Trade negotiations when market access matters*

Monika Mrázová†‡

Department of Economics and Balliol College,

University of Oxford

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Abstract

This paper analyses GATT/WTO trade negotiations in an oligopolistic multi-country setting and identifies a new rationale for trade agreements. When set unilaterally, tariffs are inefficiently high, both for familiar terms-of-trade reasons, but also to restrict market access of foreign firms. Trade agreements neutralise both the terms-of-trade and the market-access externalities and help countries reach efficient tariff levels. The paper further studies various kinds of asymmetries in trade negotiations. It is shown that the multilateral negotiations system can sustain only a certain level of free-riding which suggests why multilateralism was successful in the past, but is currently stalling.

KEYWORDS: Trade negotiations, trade liberalization, GATT/WTO, Multilateralism.
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†Address for correspondence: 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/.

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1 Introduction

The postwar era has witnessed an extraordinary liberalisation of international trade. During the past 50 years, average ad valorem tariffs on industrial goods have been reduced significantly, from over 40 percent to less than 4 percent. It is generally acknowledged that the General Agreement on Tariffs and Trade (GATT) and later the WTO played a key role in achieving these historically low tariff levels through a series of eight trade negotiation rounds (the ninth, Doha Round, is currently in progress).[1] Recently however multilateral trade negotiations have progressed rather slowly and with difficulties. The next to last Uruguay Round took seven and a half years, almost twice the original schedule. The Doha Development Round started in November 2001 and was set to be concluded in four years, but as of 2009, talks have stalled over a divide between the developed nations led by the European Union, the United States and Japan and the major developing countries represented mainly by Brazil, China, India and South Africa.

The GATT/WTO is a forum for governments to negotiate trade agreements according to a pre-agreed set of rules. These rules are lengthy and complex legal texts covering a wide range of issues, but two fundamental principles are considered as the foundation of the multilateral trading system: the principles of reciprocity and non-discrimination. Generally speaking, the principle of reciprocity requires countries to make reciprocal changes in their trade policy, in particular when negotiating trade liberalisation to exchange reciprocal concessions. The principle of non-discrimination, also called the Most-Favoured-Nation principle, forbids discrimination between GATT/WTO members. If a country grants to one of its trading partners a special favour, such as a lower import tariff rate for one of its products, it has to grant the same favour to all WTO members.

The role of these fundamental principles has attracted much attention among trade lawyers, trade officials, political scientists and naturally economists, but until relatively recently there has not been any formal economic model analysing and explaining what these principles are for. Standard undergraduate textbook trade theory shows that there is a unilateral case for free trade. Therefore, from an economic point of view, there seems to be no room for the existence of any trade agreement and any economic analysis of the GATT/WTO is vain. Traditionally, the GATT/WTO principles have been interpreted as a result of mercantilist reasoning of the negotiating countries. This point has been summarised by Krugman (1992): "There is no generally accepted label for the theoretical underpinnings of the GATT. I like to refer to it as 'GATT-think': a simple set of principles that is entirely consistent, explains most of what goes on in negotiations, but

[1] Rose (2004a,b) suggests that there may be no correlation between GATT/WTO membership and more liberal trade policy or higher trade volumes. However, Subramanian and Wei (2007), Tomz, Goldstein, and Rivers (2007), Bagwell and Staiger (2006) and others challenge Rose's conclusions about the ineffectiveness of the WTO and offer empirical evidence supportive of the important role played by the GATT/WTO in trade liberalisation.

makes no sense in terms of economics. (...) In other words, GATT-think is enlightened mercantilism."

More recent developments in theoretical economic literature have challenged this traditional view. Bagwell and Staiger (1999, 2002) have provided a seminal contribution to the analysis of trade agreements. By building on the work started by Johnson (1953-54),[2] they show that when countries set their tariffs non-cooperatively, these tariffs are set inefficiently high because of a terms-of-trade externality. Countries want to manipulate their terms of trade in their favour via their tariffs and, because all countries do so, they end up in a Prisoner's Dilemma situation. Bagwell and Staiger (1999) thus identify a reason for trade agreements and explain the role of the fundamental GATT/WTO principles: trade agreements allow countries to overcome the terms-of-trade externality by agreeing to lower their tariffs according to the GATT/WTO principles.

The GATT/WTO theory of Bagwell and Staiger (1999) represents an important step forward in our understanding of trade agreements. Nevertheless, this theory has been criticised for its focus on the terms of trade. Krugman (1997) for example states that "this optimal tariff argument plays almost no role in real-world disputes over trade policy". And Bagwell and Staiger (2002) themselves point out that "many economists are skeptical as to the practical relevance of terms-of-trade considerations for actual trade policy negotiations". Empirical analysis by Broda, Limão, and Weinstein (2008) concludes that countries have market power in imports and use it to manipulate their terms of trade, but Regan (2006) argues that this evidence is unpersuasive. More recently, Bagwell and Staiger (2006) seem to have found support for terms-of-trade manipulation,[3] but critics of the terms-of-trade theory point out that terms of trade are never mentioned in trade negotiations. Regan (2006) for example writes, "References to terms-of-trade manipulation are nowhere to be found. This seems to me strong evidence that terms-of-trade manipulation is not regarded as a significant problem by the trade community."

Furthermore, Wilfred Ethier, one of the strongest critics of the terms-of-trade theory (see for example Ethier (2004) or Ethier (2007)), underlines that "actual multilateral agreements do not prevent countries from trying to influence their terms of trade". As is well known, countries can affect their terms of trade by taxing either imports or exports. Trade negotiations have focused solely on bounding import taxes. Thus, if a country wished to manipulate its terms of trade, it could do so, under the current trade agreements, by imposing a set of export taxes. In reality, countries do not do this. So a theory explaining trade agreements only through countries' concern with terms-of-trade manipulation does not seem to provide the right insight into trade negotiations.

[2]The terms-of-trade argument has a long history. See for example Irwin (1996) for a thorough discussion.

[3]Bagwell and Staiger (2006) find a positive relationship between the magnitude of negotiated tariff concessions and the pre-negotiation volume of imports. Note that this result can also be broadly interpreted as supportive of the trade negotiations rationale suggested by the present paper.

Ossa (2009) provides an alternative motivation for trade agreements. In his 'new trade' model of trade negotiations, countries, when acting non-cooperatively, impose inefficiently high tariffs because they want to attract firms to locate in the home country. Trade agreements enable countries to overcome the Prisoner's Dilemma driven by an industry location externality. Although this interpretation of trade agreements is also an interesting contribution to the literature, if we follow the rhetoric of trade (in trade agreements themselves, public speeches made by trade officials and political discussions) we will not find many references to industry location.[4]

Market access seems to play an important role in trade negotiations and more particularly firms' profits. Moreover, even though the current theories of GATT/WTO negotiations are useful for understanding the fundamental principles of reciprocity and non-discrimination, many different aspects of trade negotiations have not yet been addressed in the literature. For example, countries negotiate tariff cuts according to formulas. How does formula-based trade liberalisation differ from trade liberalisation following the principles of reciprocity and non-discrimination? Also there do not seem to be many theories explaining past success of GATT/WTO negotiations and its current stalemate.

This paper attempts to address these points. It builds on the work of Bagwell and Staiger (1999, 2002), but uses an oligopolistic model à la Brander (1981) to analyse trade negotiations. In this setting, firms make non-zero profits and supply socially sub-optimal quantities. Governments, when acting non-cooperatively, set inefficiently high tariffs for two reasons: not only to improve their terms of trade, but also to limit foreign firms' market access in the home country and hence increase domestic output. In the absence of domestic competition policy, trade policy is used to moderate the domestic market distortion and raise socially sub-optimal domestic output. So trade agreements are partially used to neutralise a terms-of-trade externality, but also to neutralise a market-access externality through a balanced exchange of both terms-of-trade concessions and market-access concessions. This paper thus identifies a new rationale for trade agreements. In the absence of the terms-of-trade externality, trade agreements remedy a market-access externality.[5]

By identifying the market-access rationale for trade agreements, this paper suggests a possible answer to Ethier's critique. In the oligopolistic framework, countries use tariffs on imports in order to improve their terms of trade and to increase domestic production.

[4] A different branch of the economic literature on trade agreements provides a commitment motivation for trade negotiations: trade agreements help governments to make commitments to their private sectors (see for example Maggi and Rodriguez-Clare (1998)). These models study trade negotiations from a different perspective from the literature started by Johnson (1953-54) and therefore I do not discuss them here.

[5] A recent paper by Bagwell and Staiger (2009) also studies trade agreements in imperfectly competitive markets and claims that the terms-of-trade externality is the only rationale for trade agreements. This opposite claim is due to the use of a different welfare decomposition. The differences are explained in Section 3 below.

If they had the possibility to use trade policy on exports, they could either improve their terms of trade through export taxes or increase export production through export subsidies. As shown by Brander and Spencer (1985), in the case of duopoly, countries would subsidise their exports. This paper shows that this result extends to the case of many countries when the number of domestic exporting firms is small. In a country with few firms, the oligopolistic distortion is important and so it would be optimal to subsidise exports to improve the market access of domestic firms in the foreign market.[6] So the market-access externality encourages countries to choose export subsidies. The fact that export subsidies are explicitly forbidden by Article XVI of the GATT suggests that the market-access motivation is a plausible rationale for trade agreements.

Furthermore, within the oligopolistic framework of this paper, I study aspects of trade negotiations that have not yet been addressed in the literature. I examine the role of asymmetries in the negotiation process in terms of asymmetric countries and asymmetric participation. Countries differ in number of firms. Some countries have more firms than others which gives them a kind of comparative advantage in the sense that their economies are more competitive and will export more. The paper shows that this kind of asymmetry has important implications for trade negotiations: for trade liberalisation to be welfare improving for all countries, some have to liberalise more than others. The paper also studies the implications of free riding in trade negotiations. This analysis provides a possible explanation for why multilateralism was successful in the past, but is currently having problems. It is shown that the multilateral negotiations system can sustain only a certain level of free-riding, but with the emergence of developing countries in world trade, free-riding has increased above the critical level. A further contribution of this paper is to compare the analysis of trade liberalisation based on an ex post criterion of reciprocity with that based on ex ante tariff-reduction formulae, of the kind carried out in reality. This comparison throws further light on the role of asymmetries in multilateral trade liberalisation: when countries are asymmetric, not all countries necessarily benefit from formula-based trade liberalisation.

The remainder of this paper proceeds as follows. Section 2 presents the basic underlying oligopolistic multi-country model of international trade where countries differ in their number of firms. The non-cooperative equilibrium is presented in Section 3 and it is there that the rationale for trade agreements is derived. Section 4 analyses the GATT/WTO fundamental principles of reciprocity and non-discrimination and shows how they help countries reach a superior cooperative outcome. Section 5 shows how the market-access motivation provides a rationale for trade agreements in the case of export policy. The distribution of the benefits from multilateral trade liberalisation is examined

[6]The general result derived by Dixit (1984) extends to the multi-country, multi-firm setting. In a country with many firms, the oligopolistic distortion is relatively small and the country exports a lot. So for such a country it would be optimal to tax exports to improve its terms of trade.

in Section 6. Section 7 studies formula-based trade negotiations. Section 8 establishes a minimum participation constraint necessary for multilateral negotiations to work and suggests an explanation for the past success and present difficulties of the multilateral trade negotiations. Section 9 concludes.

2 The basic model

The model used to analyse trade negotiations and trade agreements is a Brander (1981) type oligopolistic model. The particular setting was derived by Yi (1996) to study customs union formation in a world with many symmetric countries. In this case, I ignore customs union formation and I adapt Yi's model to examine multilateral trade negotiations among asymmetric countries.[7]

There are n countries of the same size, but they differ in their number of firms. Subscripts i and l designate countries and subscripts j and k designate firms. Country i has k_i firms, $i = 1, ...n$. The set of firms located in country i will be denoted K_i, $i = 1, ...n$. Each country can be identified by the number of its firms and with a slight abuse of notation, I will write the set of countries in the world as the vector of the numbers of firms per country $\mathbf{k} = \{k_1, k_2, ..., k_n\}$. There are $N = \sum_{i=1}^{n} k_i$ firms in total in the world, each firm produces one good.

Consumers have quasilinear-quadratic preferences of the form

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

where q_{ij} is country i's consumption of firm j's product, $\mathbf{q_i} = (q_{i1}, q_{i2}, ..., q_{iN})$ is country i's consumption profile, $Q_i \equiv \sum_{j=1}^{N} q_{ij}$ and M_i is country i's consumption of the numeraire good. The numeraire good is transferred internationally to settle the balance of trade and, by assumption, all countries are endowed with sufficient quantities of the numeraire good to guarantee a positive consumption in equilibrium. γ is a substitution index between goods which ranges from 0 (independent goods) to 1 (homogeneous products); as γ increases, products become closer substitutes. An important feature of the model is that consumers have a taste for variety; for any given Q_i, the more balanced the consumption bundle is, the higher the utility. Maximising utility, country i's inverse demand function for firm j's good is

[7] A two-country version of this model was recently used by Fujiwara (2008) to analyse welfare effects of free trade. For other variations of this model in different contexts see for example Krishna (1998), Freund (2000) etc.

