pi^{ii} + TR^i + \sum_{\substack{j=1 \\ j\neq i}}^{N} \pi^{ji}$.

Noting that $CS^i + \pi^{ii} + TR^i = \frac{\gamma}{2} Q_i^2 + \frac{1-\gamma}{2} \sum_{j=1}^{N} q_{ij}^2 + \pi^{ii} + TR^i = u(\mathbf{q}_i) - cQ_i - \sum_{\substack{j=1 \\ j\neq i}}^{N} \pi^{ij}$, we have

$$W^i = \underbrace{v(\mathbf{q}_i) - cQ_i}_{NS} + \underbrace{\sum_{\substack{j=1 \\ j\neq i}}^{N} \pi^{ji} - \sum_{\substack{j=1 \\ j\neq i}}^{N} \pi^{ij}}_{PB}$$

and the result follows. □

Proof of Lemma 6. Assume that $C = \{k_1, k_2, \ldots, k_m\}$ is the CU structure. World welfare is the sum of welfare of all the individual countries:

$$\begin{aligned} W_W &= \sum_{i=1}^{m} k_i W_i = \sum_{i=1}^{m} k_i \left[NS(k_i) + PB(k_i, C) \right] \\ &= \sum_{i=1}^{m} k_i NS(k_i) + \sum_{i=1}^{m} k_i \left[\sum_{\substack{j=1 \\ j\neq i}}^{m} k_j q_O(k_j)^2 - (N - k_i) q_O(k_i)^2 \right] = \sum_{i=1}^{m} k_i NS(k_i) \end{aligned} \tag{11}$$

As we can see, the profit-balance part of individual countries' welfare cancels out which is normal, because for the world as a whole, the balance is 0. We want to determine now the impact on world welfare of an expansion of a CU. Without loss of generality, assume that the first CU is expanding by accepting members from the last CU. We want to see the impact of an increase in asymmetry between the two CUs, so also assume $k_1 \geq k_m$. The actual substructure $\{k_2, \ldots, k_{m-1}\}$ will be irrelevant for the changes in world welfare and the only thing that will matter will be the sum of the sizes of the other unions so set $\tilde{k} = k_2 + \ldots + k_{m-1}$, then $k_m = N - \tilde{k} - k_1$. We want to determine the sign of $\frac{dW_W(k_1, k_2, \ldots, N - \tilde{k} - k_1)}{dk_1}$.

$$\frac{dW_W}{dk_1} = \frac{\partial W_W}{\partial k_1} + \underbrace{\underbrace{\frac{\partial W_W}{\partial \tau_1}}_{\leq 0} \underbrace{\frac{\partial \tau_1(k_1)}{\partial k_1}}_{\leq 0}}_{\geq 0} + \frac{\partial W_W}{\partial \tau_m} \underbrace{\frac{\partial \tau_m(N - \tilde{k} - k_1)}{\partial k_1}}_{=0} \tag{12}$$

We assume that Article XXIV binds on the small union, the last term in (12) is zero ($\frac{\partial \tau_m}{\partial k_1} = 0$ as $\tau_m = \tau(1)$). (Note that it is irrelevant whether Article XXIV binds or not on the CUs not involved in the change considered.) Furthermore, with Article XXIV in place, whether it binds or not for the big CU, we have $\frac{\partial \tau_1}{\partial k_1} \leq 0$. We need to calculate $\frac{\partial W_W}{\partial \tau_1}$ and $\frac{\partial W_W}{\partial k_1}$. From

(11) we have

$$\frac{\partial W_W}{\partial \tau_1} = k_1 \frac{\partial NS_1}{\partial \tau_1} = -\frac{k_1(N-k_1)}{\Gamma(0)^2\Gamma(N)^2}\left[\Gamma(0)^2 + \Xi(k_1,N)\tau_1\right] \leq 0 \tag{13}$$

with $\Xi(k,N) = D(k,N) - 2\Gamma(k)^2 \geq 0$. So now we need to calculate and sign $\frac{\partial W_W}{\partial k_1}$.

