Is The WTO's Article XXIV Bad?*

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Abstract

This paper shows that Article XXIV increases the likelihood of free trade, but may worsen world welfare when free trade is not reached. Customs union (CU) formation under Article XXIV is modeled as a coalition formation game with negative externalities. We assume that the usual mechanism through which block formation exerts a negative externality on non-members - a rise in external tariffs - is precluded by Article XXIV. The equilibrium CU structure is characterized under Article XXIV and compared to the equilibrium CU structure without Article XXIV.

KEYWORDS. coalition formation game, customs union, protection, trade block, trade liberalization.

JEL CLASSIFICATION NUMBERS: F02, F13, F15.

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1 Introduction

In this paper we examine customs union (CU) formation under Article XXIV.[1] The proposition that on balance CU formation usually does harm to outsiders while benefiting insiders is generally accepted.[2] The negative externality associated with CU formation operates through the terms of trade. It is often argued by opponents of regionalism that CU formation gives its members greater power on world markets. In formal discussions, this greater power is often thought to be exercised through the raising of common external tariffs. Critics of this idea argue that external tariffs cannot be raised, as might be predicted by these models.[3] This is because such policy action is precluded by Article XXIV. And in practice external tariff rates have not risen over the recent period of regionalization.

If the *raising* of *external* barriers is precluded by Article XXIV, we are bound to ask whether the insights of the coalition formation literature still hold. Can we still argue that CU formation disrupts the multilateral liberalization process? To do so in a fully general way we must find some alternative means through which CU formation exerts a negative externality on non-members.[4]

We do identify an alternative. Adapting a framework originated by Yi (1996), we show

[1] Article XXIV is more likely to impose a binding constraint under CU formation than under FTA formation. Under CU formation, members coordinate on the removal of internal tariffs and the joint maximization of the common external tariff. Under the formation of a free trade agreement (FTA), countries coordinate on the removal of internal tariffs but do not coordinate on the setting of common external tariffs. The market power effect, exerted through raising common external tariffs, tends to be stronger under CU formation than under FTA formation. And thus the Article XXIV constraint is more likely to bind under CU formation. In fact, in their study of FTA formation Bond, Riezman and Syropoulos (2004) show that FTA formation tends to involve the lowering of external tariffs as members compete with each other for third markets.

[2] The early literature on the 'pure theory' of trade block formation focuses on whether CU formation may in fact divert trade away from the most efficient producers, thus potentially undermining the efficiency of trade between block members. See Viner (1950), Meade (1956), Lipsey (1957) and Cooper and Massell (1965) for key contributions. (Also, see Lipsey 1960 for a survey). Bhagwati (1993) discusses deleterious effects of trade block formation under Article XXIV from a 'pure theory' perspective. He does not discuss terms of trade effects associated with Article XXIV, that benefit members while harming non-members, as we will here. See also Bhagwati, Greenaway and Panagariya (1998). A key motivating feature of the literature modeling (endogenously formed) CUs as coalitions of countries is that trade block formation is beneficial to members while harming non-members. The empirical evidence, which we discuss below, backs the view not just that CU formation is in the interest of member countries but also that outside countries are injured in the process.

[3] Syropoulos (1999) undertakes a careful examination of the circumstances under which a rise of common external tariffs will be mandated by trade block formation.

[4] See Krugman (1993) for additional motivation. There he explains that an earlier paper of his on regionalism, Krugman (1991), was criticized because his results appeared to be driven by the raising of customs unions' common external tariffs. In Krugman (1993), he goes on to show that his results still hold even if common external tariffs are held fixed. But he discusses only briefly and informally why this might be true.

that a terms of trade externality is created when CU formation entails nothing other than the *removal* of *internal* barriers. The terms of trade impact on members is positive, while on non-members it is negative. By being allowed to form an exclusive club under WTO rules, members improve their own welfare at the expense of others', via the improvement in CU terms of trade. Most appealing about this motivation is that it must, by definition, be a feature of all trade block formation.

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 'exclusive regionalism'. Substitutability between goods is represented by a parameter $\gamma \in [0, 1]$, where goods are independent for $\gamma = 0$ and goods are perfect substitutes for $\gamma = 1$. For very small γ, members of any customs union become better off when the CU expands or when it merges with any other feasible CU. In that case the terms-of-trade benefits of CU formation are outweighed by the losses to members in the large block of having to consume less of the goods produced by non-member countries. For larger γ, in the unique equilibrium CU structure there is one large block and one small block. Some countries are given an advantage in the block formation process, and they use that advantage to form a relatively large block; they care more about the terms-of-trade gains than the fact they must consume less of the goods from non-member countries.

We show that the same basic characterization of the equilibrium CU structure prevails under Article XXIV. Nevertheless, there are two key differences. Free trade is the unique equilibrium outcome for a larger range of γ. The reason is that, by precluding an increase in common external tariffs, Article XXIV reduces the gains to CU expansion. One might have expected this effect to lead the larger CU to be larger and the smaller one to be smaller in equilibrium when free trade does not arise in equilibrium. Surprisingly, for the remaining range of γ the equilibrium CU structure is *less asymmetric*; the larger block is smaller and the smaller block is larger than without the Article XXIV constraint. The fact that the larger block is smaller and per-member terms-of-trade gains are lower underpins the result Article XXIV may be bad for world welfare.

In principle, WTO rules exist in the form of Article XXIII that enable non-members to seek redress for the damage done to them when a trade block is set up (see Bagwell

and Staiger 1999).[5] Under this Article, governments can make a 'non-violation' complaint when their country's trade has been adversely affected by a trade agreement reached by other governments, even if the agreement is consistent with the Articles of the GATT treaty. However, if this rule were fully effective in practice, then we would have observed an increase or no change in trade between countries not involved in the trade block formation that has taken place over the last ten years. In fact, Soloaga and Winters (1999) and Chang and Winters (2002) provide empirical evidence to support the general perception that trade block formation has increased trade between members, but at the expense of trade between non-members. These effects of trade block formation are sufficient to motivate the terms of trade effect that we identify.

On the other hand, some argue that Article XXIV is being circumvented using methods of protectionism that are less visible than tariffs, such as anti-dumping duties, effecting a *de facto* rise in external barriers through trade block formation (see for example Panagariya and Gupta (1998). These effects would clearly be complementary to those that we demonstrate. Our aim is to show that even if CUs form in accordance with WTO rules, and external protectionism does not rise at all, CU formation does not most of the time lead to free trade and the resulting equilibrium customs union structure might actually lead to a lower world welfare than without WTO rules.

