IS THE WTO'S ARTICLE XXIV BAD?

by

Monika Mrazova, David Vines, and Ben Zissimos

Working Paper No. 09-W02

January 2009

DEPARTMENT OF ECONOMICS
VANDERBILT UNIVERSITY
NASHVILLE, TN 37235

www.vanderbilt.edu/econ

Is the WTO's Article XXIV Bad?*

Monika Mrázová[†‡]
Department of Economics
and Balliol College,
University of Oxford

David Vines[§]
Department of Economics
and Balliol College,
University of Oxford;
Australian National University;
CEPR

Ben Zissimos[¶]
Vanderbilt University

December 22, 2008

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) less asymmetric 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 CLASSIFICATION NUMBERS: F02, F13, F15.

*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, Vanderbilt University, the 50th Midwest International Trade Meeting at Purdue University and the Merton Seminar in International Trade at the University of Oxford.

[†]Corresponding author: Department of Economics, University of Oxford, Manor Road, Oxford, OX1 3UQ, United Kingdom; e-mail: monika.mrazova@econonomics.ox.ac.uk; URL: http://www.economics.ox.ac.uk/members/monika.mrazova/.

[‡]Financial support for travel from the George Webb Medley Fund, Balliol College and Oriel College is gratefully acknowledged.

[§]E-mail: david.vines@economics.ox.ac.uk

[¶]E-mail: ben.zissimos@vanderbilt.edu

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:[1] First, any internal barriers to trade inside the union must be removed; second, trade barriers on non-members must not be increased on average. Intuition might suggest that 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 in a surprising way.

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 will 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.[2]

[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 across 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

Both in the benchmark model, and in the model in which the Article XXIV constraint is imposed, the substitutability between varieties of goods in consumption is crucial to the determination of the CU structure that emerges in equilibrium.[3] Substitutability is parameterized in the model by $\gamma \in [0,1]$; varieties are independent for $\gamma = 0$ and they are perfect substitutes for $\gamma = 1$.

In the benchmark model, for very small γ (including $\gamma = 0$) members of any CU always become better off when the CU expands, driving CU-expansion all the way to free trade. 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 for larger γ, in the unique equilibrium CU structure there is one large CU and one small CU.[4] 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.[5]

We will show that, holding the equilibrium CU structure constant, the introduction of the Article XXIV constraint into the benchmark model increases world welfare (or at worst

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 them through coordination and thus tend to set higher tariffs than FTAs. Indeed, Bond et al. (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.

[3]The *equilibrium CU structure* is the number of countries in each and every one of the CUs that forms in equilibrium.

[4]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.

[5]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.

has no effect). This is because if there is an incentive for a CU to increase its common external tariff 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 common external tariff 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. They are actually derived 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 same basic characterization of the equilibrium CU structure prevails but with the two key differences mentioned above. First, free trade is the unique equilibrium outcome for a larger range of γ than without the Article XXIV constraint. The reason is that, by precluding an increase in common external tariffs, Article XXIV reduces the gains to CU formation relative to free trade. As a result, free trade becomes the equilibrium outcome under the Article XXIV constraint for a wider range of γ. Second, for values of γ where free trade does not arise in equilibrium, we find that the equilibrium CU structure is nearly always *less asymmetric*; the larger CU is smaller and the smaller CU is larger than without the Article XXIV constraint. 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 less asymmetric outcome. This means that thus world welfare is reduced.[6]

The basic intuition behind why the equilibrium CU structure is less asymmetric with Article XXIV is as follows. It is easiest to think about the equilibrium CU structure with the Article XXIV constraint imposed and then consider its removal. When the Article XXIV constraint is removed, the smaller CU could have an incentive to raise its common external tariff 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

[6]To see this composition effect most clearly, think of two CUs with common external tariffs 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 less asymmetric the outcome the lower is world welfare. Note that this composition effect of Article XXIV cannot be observed in a conventional 3-country model. The constraint in a 3-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.

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 and vice versa. It is this which gives rise to the possibility of negative effects.

The most comprehensive previous analysis of Article XXIV is by Syropoulos (1999), using a model of CU formation between two countries in a 3-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.[7] Furthermore, since Syropoulos' analysis is carried out in a 3-country model, the composition effect of Article XXIV, which is crucial to our claim that the outcome for world welfare may be worse under Article XXIV, cannot be discussed in his framework.[8]

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 with 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.[9]

[7]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.

[8]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 actually study equilibrium under its conditions.

[9]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), Seidmann (2006) and Aghion et al. (2007) 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

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; we do this for changes in the CU structure both with and without the Article XXIV constraint. In order to consider endogenous CU formation, Section 4 presents the CU formation game that we use and characterizes the stable equilibrium CU structures of this game. Section 5 analyzes the effect of Article XXIV on the equilibrium CU structure; again, the outcomes with and without the Article XXIV constraint are compared. It is here that the main results are derived. Conclusions are drawn in Section 6, at which point we will return to broader issues of the context and implementation of Article XXIV raised by McMillan (1993) and Snape (1993).

2 CUs and the Article XXIV Constraint

2.1 Original model from Yi (1996)

In the following subsection, we will summarize the key characteristics and results of Yi's (1996) model, which will be adopted as our benchmark. In the subsequent subsection we will introduce the Article XXIV constraint into the model.[10]

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

Each firm in the model, one in each 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

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

agreements, blocking a subsequent move to free trade. Ethier (1998) considers how multilateral liberalization may give way to regionalism. See Bhagwati et al. (1998) for a literature review on the dynamics of regionalism.

[10] For further details about derivations of the benchmark model, see Yi (1996).

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 $Q_i \equiv \sum_{j=1}^{N} q_{ij}$. As mentioned in the introduction, the parameter γ is a substitution index between varieties which ranges from 0 (varieties are independent) to 1 (good is homogeneous); as γ is increased, the varieties become closer substitutes. A familiar feature of the model is that consumers have a taste for variety; for any given Q_i, the more balanced the consumption bundle and the more varieties there are, the higher is utility. Thus there are two sources of gains from trade: access to a wider variety of goods and increased competition in the domestic market.

There are no transportation costs in this model. Countries impose 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.[11] In equilibrium,

$$Q_i = \frac{N - T_i}{\Gamma(N)} \tag{2}$$

and

$$q_{ij} = \frac{\Gamma(0) + \gamma T_i - \Gamma(N)\tau_{ij}}{\Gamma(0)\Gamma(N)} \tag{3}$$

where $T_i = \sum_{j=1}^{N} \tau_{ij}$ is the sum of tariffs, $\Gamma(k) = 2 - \gamma + k\gamma$, $k = 0, ..., N$ and where we have normalised $a - c = 1$.

2.1.2 CUs and optimal tariffs

The countries that form a CU are assumed to abolish tariffs among union members and maximize the aggregate welfare of members. A reduced form for country i's welfare, W^i, can be obtained as the sum of four components: the domestic consumer surplus, CS^i; the domestic firm's profit in the home market, π^{ii}; tariff revenue, TR^i; and the domestic firm's export profits, π^{ji}, $j \neq i$. Using this reduced form, it is possible to solve for the common external tariff of any CU; if countries $1, ..., k$ belong to a CU of size k, to set their common external tariff they will solve

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

$$\max_{\{\tau_{ij}\}_{i=1,\ j=k+1}^{k,\ N}} \sum_{i=1}^{k} W^i = \sum_{i=1}^{k} \left\{ CS^i + \pi^{ii} + TR^i + \sum_{\substack{j=1 \\ j\neq i}}^{N} \pi^{ji} \right\} \tag{4}$$

where $\tau_{ij} = 0$, for $i = 1, ..., k$, $j = 1, ..., k$.

The unique optimal common external tariff of a CU of size k is

$$\begin{aligned} \tau(k) &= \frac{\Gamma(0)\Gamma(2k)}{D(k)} \\ &= \frac{[2-\gamma][2+(2k-1)\gamma]}{[(2-\gamma)^2+(1-\gamma)k\gamma][2+(N-1)\gamma]+[2+(k-1)\gamma][2+(2k-1)\gamma]} \end{aligned} \tag{5}$$

with $D(k) = \Psi(k)\Gamma(N) + \Gamma(k)\Gamma(2k)$ and $\Psi(k) = (\Gamma(0)+1)\Gamma(k) - \Gamma(2k)$.

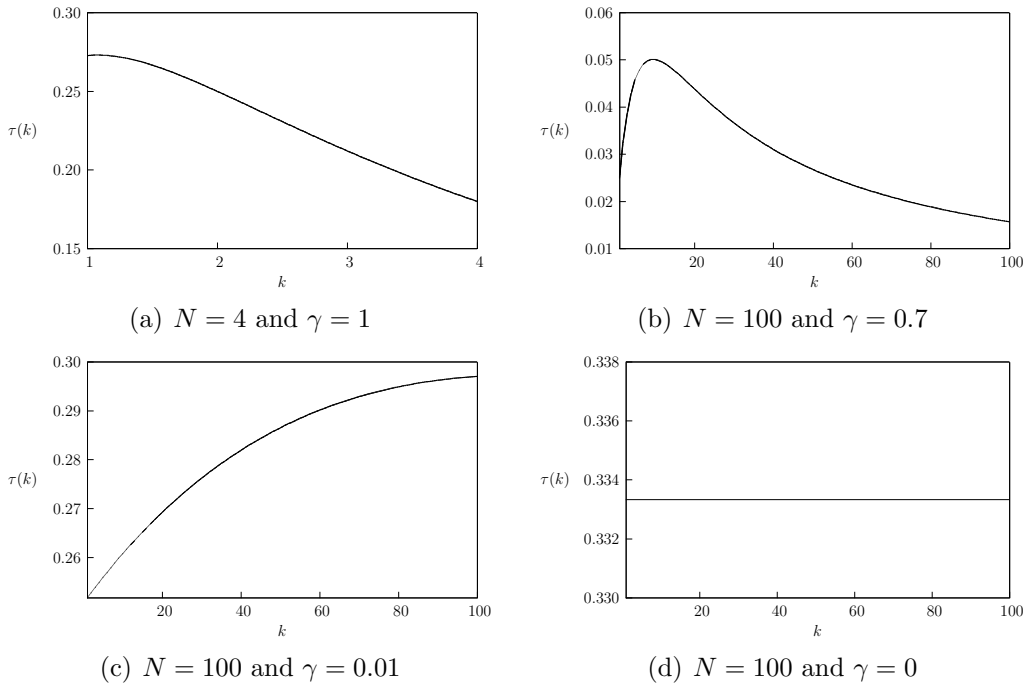
In this model, the optimal tariff of a CU of size k depends *only* on k; it does not depend on the tariffs set by the rest of the world. This property is driven by our assumptions of segmented markets, quasilinear utility function and constant marginal cost. As a CU expands, its external tariff varies with its size in a non-monotonic way depending on the parameters γ and N. More precisely, $\tau(k)$ increases with k if and only if

$$\begin{aligned} k < k^* = k^*(N,\gamma) &= \frac{\sqrt{\Gamma(0)[\Gamma(0)+1]\Gamma(N)} - \Gamma(0)}{2\gamma} \\ &= \frac{\sqrt{(2-\gamma)(3-\gamma)(2+(N-1)\gamma)} - (2-\gamma)}{2\gamma} \end{aligned} \tag{6}$$

According to (6), an expanding CU will raise its optimal external tariff providing that $k < k^*$, but once it reaches the critical size of $k^*(N,\gamma)$ members, it will decrease the optimal external tariff for further increases in k. The function $k^*(N,\gamma)$ will play an important role in our analysis since it helps to define the range over which the Article XXIV constraint binds.