$$\frac{\partial W_W}{\partial k_1} = NS(k_1) + k_1 NS'(k_1) - NS(N-\tilde{k}-k_1) - (N-\tilde{k}-k_1)NS'(N-\tilde{k}-k_1)$$

where $NS'(k) = \frac{\partial NS}{\partial k}$.

$$\begin{aligned} NS(k) =& \frac{1}{2\Gamma(0)^2\Gamma(N)^2}\{N\Gamma(0)^2\left[\Gamma(N)+1\right] - 2\Gamma(0)^2(N-k)\tau \\ &+ (N-k)\left[-\gamma\Gamma(0)^2(N-k) - (1-\gamma)\left[k\gamma^2(N-k) + \Gamma(k)^2\right]\right]\tau^2\} \end{aligned}$$

and

$$\begin{aligned} \frac{\partial NS(k)}{\partial k} =& \frac{\tau}{2\Gamma(0)^2\Gamma(N)^2}\{2\Gamma(0)^2 \\ &+ \tau\left[2\gamma\Gamma(0)^2(N-k) + (1-\gamma)\left[(\Gamma(0)+\Gamma(N))\gamma(2k-N) + \Gamma(0)^2\right]\right]\} \end{aligned}$$

For simplicity, let us assume first that Article XXIV binds also for the large union (in this case the second term of the left hand-side of (12) is also zero). In this case we have $\tau = \tau(1)$ for both the large and small unions involved and

$$\begin{aligned} \frac{\partial W_W}{\partial k_1} =& \frac{\tau(1)(k_1-k_m)}{2\Gamma(0)^2\Gamma(N)^2}\{4\Gamma(0)^2 + \tau(1)\left[\Gamma(0)^2\Gamma(N-1) + (1-\gamma)\gamma N\left[\Gamma(0)+\Gamma(N)\right]\right] \\ &- \tau(1)3\tilde{k}\gamma\left[(1-\gamma)\Gamma(N) - \Gamma(0)\right]\} \end{aligned} \tag{14}$$

Note that the first line of (14) is positive, so if there are only two CUs in the world ($\tilde{k} = 0$), an increase in the asymmetry between the unions unambiguously increases world welfare. This will still be the case with many CUs provided that the unions involved represent a sufficient proportion of countries in the world, i.e. $\frac{\partial W_W}{\partial k_1} \geq 0 \Leftrightarrow N - \tilde{k} = k_1 + k_m \geq \bar{k}$ with

$$\begin{cases} \text{if } (1-\gamma)\Gamma(N) - \Gamma(0) & \leq 0, \bar{k} = 0 \\ \text{if } (1-\gamma)\Gamma(N) - \Gamma(0) & > 0, \bar{k} = N - \frac{4\Gamma(0)^2 + \tau(1)\left[\Gamma(0)^2\Gamma(N-1) + (1-\gamma)\gamma N[\Gamma(0)+\Gamma(N)]\right]}{\tau(1)3\gamma[\Gamma(0)-(1-\gamma)\Gamma(N)]} \end{cases}$$

It is difficult to evaluate analytically $\frac{\partial W_W}{\partial k_1}$ when Article XXIV does not bind on the large CU, but numerical analysis shows that this result seems to extend to the case where Article XXIV binds on the small union only. □

Proof of Lemma 7. 1. Smallest CU: The last union to form must be the smallest since, by Lemma 5, the smallest CU entails the lowest level of welfare for its members. Note that

a symmetric customs union structure is not an equilibrium outcome. This is also a simple consequence of Lemma 5: if the last two customs union to form are of the same size, then they would be better off by merging. □

2. Second smallest CU: Again, the second smallest CU must be unique, because two symmetric CUs would be better off by merging. Suppose that the second smallest CU has less than k_0 members. Then the members of this union would be better off by admitting (at least) one more member. □