The theoretical literature on trade block formation under Article XXIV is surprisingly sparse. One paper that has been written on this subject is by Syropoulos (1999). He sets up a model for looking at the impact on tariff setting, terms of trade and welfare of CU formation. This general framework allows trade block formation under a variety of regimes to be analyzed, enabling the requirements of Article XXIV to be examined as a particular case. He too shows that CU formation under Article XXIV exerts a negative externality on non-members, while improving the welfare of members. However, because he wishes to examine aspects of a specific block structure under a variety of formation rules, he imposes the block structure exogenously in a 3×3 model. In this present paper we show that the block structure forms endogenously as a subgame perfect equilibrium in an $n \times n$ model. Generalizing the number of countries introduces an important extra dimension to the analysis. The constraint in a 3×3 model is that once two countries have formed a block, the best reply by the rest of the world in terms of block formation cannot be analyzed, being

[5]For a synthesis, which introduces, develops and extends their approach to a comprehensive treatment of the GATT/WTO as an economic institution, see Bagwell and Staiger (2002).

ruled out by the fact that it is characterized by a single country.[6]

The paper proceeds as follows. Section 2 first introduces Yi's (1996) quasilinear-quadratic model of intra-industry trade in which there are two sources of gains from trade: increased variety of goods and reduced market power of domestic industry. It is in this section that we also incorporate the Article XXIV in this model by identifying the range of the model parameters over which the Article XXIV constraint binds for all feasible CU configurations. We then restrict our attention to this parameter range. In Section 3, we analyze the effects of CU formation, expansion and of the changes in CU structure under the Article XXIV on welfare. Section 4 presents the CU formation game considered and in Section 5 stable equilibrium CU structures of this game are characterized. Section 6 analyzes the effect of Article XXIV on the equilibrium CU structure and the outcomes with and without Article XXIV are compared. It is here that the main results are derived. Section 7 concludes.

2 Introducing the Article XXIV Constraint

2.1 Original model from Yi (1996)

In this subsection, for the completeness of the argument, we present the model developed by Yi (1996). We do not claim here any original contribution.

2.1.1 Preferences and technology

There are N countries, each of which produces one good at a constant marginal cost c in terms of the numeraire good. The representative consumer in country i has a utility function of the form

$$\begin{aligned} u(\mathbf{q}_i, M_i) &= aQ_i - \frac{\gamma}{2}Q_i^2 - \frac{1-\gamma}{2}\sum_{j=1}^{N} q_{ij}^2 + M_i \\ &= a\sum_{j=1}^{N} q_{ij} - \frac{\gamma}{2}\left(\sum_{j=1}^{N} q_{ij}\right)^2 - \frac{1-\gamma}{2}\sum_{j=1}^{N} q_{ij}^2 + M_i \end{aligned} \tag{1}$$

[6]The implications of Article XXIV have been considered indirectly by Bagwell and Staiger (1998, 1999, 2002), as an instance where the two GATT/WTO pillars of reciprocity and non-discrimination are violated, so that in equilibrium a world welfare maximum cannot be guaranteed. Its implications are also discussed by McMillan (1993). But none of these authors formalize trade block formation under Article XXIV, and none examine an equilibrium under its conditions.

where q_{ij} is country i's consumption of country j's product, $\mathbf{q}_i = (q_{i1}, q_{i2}, ..., q_{iN})$ is country i's consumption profile, $Q_i \equiv \sum_{j=1}^{N} q_{ij}$, γ is a substitution index between goods ($0 \leq \gamma \leq 1$), and M_i is country i's consumption of the numeraire good. The numeraire good will be transferred across countries to settle the balance of trade. Yi (1996) assumes that each country's endowment of the numeraire good is the same across countries and is sufficient to guarantee a positive consumption of the numeraire good in each country.

The substitution index γ ranges from 0 (independent goods) to 1 (homogeneous products); as γ increases, the products become closer substitutes. The consumers have a taste for variety; for any given Q_i, the more balanced the consumption bundle is the more goods there are, the higher the utility. There are two gains from trade. First, trade increases the variety of goods available, and second, trade restrains the domestic firm's monopoly power.

Due to the quasilinear nature of the utility function, country i's inverse demand function for country j's good j is

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

There are no transportation costs in this model. Countries raise tariffs on imports from other countries. Let t_{ij} denote country i's tariff on imports from country j. Then country j's effective marginal cost of exporting to country i is

$$c_{ij} = c + t_{ij} \tag{3}$$

Yi (1996) assumes that markets are segmented so that firms compete by choosing quantities in each country (Cournot competition). In country i, country j's firm solves

$$\max_{\{q_{ij}\}} \pi^{ij} = (p_{ij} - c_{ij})q_{ij}$$

Its first order condition is given by

$$p_{ij} - c_{ij} - q_{ij} = 0 \tag{4}$$

which can be rewritten using (2) and (3) as

$$\alpha - t_{ij} - (2-\gamma)q_{ij} - \gamma Q_i = 0 \tag{5}$$

where $\alpha \equiv a - c$.

Yi (1996) normalizes $\alpha = 1$ and shows that in equilibrium

$$Q_i = \frac{N - T_i}{\Gamma(N)} \tag{6}$$

and

$$q_{ij} = \frac{\Gamma(0) + \gamma T_i - \Gamma(N) t_{ij}}{\Gamma(0)\Gamma(N)} \tag{7}$$

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

Proof. Please see Appendix page 28.

2.1.2 Customs unions and optimal tariffs

The profits of the domestic firm and the tariff revenues are rebated back to the consumers. Thus, country i's welfare (W^i) can be written as the sum of four components: the domestic consumer surplus (CS^i), the domestic firm's profit in the home market (π^{ii}), the tariff revenue (TR^i), and the domestic firm's export profits (π^{ji}, $j \neq i$).

$$W^i = CS^i + \pi^{ii} + TR^i + \sum_{\substack{j=1 \\ j \neq i}}^{N} \pi^{ji} \tag{8}$$

If a group of countries forms a customs union, they abolish tariffs among union members and jointly choose their external tariffs to maximize the *aggregate* welfare of members. Yi (1996) assumes that there are no side-payments among union members, so that each country in a customs union keeps its own tariff revenues.

Consider a customs union of size k. Without loss of generality, suppose that countries $1, ..., k$ belong to this customs union. They will solve

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

where $t_{ij} = 0$, for $i = 1, ..., k$ and $j = 1, ..., k$. Optimal external tariffs of a customs union balance the benefit of increasing the profits of firms from the member countries at the

expense of non-member countries' firms against the cost of lower consumer surplus in the member countries.

Yi (1996) derives the optimal external tariffs of a customs union in the following proposition.

Proposition 1. *The unique optimal external tariffs of a member of a customs union of size k is*

$$\begin{aligned} t(k) &= \frac{\Gamma(0)\Gamma(2k)}{D(k)} \\ &= \frac{[2-\gamma][2+(2k-1)\gamma]}{[(2-\gamma)^2+(1-\gamma)k\gamma][2+(N-1)\gamma]+[2+(k-1)\gamma][2+(2k-1)\gamma]} \end{aligned} \tag{9}$$

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

Proof. Please see Appendix page 28.

Notice that in this model, the optimal tariff of a customs union of size k depends *only* on k; in particular, it does not depend on the tariffs of the rest of the world. That is, there is no strategic interdependence of optimal tariffs across customs unions. Hence, the optimal external tariff of a customs union depends only on its size and not on the number and sizes of the other customs unions.