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

There are no transportation costs in this model. Countries impose specific tariffs on imports from other countries (import tariffs are the only available instruments). I assume tariffs country-specific, although it is convenient to note them as firm-specific. τ_{ij} denotes country i's tariff on imports from firm j, and so the tariff imposed by country i on all firms j located in country l is the same, for all $j \in K_l$, $\tau_{ij} = \tau_{il}$. There are no tariffs on domestic firms, $\tau_{ij} = 0$ for all $j \in K_i$. All firms produce at the same constant marginal cost c. Firm j's effective marginal cost of exporting to country i is $c_{ij} = c + \tau_{ij}$. I assume segmented markets and so firms compete by choosing quantities in each country. In country i, firm j will solve $\max_{\{q_{ij}\}} \pi^{ij} = (p_{ij} - c_{ij})q_{ij}$. The first order condition for this maximisation problem is

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

In the Cournot equilibrium,

$$Q_i = \frac{N - T_i}{\Gamma(N)} \quad \text{and} \quad q_{ij} = \frac{\Gamma(0) + \gamma T_i - \Gamma(N)\tau_{ij}}{\Gamma(0)\Gamma(N)} \tag{4}$$

where $\Gamma(.)$ is defined as $\Gamma(k) = 2 - \gamma + k\gamma$;[8] T_i is the sum of tariffs imposed by country i on all imported goods $T_i = \sum_{j=1}^{N} \tau_{ij}$; and where I have normalised $a - c = 1$.

The equilibrium quantities have the standard properties. If country i increases its tariff on imports from country l, then the consumption of imports from country l and the total consumption in country i will fall, but the consumption of all other goods will increase. Furthermore, firm j's equilibrium export profit to country i can be obtained using the first order condition (3)

$$\pi^{ij} = (p_{ij} - c_{ij})q_{ij} = q_{ij}^2 \tag{5}$$

so we can also note that when country i increases its tariff on imports from country l, then export profits of country l's firms to country i fall and home firms' profits and all other firms' export profits to country i rise.

[8] $\Gamma(k)$ can be interpreted as a measure of the competitiveness of the economy. The higher γ (the more goods are substitutable) and the higher k (the more firms there are), the higher the degree of competitiveness. It will be shown in Section 4.1 how sales of domestic firms and foreign firms in country i depend on the degree of competitiveness $\Gamma(k_i)$. Note that $\Gamma(N) = 2 - \gamma + N\gamma$ represents the degree of competitiveness in free trade (all firms compete), $\Gamma(1) = 2$ is the case of monopoly. When goods are independent in demand, $\gamma = 0$, $\Gamma(k) = 2$, and we have the monopoly case. $\Gamma(0) = 2 - \gamma$ represents the degree of competitiveness in monopoly less the marginal contribution of one firm.

There will be two sources of gains from trade in this setting: increased variety of goods and reduced market power of domestic industry.

3 Non-cooperative trade policy

Country i's welfare W^i is the sum of four components: the domestic consumer surplus (CS^i), the domestic firms' profit in the home market ($\sum \pi^{ij}$, for all firms j located in country i), the tariff revenue (TR^i), and the domestic firms' export profits ($\sum \pi^{lj}$, for all domestic firms j in all foreign countries l).

$$W^i = CS^i + \sum_{j \in K_i} \pi^{ij} + TR^i + \sum_{\substack{l=1 \\ l \neq i}}^{n} \sum_{j \in K_i} \pi^{lj} \tag{6}$$

Countries set tariffs on imports to maximise their welfare, so country i solves $\max_{\{\tau_{ij}\}_{j \notin K_i}} W^i$ with $\tau_{ij} = 0$, for $j \in K_i$. The tariff balances the benefit of increasing profits of the home firms at the expense of foreign firms against the cost of lower consumer surplus. More fundamentally, as discussed for example in Baldwin and Venables (1995), the effect of an increase in the import tariff on welfare can be decomposed into a terms-of-trade effect (ToT), a volume-of-trade effect (VoT) and a market-access effect (MA)[9]

$$\frac{dW^i}{d\tau_{ih}} = \boxed{-\sum_{j \notin K_i} q_{ij} \frac{dp^*_{ij}}{d\tau_{ih}}}_{ToT} + \boxed{\sum_{j \notin K_i} \tau_{ij} \frac{dq_{ij}}{d\tau_{ih}}}_{VoT} + \boxed{\sum_{j \in K_i} (p_{ij} - c) \frac{dq_{ij}}{d\tau_{ih}}}_{MA} \tag{7}$$

where p^*_{ij} is the mill price (the pre-tariff price), $p^*_{ij} = p_{ij} - \tau_{ij}$. The market-access effect is due to the inefficiency of the market. In perfect competition, prices are equal to marginal cost and so the last term of (7) would be zero. This effect will provide a new rationale for trade negotiations which is different from the terms-of-trade manipulation externality identified by Bagwell and Staiger (1999). To distinguish the terms-of-trade and market-access rationales for trade agreements, I will first determine the Nash equilibrium tariff. I will then show that part of this tariff is due to terms-of-trade manipulation and part of it reflects a concern for market access by comparing it to the tariff that governments would impose if they did not value the terms-of-trade effects of their tariff choices.[10]

[9] The derivation of this decomposition is given in the Appendix A page 37.

[10] Bagwell and Staiger (2002) interpret their terms-of-trade rationale for trade agreements in terms of market access. Under perfect competition, an increase in the import tariff has a price effect (it improves the terms of trade) and a volume effect (it decreases the volume of imports). In this sense, an increase in the import tariff restricts foreign access to the home market. However, this market-access interpretation is different from the market-access effect under oligopoly identified in this paper. The volume effect (VoT) is negative and thus decreases welfare whereas the market-access effect (MA), that arises in oligopoly and not in perfect competition, increases welfare through higher profits of domestic firms. Under perfect competition, governments do not choose higher tariffs for their volume-of-trade effects, but under oligopoly, they set higher tariffs for their market-access effects.

3.1 Nash equilibrium tariff

The following proposition derives countries' optimal tariff.

Proposition 1. *The unique Nash optimal tariff of a country with k_i firms is*

$$\tau_e(k_i;\gamma,N)=\frac{\Gamma(0)\Gamma(2k_i)}{D(k_i)}>0 \tag{8}$$

with $D(k_i)\equiv\Psi(k_i)\Gamma(N)+\Gamma(k_i)\Gamma(2k_i)$ *and* $\Psi(k_i)\equiv[\Gamma(0)+1]\,\Gamma(k_i)-\Gamma(2k_i)=(2-\gamma)^2+(1-\gamma)k_i\gamma>0$.

Proof. See Appendix page 38. □

Note that Nash equilibrium tariffs are always strictly positive.[11] From (7) we know that this is for two reasons: first, to improve the terms of trade of the domestic country and second, to restrict market access of foreign firms in the home country to increase domestic output. The following subsection isolates formally the market-access motivation of the Nash equilibrium tariff.

3.2 Optimal tariff in the absence of terms-of-trade manipulation

Bagwell and Staiger (1999) show in their perfectly competitive framework that if governments did not value the terms-of-trade effects of their tariffs, the optimal tariff would be zero. This subsection shows that in the oligopolistic model of this paper, governments would still impose non-zero tariffs even if they did not care about their terms of trade. To establish this result, I proceed in the same way as Bagwell and Staiger (1999) and consider a hypothetical world where the terms-of-trade effects of the tariff are ignored.

[11] Note also that the optimal tariff of a country with k_i firms depends only on its number of firms k_i, the total number of firms in the world N and the substitution index γ. In particular, it does not depend on the tariffs of the rest of the world. It is a dominant strategy and there is no strategic interdependence of optimal tariffs across countries. A country with k_i firms imposes $\tau_e(k_i;\gamma,N)$ on imports from any other country. This result is a consequence of the quasilinearity of the utility function, the assumption of segmented markets and of constant marginal cost. Furthermore, note that $d\tau_e(k_i;\gamma,N)/dN<0$. When the number of domestic firms is constant, the more firms there are in the world, the greater the proportion of goods produced abroad, the lower the monopoly power of the home country and the greater the loss to consumers from a tariff (consumers prefer variety). Thus the equilibrium tariff is lower. With respect to γ and k_i, τ_e varies non-monotonically. This non-monotonicity results from γ's impact on competition and from two conflicting effects of the number of domestic firms on the equilibrium tariff: first, as consumers prefer variety, if there are fewer firms at home, the country wants to impose a lower tariff to assure a balanced consumption. As the proportion of the domestically produced goods rises, the negative effect of the tariff on consumer surplus is diminished and so the country wants to impose higher tariffs. Second, as governments care about firms' profits, if there are few firms in the home country, they will suffer more from foreign competition than if the domestic market is very competitive. This tends to decrease the equilibrium tariff as the number of domestic firms increases. When γ is high, goods are homogeneous and the second effect is more important. When goods are independent, firms do not compete with each other and the first effect outweighs the second. Finally, for $\gamma=0$, the tariff is independent of k_i and all countries impose the same tariff $\tau_e(k_i;0,N)=1/3$.

To be precise, the terms-of-trade effect in (7) is omitted and the tariff in the absence of the terms-of-trade effect satisfies the following first order condition

$$\frac{d\tilde{W}^i}{d\tau_{ih}} = \boxed{\sum_{j\notin K_i} \tau_{ij}\frac{dq_{ij}}{d\tau_{ih}}}_{VoT} + \boxed{\sum_{j\in K_i}(p_{ij}-c)\frac{dq_{ij}}{d\tau_{ih}}}_{MA} = 0 \tag{9}$$

Proposition 2. *The unique Nash optimal tariff of a country with k_i firms in the absence of terms-of-trade effects is*

$$\tilde{\tau}_e(k_i;\gamma,N) = \frac{\gamma\Gamma(0)k_i}{\Gamma(0)\Gamma(N)\Gamma(k_i) - \gamma^2 k_i(N-k_i)} \geq 0 \tag{10}$$

Proof. See Appendix page 39. □

Note that this tariff is also strictly positive for $\gamma > 0$. So even if governments did not want to manipulate their terms of trade, they would still impose positive tariffs to correct the domestic market inefficiency. When $\gamma = 0$, $\tilde{\tau}_e = 0$, goods are independent and firms do not compete with each other. Domestic sales are independent of the import tariff and the tariff thus cannot address the market inefficiency. So when $\gamma = 0$, there is no point in restricting market access of foreign firms and countries use Nash tariffs τ_e solely to manipulate their terms of trade. However, when $\gamma > 0$, $\tilde{\tau}_e > 0$, part of the Nash tariff τ_e is due to terms-of-trade manipulation and part of it is due to market-access protection.[12]

Bagwell and Staiger (1999, 2002) show in a perfectly competitive framework, where there is no case for market-access protection, that terms-of-trade driven Nash tariffs are inefficiently high. The natural question now is whether Nash equilibrium tariffs τ_e are efficient or inefficient in the oligopolistic framework of this paper? And how about the optimal tariffs in the absence of terms-of-trade effects $\tilde{\tau}_e$? Is it efficient or inefficient to tax imports to increase suboptimal domestic production? To answer this question, the next subsection determines the efficient tariff levels and compares them to Nash tariffs τ_e and to optimal tariffs in the absence of terms-of-trade manipulation $\tilde{\tau}_e$.

3.3 Efficient tariffs: joint welfare maximisation

Internationally efficient tariffs would maximise the sum of all countries' welfare:

$$\max_{\{\tau_{ij}\}_{i=1,\ j=1}^{n,\ N}} \sum_{i=1}^{n} W^i \tag{11}$$

[12]Note that $\tilde{\tau}_e$ is a decreasing function of N. For a given number of domestic firms, the more firms there are in the world, the greater the proportion of goods produced abroad and so the more welfare reducing is the volume-of-trade effect of the tariff. $\tilde{\tau}_e$ is a non-monotonic function of γ and k_i. When the number of domestic firms is very small, the negative effect of a tariff coming from the volume-of-trade effect is important and so $\tilde{\tau}_e$ is small. As the number of domestic firms increases, the volume-of-trade effect becomes less important while it becomes relatively more important to correct for the domestic inefficiency and so $\tilde{\tau}_e$ increases. As the number of domestic firms becomes large, the oligopolistic inefficiency becomes small and so $\tilde{\tau}_e$ which is aimed to correct this inefficiency decreases.

where $\tau_{ij} = 0$ for $j \in K_i$, for $i = 1 \dots n$. The terms-of-trade effects of the tariffs cancel from this summation. Furthermore, when maximising joint welfare, countries would take into consideration the market inefficiencies in other countries. The first order conditions of this maximisation problem are

$$\frac{d}{d\tau_{im}}(W^1 + W^2 + \cdots + W^n) = \sum_{j=1}^{N}(p_{ij} - c)\frac{dq_{ij}}{d\tau_{im}} = 0 \tag{12}$$

for $i = 1 \dots n$, $m = 1 \dots N$ and $m \notin K_i$.