3. Number of equilibrium CUs: The second smallest CU which is the second-to-last to form has at least k_0 members and all the CUs that form before have strictly more members than this CU. Thus there cannot be more than $I(\frac{N}{k_0})$ CUs in equilibrium where $I(\frac{N}{k_0})$ is the next highest integer to $\frac{N}{k_0}$. The goal of this proof is to determine k_0 in order to get an upper bound on the number of equilibrium CUs. It is difficult to solve for k_0 in the general case when N is arbitrary and we do not know ex ante which CUs are bound by Article XXIV. Yi (1996) proves that there will be at most three CUs in equilibrium for the CU formation when Article XXIV does not bind and when N is large. We will now determine k_0 analytically for the case of any N and where Article XXIV binds for all possible CUs, i.e. in the range $\gamma \in [0, \gamma_N]$. We will then complete the proof numerically on the remainder of the γ range.

k_0 is the largest integer such that any size-k CU, $k \leq k_0$, becomes better off by merging with a single-country CU, i.e. $W(k, C) - W(k-1, C') \geq 0$.

$$W(k, C) = NS(k) - (N-k)q_O(k)^2 + \sum k_j q_O(k_j)^2$$
$$W(k-1, C') = NS(k-1) - (N-k+1)q_O(k-1)^2 + q_O(1)^2 + \sum k_j q_O(k_j)^2$$

$$W(k, C) - W(k-1, C') = \frac{\tau}{2\Gamma(0)^2\Gamma(N)^2}(\alpha k^2 + \beta k + \delta)$$

with

$$\alpha = 6\gamma^2\tau \geq 0$$
$$\beta = -2\gamma\left\{4\Gamma(0)(1-\tau) + \tau\gamma\left[\Gamma(N) + N + 3\right]\right\} \leq 0$$
$$\delta = 2\Gamma(0)\left[\Gamma(N) + 4\gamma\right] + \tau\left\{\Gamma(0)\left[\Gamma(0)\Gamma(N) - \Gamma(3N) - 7N\right] - \gamma(1-\gamma)\Gamma(N)(N+1) + 2N\gamma^2\right\}$$

Substituting $\tau(1)$ and solving the second degree polynomial equation for the relevant solution yields

$$k_0 = \frac{1}{6\gamma\Gamma(2)}\left[\gamma(3-\gamma)(6-\gamma)N + 32 - 22\gamma + 19\gamma^2 - \gamma^3 - \sqrt{aN^2 + bN + c}\right]$$

with

$$a = \gamma^2(156 - 276\gamma + 171\gamma^2 - 24\gamma^3 + \gamma^4)$$
$$b = 2\gamma(240 - 744\gamma + 632\gamma^2 - 214\gamma^3 + 25\gamma^4 + \gamma^5)$$
$$c = 352 - 1696\gamma + 2084\gamma^2 - 1068\gamma^3 + 255\gamma^4 - 26\gamma^5 + \gamma^6$$

It can be shown that k_0 is a decreasing function of γ so evaluating k_0 at $\lim_{N\to+\infty} \gamma_N = \frac{1}{2}(7 - \sqrt{41})$ gives a lower bound for k_0 on the range $[0, \frac{1}{2}(7 - \sqrt{41})]$. At γ_N, $k_0 \approx 0.4358N$. And thus there will be at most three CUs in equilibrium when Article XXIV binds for all possible CUs, i.e. for $\gamma \in [0, \frac{1}{2}(7 - \sqrt{41})]$.

Outside this range, we calculate k_0 numerically. Similarly to Yi's proof for the unconstrained case with large N, k_0 alone is not sufficient anymore to conclude that there will be at most three CUs in equilibrium and we have to find closer lower bounds on the sizes of the CUs. Following Yi, we define k_1 as the largest integer such that any size-k customs union, $k \leq k_1 - 1$, becomes better off by merging with a k_0-size CU. Then the third-to-last CU to form has at least k_1 members. Finally, we also define k_2 as the largest integer such that any size-k CU, $k \leq k_2 - 1$, becomes better off by merging with a k_1-size CU. And the fourth-to-last CU has at least k_2 members. For $0 \leq \gamma \leq 1$ and $4 \leq N \leq 1,000$, we calculate k_0, k_1 and k_2 (letting γ vary by $2 \cdot 10^{-6}$ and N by 1). For all these values we obtain $k_0 + k_1 + k_2 > N$. (For $\gamma = 1$ and $N = 1,000$, $k_0 + k_1 + k_2 < N$, but $k_2 + k_3 > N$ which yields the same result.) So, we can conclude that there will be at most three CUs in equilibrium for $N \leq 1,000$. □