When a customs union expands, what happens to its optimal external tariff? Does a large customs union impose higher external tariffs than does a small customs union? Yi (1996) shows that in the quasilinear-quadratic model, the answer is ambiguous and he derives the following result

Corollary 1. *t(k) increases with k if and only if*

$$\begin{aligned} k < k^* = k^*(N,\gamma) &= \frac{\sqrt{\Gamma(0)[\Gamma(0)+1]\Gamma(N)} - \Gamma(0)}{2\gamma} \\ &= \frac{\sqrt{(2-\gamma)(3-\gamma)(2+(N-1)\gamma)} - (2-\gamma)}{2\gamma} \end{aligned} \tag{10}$$

Proof. Please see Appendix page 29.

Hence as Yi (1996) notes, $t(k)$ is not a monotonic function of k. For example, suppose that $\gamma = 1$. Then $k^*(N,1) = \frac{\sqrt{2(N+1)}-1}{2}$. For a small N[7], $t(k)$ is a globally decreasing

[7]For example, for $N = 3$, $k^*(3,1) = \frac{\sqrt{8}-1}{2} < 1$ and thus a customs union with two members will charge a lower external tariff than a single country.

function, but for a large N[8] , $t(k)$ will initially increase with k but ultimately decreases with k and we will study this non-monotonicity more in detail in the next section. When $\gamma = 0$, $t(k) =$ constant. Figure 1 illustrates the possible different properties of the tariff function.

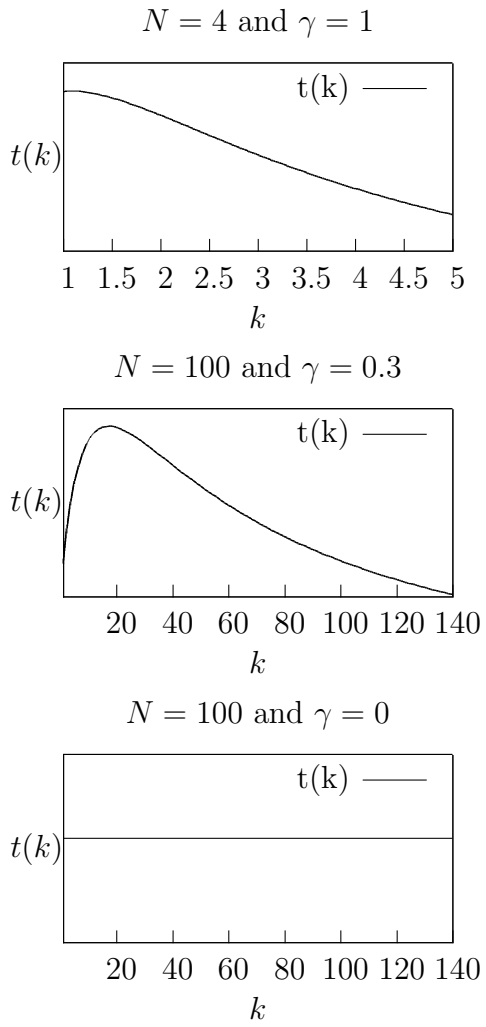

Figure 1: $t(k)$ for different values of N and γ.

[8]For example, for $N = 31$, $k^*(31, 1) = \frac{7}{2}$ and thus a customs union with three members will charge a higher external tariff than a customs union with two members who will charge a higher external tariff than a single country.

2.2 WTO Article XXIV Constraint

> "...the purpose of a customs union or of a free-trade area should be to facilitate trade between the constituent territories and not to raise barriers to the trade of other contracting parties with such territories."
> (WTO Article XXIV)

According to the WTO regulation, countries are allowed to form Customs Unions or Free Trade Areas provided they remove all internal barriers inside the union and they do not raise barriers to the trade of non members.

Concerning the second requirement, the Article XXIV exactly states that the CUs formation is allowed provided that:

> "with respect to a customs union, or an interim agreement leading to a formation of a customs union, the duties and other regulations of commerce imposed at the institution of any such union or interim agreement in respect of trade with contracting parties not parties to such union or agreement shall not on the whole be higher or more restrictive than the general incidence of the duties and regulations of commerce applicable in the constituent territories prior to the formation of such union or the adoption of such interim agreement, as the case may be."

So how can we introduce this Article XXIV in Yi's model? First, we can note that the first requirement, i.e. that internal barriers have to be removed, is already contained in Yi's model as countries set the tariffs on members to zero when forming a customs union. But we have to account for the second requirement that countries should not raise tariffs on non-members. Whether it will change anything to the previous setting will actually depend on the shape of the tariff curve $t(k)$. More precisely, if $t(k)$ is a globally decreasing function, then the obligation not to raise tariffs above the initial level will not have any impact on the model; the Article XXIV condition will not be a binding constraint. On the other hand, if $t(k)$ is initially an increasing function and becomes a decreasing function of the block size k only for higher values of k, then there will be a range of k for which this regulation will set a binding constraint on the tariff level. Thus we need to study more in detail the tariff function $t(k)$.

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

Proof. Please see Appendix page 29.

Now note that for any given N, $k^*(N,0)$ is infinite. Also, as we have already mentioned, $k^*(N,1) = \frac{\sqrt{2(N+1)}-1}{2}$, so $k^*(N,1)$ is positive for any value of N. And so by the intermediate value theorem, we know that for any N, we can find a value of $\gamma > 0$ such that $k^*(N,\gamma) > 1$.

Definition 1. Let γ^*, $\gamma^* > 0$, such that $k^*(N,\gamma^*) > 1$.

Thus, for any given number of countries in the world N and any $0 < \gamma < \gamma^*$, $t(k)$ will be initially an increasing function of k and later a decreasing function of k. The expanding customs union will initially raise its optimal external tariff and once it reaches the critical size of $k^*(N,\gamma)$ members, it will start to decrease the optimal external tariff as shown in Figure 2.

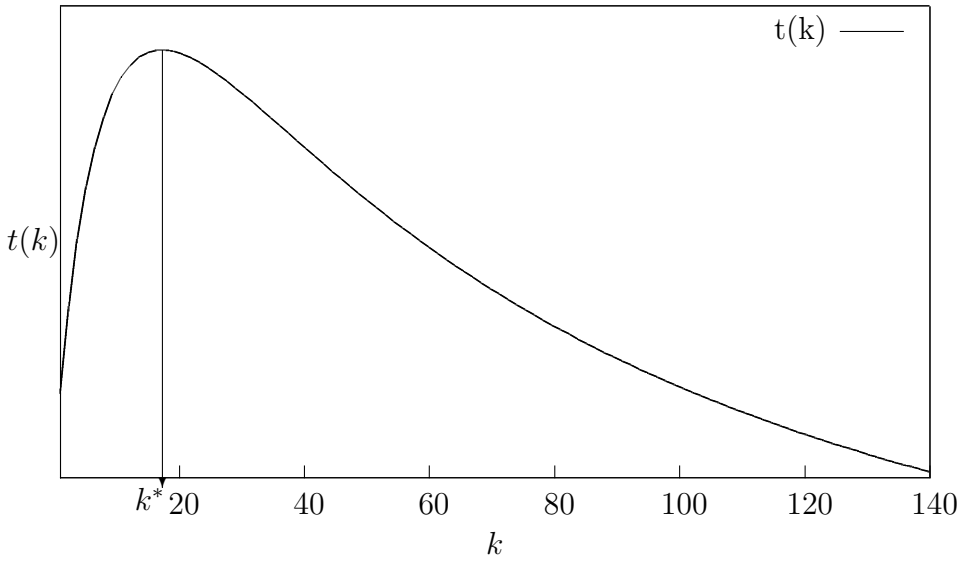

Figure 2: $t(k)$ for $N = 100$ and $\gamma = 0.3$ with $k^* \approx 17.34$.