By comparing the first order condition of the joint welfare maximisation problem (12) with the unilateral welfare maximisation problem (7) and with the maximisation problem without terms-of-trade effects (9), we can see by inspection that neither τ_e nor $\tilde{\tau}_e$ are efficient. The following proposition evaluates the efficient tariffs explicitly.

Proposition 3. *The joint-welfare-maximising tariff for a country with k_i firms is*

$$\tau_J(k_i; \gamma, N) = -\frac{\Gamma(0)^2}{\Gamma(0)^2\gamma(N - k_i) + (1 - \gamma)k_i\gamma^2(N - k_i) + (1 - \gamma)\Gamma(k_i)^2} < 0 \tag{13}$$

Proof. See Appendix page 39. □

The efficient tariffs are strictly negative, i.e. when markets are oligopolistic, it would be efficient to subsidise imports. By subsidising imports, foreign production for the domestic market would increase. This would moderate the oligopolistic inefficiencies of foreign firms in their export markets. The subsidies would push prices of foreign products down which would in turn tend to decrease the prices of domestic goods and so it would also moderate the domestic market inefficiency.

As the efficient tariffs are negative, the Nash equilibrium tariffs τ_e and the tariffs without terms-of-trade effects $\tilde{\tau}_e$, which are both positive, are obviously inefficient. It is not surprising that terms-of-trade manipulation leads to inefficient tariffs, but this result also shows that even in the absence of terms-of-trade manipulation, countries would be still setting inefficiently high tariffs because of the market-access externality. As will be shown in the next section, trade agreements will help countries neutralise both the terms-of-trade and the market-access externalities and reach a more efficient cooperative outcome.

In a recent paper, Bagwell and Staiger (2009) seem to claim the opposite of this result: in a duopoly model, "the only rationale for a trade agreement is to remedy the inefficient terms-of-trade driven restrictions in trade volume." Surprising as it may seem, their claim and the claim of this paper are not incompatible. The difference comes from the use of a different welfare decomposition. In this paper, I decompose the effect of a tariff on welfare in a standard way into three effects: a terms-of-trade effect, a volume-of-trade

effect and a market-access effect as given by (7). Using the profit-maximising first order condition (3) and $p^*_{ij} = p_{ij} - \tau_{ij}$, (7) becomes

$$\frac{dW^i}{d\tau_{ih}} = -2\sum_{j\notin K_i} q_{ij}\frac{dp^*_{ij}}{d\tau_{ih}} + \sum_{j=1}^{N}(p_{ij}-c)\frac{dq_{ij}}{d\tau_{ih}} \tag{14}$$

so the effect of an import tariff on welfare can also be expressed as a terms-of-trade effect (doubled) and the market inefficiency term for all goods. From this decomposition we can see that if we omit the terms-of-trade effects, we will obtain the first order condition for joint welfare maximisation (12) yielding efficient tariffs. This means that if we forbid any types of policies having terms-of-trade effects, governments will set efficient tariffs. In this sense, I fully agree with Bagwell and Staiger (2009). Nevertheless, I argue that their approach does not distinguish the motivations behind the tariff setting from the outcomes of tariff setting. I thus believe that their approach does not fully explain the rationales for trade agreements. The present paper shows that part of the Nash equilibrium tariff reflects the desire to manipulate terms of trade and part the desire to restrict market access of foreign firms. Of course, the part of the tariff chosen for market-access restriction will also have terms-of-trade effects, but what matters is that it is not chosen for these terms-of-trade effects. As Regan (2006) points out: "Whatever policy is chosen by a country with market power will have terms-of-trade effects; what is crucial is that the policy should not be chosen for those effects. What is crucial is the absence of terms-of-trade purpose."

An alternative way to understand the difference between the terms-of-trade motivation and the market-access motivation for the import tariff is to consider a situation where the government could use both a domestic production subsidy and an import tariff (see for example Dixit (1984) for a discussion of different instruments). In such a case, the domestic production subsidy would be used to take care of the domestic market inefficiency and the import tariff would purely serve for terms-of-trade manipulation. As is shown in Appendix C page 39, the Nash equilibrium tariff in this case would be lower than the Nash equilibrium tariff when the domestic production subsidy is not available. This shows that in the presence of an oligopolistic distortion, part of the Nash equilibrium tariff is due to the concern with market access which is a distinct motivation from the terms-of-trade manipulation.

4 Cooperative trade policy

This section studies what happens when countries set their tariffs cooperatively according to the GATT/WTO principles of reciprocity and non-discrimination. It shows how trade agreements help countries overcome both the terms-of-trade and market-access external-

ities. The analysis starts from Nash equilibrium and shows how the GATT/WTO rules can lead to an improvement over the Prisoner's Dilemma situation.

4.1 Preliminaries

As firms are symmetric, the only thing that matters to determine the sales of a given firm in a given country is whether the firm is a domestic firm or a foreign firm and how many domestic firms there are in the considered country. From (4), I thus express the domestic and foreign sales in country i with k_i firms. These quantities are functions of the import tariff $\tau(k_i)$ imposed by country i. I will be interested in the variations of these quantities with the import tariff and will evaluate them at Nash equilibrium τ_e. As N and γ are identical for all countries, for simplicity, I denote all variables as functions only of the number of domestic firms. I denote the sales of a foreign firm in country i which has k_i domestic firms by $q_F(k_i)$

$$q_F(k_i) \equiv \frac{\Gamma(0) - \Gamma(k_i)\tau(k_i)}{\Gamma(0)\Gamma(N)} \tag{15}$$

I denote the sales of one of the k_i domestic firms in its home market by $q_D(k_i)$

$$q_D(k_i) \equiv \frac{\Gamma(0) + \gamma(N - k_i)\tau(k_i)}{\Gamma(0)\Gamma(N)} \tag{16}$$

and the total consumption in country i which has k_i firms by $Q(k_i)$

$$Q(k_i) \equiv \frac{N - (N - k_i)\tau(k_i)}{\Gamma(N)} \tag{17}$$

Finally, note that due to the simplicity of preferences, it is possible to obtain a closed-form solution for welfare of country i with k_i firms, $i = 1, \ldots, n$, in a given set of countries $\mathbf{k} = \{k_1, k_2, ..., k_n\}$.

Lemma 1. *The welfare of country i with k_i firms when the set of countries in the world is $\mathbf{k} = \{k_1, k_2, ..., k_n\}$ is given by*

$$W^i(\mathbf{k}) = NS^i(k_i) + PB^i(\mathbf{k}) \tag{18}$$

with $NS^i(k_i) \equiv Q(k_i) - \frac{\gamma}{2}Q(k_i)^2 - \frac{1-\gamma}{2}\left\{k_i \left[q_D(k_i)\right]^2 + (N - k_i)\left[q_F(k_i)\right]^2\right\}$ *and*
$PB^i(\mathbf{k}) \equiv -(N - k_i)\left[q_F(k_i)\right]^2 + k_i \sum_{\substack{l=1 \\ l \neq i}}^{n} q_F(k_l)^2$

Proof. See Appendix page 40. □

$NS^i(k_i)$ are the net benefits from consumption and $PB^i(\mathbf{k})$ is the profit balance (profits that foreign firms make in country i minus export profits of country i's firms). This

decomposition of welfare will be very useful for further analysis.[13]

4.2 The principle of reciprocity with bilateral liberalisation

The principle of reciprocity has two real-world applications within the GATT/WTO negotiations. The first one that is encoded in GATT/WTO Articles enables countries to retaliate reciprocally, i.e. if a trading partner raises previously bound tariffs on imports from the home country, the home country is entitled to withdraw equivalent concessions from the trading partner. The second application that is not actually encoded in GATT/WTO Articles, but that is considered important in practice, requires countries to exchange concessions when negotiating trade liberalisation.[14]

Bagwell and Staiger (1999) formally define a tariff change as satisfying the principle of reciprocity if the change in import volumes, measured at existing world prices, is equal to the change in export volumes. In what follows, I adapt their definition of reciprocity for my model with segmented markets.

Definition 1. Consider country i and country l. A tariff change $d\boldsymbol{\tau} = (d\tau_{il}, d\tau_{li})$ is bilaterally reciprocal if it is such that $\sum_{j \in K_i} p^*_{lj} dq_{lj} - \sum_{j \in K_l} p^*_{ij} dq_{ij} = 0$.

As the principle of reciprocity is a bilateral concept, for the clarity of exposition, I first study its implication in the case with two countries in the world. I will then extend this analysis for a many-country world.

4.2.1 The principle of reciprocity in a two-country world

For the moment assume $n = 2$ and consider country i and country l. In equilibrium, trade is balanced and so we have

$$TB_{il} = \sum_{j \in K_i} p^*_{lj} q_{lj} + M_l - (\sum_{j \in K_l} p^*_{ij} q_{ij} + M_i) = 0 \tag{19}$$

Total differentiation of (19) gives

$$dTB_{il} = \sum_{j \in K_i} q_{lj} dp^*_{lj} - \sum_{j \in K_l} q_{ij} dp^*_{ij} + \sum_{j \in K_i} p^*_{lj} dq_{lj} - \sum_{j \in K_l} p^*_{ij} dq_{ij} = 0 \tag{20}$$

and thus reciprocity implies

$$\sum_{j \in K_i} q_{lj} dp^*_{lj} - \sum_{j \in K_l} q_{ij} dp^*_{ij} = 0 \tag{21}$$

[13] Furusawa and Konishi (2004) show that such a decomposition is always possible in quasi-linear economies.

[14] For a detailed discussion of the principle of reciprocity see Bagwell and Staiger (2002).

Noting that $dp^*_{ij}q_{ij} = (p_{ij} - c - \tau_{ij})dq_{ij}$, (21) is equivalent to

$$\boxed{\sum_{j\in K_i} q_{lj}dp^*_{lj} - \sum_{j\in K_l} q_{ij}dp^*_{ij}}_{ToT} + \boxed{\sum_{j\in K_i}(p_{lj} - c - \tau_{lj})dq_{lj} - \sum_{j\in K_l}(p_{ij} - c - \tau_{ij})dq_{ij}}_{MA} = 0 \tag{22}$$

which is the derivative of the bilateral 'profit balance', the difference between export profits of firms from country i in country l and export profits of firms from country l in country i.

$$PB_{il} = \sum_{j\in K_i}(p_{lj} - c - \tau_{lj})q_{lj} - \sum_{j\in K_l}(p_{ij} - c - \tau_{ij})q_{ij} \tag{23}$$

Hence we have the following proposition

Proposition 4. *In a two-country world, mutual changes in trade policy that satisfy the principle of reciprocity keep the bilateral profit balance constant.*

Proof. Follows from the previous discussion. □

In other words, a reciprocal tariff change ensures the exchange of equal terms-of-trade and market-access concessions. What does such a tariff change look like when countries are asymmetric? If country i decreases its tariff on country l by $d\tau_{il}$, by how much country l has to decrease its tariff on country i to satisfy the principle of reciprocity? Using (15) and the equilibrium profits expression (5), we can rewrite (22) as

$$dPB_{il} = 2k_i q_F(k_l)dq_F(k_l) - 2k_l q_F(k_i)dq_F(k_i) = 0 \tag{24}$$

and hence the reciprocity principle implies

$$d\tau(k_i) = \frac{k_i\Gamma(k_l)q_F(k_l)}{k_l\Gamma(k_i)q_F(k_i)}d\tau(k_l) = \frac{k_i\Gamma(k_l)\left[\Gamma(0) - \Gamma(k_l)\tau(k_l)\right]}{k_l\Gamma(k_i)\left[\Gamma(0) - \Gamma(k_i)\tau(k_i)\right]}d\tau(k_l) \tag{25}$$

So the proportion in which the two countries have to liberalise in order to satisfy the principle of reciprocity depends on their respective numbers of domestic firms and on their import tariffs.

Proposition 5. *At Nash equilibrium, to satisfy the principle of reciprocity, a country with more firms has to reduce tariffs by more than a country with fewer firms.*

Proof. See Appendix page 41. □

A country with more firms exports more and imports less than a country with fewer firms and so it has to liberalise more to offer equivalent market-access and terms-of-trade

concessions.[15]

How does a reciprocal liberalisation affect the welfare of participating countries? The effect of a reciprocal liberalisation $d\boldsymbol{\tau} = (d\tau_{il}, d\tau_{li})$ on welfare of country i can be decomposed using (18) into effects on the net benefits from consumption and the effects on the profit balance: $dW^i = dNS^i + dPB^i$. In a two-country world, consumers gain from trade liberalisation ($dNS^i < 0$), because they get access to more and cheaper products (reduced tariffs on imports mean that imported quantities increase and prices go down which also drives prices of domestic products down and produced quantities up). The profit balance is kept constant ($dPB^{il} = dPB^i = 0$) by the principle of reciprocity and so the welfare increases. Furthermore, by ensuring a mutual exchange of terms-of-trade and market-access concessions, the principle of reciprocity neutralises the two externalities driving inefficient tariff setting and governments can thus reach efficient tariff levels.