D CU formation algorithm

Assuming that there will be at most 3 CUs, we now simulate the bloc formation game and determine the exact size of each bloc. The simulation algorithm is as follows: Let us call the three blocs A, B and C in order of formation, i.e. we know that A will be the largest bloc and C the smallest one. For any k between 0 and $2N/3$ find j between 0 and $k/2$ which maximises the welfare of bloc B where the sizes of the blocs are

A	B	C
$N-k$	$k-j$	j

and where B is of same or smaller size than A and C is of same or smaller size than B ($k - j \leq N - k$ and $j \leq k - j$). Then find k (with j given in the previous step) which maximises the welfare of bloc A.

We run these simulations for $0 \leq \gamma \leq 1$ (varying γ by $2 \cdot 10^{-6}$) and for $N = 4, \ldots, 10^5$ and we find that the equilibrium structure for all these parameters consists of at most two blocs both with and without the Article XXIV constraint.

E Proofs from Section 5

Proof of Proposition 2. Assume that $C = \{k_1, k_2, \ldots, k_m\}$ is the CU structure where k_i is the size of the i^{th} CU. As shown in the proof of Lemma 6 above, world welfare is the sum of individual countries' net benefits from consumption (the profit balance is zero for the world):

$$W_W = \sum_{i=1}^{m} k_i NS_i$$

Each NS_i term represents the part of welfare arising in the i^{th} CU and depends only on the CET τ_i of the i^{th} CU. Hence

$$\frac{dW_W}{d\tau_i} = k_i \frac{dNS_i}{d\tau_i} = -\frac{k_i}{[\Gamma(0)\Gamma(N)]^2}(\lambda + \mu_i \tau_i) \leq 0$$

where $\lambda \equiv \Gamma(0)^2 > 0$ and $\mu_i \equiv \Gamma(0)^2\gamma k_i + (1-\gamma)k\gamma^2(N-k_i) + (1-\gamma)\Gamma(N-k_i)^2 > 0$. So for a given CU structure, world welfare is a decreasing function of any CET of any union. The Article XXIV either lowers CETs when it binds or leaves them unaffected when it does not bind, and thus weakly increases world welfare. □

Proof of Proposition 3. Assume that the CU structure consists of two asymmetric blocs: a large bloc denoted L of size k and a small bloc denoted S of size $N-k$ ($k \geq N-k$). The aim of this proof is to determine how does the presence of the Article XXIV constraint affect the large CU's choice of its size.

1. Article XXIV binding on the large CU leads to a more asymmetric equilibrium CU structure: the goal here is to determine how a change in the CET of the large CU affects the large CU's willingness to accept more or less members, i.e. we want to determine the sign of

$$\frac{\partial}{\partial \tau_L}\frac{\partial W^L(k)}{\partial k}$$

where τ_L is the external tariff imposed by the large union and W^L is the welfare of a member country of the large union. We are interested in the sign of this second derivative at the point where the large union is bound by Article XXIV $\tau_L = \tau(1)$ (because we want to see the local impact of removing Article XXIV and raising τ_L) and where the large union has chosen its size optimally k^c_{opt}. By the theorem of Schwarz (also known as Young's Theorem), we have $\frac{\partial}{\partial \tau_L}\frac{\partial W^L(k)}{dk} = \frac{\partial}{\partial k}\frac{\partial W^L(k)}{\partial \tau_L}$.