Corollary 3. *For any N and $0 < \gamma < \gamma^*$, there exists a $k^{**}(N,\gamma) > 1$, $t(k^{**}) = t(1)$. An expanding customs union will charge a higher external tariff than the initial tariff charged by a single country until its size reaches $k^{**}(N,\gamma)$ members.*

$$k^{**} = \frac{(\gamma - 2)(-4 + \gamma(6 + \gamma(N-1) - 3N))}{2\gamma(2+\gamma)} \tag{11}$$

Proof. Please see Appendix page 30.

Figure 3 illustrates the existence of k^{**}.

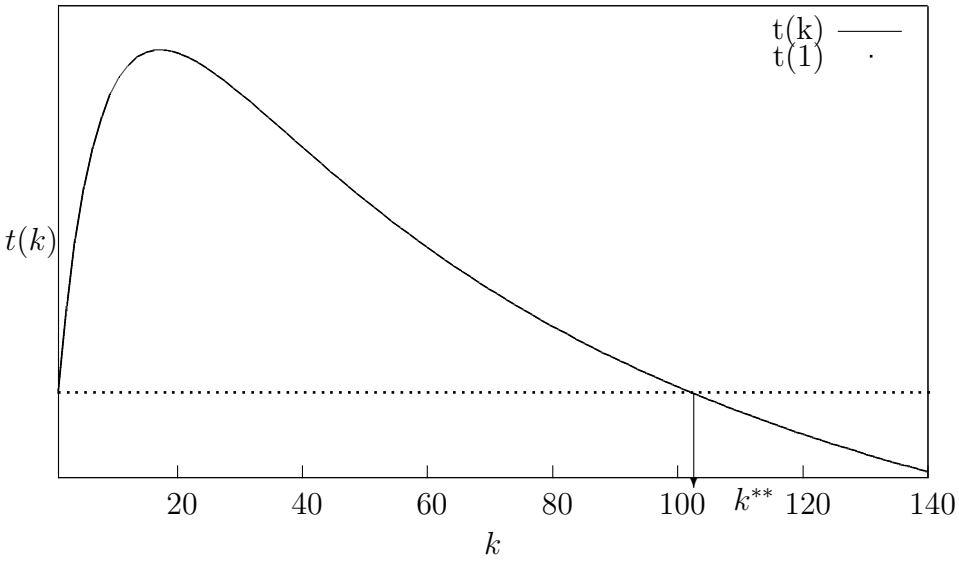

Figure 3: $t(k)$ for $N = 100$ and $\gamma = 0.3$ with $k^{**} \approx 102.6$.

Corollary 4. *For a given N, $k^{**}(N, \gamma)$ is a decreasing function of γ.*

Proof. Please see Appendix page 30.

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 2. Let $\gamma^{**}(N)$, $\gamma^{**}(N) > 0$, such that $k^{**}(N, \gamma^{**}) = N$.

$\gamma^{**}(N)$ is the value of γ such that $t(k)$ is initially an increasing function of k and later a decreasing function of k, such that it would reach its initial value $t(1)$ for $k = N$ members, $t(N) = t(1)$ as shown in Figure 4.

Table 1 presents some approximate values of $\gamma^{**}(N)$ for different values of N.

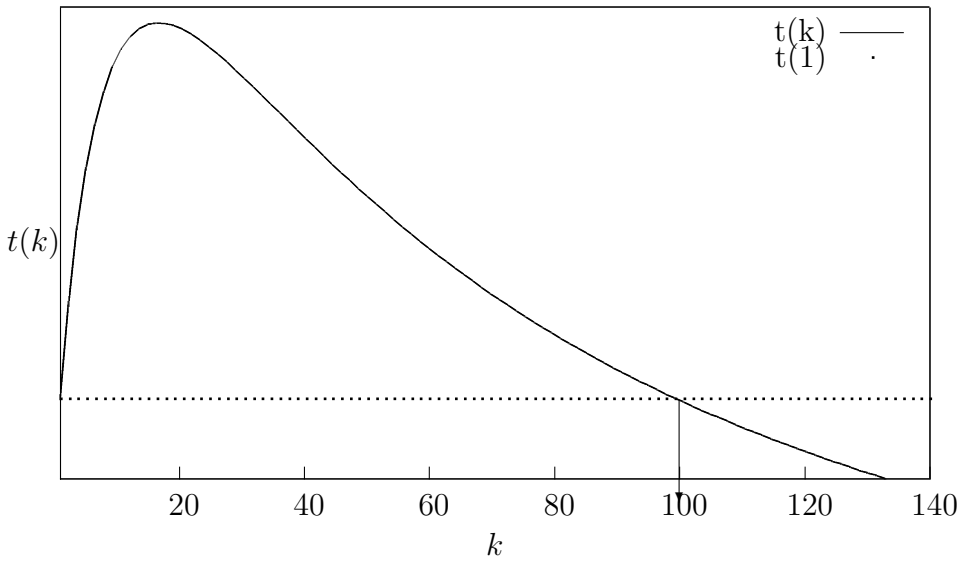

Figure 4: $t(k)$ for $N = 100$ and $\gamma^{**} \approx 0.316748$ and with $k^{**} = N = 100$.

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 $\gamma^{**}(N)$.

Note 1. It can be shown that $\gamma^{**}(N)$ is a monotonically decreasing function of N and approaches a horizontal asymptote when N goes to infinity.
$\lim_{N \to +\infty} \gamma^{**}(N) = a$ with $a \approx 0.298438$.

As $k^{**}(N, \gamma)$ is a decreasing function of γ, we know that for any γ, $0 < \gamma \leq \gamma^{**}$, $k^{**}(N, \gamma) \geq N$. Also for $\gamma = 0$, $t(k)$ being constant, $k^{**}(N, 0)$ is infinite and thus also greater than N, and so $t(k) > t(1)$ for all $k \in [2, N-1]$. For $0 \leq \gamma \leq \gamma^{**}$, the customs union of any size would charge an external tariff higher than the initial one. Thus the WTO Article XXIV will impose a binding constraint and we have the following result.

Proposition 2. *For any number of countries in the world N and any substitution index γ, $0 \leq \gamma \leq \gamma^{**}$, the WTO Article XXIV Condition is binding for any size-k customs union, $k = 1, ..., N$ and imposes*

$$\begin{aligned} t(k) &= t(1) \text{ for } k = 1, ..., N-1, \text{ and} \\ t(N) &= 0 \end{aligned} \tag{12}$$

Proof. Please see Appendix page 31.