Figure 1 illustrates the possible properties of the tariff function. Figure 1(a) shows the case of small N and $\gamma = 1$. Note that for $\gamma = 1$, $k^*(N,1) = \frac{\sqrt{2(N+1)}-1}{2}$. So for small N, $k^*(N,1) < 2$ and $\tau(k)$ is a globally decreasing function. This case occurs only for a very limited range of parameters (when N is very small and γ close to 1). For larger values of N and any value of γ, $\tau(k)$ is initially increasing but eventually decreasing in k as shown on Figure 1(b). The non-monotonicity of $\tau(k)$ is the result of two opposing effects of CU formation on the optimum tariff: 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 common external tariff. 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 external tariff in order to offset the trade diversion. Figure 1(c) illustrates the case where $\tau(k)$ is initially increasing and becomes decreasing in k for k outside the considered range ($k > N$) and thus appears increasing on the 'practical' range. Finally, Figure 1(d) shows the tariff function for $\gamma = 0$ where the tariff is constant and equal to 1/3.



(a) $N = 4$ and $\gamma = 1$

(b) $N = 100$ and $\gamma = 0.7$

(c) $N = 100$ and $\gamma = 0.01$

(d) $N = 100$ and $\gamma = 0$

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

2.2 Introducing the Article XXIV Constraint

Given the benchmark model set out above, 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. Then, since all countries are symmetric, they all initially set the same tariff, $\tau(1)$. If a set of countries forms a CU, in order 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 globally decreasing function, 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 at higher values of k, then there will be a range of k for which the Article XXIV constraint will bind.

Our aim now is to characterise the range of parameters for which the Article XXIV constraint will be binding and a range for which it will not be binding. We will begin by identifying a range of γ over which $\tau(k)$ is increasing in k for some $k > 1$.

Lemma 1. *For a given N, $k^*(N, \gamma)$ is a monotonically decreasing function of γ.*

Proof. See Appendix A page 31.

This result is a consequence of a change in γ on the two opposing effects of CU formation on optimal tariffs identified earlier. At low values of γ, substitution between goods is more limited and hence so is the trade diversion effect; the market power effect of raising the common external tariff tends to be relatively strong, resulting in a higher value of $k^*(N, \gamma)$. At higher values of γ the trade diversion effect tends to be stronger, resulting in a lower optimal tariff for any given k and a lower value of $k^*(N, \gamma)$.

A consequence of this result is that, for any N, there will be an interval of the parameter values γ for which $\tau(k)$ is initially increasing but eventually decreasing in k. The reasoning is as follows. First note that for any given N, $k^*(N, 0)$ is infinite. Also, as already mentioned, $k^*(N, 1) = \frac{\sqrt{2(N+1)}-1}{2}$, so $k^*(N, 1)$ is positive for any value of N. So by the intermediate value theorem, we know that for any N, we can find a value of $\gamma > 0$ such that $k^*(N, \gamma) > 1$. The fact that $k^*(N, \gamma)$ is a decreasing function of γ can be seen by inspection of Figure 2, which summarizes the variations of $\tau(k)$ in a 3-dimensional plot.

We will now identify a critical range of γ for which we know that $k^*(N, \gamma) > 1$. The following definition defines the upper bound of that range.

Definition 1. For a given N, let γ^* be the maximum value of γ such that $k^*(N, \gamma) > 1$.

For any given number of countries in the world, N, and any $0 < \gamma < \gamma^*$, $\tau(k)$ will be an initially-increasing-but-eventually-decreasing function of k. Thus, for any N and any $0 < \gamma < \gamma^*$, there will be a unique size-k CU (for the moment we abstract from discontinuity

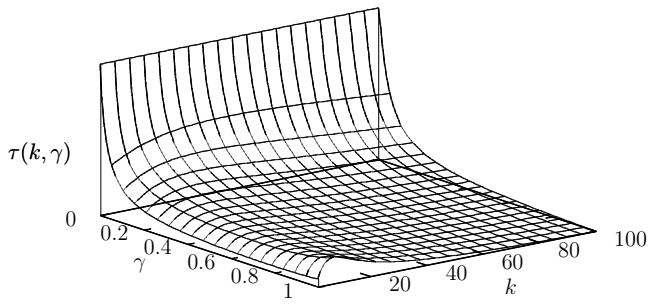


Figure 2: $\tau(k,\gamma)$ for $N = 100$

problems) that will set the same external tariff on non-members as a single country; that is, there will be a unique $k > 1$ such that $\tau(k) = \tau(1)$.

Definition 2. Let $k^{**}(N,\gamma)$ be the unique value of $k > 1$ such that $\tau(k^{**}) = \tau(1)$.

The following reduced form expression for $k^{**}(N,\gamma)$ is obtained by setting $\tau(k^{**}) = \tau(1)$ using (5) and solving for k:

$$k^{**} = \frac{(\gamma-2)(-4+\gamma(6+\gamma(N-1)-3N))}{2\gamma(2+\gamma)} \tag{7}$$

So now we can say more generally that, under the Article XXIV constraint, any CU of size k for which $1 < k < k^{**}$ members will be constrained to set a common external tariff $\tau(k) = \tau(1)$. Figure 3(a) illustrates the relationship between k^* and k^{**}.

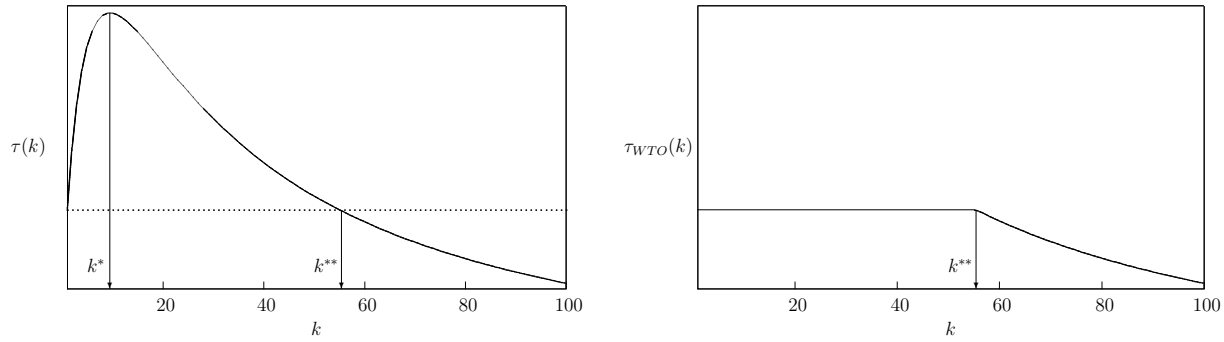
Lemma 2. *For a given N, $k^{**}(N,\gamma)$ is a decreasing function of γ.*

Proof. See Appendix A page 31.

Note that for any given N, $k^{**}(N,0)$ is infinite. Furthermore, $k^{**}(N,1) = \frac{N}{3} - \frac{1}{6} < N$. And so by the intermediate value theorem, we know that for any N, we can find a value of γ, $0 < \gamma \leq \gamma^*$ such that $k^{**}(N,\gamma) = N$.

Definition 3. Let $\gamma^{**}(N)$ be the value of γ for which $k^{**}(N,\gamma^{**}) = N$.

Observe that $\gamma^{**}(N)$ is the value of γ such that, for any N, $\tau(k)$ is initially increasing but eventually decreasing in k, with the additional property that $\tau(N) = \tau(1)$. Table 1 presents



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

Figure 3: $\tau(k)$ and $\tau_{WTO}(k)$ for $N = 100$ and $\gamma = 0.7$.

some approximate values of $\gamma^{**}(N)$ for different values of N. It can be shown that $\gamma^{**}(N)$ is a monotonically decreasing function of N and approaches a horizontal asymptote when N goes to infinity; $\lim_{N\to+\infty} \gamma^{**}(N) = a$ where $a = \frac{1}{2}(7 - \sqrt{41}) \approx 0.298438$.

N	10	30	50	100	200	500	1000	10^4	10^5	10^6
$\approx \gamma^{**}$	0.406	0.349	0.332	0.317	0.308	0.302	0.300	0.299	0.298	0.298

Table 1: Approximate values of $\gamma^{**}(N)$.

As $k^{**}(N, \gamma)$ is a decreasing function of γ, we can now conclude that for any N and any γ, $0 < \gamma \leq \gamma^{**}$, $k^{**}(N, \gamma) \geq N$. Also for $\gamma = 0$, since $\tau(k)$ is constant, $k^{**}(N, 0)$ is infinite and thus also greater than N, and so $\tau(k) > \tau(1)$ for all $k \in [2, N-1]$. Thus, for $0 \leq \gamma \leq \gamma^{**}$ a CU of any size ($k > 1$) would be constrained in its common external tariff setting by the Article XXIV constraint.

In summary, we have now found that for any number of countries, N, there will be a range of parameter values γ such that the Article XXIV constraint will be binding for any feasible CU. Alternatively, for any γ and reasonably large N, the Article XXIV will be binding for at least some CUs (the smaller ones). This set of results is summarized in the following proposition. We will use $\tau_{WTO}(k)$ to denote the optimal tariff imposed by a CU of size k under the Article XXIV constraint.

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, $k \leq k^{**}$, and imposes*

$$\tau_{WTO}(k) = \begin{cases} \tau(1) & for\ k \leq k^{**} \\ \tau(k) & for\ k^{**} < k < N\ and \\ 0 & for\ k = N \end{cases} \tag{8}$$

Figure 3(b) illustrates $\tau_{WTO}(k)$ as a function of CU size. Note that $\tau_{WTO}(k)$ is a non-increasing function of k.