$$\frac{\partial W^L(k)}{\partial \tau_L} = \frac{N-k}{\Gamma(0)^2\Gamma(N)^2}\left[\Gamma(0)\Gamma(2k) - D(k)\tau_L\right]$$

and

$$\frac{\partial^2 W^L(k)}{\partial k \partial \tau_L} = \frac{1}{\Gamma(0)^2\Gamma(N)^2}\{-\Gamma(0)\Gamma(2(2k-N)) \\ + \tau_L\left[\Gamma(0)\Gamma(N)\Gamma(2k-N) + \gamma^2(N-k)^2 + \Gamma(k)^2 - 2\gamma(N-k)\Gamma(2k)\right]\}$$

Assume Article XXIV is binding on the large union so $\tau_L = \tau(1)$.

$$\frac{\partial^2 W^L(k)}{\partial k \partial \tau_L} = \frac{1}{\Gamma(0)^2\Gamma(N)^2}\tilde{f}(k,N,\gamma)$$

with

$$\tilde{f}(k,N,\gamma) = 6\gamma^2\tau(1)k^2 + \{\tau(1)\left[2\Gamma(0)\Gamma(N)\gamma - 6N\gamma^2 + 4\Gamma(0)\gamma\right] - 4\Gamma(0)\gamma\}k \\ + \tau(1)\{\Gamma(0)\Gamma(N)\left[\Gamma(0) - \gamma N\right] + N^2\gamma^2 + \Gamma(0)^2 - \Gamma(0)2\gamma N\} - \Gamma(0)\Gamma(2N)$$

$\frac{\partial^2 \tilde{f}}{\partial k^2} = 6\gamma^2\tau(1) > 0$ and so $\frac{\partial \tilde{f}}{\partial k}$ is an increasing function of k.

$$\frac{\partial \tilde{f}}{\partial k}(0,N,\gamma) = -2\gamma\{2\Gamma(0) + \tau(1)\left[\gamma^2(N-1) + \gamma(N+6) - 8\right]\}$$

Substituting $\tau(1)$ yields

$$\frac{\partial \tilde{f}}{\partial k}(0,N,\gamma) = -\frac{2\gamma\Gamma(0)}{D(1)}\left[\underbrace{\gamma(\gamma^2 - 3\gamma + 10)}_{>0}N + \underbrace{8 - 12\gamma + 10\gamma^2 - \gamma^3}_{>0}\right] \leq 0$$

and

$$\frac{\partial \tilde{f}}{\partial k}(N,N,\gamma) = -2\gamma\{2\Gamma(0) - \tau(1)\left[\Gamma(0)(4-\gamma) + \gamma(5-\gamma)N\right]\} \lesseqgtr 0$$

so $\tilde{f}$ is either a monotonically decreasing function or an initially decreasing and then an increasing function of k. Hence to determine the sign of $\tilde{f}$ at k^c_{opt}, it will be sufficient to determine its sign at two points around k^c_{opt}. If $\tilde{f}$ is negative at both these points, we know it will be negative on the whole range between these points. We know that necessarily $k^c_{opt} \leq N$.

$$\tilde{f}(N,N,\gamma) = -\Gamma(0)\Gamma(2N) + \tau(1)\left[\Gamma(0)\Gamma(N)^2 + \Gamma(k)^2\right]$$

substituting $\tau(1)$ yields

$$\tilde{f}(N,N,\gamma) = -\frac{\Gamma(0)\gamma(N-1)}{D(1)}\left[\gamma(\gamma^2 - 7\gamma + 2)N + \Gamma(0)(\gamma^2 - 6\gamma + 4)\right]$$

Note that $\gamma^2 - 7\gamma + 2 \geq 0$ and $\gamma^2 - 6\gamma + 4 > 0$ for $\gamma \leq \gamma_N = \frac{7-\sqrt{41}}{2}$, so when the Article XXIV is binding for both unions (when $\gamma \leq \gamma_N$, Article XXIV binds for any union), $\tilde{f}(N,N,\gamma) \leq 0$.