For higher γ, the WTO Article XXIV is not binding and Yi (1996)'s model describes entirely the customs union formation in this setting. In what follows, we therefore restrict ourselves to the range of γ where the WTO Article XXIV is binding ($0 \leq \gamma \leq \gamma^{**}$) and we try to see the impact of this WTO constraint on the customs union formation process.

3 Customs unions and welfare

From now on, as mentioned above, we restrict ourselves to the range of γ where the WTO Article XXIV is binding ($0 \leq \gamma \leq \gamma^{**}$) and we impose the constraint expressed in Proposition 2.

3.1 First analysis of customs unions formation and welfare

Once the WTO Article XXIV constraint introduced in the model, we want to study the customs union formation and its effect on individual country's and global world welfare. To do so, we start by expressing from (7) the following three quantities that will be useful later in our model.

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

$$q_I(k) = \frac{\Gamma(0) + (\Gamma(N) - \Gamma(k))t(1)}{\Gamma(0)\Gamma(N)} \tag{13}$$

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

$$q_O(k) = \frac{\Gamma(0) - \Gamma(k)t(1)}{\Gamma(0)\Gamma(N)} \tag{14}$$

and the *total consumption* in a country belonging to a size$-k$ union

$$Q(k) = \frac{N - (N-k)t(1)}{\Gamma(N)} \tag{15}$$

We can immediately note that a member nation has higher sales than a non-member nation in any member country. Since the export profits are sales squared in this quasilinear-quadratic model, a member country has a higher export profit than a non-member country in any member country.

3.1.1 Non-members' welfare

From (14) we can easily show that outside countries become worse off if a customs union expands. Actually, as noted above, in this model, a non-member country is affected only through its export profits to the customs unions and it can be easily seen that $q_O(k)$ is a globally decreasing function of k. Thus, a non-member country's export profit to a customs union of size k, equal to $[q_O(k)]^2$, falls as k increases.

Proposition 3. *The non-member countries exports $q_O(k)$ and thus export profits $[q_O(k)]^2$ are a decreasing function of k. Outside countries become worse off if a custom union expands.*

Proof. Please see Appendix page 31.

3.1.2 Members' welfare

And what happens to member countries? How does an expansion of a customs union affect their welfare?

Consumer surplus: From (15), we can see that total consumption in a member country increases as a customs union expands. So how does this affect consumer surplus in a member country? As shown in the next lemma, in this simple model, we can express the consumer surplus of a member country as a combination of the three quantities (13),(14) and (15).

Lemma 1. *Consumer surplus of a country belonging to a k-size customs union can be written as*

$$CS(k) = \frac{\gamma}{2}Q(k)^2 + \frac{1-\gamma}{2}(kq_I(k)^2 + (N-k)q_O(k)^2) \tag{16}$$

Proof. Please see Appendix page 31.

Using this result, we can show that consumer surplus of a member country *increases* as the customs union expands. But this is not the case with the tariff revenue.

Tariff revenue: The tariff revenue of a member country necessarily *decreases* as the customs union expands. Actually, by the WTO Article XXIV countries are not allowed to raise their external tariffs and as the customs union expands they can thus levy at maximum the same level of tax on less countries.

Producer surplus: From (13) we can see that profits from sales in a member country also decrease as the customs union expands. In a bigger customs union, more firms have an easier access to the home market and there is thus more competition. But at the same time, the domestic firm gets a preferential access to more countries and from the comparison between (13) and (14) we know that sales are higher in a member nation than in a non-member nation thus the effect of a customs union expansion might be *ambiguous* on home firm's total profit.

In summary, we have just seen that the expansion of a customs union has a negative impact on tariff revenue, a positive impact on consumer surplus and an ambiguous impact on producer surplus of a member country. Therefore, the effect of an expansion of a customs union on the welfare of a member country is ambiguous and we will study it more in detail in the next section.

3.1.3 Global welfare

However, we can show that the *joint* welfare of the member countries (existing members plus the new member country) *improves* when a customs union expands. More generally, if several customs unions merge to form a larger customs union, the aggregate welfare of the member countries increases. This result was already shown by Yi (1996) without the Article XXIV and naturally carries through under the WTO constraint.

Proposition 4. *The formation or expansion of customs unions increases the aggregate welfare of member countries.*

Proof. Please see Appendix page 32.

Proposition 5. *The effects on global welfare of the formation or expansion of customs unions are ambiguous, except when the grand custom union is created. The world welfare is*

higher under the grand custom union (global free trade) than under any other customs union structure.

Proof. Please see Appendix page 32.

3.2 Customs union structures and welfare: further analysis

In order to study the impact of customs union formation on individual welfare of member countries, we will use a nice property of this model, namely that due to the simplicity of preferences, it is possible to obtain a closed-form solution for the per-member welfare of customs unions in a certain customs union structure.

Lemma 2. *Country i's welfare can be written as*

$$W^i = u(\mathbf{q}_i) - cQ_i - \sum_{\substack{j=1 \\ j\neq i}}^{N} \pi^{ij} + \sum_{\substack{j=1 \\ j\neq i}}^{N} \pi^{ji} \tag{17}$$

Proof. Please see Appendix page 32.

Now let $\mathcal{P}$ be the set of countries: $\mathcal{P} = \{P_1, P_2, ..., P_N\}$.

Definition 3. A customs-union structure $C = \{B_1, B_2, ..., B_m\}$ is a partition of the set of countries P. $B_i \cap B_j = \varnothing$ for $i \neq j$ and $\cup_{i=1}^{m} B_i = \mathcal{P}$.

As Yi (1996) points out in his original model, since the tariff equilibrium is unique for any given customs union structure, the welfare of a customs union of size k in any customs union structure is well defined. Furthermore, as all countries are symmetric, the welfare of a customs union in a customs union structure depends only on the numbers of unions and their sizes and not on which countries belong to which unions. We can thus with a slight abuse of notation identify customs union with their sizes and 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 ith customs union in $C = \{B_1, B_2, ..., B_m\}$. Moreover, as all countries belonging to a certain customs union have the same welfare, we will denote the welfare of a member country of a customs union of size k in a given customs union structure C as $W(k; C)$, $k = n_1, n_2, ..., n_m$. For example, $W(3; \{2, 3, 4\})$ is the welfare of a country belonging to the customs union of size three in $\{2, 3, 4\}$.

Lemma 3. *The welfare of a member of the size-n_i customs union in $C = \{n_1, n_2, ..., n_m\}$ is given by*

$$W(n_i;C) = Q(n_i) - \frac{\gamma}{2}Q(n_i)^2 - \frac{1-\gamma}{2}\left\{n_i\left[q_I(n_i)\right]^2 + (N-n_i)\left[q_O(n_i)\right]^2\right\}$$
$$-(N-n_i)\left[q_O(n_i)\right]^2 + \sum_{\substack{j=1 \\ j\neq i}}^{m} n_j q_0(n_j)^2 \tag{18}$$

Proof. Please see Appendix page 33.

The following result shows how a merger of customs unions affects outsiders.

Proposition 6. *$W(n_i;C) < W(n_i,C')$ if $n_i \in C$, C' and $C - \{n_i\}$ can be derived from $C' - \{n_i\}$ by merging customs unions in $C' - \{n_i\}$. If customs unions merge to form a larger union, outside countries not involved in the merger are worse off.*

Proof. Please see Appendix page 33.