3 CUs and welfare

In this section, we will analyze the impact of exogenous CU formation under the Article XXIV constraint on the welfare of individual countries and on global welfare. This will give us a concrete set of payoffs for use in the CU formation game analyzed in the next section, wherein the CU structure will be determined endogenously. Our analysis will proceed along the same lines as Yi (1996) but with the key difference that all common external tariffs we consider will be subject to the Article XXIV constraint.

3.1 Individual country welfare and global welfare

As will be shown in due course, the impact of CU formation and expansion on members' and non-members' welfare can be studied through the following quantities which have been derived from (2) and (3):

Sales of a member nation in a country belonging to a size-k CU,

$$q_I(k) = \frac{\Gamma(0) + (\Gamma(N) - \Gamma(k))\tau_{WTO}(k)}{\Gamma(0)\Gamma(N)} \tag{9}$$

sales of a non-member nation in a country belonging to a size-k CU,

$$q_O(k) = \frac{\Gamma(0) - \Gamma(k)\tau_{WTO}(k)}{\Gamma(0)\Gamma(N)} \tag{10}$$

the *total consumption* in a country belonging to a size$-k$ CU,

$$Q(k) = \frac{N - (N-k)\tau_{WTO}(k)}{\Gamma(N)} \tag{11}$$

We can see by inspection that a member country has a higher volume of exports than a non-member country in any member country. Since, in this quasilinear-quadratic model, the expression for export profits is the square of the expression for export volume, a member country makes higher exports profits than a non-member country in any member country.

3.1.1 Non-members' welfare

From (10) we can show that non-member countries become worse off if a CU expands. As noted above, a feature of the model is that a non-member country is affected by CU formation or expansion only through its export profits to the CUs that form. Observe that $q_O(k)$ is a globally decreasing function of k. Thus, a non-member country's export profit to a CU of size k, equal to $[q_O(k)]^2$, falls as k increases.

Proposition 2. *A non-member country's exports $q_O(k)$ and thus export profits $[q_O(k)]^2$ are decreasing functions of k. A non-member country becomes worse off if a CU expands.*

Proof. See Appendix B page 32.

Yi's (1996) model yields this result without the Article XXIV constraint, reflecting a standard property in the literature that CU formation and expansion tends to hurt non-members. Proposition 2 establishes that this result still holds even under the Article XXIV constraint. Thus even though a CU is not allowed to raise its external tariff, this does not preclude harmful trade diversion away from non-members. The following result compares the magnitude of this trade diversion with and without the Article XXIV constraint.

Proposition 3. *When the Article XXIV constraint is binding, 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 33.

The conclusion we are able to draw from the analysis so far is that the Article XXIV constraint does not prevent harmful trade diversion from non-members, but it attenuates it when it is binding.

3.1.2 Members' welfare

How does an expansion of a CU affect the welfare of member countries? In this subsection we will examine how the components of welfare (consumer surplus, tariff revenue and producer surplus) vary with k for members and hence how overall welfare varies. We will show that consumer surplus and tariff revenue are monotonic in k, a property that depends on the Article XXIV constraint and its implications for the tariff function.

Lemma 3. *(i) $q_I(k)$ is a decreasing function of k. (ii) $Q(k)$ is an increasing function of k.*

Proof. See Appendix B page 33.

Consumer surplus As shown in the next lemma, a feature of the model is that consumer surplus of a member country can be expressed as a combination of the three quantities: (9), (10) and (11).

Lemma 4. *Consumer surplus of a country belonging to a k-size CU can be written as follows:*

$$CS(k) = \frac{\gamma}{2}Q(k)^2 + \frac{1-\gamma}{2}(kq_I(k)^2 + (N-k)q_O(k)^2) \tag{12}$$

Proof. See Appendix B page 33.

Using this result, it can be shown that consumer surplus of a member country *increases* as the CU expands.

Proposition 4. *The consumer surplus in member countries increases as the CU expands.*

Proof. See Appendix B page 34.

As the 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; consumer surplus tends to decrease through the diminished consumption of non-member countries' products. Without the Article XXIV constraint, the effect of CU expansion on consumer surplus is ambiguous. However the Article XXIV constraint, by preventing member countries from raising the external tariff above the initial level, makes the second effect less important (Proposition 3). The fact that consumer surplus becomes an increasing function of the CU size is thus a direct consequence of the Article XXIV constraint.

Tariff revenue The tariff revenue of a member country necessarily *decreases* as the CU expands. Under the Article XXIV constraint, countries are not allowed to raise their external tariffs and as the CU expands they can thus levy at maximum the same level of tax on fewer countries.

Producer surplus From (9) and Lemma 3, we know that profits made by the domestic firm from sales in the home market decrease as the CU expands because, in a bigger CU, more firms have tariff-free access which increases competition and thus reduces profits per firm. But at the same time, the domestic firm gets preferential access to a larger number of countries and, from a comparison between (9) and (10), we know that sales are higher

in a member nation than in a non-member nation. Thus the effect of CU expansion on the domestic firm's total profit may be ambiguous.

In summary, we have just seen that the expansion of a CU has a positive impact on consumer surplus, a negative impact on tariff revenue and an ambiguous impact on producer surplus of a member country. Therefore, the effect of CU expansion on the welfare of a member country is ambiguous.

3.1.3 World welfare

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 the Article XXIV, we will now show that it continues to hold under the Article XXIV constraint.

Proposition 5. *Under the Article XXIV constraint, the formation or expansion of CUs increases the aggregate welfare of member countries.*

Proof. See Appendix B page 35.

Although the idea behind this result is simple, the proof is not quite trivial. It proceeds in three steps. The first deals with a situation where the Article XXIV constraint does not bind at any point; neither on the initial CUs nor on the new CU created by the merger. For this part of the proof we are able to adopt the proof for the equivalent result by Yi (1996). The second step deals with a situation where the Article XXIV constraint binds both on the initial CUs and the new CU created by the merger. With common external tariffs constrained not to change by the Article XXIV constraint, the only effect is through the removal of internal tariffs which increases aggregate welfare. Finally, the third step deals with a situation where Article XXIV is binding on at least one of the initial CUs but not on the new CU created. (Because of the properties of the optimal tariff function studied in the previous section, the converse cannot occur.) A simple comparative statics exercise reveals that the increase in aggregate welfare of members due to a merger of CUs in this situation follows from the prior two steps of the proof.

Corollary 1. *Under the Article XXIV constraint, the effects on global welfare of the formation or expansion of CUs are ambiguous, except under global free trade. World welfare is higher under global free trade than under any other CU structure.*

Proof. Follows directly from Propositions 2 and 5. As a CU expands, its members are on average better off, but non-members are made worse off. Thus the impact on global world welfare is ambiguous. The exception is when global free trade is reached, whereby in effect all countries become members of the same CU and, by Proposition 5, their aggregate welfare increases.

3.2 When must individual-member welfare increase?

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 particular, we will show in this subsection that if, through CU creation or expansion, an individual country gains tariff-free access to a larger number of other country markets then its welfare must increase.

Definition 4. 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 $\mathcal{P}$. $B_i \cap B_j = \varnothing$ 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.

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 will prove that Yi's analogous results (his Propositions 6-9) continue to

hold under the Article XXIV constraint and discuss what the differences are with respect to the situation without the Article XXIV constraint.

Proposition 6. *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 $W(n_i; C) < W(n_i; C')$.*

Proof. See Appendix C page 42.

Proposition 6 shows 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 Proposition 2; as any CU expands, the export profits made by nonmembers unambiguously fall, and this is the only effect of CU expansion on nonmembers. By Proposition 3, the Article XXIV constraint will attenuate the adverse effect of a CU merger on non-members.

The next proposition ranks the per-member welfare of CUs in a given CU structure. It says that, 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.

Proposition 7. *If $n_i > n_j$, then $W(n_i; C) > W(n_j, C)$.*

Proof. See Appendix C page 42.

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 is binding 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. But if the Article XXIV constraint is binding for both large and small CUs, this difference may be attenuated.

The next two propositions show how changes in the CU structure affect the welfare of countries involved in the change.

Proposition 8. *The members of a CU that merges with another CU of equal or larger size become better off.*

Proof. This result follows directly from Propositions 5 and 7. 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.

Proposition 9. *A member of a CU becomes better off if it leaves its CU to join another CU of equal or larger size.*

Proof. See Appendix C page 42.

Imposition of the Article XXIV constraint does not reverse any of Yi's equivalent results. It only modifies the magnitudes of the components of welfare. This will in turn have important implications for the final equilibrium CU structure with and without the Article XXIV constraint.

4 CU formation and stable CU structures

4.1 CU formation

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 accept to form the coalition.[12] Bloch (1996) shows that this game yields 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.[13]

4.2 Characterization of stable CU structures

In this subsection, we will characterize stable CU structures when countries play the size announcement game. First we will show that a symmetric CU structure cannot be an

[12]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 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 formes and those countries withdraw from the game. Then the first country among the remaining countries starts making a proposal.

[13]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.

equilibrium outcome.

Proposition 10. *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.*

Proof. See Appendix D page 43.

The reasoning here has two parts. First, we already know that CU formation must not be symmetric. By Proposition 8, two CUs of equal size would be better off by merging. Second, 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.

For the next result, 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 5. 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 $W(k; C) \geq W(k-1; C')$.

Proposition 11. *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.*

Proof. 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.

Thus we are able to put a lower bound on the size of the second-to-last CU to form. We can similarly define k_i as *the largest integer such that any size-k CU becomes better off by merging with a CU of size k_{i-1}*, $(i = 1, 2, ...)$. In so doing, we establish (in the proof of Proposition 12) that the equilibrium CU structure must entail CUs of sequentially decreasing size. We are also able to establish the maximum number of CUs that can form in equilibrium. For example, if $k_0 + k_1 > N$ then there cannot be more than two CUs in equilibrium.

We will proceed by carrying out a grid search for equilibria over all possible parameter values in our model. To do this, we will need a general representation of national welfare over all possible CU structures. This is obtained in the next result.

Lemma 5. *The welfare of a member of the size-n_i CU in $C = \{n_1, n_2, ..., n_m\}$ is given by*

$$W(n_i;C) = Q(n_i) - \frac{\gamma}{2}Q(n_i)^2 - \frac{1-\gamma}{2}\left\{n_i\left[q_I(n_i)\right]^2 + (N-n_i)\left[q_O(n_i)\right]^2\right\}$$
$$-(N-n_i)\left[q_O(n_i)\right]^2 + \sum_{\substack{j=1\\ j\neq i}}^{m} n_j q_O(n_j)^2 \tag{13}$$

Proof. See Appendix D page 43.