Ideally, we would want to choose $N/2$ as the obvious lower bound for k^c_{opt}, but unfortunately, $\tilde{f}$ can be both positive or negative at $k = N/2$ depending on the parameters N and γ. Therefore, we need to find a closer lower bound for k^c_{opt}. To do so, we will solve for the optimum size of the large union k^c_{opt}.

Solving for the optimum size of the large bloc: If the Article XXIV constraint binds for any CU, assuming that there will be only two blocs in equilibrium, we can solve for the equilibrium size of these blocs: the first bloc to form is choosing its size to maximise its welfare knowing that the second bloc will be formed by the remaining countries. The optimisation problem is thus $\underset{k}{\text{argmax}}\, W(k, \{k, N-k\})$.

$$W(k,\{k,N-k\}) = \frac{1}{2\Gamma(0)^2\Gamma(N)^2}\{N\Gamma(0)^2\left[\Gamma(N)+1\right] - 2(N-k)\Gamma(0)^2\tau(1) - (N-k)\Xi(k)\tau(1)^2 + 2(N-k)\tau(1)\gamma(2k-N)\left[2\Gamma(0) - \tau(1)\left[\Gamma(0)+\Gamma(N)\right]\right]\}$$

and

$$\frac{dW(k,\{k,N-k\})}{dk} = \frac{\tau(1)}{2\Gamma(0)^2\Gamma(N)^2}\{2\Gamma(0)\Gamma(6N) + \tau(1)\{\Gamma(0)^2\left[\Gamma(N)-1\right] - N\gamma^2\left[N-\Gamma(N)\right] - 6\gamma N\left[\Gamma(0)+\Gamma(N)\right]\} - k\left[8\gamma\left[2\Gamma(0) - \tau(1)\left[\Gamma(0)+\Gamma(N)\right]\right] - 2\gamma^2\left[N-\Gamma(N)\right]\tau(1)\right]\}$$

so

$$k^c_{opt} = \frac{2\Gamma(0)\Gamma(6N) + \tau(1)\{\Gamma(N)\left[\Gamma(0)^2 + N\gamma^2 - 6\gamma N\right] - \Gamma(N)^2 - 4\gamma N\Gamma(0)\}}{2\gamma\{8\Gamma(0) - \tau(1)\left[(5-\gamma)\Gamma(N) + 3\Gamma(0)\right]\}} \tag{15}$$

substituting $\tau(1)$

$$k^c_{opt} = \frac{\gamma^2(\gamma^2 - 41\gamma + 34)N^2 + 4\gamma(13\gamma^2 - 29\gamma + 30)N + \Gamma(0)(\gamma^3 + 5\gamma^2 - 20\gamma + 28)}{2\gamma\left[\gamma(\gamma^2 - 27\gamma + 22)N - \gamma^3 + 32\gamma^2 - 60\gamma + 64\right]} \tag{16}$$

Now back to the proof of Article XXIV binding on the large CU increasing asymmetry: it can also be shown that $k^c_{opt} > \frac{3N}{4}$. Thus if we show that $\tilde{f}(3N/4, N, \gamma) \leq 0$ we will have proved the result.

$$\tilde{f}(3N/4, N, \gamma) = -\frac{\Gamma(0)\gamma}{8D(1)}Num \tag{17}$$

with $Num \equiv \gamma(18 - 23\gamma + 4\gamma^2)N^2 + 4(2-3\gamma)(4 - 6\gamma + \gamma^2)N - 8\Gamma(0)(4 - 6\gamma + \gamma^2)$. When $\gamma = 0$, $Num = 32N - 64 \geq 0$ for $N \geq 2$. When $\gamma > 0$, Num is an increasing function of N as $18 - 23\gamma + 4\gamma^2$ and $(2-3\gamma)(4-6\gamma+\gamma^2)$ are both strictly positive for $\gamma \leq \gamma_N$ and for $N = 2$, $Num = 4\gamma(2+\gamma) \geq 0$. So for $\gamma \leq \gamma_N$, $\tilde{f}(3N/4, N, \gamma) \leq 0$ and so as $3N/4 \leq k^c_{opt} \leq N$, $\frac{\partial^2 W^L(k)}{\partial k \partial \tau_L} \leq 0$. So, when Article XXIV is binding on the big bloc, if it could raise its tariff, it would want to accept fewer members. □