The next proposition ranks the per-member welfare of customs unions in a given union structure.

Proposition 7. *$W(n_i;C) > W(n_j,C)$ if $n_i > n_j$. In any customs union structure, a member of a large customs union has a higher level of welfare than does a member of a small customs union.*

Proof. Please see Appendix page 33.

Propositions 6 and 7 are very similar to the equivalent results derived by Yi (1996) without the Article XXIV with the following slight difference. Under the Article XXIV constraint, countries forming a customs union are now not allowed to raise their common external tariffs and they are therefore now extracting less rent from the outsiders. When we compare Proposition 6 with Yi's equivalent result, in both cases non-members are made worse off when two customs unions merge, but they are made less worse off under the Article XXIV. For the same reason, the difference between welfare of a bigger customs union and a smaller customs union in the same customs union structure as expressed in Proposition 7 is slightly attenuated under the Article XXIV compared to the situation without the Article XXIV.

The next two propositions express how changes in the customs union structure affect the welfare of countries involved in the change.

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

Proof. Please see Appendix page 33.

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

Proof. Please see Appendix page 33.

Also these two results are very similar to the equivalent results derived in Yi (1996). But after introducing the customs union formation game, we will see how the Article XXIV changes the equilibrium customs union structure.

4 Customs union formation: unanimous regionalism

Bloch (1992) studied what is now called an infinite-horizon sequential-move coalition unanimity game. In this game, players form a coalition only if all potential members agree on it. There are $P_1, P_2, ..., P_N$ players. First, player P_1 makes a proposal to form a coalition with for example P_3, P_5, and P_6. Then the player with the smallest index on P_1's list (not including P_1), here P_3, accepts or rejects the coalition. If P_3 accepts to form the coalition, then the next player with the smallest index on the list, here P_5, accepts or rejects the proposal to form the coalition and the process goes on until the last player on the list, here P_6, is reached. If however any of the potential members rejects the coalition, then the proposal is abandoned (there is no coalition formation among the players who agree) and the player who first rejects the proposal starts over by making a new proposal. If all potential members accept P_1's proposal, then they form this coalition and withdraw from the game. The remaining players continue the same game where the player with the smallest index starts by making a coalition proposal to the rest of the players.
Bloch (1992) shows that this infinite-horizon sequential-move coalition unanimity game yields

the same (stationary) subgame perfect equilibrium coalition structure as the following "size announcement" game. In this game, players are ranked on a list. First, P_1 announces k and the first k players form a size-k coalition. Then, P_{k+1} announces r and the next r players form a size-r coalition, and this process goes on until P_N is reached. The intuition behind this result is that in the stationary equilibrium of the infinite-horizon sequential-move coalition unanimity game, P_1 will propose a coalition that will be accepted by all the potential members knowing that the next player will make a proposal accepted by all the potential members etc.. Given the symmetry of players, the same coalition structure can be obtained if players announce the size of their coalitions.
Bloch (1992) also shows that this size announcement game has a (generically) unique subgame perfect equilibrium coalition structure.

In what follows we try to determine the equilibrium outcome of N countries playing this size announcement game where their decision criterion is their welfare. At the beginning of the game, the N countries are singletons and they are ranked on a list. Country 1 starts by announcing the size of the customs union it wishes to form, such a customs union that maximizes its welfare. In Section 5, we characterize the equilibrium custom union structure of this game.

5 Characterization of stable customs union structures

In this section, we try to characterize stable customs union structures when countries play the previously mentioned size announcement game.

Definition 4. k_0 is the largest integer which satisfies $W(k;C) \geq W(k-1;C')$, for all customs union 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 such that any size-k customs union, $k \leq k_0 - 1$, becomes better off by merging with a single-country customs union.

Note 2. Proposition 8 implies that $k_0 \geq 2$. Members of a customs union become always better off when their customs union merges with another customs union of equal size and thus a single country is always better off by merging with another single country.

The next two propositions show that a symmetric customs union structure cannot be an equilibrium outcome.

Proposition 10. *The unique subgame perfect equilibrium customs union structure of the unanimous regionalism game has a unique smallest customs union, which is the last customs union to form.*

Proof. Please see Appendix page 34.

Proposition 11. *The unique subgame perfect equilibrium customs union structure of the unanimous regionalism game has a unique second-smallest customs union, which is the second-to-last customs union to form and which has a least k_0 members.*

Proof. Please see Appendix page 34.

The above characterization of the unique subgame perfect equilibrium union structure of the unanimous regionalism game follows directly from Propositions 6 and 8. But in our quasilinear-quadratic setting, a further characterization of the equilibrium outcome is possible, using the fact that the relative ranking of the welfare of a size-k union in a customs-union structure $\{k, B\}$ and the welfare of a size-r union in another union structure $\{r, k - r, B\}$ is independent of the sub-union structure $\{B\}$. (The changes in the sub-union structure in $\{B\}$ affect the welfare of the size-k and size-r customs unions only through their export profits to $\{B\}$. However the per-member export profits of these two customs unions to $\{B\}$ are the same for all $\{B\}$.)

Proposition 12. *In the quasilinear-quadratic model, for practical N, the number of equilibrium customs unions in the unanimous regionalism game is not greater than two.*

Proof. Please see Appendix page 34.

As we show in the Appendix, the number of equilibrium customs unions in the unanimous regionalism game is at most three and for practical N, i.e. $N \leq 200,000$, there are no more than two customs unions in equilibrium of this game. This result is exactly the same as Yi (1996) obtains for customs union formation without the Article XXIV constraint.

Nevertheless, as we will see in the next section, the equilibrium customs union structures of the unanimous regionalism games do differ under and without the WTO regulation.

6 The impact of the WTO Article XXIV Condition

As we have just shown, there are at most two asymmetric customs unions in the equilibrium of the unanimous regionalism game. This means that in equilibrium, either the grand union is formed (i.e. free trade is reached) or the equilibrium structure corresponds to two customs unions, one bigger and one smaller. First, lets try to determine under what conditions, free trade is the equilibrium outcome.

6.1 Free trade equilibrium

Lemma 4. *For the unanimous regionalism game, in the quasilinear-quadratic model, a necessary and sufficient condition for the grand customs union to be the subgame perfect equilibrium outcome is* $W(N;\{N\}) \geq W(N-1;\{N-1,1\})$.

Proof. Please see Appendix page 34.

The next result expresses the condition under which free trade is the equilibrium outcome of the unanimous regionalism game.

Proposition 13. *For any number of countries N, there exists a critical value of* γ^{FT}, $\gamma^{FT} < \gamma^{**}$, *such that the grand customs union is the unique stable outcome of the unanimous regionalism game for* $\gamma \leq \gamma^{FT}$.

Proof. Please see Appendix page 35.

A similar condition was found by Yi (1996) when studying customs union formation without the WTO Article XXIV constraint. The intuition behind this result is that for small γ, goods become less substitutable and the gains from freer trade outweigh the benefits from foreign rent extraction through a "tariff war" even for a large customs union. Thus there is a strong incentive for countries to form the grand customs union.