Note that this expression simplifies further in Yi's model, but due to the non-linearity introduced by the Article XXIV constraint, this further simplification is not possible in our model. Nevertheless, in both specifications, the welfare functions have a property that is useful for the derivation of the following results. The property is that the relative ranking of the welfare of a size-k CU in a CU structure $\{k, B\}$ and the welfare of a size-r CU in another CU structure $\{r, k-r, B\}$ is independent of the sub-CU structure $\{B\}$. (The changes in the CU sub-structure in $\{B\}$ affect the welfare of the size-k and size-r CUs only through their export profits to $\{B\}$. However the per-member export profits of these two CUs to $\{B\}$ are the same for all $\{B\}$.)

The remaining results of the paper require us to calculate values for payoffs to CU formation using the payoff function derived in Lemma 5. To do this, in the sequel we will restrict attention to a 'practical' value for N. The remaining results of the paper will be established under the standing assumption that $N \leq 1000$.

Proposition 12. *Under the Article XXIV constraint, the number of equilibrium CUs in the size announcement game is not greater than three.*

Proof. See Appendix D page 44.

This result is similar to the one Yi (1996) obtains for CU formation without the Article XXIV constraint. Nevertheless, as we will see in the next section, the equilibrium CU structure is affected by the introduction of the Article XXIV constraint.

5 The effect of the WTO Article XXIV Constraint

As we have just shown, for 'practical' N, there are at most three asymmetric CUs in the equilibrium of the size announcement game. This means that in equilibrium, either global free trade is reached or the equilibrium structure corresponds to two or three CUs of different sizes. Let us now determine under what conditions free trade is the equilibrium outcome.

5.1 Global free trade equilibrium

Lemma 6. *A necessary and sufficient condition for global free trade to be the subgame perfect equilibrium outcome is* $W(N;\{N\}) \geq W(N-1;\{N-1,1\})$.

Proof. See Appendix E page 44.

Definition 6. Let $f(\gamma) = W(N;\{N\}) - W(N-1;\{N-1,1\})$.

The next result expresses the condition under which global free trade is the equilibrium outcome of the size announcement game.

Proposition 13. *For a given value of* N*, there exists a critical value,* γ^{FT}*, such that global free trade is the unique stable outcome of the size announcement game for* $0 \leq \gamma \leq \gamma^{FT}$.

Proof. See Appendix page 45.

Due to the non-linearity 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 $\gamma \leq \gamma_{FT}$. Figure 4 shows the variation of $f(\gamma)$ for $N = 100$ for example.

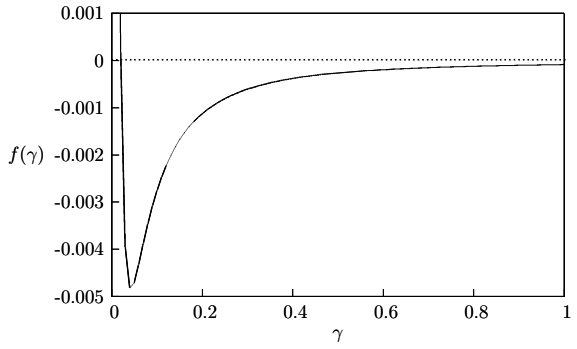


Figure 4: $f(\gamma)$ for $N = 100$.

A similar condition is found by Yi (1996) when studying CU formation without the Article XXIV constraint. The intuition behind this result is that, for small γ, varieties become less substitutable and 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. What is noteworthy about our result is the impact of the Article XXIV constraint on the value of this critical γ^{FT}, as shown by the next proposition.

Proposition 14. *Under the Article XXIV constraint,* $\gamma^{FT}_{ArtXXIV} \geq \gamma^{FT}$. *The Article XXIV constraint enlarges the range of parameters for which free trade is the equilibrium outcome.*

Proof. See Appendix page 45.

The intuition behind this result is clear: 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.

Table 2 summarizes a few approximate values of γ^{FT} with and without the Article XXIV constraint.

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

Table 2: Approximate values of γ^{FT} and $\gamma^{FT}_{ArtXXIV}$.

Note that γ^{FT} is a decreasing function of N; the more countries there are in the world, the more difficult it is to reach the free trade equilibrium. As stated in Proposition 14, γ^{FT} is higher under the Article XXIV constraint. Note that this improvement is numerically small and vanishes when N increases. This result rests on an intuitively reasonable feature of the model; the more countries there are in the world, the more varieties there are available and so the benefits to consumers from having tariff-free access to marginal varieties diminish.

5.2 Asymmetrical equilibrium

In the next result we will determine the effect of the Article XXIV constraint on the equilibrium CU structure when global free trade does not arise.

Proposition 15. *Under the Article XXIV constraint, for the range of parameters for which free trade is not the equilibrium outcome ($\gamma > \gamma^{FT}$), the CU structure may be less asymmetrical than without the Article XXIV constraint.*

Proof. See Appendix page 45.

Tables 3 (a) and (b) compare, for $N = 30$ and $N = 100$ respectively, the equilibrium CU structures with and without the Article XXIV constraint under a range of different values of γ. We can see the previously mentioned increase in the range of parameters γ for which global free trade is the equilibrium outcome. As shown in Table 3(a) for example, for $N = 30$, at $\gamma = 0.07$ free trade arises in equilibrium under the Article XXIV constraint whereas in the absence of the Article XXIV constraint it does not. A similar feature is illustrated in Table 3(b) for $N = 100$ at $\gamma = 0.02$.

(a) $N = 30$

γ	C	$C_{ArtXXIV}$
0.01	{30}	{30}
0.07	{29,1}	{30}
0.08	{29,1}	{29,1}
0.09	{29,1}	{28,2}
0.10	{28,2}	{28,2}
0.13	{28,2}	{27,3}
0.15	{27,3}	{26,4}
0.20	{27,3}	{26,4}
0.25	{27,3}	{25,5}
0.34	{27,3}	{25,5}

(b) $N = 100$

γ	C	$C_{ArtXXIV}$
0.01	{100}	{100}
0.02	{99,1}	{100}
0.03	{94,6}	{93,7}
0.04	{92,8}	{89,11}
0.05	{91,9}	{87,13}
0.06	{90,10}	{85,15}
0.07	{89,11}	{84,16}
0.08	{89,11}	{83,17}
0.10	{88,12}	{82,18}
0.30	{88,12}	{79,21}

Table 3: Equilibrium CU structures.

Another feature illustrated in both tables is the decrease in asymmetry of the equilibrium CU structure when global free trade is not reached. For example, for $N = 30$, at $\gamma = 0.34$, the equilibrium outcome under the Article XXIV constraint exhibits two CUs, one with 25 members and the other with 5 members. By contrast, without the Article XXIV constraint, the bigger CU has 27 members and the smaller one only 3 members.

The two previous results thus imply that the Article XXIV constraint does facilitate free trade in the sense that global free trade is reached for a larger interval of parameters γ. But we also see that when free trade is not the equilibrium outcome, the equilibrium CU

structure may be less asymmetrical under the Article XXIV constraint.[14]

Also, as we saw in Section 3, the difference between the welfare of members of the bigger CU and the smaller CU is attenuated. World welfare may be worsened under the Article XXIV constraint as a result, as shown by the next result.

Proposition 16. *Under the Article XXIV constraint, for the range of parameters for which free trade is not the equilibrium outcome, world welfare may be lower than without the Article XXIV constraint.*

Proof. See Appendix page 45.

The reduction of world welfare occurs as a result of the composition effect discussed in the introduction; when CUs are more symmetrical, a larger number of goods must pass between CUs and be subject to a tariff.

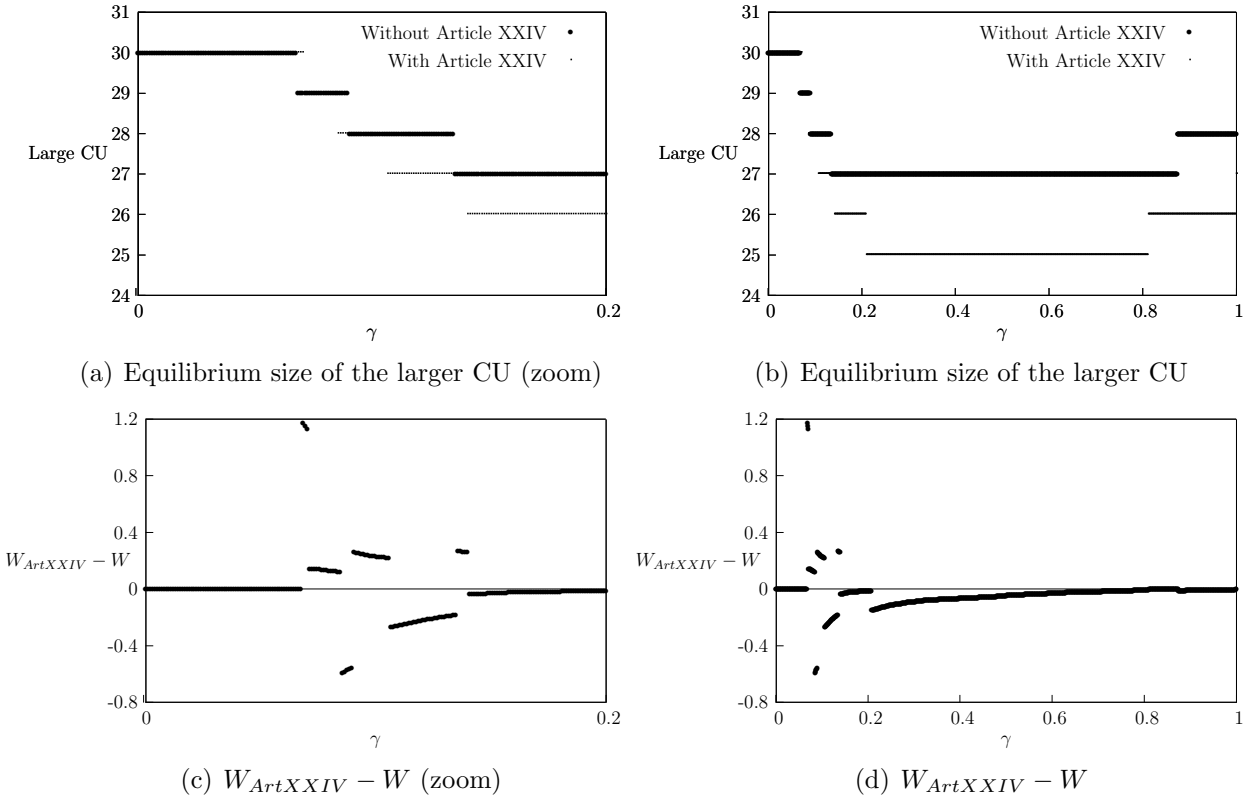
γ	C	$C_{ArtXXIV}$	$W_{ArtXXIV} - W$
0.01	{30}	{30}	0
0.08	{29,1}	{29,1}	+
0.09	{29,1}	{28,2}	-
0.10	{28,2}	{28,2}	+
0.11	{28,2}	{27,3}	-
0.12	{28,2}	{27,3}	-
0.13	{28,2}	{27,3}	-
0.14	{27,3}	{27,3}	+
0.15	{27,3}	{26,4}	-
0.20	{27,3}	{25,5}	-
0.25	{27,3}	{25,5}	-
0.30	{27,3}	{25,5}	-
0.34	{27,3}	{25,5}	-

Table 4: Equilibrium CU structures and global welfare comparison with and without the WTO Article XXIV constraint for $N = 30$.