Proposition 6. *In a two-country world, bilaterally reciprocal trade liberalisation monotonically increases welfare in both countries and enables countries to reach the efficient tariff levels.*

Proof. See Appendix page 41. □

4.2.2 The principle of reciprocity in a many-country world

What are the impacts of a bilateral reciprocal trade liberalisation if there are more than two countries in the world? Is such trade liberalisation still welfare increasing for the liberalising countries?

Assume now $n > 2$ and consider a trade liberalisation among country i and l such that their bilateral trade balance is kept constant. As non-participating countries in this liberalisation are not changing their tariffs, export profits of country i in these countries do not change. On the other hand, export profits of the non-liberalising countries in country i decrease by trade diversion so the multilateral profit balance increases ($dPB^{il} = 0$, but $dPB^i < 0$). Consumers benefit from cheaper imports from the trading partner taking part in the liberalisation, but they might be hurt by reduced imports from the other trading partners (trade diversion). So consumers do not necessarily benefit in this case.

[15]This result could be linked to the actual progress in trade liberalisation. Developed countries have on average liberalised trade more than developing countries. In reality, there are provisions in the WTO agreements allowing developing countries to liberalise less and take more time to implement trade liberalisation. If we model developed countries as more competitive, my model shows that, even without these provisions, with the given definition of reciprocity, developing countries would be required to liberalise less. A similar result was derived by Baldwin and Robert-Nicoud (2000) who study free trade agreements between asymmetric countries in an economic geography model. To motivate their analysis, they list several North-South type trade agreements where Northern (larger and more developed) countries were required to liberalise faster (e.g. free trade deals between the European Union and the Central and Eastern European countries, Asia-Pacific Economic Co-operation initiative or the ASEAN Free Trade Area). Their model explains this asymmetry as preventing firm delocation whereas here it assures the exchange of equivalent market-access and terms-of-trade concessions.

The increase in the profit balance may be smaller than the decrease in net benefits of consumption, depending on the parameters of the model, and so overall welfare may decrease. This situation arises for example when the bilateral trade liberalisation starts from a situation where country i is charging high tariffs on imports from other countries than country l. This result is reminiscent of the so-called "concertina rule" for tariff reform which aims to lower the variance of the tariff structure.[16] The following proposition summarises the effects of a reciprocal liberalisation on welfare of the liberalising countries.

Proposition 7. *In an n-country world, $n > 2$, bilaterally reciprocal trade liberalisation between two countries has an ambiguous impact on the welfare of these countries.*

Proof. See Appendix page 41. □

4.3 The principle of non-discrimination

The previous subsection showed that reciprocal liberalisation can increase welfare of both participating countries, but does not always necessarily do so in a many-country world. In this subsection, I show that if two countries liberalise trade between themselves, outsiders are made unambiguously worse off. This phenomenon is well known in the literature since Viner (1950) as trade diversion. Thus the bilateral principle of reciprocity is not sufficient to ensure a monotonic increase in welfare of all countries in a many-country world. This will provide motivation for the non-discrimination principle.

Note that in this model, a given country is affected by other countries' tariffs only through its export profits to these countries. Suppose that a subset of s countries decide to liberalise trade among themselves. S firms in total are located in this subset of countries. How will this liberalisation affect the $n - s$ non-involved countries? Suppose country i is involved in the trade liberalisation. The following expression gives the sales in country i of a firm located in one of the non-involved countries

$$q_F(k_i) = \frac{\Gamma(0) - \Gamma(S)\bar{\tau}(k_i) + \gamma(S - k_i)\tau(k_i)}{\Gamma(0)\Gamma(N)} \tag{26}$$

where $\bar{\tau}(k_i)$ is the tariff imposed by country i on countries not involved in the liberalisation and is thus constant, and $\tau(k_i)$ is the tariff that country i imposes on its trading partners involved in the liberalisation. This tariff will be reduced in the trade liberalisation considered.

Proposition 8. *A discriminatory liberalisation harms countries that are not involved in it.*

Proof. From (26), $\frac{dq_F(k_i)}{d\tau(k_i)} = \frac{\gamma(S-k_i)}{\Gamma(0)\Gamma(N)} > 0$. □

[16] For a discussion of the "concertina rule" for tariff reform see for example Neary (1998).

The role of the non-discrimination principle will be to prevent discriminatory trade liberalisation.

4.4 Multilateral trade liberalisation under the GATT/WTO principles

In this subsection, I determine the impacts on welfare of a trade liberalisation that follows both the reciprocity and non-discrimination principles. The non-discrimination principle 'multilaterises' the reciprocity principle. A reciprocal tariff change leaves the trade balance between the two trading partners constant. The non-discrimination principle says that if a country decreases its trade barriers with respect to one of its trading partners, it has to do so with all other trading partners. The combination of these two principles can be formally stated as follows.

Definition 2. A tariff change $d\boldsymbol{\tau}$ is multilaterally reciprocal if it is such that

$$\sum_{\substack{l=1\\l\neq i}}^{n}\sum_{j\in K_i} p^*_{lj}dq_{lj} - \sum_{j\notin K_i} p^*_{ij}dq_{ij} = 0 \tag{27}$$

Similarly to the bilateral case, (27) implies that the multilateral profit balance

$$PB^i = \sum_{\substack{l=1\\l\neq i}}^{n}\sum_{j\in K_i}(p_{lj} - c - \tau_{lj})q_{lj} - \sum_{j\notin K_i}(p_{ij} - c - \tau_{ij})q_{ij} \tag{28}$$

is kept constant, i.e. (27) implies

$$\underbrace{\boxed{\sum_{\substack{l=1\\l\neq i}}^{n}\sum_{j\in K_i} q_{lj}dp^*_{lj} - \sum_{j\notin K_i} q_{ij}dp^*_{ij}}}_{ToT} + \underbrace{\boxed{\sum_{\substack{l=1\\l\neq i}}^{n}\sum_{j\in K_i}(p_{lj} - c - \tau_{lj})dq_{lj} - \sum_{j\notin K_i}(p_{ij} - c - \tau_{ij})dq_{ij}}}_{MA} = 0 \tag{29}$$

Proposition 9. *The principle of reciprocity together with the principle of non-discrimination ensure that the multilateral profit balance is kept constant during multilateral trade liberalisation.*

Proof. Follows from the previous discussion. □

When countries liberalise trade with all their trading partners following the principles of reciprocity and non-discrimination, consumers benefit from cheaper imports from all countries and the multilateral profit balance is kept constant, so welfare unambiguously increases.

Proposition 10. *A trade liberalisation following both the principle of reciprocity and non-discrimination monotonically increases the welfare of all countries and enables countries to reach efficient tariff levels.*

Proof. See Appendix page 43. □

By neutralising both the terms-of-trade and market-access externalities, the principles of reciprocity and non-discrimination enable countries to reach the efficient outcome.

5 Market-access rationale and export policy

The previous analysis showed how countries, when acting non-cooperatively, use import tariffs to improve their terms of trade and to restrict market access of foreign firms. This leads to inefficiently high tariff levels. Trade agreements help countries overcome both the terms-of-trade and market-access externalities and reach the efficient tariff levels. But what if countries use export instruments instead of import tariffs? Does the concern for market access still provide a rationale for trade agreements? To answer this question, this subsection examines the case where governments use export subsidies instead of import tariffs. The welfare of country i is now

$$W^i = CS^i + \sum_{j \in K_i} \pi^{ij} - SE^i + \sum_{\substack{l=1 \\ l \neq i}}^{n} \sum_{j \in K_i} \pi^{lj} \tag{30}$$

where SE^i is the subsidy expenditure. The effect of an increase in the export subsidy can be, similarly to the tariff case, decomposed into a terms-of-trade effect and volume-of-trade effect and a market-access effect[17]

$$\frac{dW^i}{d\sigma_{hk}} = \boxed{\sum_{j \in K_i} q_{hj} \frac{dp_{hj}}{d\sigma_{hk}}}_{ToT} \boxed{- \sum_{j \in K_i} \sigma_{hj} \frac{dq_{hj}}{d\sigma_{hk}}}_{VoT} + \boxed{\sum_{j \in K_i} (p_{hj} - c + \sigma_{hj}) \frac{dq_{hj}}{d\sigma_{hk}}}_{MA} \tag{31}$$

An export subsidy deteriorates country i's terms of trade, increases the volume of exports and improves domestic firms market access to the foreign markets.

5.1 Nash equilibrium subsidy

The following proposition derives countries' optimal subsidy.

Proposition 11. *The unique Nash optimal subsidy of country i with k_i firms to export to country h with k_h firms is*

[17] The derivation of this decomposition is given in Appendix B page 38.

$$\sigma_{e_{hi}} = \frac{c(k_i)}{[a(k_i) - k_i]\left[1 + \sum_{\substack{l=1 \\ l \neq h}}^{n} \frac{k_l}{a(k_l) - k_l}\right]} \tag{32}$$

with $a(k_i) \equiv \frac{2\Gamma(N-k_i)[(1-\gamma)\Gamma(N)+k_i\gamma]}{\gamma^2[\Gamma(N)-2k_i]}$ *and* $c(k_i) \equiv \frac{\Gamma(0)}{\gamma}$. $\sigma_{e_{hi}} > 0 \Leftrightarrow k_i < \frac{\Gamma(N)}{2}$.

Proof. See Appendix page 44. □

Similarly to the two-country case solved by Dixit (1984), in the many-country case, the sign of the optimal subsidy depends on the number of exporting firms. If country i has relatively few firms ($k_i < \frac{\Gamma(N)}{2}$), the oligopolistic distortion is important and the country does not export a lot, so it is optimal to subsidise exports to correct this distortion. If country i has relatively many firms ($k_i > \frac{\Gamma(N)}{2}$), the oligopolistic distortion is small and the country exports a lot, so it is optimal to tax exports to improve the terms of trade. Note that the cut off number of domestic firms depends on the substitution index γ. If goods are not very substitutable, a subsidy cannot sufficiently improve the market access of domestic firms to the foreign market at the expense of other firms and so it is less effective to subsidise exports. When $\gamma = 0$ or $k_i = \frac{\Gamma(N)}{2}$, $\sigma_{e_{hi}} = 0$, the optimal subsidy is zero.

5.2 Optimal subsidy in the absence of terms-of-trade manipulation

To make it clear that the market-access rationale encourages countries to subsidise exports, I proceed in the same way as in the case of an import tariff and consider a hypothetical world where the terms-of-trade effects of the export instrument are ignored. To be precise, the terms-of-trade effect in (31) is omitted and the subsidy in the absence of the terms-of-trade effect satisfies the following first order condition

$$\frac{d\tilde{W}^i}{d\sigma_{hk}} = \boxed{-\sum_{j \in K_i} \sigma_{hj} \frac{dq_{hj}}{d\sigma_{hk}}}_{VoT} + \boxed{\sum_{j \in K_i} (p_{hj} - c + \sigma_{hj}) \frac{dq_{hj}}{d\sigma_{hk}}}_{MA} = 0 \tag{33}$$

Proposition 12. *The unique Nash optimal subsidy of country i with k_i firms to export to country h with k_h firms in the absence of terms-of-trade effects is*

$$\tilde{\sigma}_{e_{hi}} = \frac{c(k_i)}{[\tilde{a}(k_i) - k_i]\left[1 + \sum_{\substack{l=1 \\ l \neq h}}^{n} \frac{k_l}{\tilde{a}(k_l) - k_l}\right]} \geq 0 \tag{34}$$

with $\tilde{a}(k_i) \equiv \frac{\Gamma(0)\Gamma(N)-\Gamma(N-k_i)}{\gamma} > 0$.

Proof. See Appendix page 46. □

So in the absence of terms-of-trade effects, countries would unambiguously subsidise exports.

5.3 Optimal subsidy in the absence of market-access concern

Now consider a hypothetical world where the market-access effects of the export instrument are ignored. To be precise, the market-access effect in (31) is omitted and the subsidy in the absence of the market-access effect satisfies the following first order condition

$$\frac{d\hat{W}^i}{d\sigma_{hk}} = \boxed{\sum_{j\in K_i} q_{hj}\frac{dp_{hj}}{d\sigma_{hk}}}_{ToT} - \boxed{\sum_{j\in K_i}\sigma_{hj}\frac{dq_{hj}}{d\sigma_{hk}}}_{VoT} = 0 \tag{35}$$

Proposition 13. *The unique Nash optimal subsidy of country i with k_i firms to export to country h with k_h firms in the absence of terms-of-trade effects is*

$$\hat{\sigma}_{e_{hi}} = \frac{c(k_i)}{[\hat{a}(k_i)-k_i]\left[1+\sum_{\substack{l=1\\ l\neq h}}^{n}\frac{k_l}{\hat{a}(k_l)-k_l}\right]} \leq 0 \tag{36}$$

with $\hat{a}(k_i) \equiv -\frac{\Gamma(N-k_i)[2(1-\gamma)\Gamma(N)+\Gamma(N+k_i)]}{\gamma[\Gamma(N+k_i)-\gamma\Gamma(N)]} < 0.$

Proof. See Appendix page 46. □

So in the absence of market-access effects, countries would unambiguously tax exports. This would be the case under perfect competition (in the absence of political motivations) where governments use trade instruments purely to manipulate their terms of trade. This result forms the basis of Ethier's critique of the terms-of-trade rationale for trade agreements. The GATT does not contain any restrictions on export taxes and under the current trade agreements, governments can still manipulate their terms of trade if they wished to do so. So restricting terms-of-trade manipulation does not seem to provide the right motivation for trade agreements.[18]

This section shows that the concern for market access makes countries tend to subsidise exports. Export subsidies are explicitly forbidden by Article XVI of the GATT. So the market-access motivation seems to provide a plausible rationale for trade agreements in the case of export subsidies. The natural follow-up question is why do trade agreements restrict the use of subsidies? What is the efficient level of export subsidies?