What is interesting about our result is the impact of the WTO Article XXIV on the value of this critical γ^{FT} as shown by the next proposition.

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

Proof. Please see Appendix page 35.

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

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
10000	0.0002	0.0002

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

We can note that γ^{FT} is a decreasing function of N, the more there are countries in the world, the more it is difficult to reach the free trade equilibrium. As stated in Proposition 14, γ^{FT} are slightly higher under the Article XXIV. Nevertheless, this improvement seems to vanish when N increases.

6.2 Asymmetrical equilibrium

Another very interesting result of the study of the impact of the Article XXIV on the customs union formation is the difference of the equilibrium customs union structure when free trade is not reached as explained in the following statement.

Proposition 15. *Under the Article XXIV constraint, for the range of parameters for which free trade is not the equilibrium outcome,* $\gamma^{FT} < \gamma \leq \gamma^{**}$, *the customs union structure is less asymmetrical than without the WTO constraint.*

Proof. Please see Appendix page 35.

Tables 3 and 4 compare the equilibrium customs union structures with and without the WTO Article XXIV for several different values of γ for $N = 30$ and $N = 100$ respectively. We can see the previously mentioned increase in the range of parameters γ for which free trade is the equilibrium outcome. Actually, as shown in Table 3 for example, for $N = 30$, at $\gamma = 0.07$ the customs union formation leads to free trade under the Article XXIV whereas it does not without the Article XXIV. A similar feature is illustrated in Table 4 for $N = 100$ at $\gamma = 0.02$.

Furthermore, both tables illustrate the decrease in asymmetry of the equilibrium customs union structure when free trade is not reached. For example, for $N = 30$, at $\gamma = 0.34$, the equilibrium outcome under the Article XXIV are two customs unions, one with 25 members and the other with 5 members. Whereas without the Article XXIV, the bigger customs union has 27 members and the smaller one only 3 members.

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}

Table 3: Equilibrium customs union structures for $N = 30$.

The two previous results thus imply that the WTO Article XXIV facilitates a little bit free trade in the sense that the grand customs union is reached for a slightly larger interval of parameters γ.

Furthermore, when free trade is not the equilibrium outcome, the equilibrium customs union structure is less asymmetrical under the Article XXIV.

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 4: Equilibrium customs union structures for $N = 100$.

Also, as we have seen in Section 3, the difference between the welfare of members of the bigger customs union and the smaller customs union is slightly attenuated. But what happens to global world welfare? Surprisingly, as shown by the next result, world welfare might be worsened under the Article XXIV.

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

Proof. Please see Appendix page 35.

Table 5 compares the world welfare of the equilibrium customs union structures of the unanimous regionalism game for various values of γ with and without WTO Article XXIV for $N = 30$.

The first column lists the different parameters γ considered, the second and third columns show the equilibrium customs union structure without and with the Article XXIV respectively and the last column presents the difference in world welfare of the equilibrium structure under the Article XXIV and without. We can see, that for small γ, the customs union formation game leads to free trade in both situations and thus the world welfare is exactly the same (the difference is null). For γ such that free trade is reached under the Article XXIV, but not without, there is a very significant improvement of world welfare. But for situations, where the grand union is not formed in equilibrium in neither setting (with or without the Article XXIV), world welfare might be lower under the Article XXIV (the difference is neg-

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 5: Equilibrium customs union structures and global welfare comparison with and without the WTO Article XXIV constraint for $N = 30$.

ative). This surprising result comes from the fact that under the Article XXIV the bigger customs union, whose members have higher welfare, has now less members and the smaller customs union, whose members have lower welfare, is now more numerous. Thus, world welfare might be lower under the Article XXIV than without. This result is also illustrated in Figure 5.

Figure 5: Welfare comparison

7 Conclusion

This paper has examined the impact of the WTO Article XXIV on customs union formation, the equilibrium customs union structure and resulting welfare of individual countries as well as world welfare. To implement our analysis, we have used an established model of customs union formation provided by Yi (1996) in which we have introduced the Article XXIV. Our main results show on one hand that the Article XXIV slightly encourages free trade, but this improvement is very small. On the other hand, Article XXIV may be bad for world welfare

in cases where free trade is not the equilibrium outcome.

Our model is of course very simplistic, and highly stylized and we have to be careful when drawing policy implications from such models. Nevertheless, our results do suggest that the WTO regulation concerning customs union formation does not seem to be of the most fortunate nature. Actually, under the Article XXIV, customs unions seem to continue to be stumbling blocks on the way to free trade and what is even more alarming, customs union formation under the Article XXIV might lead to a lower world welfare.

A Appendix

Derivation of equilibrium quantities. The normalized (5) is

$$1 - t_{ij} - (2-\gamma)q_{ij} - \gamma Q_i = 0 \tag{19}$$

Summing it over j, $j = 1, 2, ..., N$, gives

$$N - T_i - (2-\gamma)Q_i - \gamma N Q_i = 0$$

Thus

$$Q_i = \frac{N - T_i}{2 - \gamma + \gamma N}$$

Now using (6) in (19) gives (7).

Proof of Proposition 1. From Yi(1996): Suppose that Country 1 belongs to a customs union of size k. It sets tariffs on countries $k+1, ..., N$ to maximize aggregate welfare of k member countries. Since Country 1's do not affect production and consumption decisions in other countries, it , in effect, solves

$$\max_{\{t_{1j}\}_{j=k+1}^{N}} W^1 + \sum_{i=2}^{k} \pi^{1i} = Q_1 - \frac{\gamma}{2}Q_1^2 - \frac{1-\gamma}{2}\sum_{j=1}^{N} q_{1j}^2 - \sum_{j=k+1}^{N} q_{1j}^2$$

In order to save on notations, drop subscript 1. The first order condition with respect to t_p, $p = k+1, ..., N$, is

$$(1-\gamma)Q\frac{dQ}{dt_p} - (\Gamma(0) - 1)\sum_{j=1}^{N} q_j \frac{dq_j}{dt_p} - 2\sum_{j=k+1}^{N} q_j \frac{dq_j}{dt_p} = 0 \tag{20}$$

Since the objective function is globally concave in t_p's, there exists a unique symmetric solution, denoted by $t(k)$.