Table 4 compares, for $N = 30$, the world welfare of the equilibrium CU structures for various values of γ with and without the Article XXIV constraint. The first column lists the

[14] Although the results reported here assume $N \leq 1000$, simulations show that these results remain valid for higher values of N. In fact, these simulations show that the world-welfare-reducing effects of Article XXIV may be even stronger for higher values of N, $(N > 1,000)$. At these higher values of N, the equilibrium CU structure under the Article XXIV constraint may consist of not two but three asymmetric blocs whereas without the Article XXIV constraint it consists of two asymmetric blocs for the same parameters. In such cases, the asymmetry of the equilibrium CU structure is further reduced and world welfare is decreased further as well. The intuition behind this result is the same as discussed for 'practical' values of N. The simulations showing these possibilities are available from the authors upon request.

different values of γ considered, while the second and third columns show the equilibrium CU structure without and with the Article XXIV constraint respectively. The last column presents the difference in world welfare of the equilibrium CU structure under the Article XXIV constraint and without. We can see that, for small γ, the CU formation game leads to free trade in both situations and thus world welfare is exactly the same (the difference is null). But for situations where global free trade is not reached in equilibrium, world welfare may be lower under the Article XXIV constraint (the difference is negative). This result comes from the fact that under the Article XXIV constraint the bigger CU, whose members have higher welfare, now has less members and the smaller CU, whose members have lower welfare, now has more members. Thus, world welfare might be lower under the Article XXIV constraint than without.



(a) Equilibrium size of the larger CU (zoom)

(b) Equilibrium size of the larger CU

(c) $W_{ArtXXIV} - W$ (zoom)

(d) $W_{ArtXXIV} - W$

Figure 5: Equilibrium CU structure and difference in world welfare with and without Article XXIV as a function of γ for $N = 30$.

This result is also illustrated in Figure 5. Figure 5(a) shows the size of the larger bloc in the equilibrium CU structure for $N = 30$ as a function of γ when γ is low, and Figure 5(b) shows this size for the full range $0 \leq \gamma \leq 1$. Notice that under the Article XXIV constraint

the larger bloc is smaller than in the benchmark case for a wide range of parameters. Notice also that free trade is reached under the Article XXIV constraint for a slightly broader range of parameters than without the Article XXIV constraint (visible on Figure 5(a)). Figures 5(c) and 5(d) show the difference in world welfare with and without the Article XXIV constraint for the same ranges of γ. When free trade is reached, both with and without Article XXIV, world welfare is identical and the difference is zero. When free trade is reached under the Article XXIV constraint, but not without it, there is a significant improvement in world welfare. When the equilibrium structure is the same in both cases, world welfare is improved under the Article XXIV constraint. But when the equilibrium structure is less asymmetric under the Article XXIV constraint, world welfare is lower. This is the crucial possibility examined in this paper.[15]

Finally note that as γ is increased above $\gamma = 0.8$ the size of the equilibrium CU structure changes in such a way that the large CU increases in size, drawing members away from the small CU. It may be helpful to think about the intuition behind this effect in the context of the underlying incentives that operate across the full range of γ. As γ is increased from $\gamma = 0$, as discussed previously, rent extraction becomes increasingly important and the equilibrium CU structure eventually switches from being one of global free trade to one of two CUs with the larger CU decreasing in size with further increases in γ. But as γ becomes sufficiently large, the pro-competitive effect of CU expansion becomes more significant, eventually dominating the gains to rent extraction and so the larger CU increases in size for further increases in γ. Note that the same effect operates both with and without the Article XXIV constraint though with differing degrees of magnitude. And even though the pro-competitive effect tends to increase the size of the big CU, free trade does not arise even at $\gamma = 1$.

[15] A case that is not illustrated in Figure 5 is the case where the equilibrium CU structure is more asymmetric under the Article XXIV constraint than without. This case may arise "by continuity" for larger N for a very small range of parameters γ. For $\gamma^{FT} \leq \gamma \leq \gamma^{FT}_{ArtXXIV}$ free trade is the equilibrium outcome under the Article XXIV constraint, but not without. This is the extreme case where the equilibrium CU structure is more asymmetric under the Article XXIV constraint than without. As γ increases, the equilibrium CU structure under the Article XXIV constraint becomes less asymmetric, but for larger values of N, there may be (the particular cases are affected by discreteness issues) a small range of γ just above $\gamma^{FT}_{ArtXXIV}$ for which free trade is not reached, and the equilibrium CU structure is still more asymmetric under the Article XXIV. In such a case, world welfare is higher with the Article XXIV constraint than without, because trade distortions are reduced (the Article XXIV constraint binds for both CUs) and because the composition effect discussed above affects CU formation in the opposite way and reduces trade distortions even further. This case arises only for certain values of N and for a very small range of γ slightly above the critical value $\gamma^{FT}_{ArtXXIV}$.

6 Conclusion

This paper has examined the effect of the WTO's Article XXIV on CU formation, the equilibrium CU structure, the implications for individual country welfare 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 common external tariff. 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 less asymmetric, 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 common external tariff 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 see whether this feature of their model rules out the reduced asymmetry of CUs under Article XXIV 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 heavier 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. McMillan (1993) argues that any group of countries forming a trade agreement should be required to adjust the external tariff so that trade flows with the rest of the world are unaffected; the Kemp-Wan adjustment (see Kemp and Wan (1976)). It would be interesting to re-do the analysis of the present paper with a 'Kemp-Wan constraint' instead of our Article XXIV constraint. The existing analysis does not yield a clear indication as to whether the introduction of a Kemp-Wan constraint would lead to an increase in world welfare. In the original paper of Kemp and Wan (1976), a CU would always benefit by adding an additional member since trade flows between members increase while flows with non-members remain constant under the Kemp-Wan constraint. So CU formation leads to free trade. In our framework of many countries it is probable that a Kemp-Wan constraint would result in free trade for a larger range of γ than the Article XXIV constraint, facilitating free trade as in Kemp and Wan (1976). But it is also possible that by even further limiting the adverse terms-of-trade effects that the smaller CU would inflict on the larger CU, it might exacerbate the composition effect identified in this paper. This effect would further limit the incentive for the larger CU to invite members of the smaller CU to join. This might reduce the asymmetry of the outcome even more than with the Article XXIV constraint, potentially worsening world welfare in the range of γ where free trade would not arise. Future research could usefully establish the conditions under which McMillan's proposal for a revision to Article XXIV would be beneficial and when it would not.[17]

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

[17] Syropoulos (1999) examines a 'modified' Kemp-Wan adjustment in the context of a conventional 3-country model with strategic interdependence between tariffs. In this model, a requirement of CU formation is that trade flows with the rest of the world are held constant, but CUs are additionally allowed to set an optimal common external tariff which takes into account any best-response-tariff set by the non-member country. Syropoulos argues that under such a 'modified Kemp-Wan constraint,' a (two-member) CU may do better than under a three-member CU (i.e. free trade). Thus he argues that if strategic tariff interactions are taken into account, a modified Kemp-Wan constraint may not limit the gains to CU formation enough, suggesting that CU formation could still be inimical to free trade under the modification to Article XXIV proposed by McMillan. In our model, there is no strategic interdependence between tariffs and it would be interesting to analyse a modified Kemp-Wan adjustment in a multi-country model with such a feature.

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 who 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 developing, that this undermines negotiations directed at further liberalisation of the WTO. Baldwin (2006) argues the opposite. An interesting agenda for future research would be to study whether Article XXIV lessens the impediments to WTO bargaining created by the existence of CUs, because it reduces the gains from CU formation. And it may be that some 'Kemp-Wan' revision of Article XXIV would reduce these impediments even more.

Appendix

A Proofs from subsection 2.3

Proof of Lemma 1. For $\gamma > 0$, $k^*(N,\gamma) = \frac{\sqrt{(2-\gamma)(3-\gamma)(2+(N-1)\gamma)}-(2-\gamma)}{2\gamma}$, (for $\gamma = 0$, k^* is infinite), so differentiating with respect to γ yields

$$\frac{dk^*(N,\gamma)}{d\gamma} = \frac{4\sqrt{(2-\gamma)(3-\gamma)(2+(N-1)\gamma)} + \gamma^3(N-1) + \gamma(16-6N) - 24}{4\gamma\sqrt{(2-\gamma)(3-\gamma)(2+(N-1)\gamma)}} \tag{14}$$

Because the denominator is strictly positive, this derivative is of the same sign as its numerator. Thus let's study the sign of the numerator

$$Num1 = 4\sqrt{(2-\gamma)(3-\gamma)(2+(N-1)\gamma)} + \gamma^3(N-1) + \gamma(16-6N) - 24 \tag{15}$$

Note that $Num1$ is a decreasing function of N.

$$\frac{dNum1}{dN} = -6\gamma + \gamma^3 + \frac{2\gamma^{\frac{3}{2}}}{\sqrt{N}} \tag{16}$$

which is strictly negative for $0 \leq \gamma \leq 1$ and $N \geq 1$. If we can show that $Num1$ is negative for $N = 1$, then we will know that it will be negative for all $N \geq 1$.

$$Num1(N=1) = 4\sqrt{2(2-\gamma)(3-\gamma)} + 10\gamma - 24 < 4\sqrt{12} + 10 - 24 < 0 \tag{17}$$

Thus $Num1$ is negative for all $0 \leq \gamma \leq 1$ and $N \geq 1$ and hence $k^*(N,\gamma)$ is a decreasing function of $\gamma > 0$ for any given N. □