[18]Bagwell and Staiger (2001) provide a motivation for export subsidies in a three-country extension of the traditional international trade model with perfect competition where governments are politically motivated. It is only because of the political motive to increase producer surplus of export industries that the optimal policy is an export subsidy. The terms-of-trade motivation does not provide a rationale for export subsidies.

5.4 Efficient export policy: joint welfare maximisation

Internationally efficient export instruments would maximise the sum of all countries' welfare. Terms-of-trade effects cancel each other out in the sum of welfare functions and the objective function now takes into account the oligopolistic inefficiency in all countries. The efficient export policy satisfies the following first order condition

$$\frac{d}{d\sigma_{hk}} \sum_{l=1}^{n} W^l = \sum_{j=1}^{N} (p_{hj} - c) \frac{dq_{hj}}{d\sigma_{hk}} = 0 \tag{37}$$

Proposition 14. *The joint-welfare-maximising export subsidy of country i with k_i firms to export to country h with k_h firms is*

$$\sigma_{J_{hi}} = \frac{c_J(k_i)}{[a_J(k_i) - k_i] \left[1 + \sum_{\substack{l=1 \\ l \neq h}}^{n} \frac{k_l}{a_J(k_l) - k_l} \right]} \geq 0 \tag{38}$$

with $a_J(k_i) \equiv -\frac{\Gamma(N)\Gamma(N-k_i)(1-\gamma)+k_i\gamma\Gamma(0)}{\gamma^2[\Gamma(N)-N]}$ *and* $c_J(k_i) \equiv \frac{\Gamma(0)^2}{\gamma^2[\Gamma(N)-N]}$.

Proof. See Appendix page 47. □

The efficient subsidy is a real subsidy, so is there a reason for trade agreements to restrict export subsidies? It is easy to show that the subsidy applied in the absence of terms-of-trade effects (34) is greater than the efficient subsidy (38). So when countries do not cooperate, the market-access effect would tend to make them chose inefficiently high subsidies. Subsidising exporting firms improves market access of these firms to foreign markets, but this harms other exporting countries and the import-competing domestic firms. The efficient subsidy takes into account these harmful effects and is thus lower. This provides a motivation for the restriction of export subsidies.

6 Distribution of benefits from multilateral trade liberalisation

I now return to the case where import tariffs are the only instruments. Subsection 4.4 showed that multilateral liberalisation according to the GATT/WTO principles unambiguously increases welfare of all countries. It might therefore seem puzzling why there is sometimes resistance towards trade liberalisation if everyone benefits. Here, I clarify this point by analysing the within- as well as between-country distribution of benefits from multilateral trade liberalisation.

6.1 Impacts of multilateral trade liberalisation on consumer surplus

Intuitively, consumers are better off when trade is liberalised as trade increases the variety of available products and restricts the monopoly power of domestic firms. The following study shows this formally. The consumer surplus of country i is given by

$$CS(k_i) = \frac{\gamma}{2} Q(k_i)^2 + \frac{1-\gamma}{2} \left[k_i q_D(k_i)^2 + (N - k_i) q_F(k_i)^2 \right] \tag{39}$$

Proposition 15. *Consumer surplus is a decreasing function of the country's own tariff.*

Proof. See Appendix page 49 □

Consumers unambiguously gain from trade liberalisation. As consumer surplus does not depend on tariffs of foreign countries and it is a decreasing function of country's own tariff, consumers would be better off even in the case of a unilateral trade liberalisation.

6.2 Impacts of multilateral trade liberalisation on producer surplus

Producers are affected both by tariffs of their own country which protect them from foreign competition and by tariffs imposed by foreign countries which limit their exports. In country i, the sum of profits of the k_i domestic firms is

$$\Pi^i(\mathbf{k}) = \sum_{j \in K_i} \pi^{ij} + \sum_{\substack{l=1 \\ l \neq i}}^{n} \sum_{j \in K_i} \pi^{lj} = k_i q_D(k_i)^2 + k_i \sum_{\substack{l=1 \\ l \neq i}}^{n} q_F(k_l)^2 \tag{40}$$

Profits in the home country are an increasing function of the country's own tariff, but export profits are a decreasing function of the tariffs imposed by the foreign countries. The following proposition summarises the impact on profits of a multilateral trade liberalisation following the GATT/WTO principles of reciprocity and non-discrimination.

Proposition 16. *When countries liberalise multilaterally according to the principles of reciprocity and non-discrimination, country i's firms' profits increase if and only if $\tau(k_i) < \tau_{\Pi min}$ with*

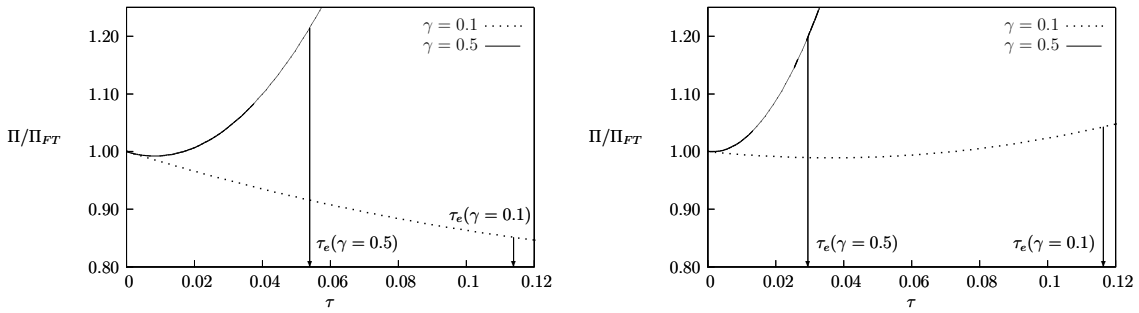
$$\tau_{\Pi min} = \frac{\Gamma(0)^2}{\Gamma(k_i)^2 + k_i \gamma^2 (N - k_i)} \tag{41}$$

and $\tau_{\Pi min} > \tau_e(k_i)$ for $\gamma < \gamma_c \equiv 2 + k_i - \sqrt{k_i^2 + 4k_i}$.

Proof. See Appendix page 50. □

Profits are a quadratic function of tariffs. Proposition 16 establishes that for low γ, profits are a decreasing function of the tariff vector (when all countries are liberalising

according to the principles of reciprocity and non-discrimination). So for low γ, firms are made better off by multilateral liberalisation. On the other hand for high γ, profits are a non-monotonic function of the tariff vector. If countries liberalise from the Nash tariff level τ_e, profits will initially decrease and then increase. Figure 1 shows how profit varies for tariffs between 0 and τ_e for different values of γ.



(a) $k_i = 10$ (b) $k_i = 70$

Figure 1: Profits normalised by profits in free trade as a function of the country's own tariff in a multilaterally reciprocal liberalisation with $N = 100$.

The non-monotonicity of the profit function comes from two opposing effects of trade liberalisation. When countries lower their tariffs, firms get better access to foreign markets, but at the same time they face also more competition in the domestic market. For low γ (below γ_c), goods are more independent and so access to foreign markets outweighs the disadvantages from more competition as consumers are not likely to substitute the products. But when γ is above γ_c and goods are more substitutable, the losses from more competition in the domestic market outweigh the benefits from gaining better access to foreign markets.[19]

The critical value γ_c below which gains in market access abroad outweigh losses in market access at home depends on the number of domestic firms k_i: the more firms country i has, the lower this critical value and the smaller the range of parameters where the profits are a decreasing function of the tariff. This is a consequence of the reciprocity principle: from Nash equilibrium, the more firms country i has, the more it needs to liberalise to satisfy the reciprocity principle and firms will lose more in the domestic market than they gain abroad. For example, when $k_i = 1$, $\gamma_c = 3 - \sqrt{5} \approx 0.764$ whereas when $k_i = 10$, $\gamma_c = 2(6 - \sqrt{35}) \approx 0.168$ and when $k_i = 70$, $\gamma_c \approx 0.028$.

This result suggests an explanation for why certain sectors are more difficult to liberalise than others. When goods are independent, firms are not afraid of competition and are happy to gain better access to foreign markets. When goods are more substitutable, competition is more harmful than gains from foreign market access. So in this case, firms would be willing to lobby the government not to take part in liberalisation. Trade lib-

[19]See Neary (2009) for a discussion of this U-shaped relationship in a slightly different setting.

eralisation in manufacturing versus trade liberalisation in agriculture could be seen as a possible example of this phenomenon. Liberalisation in manufacturing where goods can be viewed as independent (because different) was highly successful. On the other hand, liberalisation in agriculture (where goods are close substitutes - a banana from Brazil or Costa Rica is still a banana) was and still is very difficult.

7 Formula-based trade liberalisation

The previous section analysed cooperative trade liberalisation following the principles of reciprocity and non-discrimination as generally defined in the literature. It is important to note that the interpretation of the principle of reciprocity presented in the previous section is an elegant and convenient way of introducing this principle into models of international trade, but does not quite represent the reality of the trade liberalisation process. The reciprocity condition defined in the previous section is an *ex post* criterion and is thus difficult to implement in reality. Also, it would be impossible to negotiate tariff cuts separately for every individual product. As Ossa (2009) points out "Bagwell and Staiger's (1999) definition [of reciprocity] characterizes the ideal guiding GATT/WTO negotiations. Since this ideal is hard to implement in practice, governments often approximate it by using simple rules of thumb." Francois and Martin (2003) note that formulas are often used in real-world negotiations to determine the commitments made by each country. The goal of these formulas is to approximate the principle of reciprocity and to ensure a balanced exchange of concessions.

The simplest tariff cutting formula is a flat-rate percentage reduction (also called radial tariff cut): the same percentage reduction for all products, no matter whether the starting tariff is high or low. This kind of formula was used during the Kennedy Round. Francois and Martin (2003) note that thanks to the introduction of the formula approach it was possible to achieve a substantial cut in tariffs of about 35%. The Tokyo Round used a more sophisticated formula called the Swiss formula and reduced average tariffs by 30%. In the Uruguay Round a variety of methods was used to negotiate tariff cuts and to reach a reduction average target comparable to that of the Tokyo Round (1/3 cut).[20]

The previous analysis showed that when countries liberalise according to the theoretical principles of reciprocity and non-discrimination their welfare unambiguously increases. Is this also true for formula-based liberalisation? Are formulas a good approximation of the reciprocity principle? If not, under which conditions is a formula-based liberalisation welfare increasing? This section addresses this issue by studying trade liberalisation following the simplest formula-based method: a flat-rate percentage reduction. What is the

[20]The distribution of the tariff cut across sectors was left to negotiations between trading partners in the Uruguay Round. The result of this was that this round reduced more tariffs that were already relatively low than higher tariffs.

impact on welfare of country i of a uniform marginal tariff cut $d\alpha$ from the tariff $\alpha\tau_e(k_i)$?

The effect of such a liberalisation can again be decomposed into the effect on the net benefits from consumption and the profit balance $\frac{dW^i}{d\alpha} = \frac{dNS^i}{d\alpha} + \frac{dPB^i}{d\alpha}$. As shown above, consumers always benefit from non-discriminatory liberalisation ($dNS^i/d\alpha < 0$). On the other hand, the effect of a flat-rate tariff reduction on the profit balance can be both positive or negative depending on the parameters of the model. To further analyse the effect of a flat-rate tariff reduction, it is useful to rewrite the profit balance in the following way.

Lemma 2. *The profit balance of country i with k_i firms can be rewritten as*

$$\begin{aligned} PB^i(\mathbf{k}) = & -Nq_F(k_i)^2 + \frac{k_i}{\Gamma(0)^2\Gamma(N)^2}\{n\Gamma(0)^2 - 2\Gamma(0)n\Gamma(N/n)\bar{\tau} \\ & + \left[\check{\tau}^2 + Var(\boldsymbol{\tau})\right]\left[n\Gamma(0)^2 + 2\Gamma(0)\gamma N + \gamma^2 n(Var(\mathbf{k}) + (N/n)^2)\right]\} \end{aligned} \tag{42}$$

with $\bar{\tau} = \sum_{l=1}^{n}\omega_l\tau(k_l)$, $\omega_l = \frac{\Gamma(k_l)}{n\Gamma(N/n)}$, $\check{\tau} = \sum_{l=1}^{n}\xi_l\tau(k_l)$, $\xi_l = \frac{\Gamma(k_l)^2}{\sum_{f=1}^{n}\Gamma(k_f)^2}$, $Var(\boldsymbol{\tau}) = \sum_{l=1}^{n}\xi_l\tau(k_l)^2 - \check{\tau}^2$ *and* $Var(\mathbf{k}) = \frac{1}{n}\sum_{l=1}^{n}k_l^2 - (N/n)^2$.