2. Article XXIV binding on the small CU leads to a more symmetric equilibrium CU structure: the goal here is to determine how a change in the CET of the small CU affects the large CU's willingness to accept more or less members, i.e. we want to determine the sign of

$$\frac{\partial}{\partial \tau_S}\frac{\partial W^L(k)}{\partial k}$$

where τ_S is the external tariff imposed by the small union and W^L is the welfare of a member country of the large union. Again, we are interested in the sign of this second derivative at the point where the small union is constrained by Article XXIV and where the large union has chosen its size optimally. The welfare of a country belonging to the large CU is

$$W(k) = Q(k) - \frac{\gamma}{2}Q(k)^2 - \frac{1-\gamma}{2}\left[kq_I^2(k) + (N-k)q_O^2(k)\right] - (N-k)q_O^2(k) + (N-k)q_O^2(N-k) \tag{18}$$

where the last term represents the exports of a firm located in the large CU into the countries belonging to the small CU. Only this term depends on the tariff imposed by the small union. Differentiating (18) with respect to the tariff of the small union gives

$$\frac{\partial W^L(k)}{\partial \tau_S} = -\frac{2}{\Gamma(0)^2\Gamma(N)^2}\left[(N-k)\Gamma(N-k)\Gamma(0) - \tau_S(N-k)\Gamma(N-k)^2\right]$$

Differentiating with respect to k yields

$$\frac{\partial}{\partial k}\frac{\partial W^L(k)}{\partial \tau_S} = \frac{2}{\Gamma(0)^2\Gamma(N)^2}\left[\underbrace{\Gamma(0)\Gamma(2(N-k))}_{\geq 0} - \tau_S \underbrace{\Gamma(N-k)\Gamma(3(N-k))}_{\geq 0}\right]$$

So the second derivative is a linear monotonically decreasing function of the tariff imposed by the small union and we have $\frac{\partial}{\partial \tau_S}\frac{\partial W^L(k)}{\partial k} \geq 0$ if and only if $\Gamma(0)\Gamma(2(N-k)) - \tau_S\Gamma(N-k)\Gamma(3(N-k)) \geq 0$. With Article XXIV imposed, $\tau_S \leq \tau(1)$ (with equality if it binds on the small CU), so $\Gamma(0)\Gamma(2(N-k)) - \tau_S\Gamma(N-k)\Gamma(3(N-k)) \geq f(k,N,\gamma)$ with

$$\begin{aligned} f(k,N,\gamma) &= \Gamma(0)\Gamma(2(N-k)) - \tau(1)\Gamma(N-k)\Gamma(3(N-k)) \\ &= -3\tau(1)\gamma^2k^2 + \gamma\{\tau(1)\left[3\Gamma(N) + \Gamma(3N)\right] - 2\Gamma(0)\}k + \Gamma(0)\Gamma(2N) - \tau(1)\Gamma(N)\Gamma(3N) \end{aligned}$$

$\frac{\partial^2 f}{\partial k^2} = -6\tau(1)\gamma^2 \leq 0$ and so $\frac{\partial f}{\partial k}$ is a decreasing function of k. Furthermore,

$$\begin{aligned} \frac{\partial f}{\partial k}(0,N,\gamma) &= \gamma\{\tau(1)\left[3\Gamma(N) + \Gamma(3N)\right] - 2\Gamma(0)\} \lesseqgtr 0 \\ \frac{\partial f}{\partial k}(N/2,N,\gamma) &= \gamma\{\tau(1)\left[3\Gamma(N) + \Gamma(0)\right] - 2\Gamma(0)\} \lesseqgtr 0 \\ \frac{\partial f}{\partial k}(N,N,\gamma) &= 2\Gamma(0)\gamma\left[2\tau(1) - 1\right] \leq 0 \end{aligned}$$