Proof of Lemma 2. For $\gamma > 0$, $k^{**} = \frac{(\gamma-2)(-4+\gamma(6+\gamma(N-1)-3N))}{2\gamma(2+\gamma)}$ (for $\gamma = 0$, k^{**} is infinite), so differentiating with respect to γ yields

$$\frac{dk^{**}}{d\gamma} = \frac{-16+\gamma(-16+\gamma(-16(-2+N)+\gamma(4+\gamma)(N-1)))}{2\gamma^2(2+\gamma)^2} \tag{18}$$

Because the denominator is strictly positive, this derivative is of the same sign as its numerator. Thus let's study the sign of the numerator

$$Num2 \;=\; -16+\gamma(-16+\gamma(-16(-2+N)+\gamma(4+\gamma)(N-1))) \tag{19}$$

To sign this expression, we have to differentiate it again with respect to γ.

$$\frac{dNum2}{d\gamma} = -16 + 64\gamma - 12\gamma^2 - 4\gamma^3 - 32\gamma N + 12\gamma^2 N + 4\gamma^3 N = A \quad (20)$$

$$\frac{dA}{d\gamma} = 64 - 24\gamma - 12\gamma^2 - 32N + 24\gamma N + 12\gamma^2 N = B \quad (21)$$

$$\frac{dB}{d\gamma} = -24 - 24\gamma + 24N + 24\gamma N = C \quad (22)$$

$$\frac{dC}{d\gamma} = 24(N-1) = D \quad (23)$$

From (23), we can see D is strictly positive for $N > 1$, so C is a monotonically increasing function of γ.

From (22), note that $C(N,0) = -24 + 24N = 24(N-1)$ so for $N > 1$, $C(N,0) > 0$ and thus C is strictly positive for any value of γ, $0 < \gamma \leq 1$.

So B is a monotonically increasing function of γ. Furthermore, from (21) note that $B(N,0) = 64 - 32N = 32(2-N)$ so for $N > 1$, $B \leq 0$ and $B(N,1) = 28 + 4N > 0$. So B is initially negative and becomes strictly positive for higher values of γ.

This implies that A is initially a decreasing function of γ and then and increasing function of γ. From (20), $A(N,0) = -16$ and $A(N,1) = 16(2-N)$, so for $N > 1$, $A(N,1) \leq 0$. Thus A is negative for all values of γ, $0 < \gamma \leq 1$.

So finally, we can say that $Num2$ is a decreasing function of γ and from (19) we can note that $Num2(0) = -16$. Hence the numerator of the derivative of k^{**} with respect to γ is negative and thus k^{**} is a decreasing function of γ. □

B Proofs from Subsection 3.1

Proof of Proposition 2.

$$q_O(k) = \frac{\Gamma(0) - \Gamma(k)\tau_{WTO}(k)}{\Gamma(0)\Gamma(N)}$$

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

So

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

which ends the proof. □

Proof of Proposition 3. The first derivative of $q_O(k)$ can be more generally written as

$$\Gamma(0)\Gamma(N)\frac{dq_O(k)}{dk} = -\gamma\tau(k) - \Gamma(k)\frac{d\tau}{dk}(k)$$

When the Article XXIV constraint is binding, $\tau_{WTO}(k) \leq \tau(k)$, 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 decreasing starts to diminish until it disappears at k^{**}. □

Proof of Lemma 3. Note that $\frac{d\tau_{WTO}(k)}{dk} \leq 0$ and $\tau_{WTO}(k) \geq 0$, so

$$\begin{aligned}
\frac{dq_I(k)}{dk} &= \frac{1}{\Gamma(0)\Gamma(N)}\left[(\Gamma(N) - \Gamma(k))\frac{d\tau_{WTO}(k)}{dk} - \gamma\tau_{WTO}(k)\right] < 0 \\
\frac{dQ(k)}{dk} &= \frac{1}{\Gamma(N)}\left[-(N-k)\frac{d\tau_{WTO}(k)}{dk} + \tau_{WTO}(k)\right] > 0
\end{aligned}$$

Proof of Lemma 4. Let's calculate the consumer surplus (CS^i). There are $j = 1, .., N$ goods. For each good, by definition,

$$\begin{aligned}
CS^{ij} &= \frac{1}{2}(a - p_{ij})\, q_{ij} \\
&= \frac{1-\gamma}{2}q_{ij}^2 + \frac{\gamma}{2}Q_i q_{ij}
\end{aligned}$$

Thus

$$
\begin{aligned}
CS^i &= \sum_{j=1}^{N} CS^{ij} \\
&= \sum_{j=1}^{N} \left[\frac{1-\gamma}{2} q_{ij}^2 + \frac{\gamma}{2} Q_i q_{ij} \right] \\
&= \frac{\gamma}{2} Q_i \sum_{j=1}^{N} q_{ij} + \frac{1-\gamma}{2} \sum_{j=1}^{N} q_{ij}^2 \\
&= \frac{\gamma}{2} Q_i^2 + \frac{1-\gamma}{2} \sum_{j=1}^{N} q_{ij}^2
\end{aligned}
$$

The result follows. □

Proof of Proposition 4.

$$CS(k) = \frac{\gamma}{2} Q(k)^2 + \frac{1-\gamma}{2} (k q_I(k)^2 + (N-k) q_O(k)^2)$$

For $k \leq k^{**}$, we have

$$\frac{dCS(k)}{dk} = \frac{A}{B}$$

with $A = (\gamma+2)(40+\gamma(-92+56N+\gamma(82-4k(N-2)+\gamma^2(N-1)(-7+2k+5N)+2N(9N-46)+\gamma(-37+(56+2k-21N)N))))$ and $B = 2(-12+\gamma(8+3\gamma(N-1)-4N))^2(2+\gamma(N-1))^2$.

The denominator of this expression is the product of two squares and is thus positive. The derivative is therefore of the same sign as it's numerator A.

$$\frac{dA}{dk} = 2\gamma^2(2+\gamma)^2(2+\gamma(N-1)-N) < 0$$

So A is a decreasing function of k.

$$
\begin{aligned}
A(k^{**}) \;=\; & 80 - 112\gamma + 8\gamma^2 + 32\gamma^3 - 11\gamma^4 - \gamma^5 + \gamma^6 \\
& + (96\gamma - 64\gamma^2 - 24\gamma^3 + 24\gamma^4 - 2\gamma^6)N \\
& + (24\gamma^2 - 8\gamma^3 - 12\gamma^4 + \gamma^5 + \gamma^6)N^2
\end{aligned}
$$

and $A(k^{**})$ can be shown positive for $0 \leq \gamma \leq 1$ and $N > 1$. So A is positive and consumer surplus is an increasing function of the bloc size for $k \leq k^{**}$.

For $k^{**} < k \leq N$, we have

$$\frac{dCS(k)}{dk} = \frac{\tilde{A}}{\tilde{B}}$$

with $\tilde{A} = (12 + \gamma(4(-4 + 2k + N) + \gamma(7 - 4N + k(-6 + 2k + N) + \gamma(-1 + k + N - kN))))(16\gamma^3k^3 + 12\gamma^2k^2(4 + \gamma(-4 + \gamma + N - \gamma N)) - (-2 + \gamma)^2(-5 + \gamma(7 - 6N + 2\gamma(-1 + (3 + \gamma(-1 + N) - N)N))) + 2\gamma k(32 + \gamma(-58 + 21N + \gamma(33 - 6\gamma - 25N - (-9 + \gamma)\gamma N + (-1 + \gamma)^2N^2)))) - 2\gamma(8 + \gamma(-6 + \gamma + 4k + N - \gamma N))(4\gamma^3k^4 + (-2 + \gamma)^4(1 + \gamma(-1 + N))N + 4\gamma^2k^3(4 + \gamma(-4 + \gamma + N - \gamma N)) - (-2 + \gamma)^2k(-5 + \gamma(7 - 6N + 2\gamma(-1 + (3 + \gamma(-1 + N) - N)N))) + \gamma k^2(32 + \gamma(-58 + 21N + \gamma(33 - 6\gamma - 25N - (-9 + \gamma)\gamma N + (-1 + \gamma)^2N^2))))$ and $\tilde{B} = 2(12 + \gamma(4(-4 + 2k + N) + \gamma(7 - 4N + k(-6 + 2k + N) + \gamma(-1 + k + N - kN))))^3$.

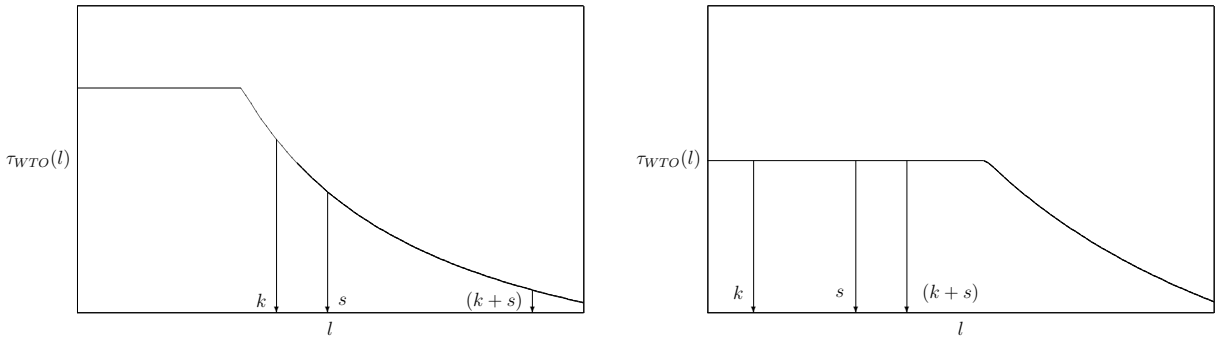
It can further be shown that $\tilde{A}$ is an increasing function of k and that $\tilde{A}(k^{**}) > 0$ as well as that $\tilde{B}$ is an increasing function of k and that $\tilde{B}(k^{**}) > 0$. So consumer surplus is an increasing function of the bloc size for $k > k^{**}$. □

Proof of Proposition 5. We want to prove that formation or expansion of customs unions under the Article XXIV constraint increases the aggregate welfare of member countries. To do so, we suppose that customs unions 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$-k$ customs union and a size$-s$ customs union where $s = l + m + \ldots + r$.