Proof. Directly follows from (18). □

So the profit balance is a function of the number of domestic firms and of the tariff distribution and the distribution of the number of firms per country. From (42), we can express the effect of a flat-rate tariff cut $d\alpha$ from the tariff $\alpha\tau_e(k_i)$ on the profit balance

$$\begin{aligned} \frac{dPB^i(\mathbf{k},\alpha)}{d\alpha} = & \frac{2N\Gamma(k_i)\tau_e(k_i)}{\Gamma(0)^2\Gamma(N)^2}\left[\Gamma(0) - \alpha\Gamma(k_i)\tau_e(k_i)\right] + \frac{k_i}{\Gamma(0)^2\Gamma(N)^2}\{-2\Gamma(0)n\Gamma(N/n)\bar{\tau}_e \\ & + 2\alpha\left[\check{\tau}_e^2 + Var(\boldsymbol{\tau_e})\right]\left[n\Gamma(0)^2 + 2\Gamma(0)\gamma N + \gamma^2 n(Var(\mathbf{k}) + (N/n)^2)\right]\} \end{aligned} \tag{43}$$

In a perfectly symmetric world, where all countries would have the same number of firms (equal to the average number of firms per country N/n), the variation of the profit balance would be zero and so the trade liberalisation would be welfare increasing. In this case, a radial tariff cut would be exactly equivalent to a tariff cut following the principles of reciprocity and non-discrimination discussed in Section 4 where it has already been shown that such a multilateral trade liberalisation is welfare increasing. From (43), we can see that the derivative of the profit balance is an increasing function of both the tariff variance and the variance of the number of firms per country. So for a given country,

if the variance of the Nash tariffs or the variance of the number of firms per country[21] increase by a mean preserving spread, other things being equal, the derivative of the profit balance will increase. For a small increase in the variance, the flat-rate tariff cut can still be welfare increasing as long as the deterioration of the profit balance does not outweigh the gains in the net benefits from consumption. In other words, for a slightly asymmetric world, a flat-rate tariff cut formula is a good approximation of the principles of reciprocity and non-discrimination (by continuity). If the variances become very large, from (43) we can see that the flat-rate tariff cut may be welfare decreasing ($\frac{dPB^i(\mathbf{k},\alpha)}{d\alpha}$ may become positive and large). For a very asymmetric world, the simple formula of the radial cut is not a good approximation of the principles of reciprocity and non-discrimination.

Proposition 17. *A flat-rate tariff cut has ambiguous impacts on welfare. It may be welfare decreasing if the variance of the Nash tariffs or the variance of the number of firms per country is large.*

Proof. Follows from the previous derivations. □

Which countries would benefit from a flat-rate tariff cut for a given distribution of the firms per country (and so a given tariff distribution)? When $\gamma = 0$, a marginal flat-rate tariff cut is welfare increasing for countries that have more than $\bar{k}$ firms, where

$$\bar{k} = \frac{3(1-\alpha)N}{2(3-\alpha)n - 3 - \alpha} \tag{44}$$

So starting from Nash equilibrium ($\alpha = 1$), any country would benefit from a radial tariff cut ($\bar{k} = 0$). Starting from below the Nash equilibrium ($\alpha < 1$), a minimum number of firms is necessary. When $\gamma = 0$, goods are independent, firms do not compete with each other and governments impose tariffs to manipulate their terms-of-trade. The benefits to consumers from a more liberalised trade are limited to gains from variety as increased imports will not decrease the monopoly power of domestic firms. For the profit balance to increase, the country needs to be sufficiently an exporter.

When $\gamma > 0$, it is hard to solve for the exact conditions on the number of firms necessary for a country to benefit from a flat-rate tariff cut. As discussed above, all countries will benefit from a flat-rate tariff cut if the variance of the number of firms per country and the tariff variance are small. Intuition suggests and simulations confirm that for moderate values of the variances, countries with a sufficient number of firms and countries with very few firms will benefit. Countries with many firms, that export a lot, will benefit because their consumers will benefit and because their profit balance would improve through gains in terms of trade and market access. The profit balance of countries with very few firms will deteriorate, but their consumers will gain enormously from trade

[21] Because of the non-monotonicity and non-convexity of the Nash tariff function, the variance of the Nash tariffs depends non-monotonically on the variance of the number of firms per country.

liberalisation so that the increase in consumer surplus will outweigh the deterioration of the profit balance. For very large variances, for countries with few firms, the deterioration of the profit balance will be more important than the gain in the net benefits from consumption and so only countries with a sufficient number of firms will benefit from a flat-rate tariff cut.[22]

8 Partial participation: Why multilateralism worked and is now broken

Section 4 showed that multilateral trade liberalisation following the reciprocity and non-discrimination principles is welfare increasing for all countries, nevertheless Section 6 showed that not all interest groups gain from this liberalisation in the same way and some might even lose. Section 7 suggested that formula-based trade liberalisation may be welfare decreasing for some countries in certain circumstances. It is therefore understandable that it might be difficult to reach an agreement among all countries. This section explores what happens when all countries do not agree to liberalise trade, but a subgroup does.

8.1 Participation constraint in reciprocity-based trade liberalisation

If all countries do not agree on a trade liberalisation, a subset of countries might. This subset of countries might be tempted to liberalise trade among themselves. This, as we have seen in subsection 4.3, would make the non-involved countries worse off and it is forbidden by the non-discrimination principle.[23] What if a subset of countries agree to lower their tariffs unilaterally, i.e. on everyone else? The non-involved countries, the free-riders, would unambiguously benefit as they would gain free market access in the liberalising countries and their terms of trade would improve. The following proposition states under which conditions a unilateral trade liberalisation by a subgroup of countries is welfare increasing for a country belonging to this subgroup. The liberalisation considered here follows the principles of reciprocity and non-discrimination: a subgroup of countries liberalise reciprocally and they extend this liberalisation unilaterally to all other countries.

Assume a subset of p countries decides to liberalise trade unilaterally. P firms are located in these countries. What is the effect of such a liberalisation on welfare of country

[22] If we interpret countries with many firms as developed countries and countries with few firms as developing countries, this result provides another justification for why developing countries liberalise less than developed countries.

[23] Article XXIV of the WTO provides an exception to the non-discrimination principle and allows formation of regional trade agreements. But one of the conditions for these agreements is that internal barriers should be completely removed. Partial discriminatory trade liberalisation is not permitted.

i who is reducing its tariffs by $d\alpha$ from $\alpha\tau_e(k_i)$ while the other liberalising countries reduce their tariffs in such a way as to satisfy the principles of reciprocity and non-discrimination? The effect can again be decomposed into the effect on the net benefits from consumption and the profit balance. Once more consumers gain. The profit balance among the liberalising countries is kept constant by reciprocity and non-discrimination. Non-participating countries keep their tariffs fixed, so export profits of the liberalising countries into the free-riding countries do not change. On the other hand, liberalising countries are giving away free profit concessions to the free-riders.

$$\frac{dW^i}{d\alpha} = \frac{dNS(k_i)}{d\alpha} - (N-P)\frac{d\left[q_F(k_i)^2\right]}{d\alpha} \tag{45}$$

Lemma 3. *The more countries with more firms are involved in unilateral reciprocity-based trade liberalisation, the larger the increase in welfare of these countries. I.e.*

$$\frac{d}{dP}\left(\frac{dW}{d\alpha}\right) < 0$$

Proof. $\frac{d}{dP}\left(\frac{dW^i}{d\alpha}\right) = 2\frac{dq_F(k_i)}{d\alpha}q_F(k_i) < 0$ □

The derivative of welfare with respect to the tariff is a linear decreasing function of the number of firms involved in the trade liberalisation P. There exists a minimum number of firms necessary for the trade liberalisation to be welfare increasing. The following proposition establishes the minimum participation constraint so that a marginal reciprocity-based trade liberalisation is welfare increasing for country i that has k_i firms.

Proposition 18. *A marginal unilateral tariff cut from $\alpha\tau_e(k_i)$ is welfare increasing for a liberalising country with k_i firms if and only if the subgroup of trade liberalising countries has more than $\bar{P}_r$ firms ($k_i \leq \bar{P}_r \leq N$), where*

$$\bar{P}_r = \bar{P}_r(\alpha, k_i, N, \gamma) = \frac{A(k_i) - \alpha B(k_i)\tau_e(k_i)}{2\Gamma(k_i)\left[\Gamma(0) - \alpha\Gamma(k_i)\tau_e(k_i)\right]} \tag{46}$$

with $A(k_i) \equiv \Gamma(0)\left[N\Gamma(2k_i) + k_i\Gamma(0)\right]$ *and*
$B(k_i) \equiv (N-k_i)^2\gamma\left[\Gamma(0)^2 + (1-\gamma)k_i\gamma\right] + \Gamma(k_i)^2\left[(3-\gamma)N - (1-\gamma)k_i\right]$

Proof. See Appendix page 51. □

Proposition 18 says that unilateral trade liberalisation following reciprocity and non-discrimination principles can be welfare-increasing if the countries involved represent a sufficient part of world production. The larger the tariff cut, the more participation is needed to make this cut welfare increasing.

The minimum participation constraint is a constraint in terms of the number of participating firms. This is a consequence of the fact that the principle of reciprocity takes

into account the different numbers of firms in the participating countries. It ensures that liberalising countries exchange balanced terms-of-trade and market-access concessions. The only adverse effects on welfare come from giving away free terms-of-trade and market-access concessions to the free-riding countries. So the number of firms located in the free-riding countries which will export to the liberalising countries determines whether this partial liberalisation will be welfare increasing or not. And hence the number of firms located in the participating countries is a sufficient indicator.

The following corollaries study the unilateral trade liberalisation with partial participation in particular situations to better illustrate the minimum participation condition given by equation (46).

Corollary 1. *Starting from Nash equilibrium* ($\alpha = 1$)*, a marginal unilateral reciprocity-based trade liberalisation is welfare increasing for a liberalising country with* k_i *firms if and only if at least one other trading partner liberalises as well,* $P > \bar{P}_r(1, k_i, N, \gamma) = k_i$.

Figure 2 shows how welfare changes as a function of the import tariff when only one country liberalises trade unilaterally ($P = k_i$) and where several countries ($P > k_i$) liberalise unilaterally following the GATT/WTO principles. If only one country were to liberalise from Nash equilibrium, its welfare would obviously decrease, but as soon as another country liberalises as well, the trade liberalisation can lead to higher welfare.

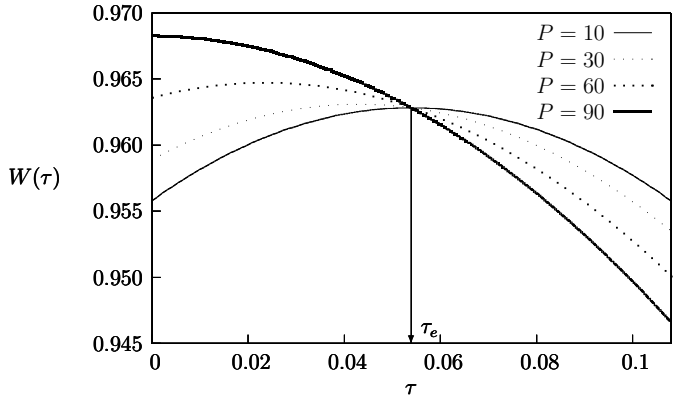


Figure 2: Welfare as a function of tariff with $N = 100$, $\gamma = 0.5$, $k_i = 10$.

Corollary 2. *Unilateral free trade* ($\alpha = 0$) *is welfare maximising for a liberalising country with* k_i *firms if and only if the subgroup of trade liberalising countries has* $\bar{P}_{r_{FT}}$ *firms, where*

$$\bar{P}_{r_{FT}} = \bar{P}_r(0, k_i, N, \gamma) = \frac{A(k_i)}{2\Gamma(k_i)} = \frac{N\Gamma(2k_i) + k_i\Gamma(0)}{2\Gamma(k_i)} \tag{47}$$

Figure 2 illustrates this result: when $N = 100$ and $k = 10$, unilateral free trade is welfare maximising if the participating countries have in total 90 firms.