From (6) we have

$$\frac{dQ_i}{dt_{ij}} = -\frac{1}{\Gamma(N)} \tag{21}$$

and from (7)

$$\frac{dq_{ik}}{dt_{ij}} = \frac{\gamma}{\Gamma(0)\Gamma(N)}, \text{ for } k \neq j, \text{ and } \frac{dq_{ij}}{dt_{ij}} = \frac{\gamma - \Gamma(N)}{\Gamma(0)\Gamma(N)} \tag{22}$$

Now substituting (21) and (22) into (20), denoting a non-member country's sales by $q_O(k)$, total sales by $Q(k)$, and multiplying by $\Gamma(0)\Gamma(N)$,

$$-\Gamma(0) + \gamma Q(k) + [\Gamma(N)(\Gamma(0)+1) - 2(N-k)\gamma]q_O(k) = 0 \tag{23}$$

Substituting (6) and (7) into (23) and rearranging the terms yields the formula. □

Proof of Corollary 1. $\frac{dt(k)}{dk} = \frac{\Gamma(0)\gamma}{D(k)^2}\{\Gamma(0)[\Gamma(0)+1]\Gamma(N) - \Gamma(2k)^2\} > 0$ if and only if $k < k^*(N,\gamma)$. □

Proof of Corollary 2. 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

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

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

$$Num1 = 4\sqrt{(2-\gamma)(3-\gamma)(2+(N-1)\gamma)} + \gamma^3(N-1) + \gamma(16-6N) - 24 \tag{25}$$

We can note that $Num1$ is a decreasing function of N. Actually,

$$\frac{dNum1}{dN} = -6\gamma + \gamma^3 + \frac{2\gamma^{\frac{3}{2}}}{\sqrt{N}} \tag{26}$$

which is strictly negative for $0 \leq \gamma \leq 1$ and $N \geq 1$.

So if $Num1$ is negative for $N = 1$, it will be negative for all $N \geq 1$.

$$Num1(N=1) = 4\sqrt{2(2-\gamma)(3-\gamma)} + 10\gamma - 24 < 4\sqrt{12} + 10 - 24 < 0 \tag{27}$$

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 Corollary 3. For a given N and γ, $0 \leq \gamma \leq \gamma^*$, by Corollary 2, $t(k)$ is a monotonically decreasing function on the interval (k^*, N) with $t(k^*) > t(1) > 0$ and $t(k) \xrightarrow[k\to\infty]{} 0$ so by the intermediate value theorem, there exists a $k^{**}(N,\gamma) > k^*(N,\gamma) > 1$, $t(k^{**}) = t(1)$. The calculation gives $k^{**} = \frac{(\gamma-2)(-4+\gamma(6+\gamma(N-1)-3N))}{2\gamma(2+\gamma)}$. $\square$

Proof of Corollary 4. 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

$$\frac{dk^{**}}{d\gamma} = \frac{-16+\gamma(-16+\gamma(-16(-2+N)+\gamma(4+\gamma)(N-1)))}{2\gamma^2(2+\gamma)^2} \tag{28}$$

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

$$Num2 = -16+\gamma(-16+\gamma(-16(-2+N)+\gamma(4+\gamma)(N-1))) \tag{29}$$

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

$$\frac{dNum2}{d\gamma} = -16+64\gamma-12\gamma^2-4\gamma^3-32\gamma N+12\gamma^2 N+4\gamma^3 N = A \tag{30}$$

$$\frac{dA}{d\gamma} = 64-24\gamma-12\gamma^2-32N+24\gamma N+12\gamma^2 N = B \tag{31}$$

$$\frac{dB}{d\gamma} = -24-24\gamma+24N+24\gamma N = C \tag{32}$$

$$\frac{dC}{d\gamma} = 24(N-1) = D \tag{33}$$

From (33), we can see D is strictly positive for $N > 1$, so C is a monotonically increasing function of γ.

From (32), 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 (31) 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 (30), $A(N,0) = -16$ 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 (29) 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. $\square$

Proof of Proposition 2. Follows directly from the previously established results. For any N and $0 \leq \gamma \leq \gamma^{**}(N)$, $t(k) > t(1)$ for $1 \leq k \leq N$ and so the WTO Article is binding and imposes (12).

Proof of Proposition 3. $\frac{dq_O(k)}{dk} = -\frac{\gamma t(1)}{\Gamma(0)\Gamma(N)} < 0$ $\square$

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

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

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. $\square$

Proof of Proposition 4. The same as in Yi (1996). TO BE COMPLETED. □

Proof of Proposition 5. Follows from Proposition 4. □

Proof of Lemma 2. Using the Lemma 1, the first three terms of (8) can be rewritten as:

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

On the other hand,the first three terms from (17)

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

The result follows. □

Proof of Lemma 3. Follows directly from (17) using (13), (14) and (15). □

Proof of Proposition 6. Suppose that two unions of size-k and size-r merge. (The general case is analogous.) 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 3). The merger does not affect the optimal tariffs of other unions (they stay at the initial binding level t(1)). 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 customs union and 2 to the size-n_j customs union, 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 customs unions). Notice that, 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 customs union net of export profits to non-member countries and non-member countries' profits in the home market. Then the claim holds if $NS(n_i)+n_jq_O(n_j)^2 > NS(n_j) + n_iq_O(n_i)^2$. By Proposition 3, $q_O(n_i)^2 < q_O(n_j)^2$. By Proposition 4, if n_j countries abolish tariffs on $n_i - n_j$ countries and keep tariffs on $N - n_i$ countries at t(1), 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 8. Directly follows from combining Propositions 3 and 7. +discussion of the graph. TO BE COMPLETED.□

Proof of Proposition 9. Suppose a member of the size-n_j customs union, say Country 1, in the customs union structure C joins the size-n_i customs union. Country 1's welfare will be the same if, instead of Country 1 joining the size-n_i customs union, $n_i - n_j + 1$ members of the size-n_i customs union leave their customs union to join the size-n_j customs

union. Decompose the transition into three steps. First, the existing members of the size-n_j customs union abolish tariffs on $n_i - n_j + 1$ new members and keep tariffs on $N - n_i - 1$ countries at t(1). Second, $n_i - n_j + 1$ new members abolish tariffs on the n_j countries, charge t(1) on $n_j - 1$ and keep the same tariffs on $N - n_i - 1$ countries. By Proposition 4, in each of $n_i + 1$ countries involved, aggregate welfare improves. Third, the remaining $n_j - 1$ members of the formerly size-n_i customs union continue charging t(1) on the n_j countries and also levy t(1) on the $n_i - n_j + 1$ countries (which leave their union). The third step benefits the existing members of the size-n_j customs union by Proposition 3. The first two steps also benefit the existing members of size-n_j custom union by Proposition 7. □

Proof of Proposition 10. This Proposition says that the last union to form will be the smallest, ie a symmetric customs union structure is not an equilibrium outcome. It 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 Proposition 11. Suppose that the second smallest union has less than k_0 members. Then the members of this union would be better off by admitting one more member. □

Proof of Proposition 12. See Yi. In our case, need to do the proof for γ^{**} which complicates all, but for $\gamma = 0.3$ for example, it works. TO BE COMPLETED. □

Proof of Lemma 4. $W(N; \{N\}) \geq W(N-1; \{N-1, 1\})$ is a necessary condition for the grand customs union 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 union structures C. □

Proof of Proposition 13. Comes from the study of the difference $W(N;\{N\}) \geq W(N-1;\{N-1,1\})$. TO BE COMPLETED (graph). $\square$

Proof of Proposition 14. Comes from the study of the difference $W(N;\{N\}) \geq W(N-1;\{N-1,1\})$. TO BE COMPLETED (graph). $\square$

Proof of Proposition 15. For the moment, a simulation result (for N=2 to 1000 and $0 \leq \gamma \leq \gamma^{**}$). $\square$

Proof of Proposition 16. For the moment, a simulation result (for N=2 to 1000 and $0 \leq \gamma \leq \gamma^{**}$). $\square$

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