The proof will consist of three steps: First, to prove the case where the Article XXIV constraint does not bind on the CUs involved in the merger, we will invoke the proof of Yi's (1996) Proposition 3; the case shown in Figure 6(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. (Yi's proof is reproduced here for completeness.) Second, we will prove the proposition for CUs on which the Article XXIV constraint is binding as shown in Figure 6(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 the Article XXIV (from Yi (1996), Appendix B)

Here we consider the merger of size$-k$ and size$-s$ CUs such that the Article XXIV constraint is neither binding for the two individual CUs nor for the resulting size$-(k + s)$ CU.



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

Figure 6: Two different merger situations: external tariffs of original and resulting CUs.

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, $s \leq N-q$, and changes tariffs on the remaining $N-k-s$ countries from $\tau(k)$ to $\tau(k+s)$, then the 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.

Proof: 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 $\tau(k+s)$?
Let

$$\Delta\tau \equiv \tau(k) - \tau(k+s) \tag{24}$$

Consider a tariff vector

$$\mathbf{t} \equiv (0, \ldots, 0, \tau, \ldots, \tau, \tau', \ldots, \tau') \tag{25}$$

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 (25)

$$d\mathbf{t} \equiv (0, \ldots, 0, d\tau, \ldots, d\tau, d\tau', \ldots, d\tau') \tag{26}$$

with

$$d\tau' \equiv \frac{\Delta\tau}{\tau(k)} d\tau \tag{27}$$

$$\mathbf{t}(k) = \mathbf{t}(k+s) + \int_0^{\tau(k)} d\mathbf{t}$$

To prove his claim, Yi shows that $d(\sum_{j=1}^{k+s} W^j)/d\mathbf{t} < 0$ for all $\mathbf{t}$ along such a path of integration. His proof proceeds in two steps: first, he shows that $d(\sum_{j=1}^{k+s} W^j)/d\mathbf{t} < 0$ for $\mathbf{t}(k+s) \equiv (0, \ldots, 0, \tau(k+s), \ldots, \tau(k+s))$. Second, he shows that $d^2(\sum_{j=1}^{k+s} W^j)/d\mathbf{t}^2 < 0$.

Step 1a: 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

$$dT = sd\tau + (N-k-s)s\tau' = \frac{s\tau(k) + (N-k-s)\Delta\tau}{\tau(k)} d\tau \tag{28}$$

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 (3), $dq_j = \frac{\gamma dT - \Gamma(N) d\tau_j}{\Gamma(0)\Gamma(N)}$. Thus,

$$\frac{dq_1}{d\mathbf{t}} = \frac{\gamma\left[s\tau(k)+(N-k-s)\Delta\tau\right]}{\tau(k)\Gamma(0)\Gamma(N)} \tag{29}$$

$$\frac{dq_{k+1}}{d\mathbf{t}} = \frac{\gamma\left[s\tau(k)+(N-k-s)\Delta\tau\right]-\Gamma(N)\tau(k)}{\tau(k)\Gamma(0)\Gamma(N)} \tag{30}$$

$$\frac{dq_N}{d\mathbf{t}} = \frac{\gamma\left[s\tau(k)+(N-k-s)\Delta\tau\right]-\Gamma(N)\Delta\tau}{\tau(k)\Gamma(0)\Gamma(N)} \tag{31}$$

Using these results,

$$\begin{aligned}\frac{d}{d\mathbf{t}}\left(\hat{W}+\sum_{j=2}^{k+s}\pi^j\right) &= \frac{d}{d\mathbf{t}}\left[v(\mathbf{q})-cQ\right]-\frac{d}{d\mathbf{t}}\sum_{j=k+s+1}^{N}\pi^j \\ &= \sum_{j=1}^{N}\left[p_j-c\right]\frac{dq_j}{d\mathbf{t}}-\sum_{j=k+s+1}^{N}2q_j\frac{dq_j}{d\mathbf{t}} \\ &= \frac{1}{\tau(k)\Gamma(0)\Gamma(N)}\left[s\tau(k)\Omega+(N-k-s)\Phi\Delta\tau\right] \end{aligned} \tag{32}$$

where $\Omega \equiv \gamma(Q+T)-\Gamma(N)\left[q_{k+1}+\tau\right]-2(N-k-s)\gamma q_N$ and $\Phi \equiv \gamma(Q+T)-\Gamma(N)\left[q_N+\tau'\right]+2\Gamma(k+s)q_N$.

Furthermore, Yi notes that, as Φ is the derivative of $\hat{W}+\sum_{j=2}^{k+s}\pi^j$ with respect to the tariff on country j, $j > k+s$, and $\tau(k+s)$ is the optimal tariff of the size-$(k+s)$ customs union on $N-k-s$ non-members given free trade among $k+s$ members, at $\mathbf{t}(k+s)$, $\Phi = 0$.

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 at $\mathbf{t}(k+s)$,

$$\begin{aligned} q_1+q_N-\tau(k+s) &= \frac{1}{\Gamma(0)\Gamma(N)}\left\{2\Gamma(0)-\left[\Gamma(N)\left[\Gamma(0)+1\right]-2(N-k-s)\gamma\right]\tau(k+s)\right\} \\ &= \frac{1}{D(k+s)\Gamma(N)}\left\{2D(k+s)-\left[\Gamma(N)\left[\Gamma(0)-1\right]+2\Gamma(k+s)\right]\Gamma(2(k+s))\right\} \\ &= \frac{1}{D(k+s)}\left\{\Gamma(0)\left[\Gamma(0)+1\right]\right\} > 0 \end{aligned}$$

Step 1b: Yi defines the following quantities: $\zeta(k) \equiv \Gamma(N)\left[\Gamma(0)-1\right]-\Gamma(0)+2\Gamma(k)$ and $\lambda(k) \equiv \Gamma(k)\zeta(k)+\Gamma(0)\Gamma(N)$. Then, after some manipulations,

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

from the fact that $\Gamma(k+s)\Gamma(N-s) > (N-k-s)s\gamma^2$. This ends the proof of the claim that when customs unions of size-k and size-s merge, the aggregate welfare of countries involved in the merger increases when the Article XXIV in not binding; neither for the initial customs unions nor for the resulting customs union of size-$(k+s)$.

This completes the reproduction of Yi's (1996) proof of his Proposition 3. In the remaining steps the cases considered are where the Article XXIV constraint is binding on at least some of the countries whose CUs merge.

Step 2: merger of CUs that are constrained by the 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 as the previous one. First, we show that $d(\sum_{j=1}^{k+s} W^j)/d\mathbf{t} < 0$

for $\mathbf{t}(k+s) \equiv (0,\ldots,0,\tau(k+s),\ldots,\tau(k+s))$. Second, we show that $d^2(\sum_{j=1}^{k+s} W^j)/d\mathbf{t}^2 < 0$.

Step 2a: With the same notation and definitions, equation (32) still holds:

$$\frac{d}{d\mathbf{t}}\left(\hat{W} + \sum_{j=2}^{k+s} \pi^j\right) = \frac{1}{\tau(k)\Gamma(0)\Gamma(N)}\left[s\tau(k)\Omega + (N-k-s)\Phi\Delta\tau\right]$$

with $\Omega \equiv \gamma(Q+T) - \Gamma(N)\left[q_{k+1}+\tau\right] - 2(N-k-s)\gamma q_N$ 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. 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 at $\mathbf{t}(k+s)$,

$$\begin{aligned}
q_1 + q_N - \tau(k+s) &= \frac{1}{\Gamma(0)\Gamma(N)}\left\{2\Gamma(0) - \left[\Gamma(N)\left[\Gamma(0)+1\right] - 2(N-k-s)\gamma\right]\tau(k+s)\right\} \\
&= \frac{1}{\Gamma(0)\Gamma(N)}\left\{2\Gamma(0) - \left[\Gamma(N)\left[\Gamma(0)+1\right] - 2(N-k-s)\gamma\right]\tau(1)\right\} \\
&= \frac{1}{D(1)\Gamma(N)}\left\{2D(1) + 2\Gamma(2)\gamma(N-k-s) - \Gamma(N)\Gamma(2)\left[\Gamma(0)+1\right]\right\} \\
&= \frac{1}{D(1)\Gamma(N)}\left\{\Gamma(N)\left[\Gamma(0)+1\right]\Gamma(0) + \Gamma(2)2\gamma(1-k-s)\right\} \\
&= \frac{1}{D(1)\Gamma(N)}\Theta
\end{aligned}$$

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 $\Theta \geq (N-1)\gamma^3 + [9-5N-2k^{**}]\,\gamma^2 + [6N-4k^{**}-12]\,\gamma + 12$. Using the expression of k^{**} given by (7), $\Theta \geq (2+\gamma)^2 > 0$.

Step 2b: Again using the same notations as Yi, we have

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

Now $\Delta\tau = 0$, so

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

Step 3: generalisation

For the moment 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 $ArtXXIV$ 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 $kW_u(k) + sW_u(s) \geq kW_{ArtXXIV}(k) + sW_{ArtXXIV}(s)$. So, we have $(k+s)W_u(k+s) \geq kW_{ArtXXIV}(k) + sW_{ArtXXIV}(s)$. □

C Proofs from Subsection 3.2

Note that the proofs presented here follow very closely the proofs of equivalent results by Yi (1996). In particular, the proof of Proposition 6 reproduces that of Yi's identically and is included here for completeness. The proofs of Propositions 7 and 8 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 $\tau_{WTO}(n_i)$.