note that $\tau(1)$ is a decreasing function of N and for $N=1$, $\tau(1)=\frac{\Gamma(0)\Gamma(2)}{[\Gamma(0)+1]\Gamma(1)^2}=\frac{4-\gamma^2}{4(3-\gamma)}<\frac{4}{4(3-1)}=\frac{1}{2}$, so $\frac{\partial f}{\partial k}(N,N,\gamma)\leq 0$ and so f is initially either increasing and then decreasing or monotonically decreasing depending on the parameters.

$$f(N,N,\gamma)=\Gamma(0)^2\left[1-\tau(1)\right]\geq 0$$

$$f(N/2,N,\gamma)=\frac{\Gamma(0)}{4D(1)}\left[5\gamma^2(2-3\gamma)N^2+\underbrace{\gamma(4\gamma^2-9\gamma+6)}_{\geq 0}N+\underbrace{16\Gamma(0)(2-2\gamma+\gamma^2)}_{\geq 0}\right]$$

$f(N/2,N,\gamma)$ is positive for any $N\geq 0$ for $\gamma\leq\frac{2}{3}$, so we know that for $\gamma\leq\frac{2}{3}$, $\frac{d}{dk}\frac{dW^L(k)}{d\tau_S}\geq 0$. So for $\gamma\leq\frac{2}{3}$, removal of Article XXIV would give an incentive to the large union to accept more members, i.e. Article XXIV may lead to a more symmetric structure.

This proof is only for the range of parameters where $\gamma\leq\frac{2}{3}$, because $N/2$ is a very coarse lower bound for the optimum size of the large CU. When Article XXIV does not bind on the large CU, we are not able to calculate the optimum size analytically, but we can determine it numerically. Signing the second derivative at the optimum size of the large CU shows that the result holds also for $\gamma>\frac{2}{3}$. □

Free trade threshold

As Yi (1996) shows, a necessary and sufficient condition for global free trade to be the subgame-perfect equilibrium outcome is $W(N;\{N\})\geq W(N-1;\{N-1,1\})$. It is obviously a necessary condition and in this quasilinear-quadratic setting, it is also a sufficient condition, since it implies $k_0=N$ and as a result, $W(N;\{N\})\geq W(k;C)$ for all k and all CU structures C.

Let $f(\gamma,N)=W(N;\{N\})-W(N-1;\{N-1,1\})$. f is a continuous function of γ. For $\gamma=0$, we know that the Article XXIV constraint is binding for any size CU and we have for any N, $f(0)=\frac{7}{72}>0$. On the other hand, as $k^{**}(\gamma=1)=\frac{2N-1}{6}$, we know that for $N>2$, at $\gamma=1$, a CU with $N-1$ members is never constrained by the Article XXIV constraint and we have, $f(1)=-\frac{4N^4+4N^3-51N^2-206N-47}{2(1+N)^2(7+N)^2(1+2N^2)}$ which is negative for any $N>4$. So for $N>4$, by the intermediate values theorem, there exists a critical value of γ, such that $f(\gamma_{FT})=0$.

Due to the kink introduced by the Article XXIV constraint, it is difficult to study the variations of $f(\gamma)$ analytically, but simulations show the uniqueness of this critical value. Furthermore, for $N\leq 4$, $f(\gamma)$ is always positive and so free trade is always the equilibrium outcome for very small N. For $N>4$, $f(\gamma)$ is positive for $\gamma\leq\gamma_{FT}$ and negative for $\gamma>\gamma_{FT}$ and so free trade is the equilibrium outcome for $\gamma\leq\gamma_{FT}$.

Our goal is to compare γ_{FT} such that $f(\gamma_{FT})=0$ with and without the Article XXIV constraint. Calculating γ_c^{FT} and γ_u^{FT} for all N, $N=5,\ldots,10^5$ shows that $\gamma_c^{FT}\geq\gamma_u^{FT}$ in each case.

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