Note that $\Gamma(2k_i)+\Gamma(0) = 2\Gamma(k_i)$ and so $\bar{P}_{r_{FT}}$ is a weighted average of the total number of firms in the world N and the number of domestic firms k_i. So $\bar{P}_{r_{FT}}$ is an increasing function of the total number of firms in the world ($\frac{d\bar{P}_{r_{FT}}}{dN} > 0$). A sufficient proportion of the total number of firms in the world is needed. If the total number of firms in the world increases, this proportion increases. $\bar{P}_{r_{FT}}$ is also an increasing function of the number of domestic firms ($\frac{d\bar{P}_{r_{FT}}}{dk_i} = \frac{\Gamma(0)\Gamma(N)}{2\Gamma(k_i)^2} > 0$). If the country considered has a lot of firms compared to its liberalising partners, it will have to liberalise a lot to satisfy the reciprocity condition and it will need a sufficient number of partner countries with few firms to make the trade liberalisation welfare increasing. If the country considered has few firms compared to its liberalising partners, it will liberalise less than its partners according to the reciprocity condition and so the minimum number of necessary partners is smaller. Finally, $\bar{P}_{r_{FT}}$ is an increasing function of the substitution index γ ($\frac{d\bar{P}_{r_{FT}}}{d\gamma} = \frac{k_i(N-k_i)}{\Gamma(k_i)^2} > 0$). The more goods are substitutable, the more participation is needed to offer enough market access to firms in foreign markets to compensate for more competition in the domestic market.

In a perfectly symmetric world where each country has only one firm, the minimum condition becomes a condition on the minimum number of countries involved.

Corollary 3. *In a perfectly symmetric world, unilateral free trade is welfare maximising for liberalising countries if and only if $\bar{p}_{r_{SymFT}}$ countries participate, where*

$$\bar{p}_{r_{SymFT}} = \frac{2N + \gamma(N-1) + 2}{4} \tag{48}$$

Note that with $\gamma = 0$, the number of countries that has to agree to liberalise (with everyone else) has to be greater than $(N+1)/2$ and when $\gamma = 1$, this group has to have more than $(3N+1)/4$ for the liberalisation to be welfare enhancing.

8.2 Participation constraint in formula-based trade liberalisation

As discussed in Section 7, countries typically negotiate tariff cuts according to formulas. Does the previous result of minimum participation carry through in the flat-rate liberalisation case? More interestingly, Section 7 showed that some countries might not benefit from a formula-based trade liberalisation. What if only countries that would benefit from such a liberalisation decided to participate? Could they still achieve a higher level of welfare?

Assume again that a subset of p countries with P firms decide to liberalise trade unilaterally, but this time trade liberalisation is a flat-rate tariff cut $d\alpha$ from $\alpha\tau_e$ for all the participating countries. Without loss of generality, assume that the p liberalising countries are the first p countries in the set of countries $\mathbf{k} = \{k_1, k_2, \ldots, k_n\}$. The effect

of the tariff cut on welfare can again be decomposed into the effect on the net benefits from consumption and the effect on the profit balance, but as the flat-rate tariff cut does not internalise the market structure of the liberalising countries (contrarily to the reciprocity-based liberalisation), the effect on the profit balance now depends on the tariff distribution and the distribution of the number of firms per country among the liberalising countries.

$$\frac{dW^i}{d\alpha} = \frac{dNS(k_i)}{d\alpha} - N\frac{d\left[q_F(k_i)^2\right]}{d\alpha} - \frac{2pk_i}{\Gamma(0)^2\Gamma(N)^2} f_p(\mathbf{k}) \tag{49}$$

with $f_p(\mathbf{k}) = \Gamma(0)\Gamma(P/p)\bar{\tau}_{e_p} - \alpha\left[\check{\tau}_{e_p}^2 + Var_p(\boldsymbol{\tau_e})\right]\left[\Gamma(0)^2 + 2\Gamma(0)\gamma P/p + \gamma^2(Var_p(\mathbf{k}) + (P/p)^2)\right]$ where $\bar{\tau}_{e_p} = \sum_{l=1}^{p}\omega_l\tau_e(k_l)$, $\check{\tau}_{e_p} = \sum_{l=1}^{p}\xi_l\tau_e(k_l)$, $Var_p(\boldsymbol{\tau_e}) = \sum_{l=1}^{p}\xi_l\tau_e(k_l)^2 - \check{\tau}_{e_p}^2$ and $Var_p(\mathbf{k}) = \frac{1}{p}\sum_{l=1}^{p}k_l^2 - (P/p)^2$.

Lemma 4. *The more countries are involved in unilateral formula-based trade liberalisation, the larger the increase in welfare of these countries. I.e.*

$$\frac{d}{dp}\left(\frac{dW}{d\alpha}\right) < 0$$

Proof. Export profits decrease when foreign countries raise tariffs so $\frac{d}{dp}\left(\frac{dW}{d\alpha}\right) = -\frac{2k_i}{\Gamma(0)^2\Gamma(N)^2} f_p(\mathbf{k}) < 0$. □

The derivative of welfare with respect to the tariff is also in this case a decreasing function of the number of countries involved in the trade liberalisation p. There exists a minimum number of countries necessary for the trade liberalisation to be welfare increasing. The following proposition establishes the minimum participation constraint so that a marginal formula-based trade liberalisation is welfare increasing for country i that has k_i firms.

Proposition 19. *A marginal unilateral radial tariff cut from $\alpha\tau_e(k_i)$ is welfare increasing for a liberalising country with k_i firms if and only if at least $\bar{p}_f^i$ countries participate, where*

$$\bar{p}_f^i = \bar{p}_f^i(\alpha, \mathbf{k}, N, \gamma) = \frac{\tau_e(k_i)\left[A(k_i) - \alpha B(k_i)\tau_e(k_i)\right]}{2k_i f_p(\mathbf{k})} \tag{50}$$

Proof. See Appendix page 51. □

Proposition 19 establishes an equivalent result to Proposition 18. In the case of a radial trade liberalisation, the minimum participation constraint is a constraint in terms of the number of participating countries. A flat-rate tariff cut does not ensure the exchange of balanced concessions among the liberalising countries if countries are asymmetric. Thus in this partial liberalisation, liberalising countries are giving away free terms-of-trade and

market-access concessions to the free-riding countries, but also some countries may be giving away more concessions to their liberalising partners than they receive in return. So for a partial liberalisation to be welfare increasing, there needs to be a sufficient number of participating countries and this number depends on the distribution of firms per country within the participating countries. The higher the variance of the number of firms per country, the more participation is needed. One crucial difference with the reciprocity-based case is that depending on the parameters of the model, the minimum number of participating countries is not necessarily smaller than the total number of countries. As Section 7 showed, a multilateral flat-rate tariff cut may be welfare decreasing for some countries. If this is the case, there is obviously no way the same tariff cut with less participants could be welfare increasing.

An important policy-related consequence of this minimum participation constraint is that in cases where a flat-rate tariff cut may not be welfare increasing for all countries, it may be possible to design a welfare increasing trade liberalisation where only countries that benefit participate.

The following corollaries establish the minimum participation constraint in the same particular cases as discussed in the previous subsection.

Corollary 4. *Starting from Nash optimal tariffs* ($\alpha = 1$)*, a marginal unilateral formula-based trade liberalisation is welfare increasing for a liberalising country with* k_i *firms if and only if at least* $\bar{p}_f^i(1, \mathbf{k}, N, \gamma)$ *countries participate, where*

$$\bar{p}_f^i(1, \mathbf{k}, N, \gamma) = \frac{\tau_e(k_i)\left[A(k_i) - B(k_i)\tau_e(k_i)\right]}{2k_i f_p(\mathbf{k})}$$

So in general, starting from Nash equilibrium, it may not be sufficient to have just any one liberalising partner. The number of necessary liberalising partners depends on the distribution of the number of firms among these partners.

Corollary 5. *Unilateral free trade* ($\alpha = 0$) *is welfare maximising for a liberalising country with* k_i *firms if and only if* $\bar{p}_{f_{FT}}^i$ *countries participate, where*

$$\bar{p}_{f_{FT}}^i = \bar{p}_f^i(0, \mathbf{k}, N, \gamma) = \frac{\tau_e(k_i)\left[N\Gamma(2k_i) + k_i\Gamma(0)\right]}{2k_i\Gamma(P/p)\bar{\tau}_{e_p}} \tag{51}$$

$\bar{p}_{f_{FT}}$ is an increasing function of the total number of firms in the world N, but it is a non-monotonic function of the number of domestic firms k_i.

In a perfectly symmetric world where each country has only one firm, the minimum participation constraint in the formula-based case is exactly the same as the minimum participation constraint in the reciprocity-based.

Corollary 6. *In a perfectly symmetric world, unilateral free trade is welfare maximising for liberalising countries if and only if* $\bar{p}_{f_{SymFT}}$ *countries participate, where*

$$\bar{p}_{f_{SymFT}} = \frac{2N + \gamma(N-1) + 2}{4} \tag{52}$$

8.3 Interpretation: explaining success and failure of multilateralism

The previous two subsections showed that full participation in trade liberalisation is not necessary to make trade liberalisation welfare increasing for everyone. What is necessary is a certain critical mass of participants. This result provides a motivation for participation constraints observed in various international agreements. In trade negotiations, a participation constraint has for example been required in the Information Technology Agreement (ITA): "Participants will implement the actions foreseen in the Declaration *provided that participants representing approximately 90 per cent of world trade in information technology products* have by then notified their acceptance, and provided that the staging has been agreed to the participants satisfaction."[24]

The minimum participation result also suggests a possible explanation of the initial success of GATT and the current difficulties of the multilateral trade negotiations. In all rounds before the Uruguay Round, the GATT was a two-tier organisation: developed-country members undertook trade liberalisation while developing-country members were allowed to free ride. As Irwin (1995) points out "the developing countries, for much of the postwar period, stood largely outside the GATT system in that membership did not require them to reciprocate fully the actions of other participants." Rose (2007) is even more explicit in saying "developing countries were free riders on the GATT system until the Uruguay Round." This worked, because the liberalising developed countries represented a sufficient part of world trade and the critical mass necessary for trade liberalisation to be welfare increasing for everyone was achieved. But with the recent emergence of developing countries like Brazil, China and India in world trade, this situation has changed and it is not sufficient anymore for only the subgroup of developed countries to liberalise. Without the participation of these developing countries, the minimum participation constraint is not met. Even though there are still special provisions for developing countries, all countries are now asked to make concessions in the Doha Round. Subramanian and Wei (2007) write "with the conclusion of the Uruguay Round and the creation of the WTO, this permissiveness toward developing countries started to change." Not all the developing members are willing to make these concessions.[25] Obviously, there are

[24]'Ministerial declaration on trade in information technology products', available at `http://www.wto.org/english/docs_e/legal_e/itadec_e.htm`.

[25]Developing countries that joined the WTO after 1994 have been required to make serious concessions so for example China had to liberalise trade considerably. But old developing members were not required

many other reasons why the multilateral trade negotiations are now stalling (including the disagreement between developed and developing countries over agriculture, property rights etc.) that the present simple model cannot account for, but my model suggests an additional reason which has not yet been adequately recognised.

9 Conclusion

This paper analysed trade negotiations in an oligopolistic framework and identified a new rationale for trade agreements. Countries impose inefficiently high tariffs partially because of a terms-of-trade externality identified by Bagwell and Staiger (1999), but also because of a market-access externality: in the absence of domestic competition policy, governments use trade policy to correct the oligopolistic inefficiency, i.e. they impose tariffs on imports to restrict market access of foreign firms and increase domestic production. This paper argued that trade agreements allow countries to overcome both of these externalities and reach a superior cooperative equilibrium by ensuring that countries exchange balanced profit concessions. The market-access motivation provided a rationale for agreements regarding both import and export policy.

Furthermore, this rich but tractable model enabled me to analyse features of the multilateral trade negotiations that have not yet been addressed in the literature. I have studied the role of asymmetries in trade negotiations and compared the trade liberalisation based on ex post criterion of reciprocity with that based on ex ante tariff-reduction formulae, of the kind carried out in reality. My analysis showed that asymmetries play an important role in both types of trade liberalisation. In the reciprocity-based liberalisation, starting from Nash equilibrium, countries with more firms have to cut tariffs by a greater amount than countries with fewer firms to ensure the exchange of balanced terms-of-trade and market-access concessions. In the formula-based case, some countries that do not have a sufficient number of firms may be harmed by trade liberalisation. Although one has to be careful when drawing policy implications from a highly stylized model, these results suggest a motivation for why developing countries should be required to liberalise less than their developed trading partners.

My model also proposed a possible explanation for why GATT/WTO negotiations were successful in the past but are currently struggling, through a minimum participation constraint necessary to make trade liberalisation welfare increasing. At the beginning of the GATT, mostly developed countries were liberalising trade among themselves and extending the benefits to free-riding developing countries. The participating countries represented the necessary critical mass for trade liberalisation to be welfare increasing. Now, as developing countries like Brazil or India became more important in world trade,

to make the same concessions.

the original developed countries do not represent the necessary critical mass any more and so more participation is needed which is hard to achieve.