Proof of Proposition 6. Suppose that two unions of size-k and size-r merge. An outside country's export profits to the members of the merging unions fall from $kq_O(k)^2 + rq_O(r)^2$ to $(k+r)q_O(k+r)^2$ (Proposition 2). The merger does not affect the optimal tariffs of other unions. Hence, the consumers in the countries not involved in the merger consume less of the numeraire good and the same amount of goods 1, 2, ..., N. □

Proof of Proposition 7. Suppose that country 1 belongs to the size-n_i CU and 2 to the size-n_j CU, where $n_i > n_j$. 1 and 2 have the same export profits to $N - n_i - n_j$ countries (the countries which do not belong to these two CUs). By symmetry, country 1's export profits to another member country are the same as that member's export profits to country 1. Denote by $NS(n_i)$ the welfare of a member of the size-n_i CU net of export profits to non-member countries and non-member countries' profits in the home market. Then the claim holds if $NS(n_i) + n_j q_O(n_j)^2 > NS(n_j) + n_i q_O(n_i)^2$. By Proposition 2, $q_O(n_i)^2 < q_O(n_j)^2$. By Proposition 5, if n_j countries abolish tariffs on $n_i - n_j$ countries and change tariffs on $N - n_i$ countries from $\tau_{WTO}(n_j)$ to $\tau_{WTO}(n_i)$, the aggregate welfare of the n_i countries involved improves. Thus, $NS(n_i) > NS(n_j) + (n_i - n_j)q_O(n_i)^2$. □

Proof of Proposition 9. Suppose a member of the size-n_j CU, say country 1, in the CU structure C joins the size-n_i CU. Country 1's welfare will be the same if, instead of country 1 joining the size-n_i CU, $n_i - n_j + 1$ members of the size-n_i CU leave their CU to join the size-n_j CU. Decompose the transition into three steps. First, the existing members of the size-n_j CU abolish tariffs on $n_i - n_j + 1$ new members and change tariffs on $N - n_i - 1$ countries from $\tau_{WTO}(n_j)$ to $\tau_{WTO}(n_i + 1)$. Second, $n_i - n_j + 1$ new members abolish tariffs on the n_j countries, charge $\tau_{WTO}(n_i + 1)$ on $n_j - 1$ and change tariffs on $N - n_i - 1$ countries from $\tau_{WTO}(n_i)$ to $\tau_{WTO}(n_i + 1)$. By Proposition 5, in each of $n_i + 1$ countries involved, aggregate welfare improves. Third, the remaining $n_j - 1$ members of the formerly size-n_i CU change tariffs on the n_j countries from $\tau_{WTO}(n_i)$ to $\tau_{WTO}(n_j - 1)$ and levy $\tau_{WTO}(n_j - 1)$ on the

$n_i - n_j + 1$ countries (which leave their CU). The third step benefits the existing members of the size-n_j CU by Proposition 3. The first two steps also benefit the existing members of size-n_j CU by Proposition 7. □

D Proofs from Section 4

Proof of Proposition 10. The last union to form must be the smallest since, by Proposition 7, 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 a simple consequence of Proposition 8: if the last two customs union to form are of the same size, then they would be better off by merging.□

Proof of Lemma 5. The welfare of Country i is by definition

$$W^i = CS^i + \pi^{ii} + TR^i + \sum_{\substack{j=1 \\ j\neq i}}^{N} \pi^{ji}$$

We can use Lemma 4 to rewrite the first three terms of the right hand-side of this equation as

$$CS^i + \pi^{ii} + TR^i = \frac{\gamma}{2} Q_i^2 + \frac{1-\gamma}{2} \sum_{j=1}^{N} q_{ij}^2 + \pi^{ii} + TR^i$$

and we can also note that

$$\begin{aligned}
u(\mathbf{q}_i) - cQ_i - \sum_{\substack{j=1 \\ j\neq i}}^{N} \pi^{ij} &= aQ_i - \frac{\gamma}{2} Q_i^2 - \frac{1-\gamma}{2} \sum_{j=1}^{N} q_{ij}^2 - cQ_i - \sum_{\substack{j=1 \\ j\neq i}}^{N} \pi^{ij} \\
&= aQ_i - \frac{\gamma}{2} Q_i^2 - \frac{1-\gamma}{2} \sum_{j=1}^{N} q_{ij}^2 - cQ_i - \sum_{j=1}^{N} (p_{ij} - c - t_{ij}) q_{ij} + \pi^{ii} \\
&= aQ_i - \frac{\gamma}{2} Q_i^2 - \frac{1-\gamma}{2} \sum_{j=1}^{N} q_{ij}^2 - \sum_{j=1}^{N} \left[a - (1-\gamma) q_{ij} - \gamma Q_i \right] q_{ij} + \pi^{ii} + TR^i \\
&= \frac{\gamma}{2} Q_i^2 + \frac{1-\gamma}{2} \sum_{j=1}^{N} q_{ij}^2 + \pi^{ii} + TR^i
\end{aligned}$$

So

$$W^i \;=\; u(\mathbf{q}_i) - cQ_i - \sum_{\substack{j=1\\ j\neq i}}^{N} \pi^{ij} + \sum_{\substack{j=1\\ j\neq i}}^{N} \pi^{ji}$$

and the result follows. □

Proof of Proposition 12.

Definition 7. k_{i+1} is the largest integer which satisfies $W(k+k_i; C) \geq W(k; C')$, for all CU structures C and C', $C' = C - \{k+k_i\} \cup \{k, k_i\}$, and all k, $1 \leq k \leq k_{i+1}$,$i = 0, 1, \ldots$.

k_0 is the largest integer such that any size-k customs union, $k \leq k_0 - 1$, becomes better off by merging with a single-country customs union. The second-to-last CU to form has at least k_0 members, because if it were possible to increase the welfare of the second-to-last CU by accepting an additional member, they could lure away a member of the last CU to form.

k_1 is 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. The third-to-last CU to form has at least k_1 members by the same argument as above.

Finally, k_2 is the largest integer such that any size-k customs union, $k \leq k_2 - 1$, becomes better off by merging with a k_1-size customs union. And the fourth-to-last CU has at least k_2 members.

For $0 \leq \gamma \leq 1$ and $3 \leq N \leq 1,000$, we calculate k_0, k_1 and k_2 (letting γ vary by 0.001 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, by continuity, we can conclude that there will be at most three CUs in equilibrium for $N \leq 1,000$. □

E Proofs from Section 5

Proof of Lemma 6. $W(N; \{N\}) \geq W(N-1; \{N-1, 1\})$ is a necessary condition for global free trade to be the subgame perfect equilibrium outcome. 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. □

Proof of Proposition 13. 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 $f(\gamma_{FT}) = 0$. □

Proof of Proposition 14. The goal here is to compare γ_{FT} such that $f(\gamma_{FT}) = 0$ with and without the Article XXIV constraint. Calculating $\gamma^{FT}_{ArtXXIV}$ and γ^{FT} for all N, $N = 5, \ldots, 1,000$ shows that $\gamma^{FT}_{ArtXXIV} \geq \gamma^{FT}$ in each case. □

Proof of Proposition 15. Proposition 12 showed that for $N < 1000$ there will be at most three CUs in equilibrium. 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 0.001) and for $N = 4, \ldots, 1000$ and we show that the equilibrium structure for all these parameters consists of at maximum two blocs both with and without the Article XXIV constraint. Under the Article XXIV constraint, the bigger bloc may be smaller and the smaller bloc may be bigger. Thus, under the Article XXIV constraint, the equilibrium structure may be less asymmetrical. □

Proof of Proposition 16. For each of the parameter values $0 \leq \gamma \leq 1$ (varying γ by 0.001) and $N = 4, \ldots, 1000$, we can calculate the per-member welfare of each bloc (using (13)) and total world welfare for the world in equilibrium with and without the Article XXIV constraint. These calculations show that world welfare may be lower under the Article XXIV constraint. □

References

Aghion, P., Antras, P., Helpman, E., 2007. Negotiating free trade. Journal of International Economics 73 (1), 1–30.

Bagwell, K., Staiger, R., 1998. Will preferential arrangements underline the multilateral trading system? Economic Journal 108 (449), 1162–1182.

Bagwell, K., Staiger, R., 1999. An economic theory of the GATT. American Economic Review 89 (1), 215–48.

Bagwell, K., Staiger, R., 2002. The Economics of the World Trading System. MIT Press, Cambridge, Massachusetts.

Baldwin, R. E., 1996. A domino theory of regionalism. In: Baldwin, R. E., Haaparanta, P. J., Kiander, J. (Eds.), Expanding the Membership of the EU. Cambridge University Press, Cambridge.

Baldwin, R. E., 2006. Multilateralising regionalism: Spaghetti bowls as building blocs on the path to global free trade. World Economy 29 (11), 1451–1518.

Bhagwati, J., 1993. Regionalism and multilateralism: An overview. In: De Melo, J., Panagariya, A. (Eds.), New Dimensions in Regional Integration. CEPR, London.

Bhagwati, J., 2008. Termites in the Trading System: How Preferential Agreements Undermine Free Trade. Oxford University Press, USA.

Bhagwati, J., Greenaway, D., Panagariya, A., 1998. Trading preferentially: Theory and policy. Economic Journal 108, 1128–1148.

Bloch, F., 1996. Sequential formation of coalitions with fixed payoff division and externalities. Games and Economic Behavior 14, 90–123.

Bond, E., Riezman, R., Syropoulos, C., 2004. A strategic and welfare theoretic analysis of free trade areas. Journal of International Economics 64 (1), 1–27.

Bond, E., Syropoulos, C., 1996. The size of trading blocs, market power and world welfare effects. Journal of International Economics 40 (3-4), 411–437.

Ethier, W., 1998. Regionalism in a multilateral world. Journal of Political Economy 106 (6), 1214–1245.

Grossman, G., Helpman, E., 1994. Protection for sale. American Economic Review 84 (4), 833–850.

Kemp, M., Wan, H., 1976. An elementary proposition concerning the formation of customs unions. Journal of International Economics 6 (1), 95–97.

Krishna, P., 1998. Regionalism and multilateralism: A political economy approach. Quarterly Journal of Economics 113 (1), 227–251.

Krugman, P., 1991. Is bilateralism bad? In: Helpman, E., Razin, J. (Eds.), International Trade and Trade Policy. MIT Press, Cambridge, MA.

Maggi, G., Rodriguez-Clare, A., 1998. The value of trade agreements in the presence of political pressures. Journal of Political Economy 106 (3), 574–601.

McMillan, J., 1993. Does regional integration foster open trade? Economic theory and GATT's Article XXIV. In: Anderson, K., Blackhurst, R. (Eds.), Regional Integration and the Global Trading System. Harvester Wheatsheaf, Hemel Hempstead.

Ornelas, E., 2005a. Endogenous free trade agreements and the multilateral trading system. Journal of International Economics 67 (2), 471–497.

Ornelas, E., 2005b. Trade creating free trade areas and the undermining of multilateralism. European Economic Review 49 (7), 1717–1735.

Riezman, R., 1999. Can bilateral trade agreements help induce free trade? Canadian Journal of Economics 32 (3), 751–766.

Seidmann, D., 2006. Preferential trading arrangements as strategic positioning. CeDEx Discussion Paper No. 2006-09.

Snape, R., 1993. History and economics of GATT's Article XXIV. In: Anderson, K., Blackhurst, R. (Eds.), Regional Integration and the Global Trading System. Harvester Wheatsheaf, Hemel Hempstead.

Syropoulos, C., 1999. Customs unions and comparative advantage. Oxford Economic Papers 51 (2), 239–266.

Viner, J., 1950. The Customs Union Issue. Carnegie Endowment for International Peace, New York.

Yi, S.-S., 1996. Endogenous formation of customs unions under imperfect competition: Open regionalism is good. Journal of International Economics 41 (1), 151–177.