One of the current pressing trade policy questions is: how should trade negotiations be designed to make them work? The minimum participation constraint established in this paper might be the way forward. The literature on international environmental treaties (see for example Black, Levi, and de Meza (1993) or Carraro, Marchiori, and Oreffice (2004) has established that in the presence of uncertainty over net benefits of action, an agreement requiring only sufficient, but not necessarily full, participation might be preferable. This feature needs to be further explored in the context of international trade. The present paper showed that even in the case where formula-based trade liberalisation may not be welfare increasing for all countries, it may be possible to design a welfare increasing trade liberalisation with partial participation where only benefiting countries participate. Further study of the minimum participation constraint is obviously necessary, but for the moment, the present paper suggests that the minimum participation constraint may be the future of successful trade agreements.

Appendix

A Welfare decomposition in the case of an import tariff: derivation of equation (7)

By definition, from (6) we have

$$W^i = \sum_{j=1}^{N} \frac{1}{2}(a - p_{ij})q_{ij} + \sum_{j \in K_i} (p_{ij} - c)q_{ij} + \sum_{j \notin K_i} \tau_{ij} q_{ij} + \sum_{\substack{l=1 \\ l \neq i}}^{n} \sum_{j \in K_i} (p_{lj} - c - \tau_{lj})q_{lj}$$

Country i's tariffs do not affect production or consumption decisions in other countries, so

$$\begin{aligned} \frac{dW^i}{d\tau_{ih}} = & \sum_{j=1}^{N} -\frac{1}{2}\frac{dp_{ij}}{d\tau_{ih}} q_{ij} + \sum_{j=1}^{N} \frac{1}{2}(a - p_{ij})\frac{dq_{ij}}{d\tau_{ih}} \\ & + \sum_{j \in K_i} (p_{ij} - c)\frac{dq_{ij}}{d\tau_{ih}} + \sum_{j \in K_i} \frac{dp_{ij}}{d\tau_{ih}} q_{ij} \\ & + \sum_{j \notin K_i} \frac{d\tau_{ij}}{d\tau_{ih}} q_{ij} + \sum_{j \notin K_i} \tau_{ij} \frac{dq_{ij}}{d\tau_{ih}} \end{aligned} \tag{53}$$

where the first line is the derivative of consumer surplus, the second is the derivative of domestic firms' profits in the home country and the last line is the derivative of tariff revenue. Differentiating country i's inverse demand function for firm j's good (2) gives

$$\frac{dp_{ij}}{d\tau_{ih}} = -\Big(\frac{dq_{ij}}{d\tau_{ih}} + \gamma \sum_{\substack{k=1 \\ k \neq j}}^{N} \frac{dq_{ik}}{d\tau_{ih}}\Big) \tag{54}$$

Substituting (2) and (54) in (53), noting that $\sum_{j=1}^{N} q_{ij} \sum_{\substack{k=1 \\ k \neq j}}^{N} \frac{dq_{ik}}{d\tau_{ih}} = \sum_{j=1}^{N} \frac{dq_{ij}}{d\tau_{ih}} \sum_{\substack{k=1 \\ k \neq j}}^{N} q_{ik}$, pure transfers cancel out and we obtain

$$\frac{dW^i}{d\tau_{ih}} = -\sum_{j \notin K_i} q_{ij} \frac{dp_{ij}}{d\tau_{ih}} + \sum_{j \in K_i} (p_{ij} - c)\frac{dq_{ij}}{d\tau_{ih}} + \sum_{j \notin K_i} \frac{d\tau_{ij}}{d\tau_{ih}} q_{ij} + \sum_{j \notin K_i} \tau_{ij} \frac{dq_{ij}}{d\tau_{ih}} \tag{55}$$

which can be further simplified using mill prices $p_{ij} = p_j^* + \tau_{ij}$ to give (7). □

B Welfare decomposition in the case of an export subsidy: derivation of equation (31)

Similarly to the case with import tariffs (equation (6)), in the presence of export subsidies, welfare of country i is

$$\begin{aligned} W^i &= CS^i + \sum_{j\in K_i} \pi^{ij} - SE^i + \sum_{\substack{l=1\\l\neq i}}^{n} \sum_{j\in K_i} \pi^{lj} \qquad (56)\\ &= \sum_{j=1}^{N} \frac{1}{2}(a-p_{ij})q_{ij} + \sum_{j\in K_i}(p_{ij}-c)q_{ij} - \sum_{\substack{l=1\\l\neq i}}^{n}\sum_{j\in K_i}\sigma_{lj}q_{lj} + \sum_{\substack{l=1\\l\neq i}}^{n}\sum_{j\in K_i}(p_{lj}-c+\sigma_{lj})q_{lj} \end{aligned}$$

where SE^i is the subsidy expenditure of country i. Markets are segmented and country i takes subsidies from other countries as given. The effect of a subsidy to country i's firm k to export to country h is

$$\frac{dW^i}{d\sigma_{hk}} = \frac{d}{d\sigma_{hk}} \sum_{j\in K_i}(p_{hj}-c)q_{hj} = \sum_{j\in K_i} q_{hj}\frac{dp_{hj}}{d\sigma_{hk}} + \sum_{j\in K_i}(p_{hj}-c)\frac{dq_{hj}}{d\sigma_{hk}} \qquad (57)$$

The market-access term now corresponds to the increase in market access when exports are subsidised. It would be zero under perfect competition. The correct way to write this term is therefore

$$(p_{hj}-c+\sigma_{hj})\frac{dq_{hj}}{d\sigma_{hk}}$$

which makes appear also the volume-of-trade effect and yields (31). □

C Proofs from Section 3

Proof of Proposition 1. The Nash tariff imposed by country i on imports from country h satisfies the first order condition $\frac{dW^i}{d\tau_{ih}} = 0$. From (55) we have

$$\frac{dW^i}{d\tau_{ih}} = \sum_{j\notin K_i} q_{ij}\Big(\frac{dq_{ij}}{d\tau_{ih}} + \gamma\sum_{\substack{k=1\\k\neq j}}^{N}\frac{dq_{ik}}{d\tau_{ih}}\Big) + \sum_{j\in K_i}\Big(a-c-q_{ij}-\gamma\sum_{\substack{k=1\\k\neq j}}^{N} q_{ik}\Big)\frac{dq_{ij}}{d\tau_{ih}} + \sum_{j\notin K_i}\frac{d\tau_{ij}}{d\tau_{ih}}q_{ij} + \sum_{j\notin K_i}\tau_{ij}\frac{dq_{ij}}{d\tau_{ih}}$$

I am looking for a symmetric solution $\tau(k_i)$ for a country with k_i firms. I denote $q_D(k_i)$ the sales of a domestic firm and $q_F(k_i)$ the sales of a foreign firm.

$$\frac{dW}{d\tau(k_i)} = (N-k_i)q_F(k_i)\left[\frac{dq_F(k_i)}{d\tau(k_i)} + \gamma(N-k_i-1)\frac{dq_F(k_i)}{d\tau(k_i)} + \gamma k_i \frac{dq_D(k_i)}{d\tau(k_i)}\right]$$
$$+ k_i\left[1-(1+\gamma(k_i-1))q_D(k_i) - \gamma(N-k_i)q_F(k_i)\right]\frac{dq_D(k_i)}{d\tau(k_i)}$$
$$+ (N-k_i)q_F(k_i) + (N-k_i)\frac{dq_F(k_i)}{d\tau(k_i)}\tau(k_i) = 0$$

Substituting $q_F(k_i)$ and $q_D(k_i)$ from (15) and (16), and rearranging terms yields (8). □

Proof of Proposition 2. If a country does not value the terms-of-trade effects of import tariffs, its Nash tariff will be given by the first order condition (9). Substituting the inverse demand (2) gives

$$\frac{d\tilde{W}^i}{d\tau_{ih}} = \sum_{j\in K_i}\Big(a-c-q_{ij}-\gamma\sum_{\substack{k=1\\k\neq j}}^{N} q_{ik}\Big)\frac{dq_{ij}}{d\tau_{ih}} + \sum_{j\notin K_i}\tau_{ij}\frac{dq_{ij}}{d\tau_{ih}} = 0$$

I am looking for a symmetric solution $\tau(k_i)$ for a country with k_i firms:

$$\frac{d\tilde{W}^i}{d\tau(k_i)} = k_i\{1-[1+\gamma(k_i-1)]\,q_D(k_i) - \gamma(N-k_i)q_F(k_i)\}\frac{dq_D(k_i)}{d\tau(k_i)} + (N-k_i)\tau(k_i)\frac{dq_F(k_i)}{d\tau(k_i)} = 0$$

Substituting $q_F(k_i)$ and $q_D(k_i)$ from (15) and (16), and rearranging terms yields (10). □

Proof of Proposition 3. Efficient tariffs satisfy the first order conditions (12).

$$\frac{d}{d\tau_{im}}(W^1+W^2+\cdots+W^n) = \sum_{j=1}^{N}\Big(a-c-q_{ij}-\gamma\sum_{\substack{k=1\\k\neq j}}^{N} q_{ik}\Big)\frac{dq_{ij}}{d\tau_{im}} = 0$$

I am looking for a symmetric solution $\tau(k_i)$ for a country with k_i firms:

$$k_i\left[1-q_D(k_i)-\gamma(k_i-1)q_D(k_i)-\gamma(N-k_i)q_F(k_i)\right]\frac{dq_D(k_i)}{d\tau(k_i)}$$
$$+(N-k_i)\left[1-q_F(k_i)-\gamma k_i q_D(k_i)-\gamma(N-k_i-1)q_F(k_i)\right]\frac{dq_F(k_i)}{d\tau(k_i)} = 0$$

Substituting $q_F(k_i)$ and $q_D(k_i)$ from (15) and (16), and rearranging terms yields (13). □

D Multiple instruments

Consider for simplicity the case of two countries with one firm in each and assume that countries can use tariffs on imports τ, taxes/subsidies on exports σ and domestic produc-

tion subsidies s. The following table summarises the optimal levels of these instruments for country 1 for different situations in which different combinations of these instruments are available.

Optimal values	Available instruments (a) τ_{12}	(b) τ_{12}, s_{11}	(c) σ_{21}, s_{11}	(d) τ_{12}, σ_{21}	(e) τ_{12}, σ_{21}, s_{11}
τ_{12}^*	$\frac{1}{3}$	$\frac{1-\gamma}{3-\gamma^2}$	-	$\frac{8-2\gamma^2-\gamma^3}{2(12-5\gamma^2)}$	$\frac{2(1-\gamma)}{3(2-\gamma^2)}$
σ_{21}^*	-	-	$\frac{\gamma^2(1-\gamma)}{2(2-\gamma^2)}$	$\frac{\gamma^2(4-3\gamma)}{2(12-5\gamma^2)}$	$\frac{\gamma^2(1-\gamma)}{3(2-\gamma^2)}$
s_{11}^*	-	$\frac{3-\gamma}{3-\gamma^2}$	1	-	$\frac{6-2\gamma-\gamma^2}{3(2-\gamma^2)}$
q_{11}^*	$\frac{2(3-\gamma)}{3(4-\gamma^2)}$	$\frac{3-\gamma}{3-\gamma^2}$	$\frac{4-\gamma-\gamma^2}{2(2-\gamma^2)}$	$\frac{6-2\gamma-\gamma^2}{12-5\gamma^2}$	$\frac{6-2\gamma-\gamma^2}{3(2-\gamma^2)}$
q_{12}^*	$\frac{4-3\gamma}{3(4-\gamma^2)}$	$\frac{1-\gamma}{3-\gamma^2}$	$\frac{1-\gamma}{2-\gamma^2}$	$\frac{4-3\gamma}{12-5\gamma^2}$	$\frac{2(1-\gamma)}{3(2-\gamma^2)}$
p_{11}^*	$c+\frac{2(3-\gamma)}{3(4-\gamma^2)}$	c	$c-\frac{\gamma(1-\gamma)}{2(2-\gamma^2)}$	$c+\frac{6-2\gamma-\gamma^2}{12-5\gamma^2}$	c
p_{12}^*	$c+\frac{8-3\gamma-\gamma^2}{3(4-\gamma^2)}$	$c+\frac{2(1-\gamma)}{3-\gamma^2}$	$c+\frac{1-\gamma}{2}$	$c+\frac{8-3\gamma-3\gamma^2+\gamma^3}{12-5\gamma^2}$	$c+\frac{4-4\gamma-\gamma^2+\gamma^3}{3(2-\gamma^2)}$

Note that when the domestic production subsidy s_{11} is available (columns b, c and e), this subsidy is used to correct the domestic market inefficiency: $p_{11}^* \leq c$. In this case, the import tariff is used purely for terms-of-trade manipulation. This tariff is lower than the optimal tariff when the tariff is the only instrument $\tau_{12}^* \leq \tau_e = 1/3$.

E Proofs from sections 4, 5, 6, 7 and 8

Proof of Lemma 1. The welfare of Country i with k_i firms is given by (6). By definition $CS^{ij} = \frac{1}{2}(a-p_{ij})q_{ij} = \frac{1-\gamma}{2}q_{ij}^2+\frac{\gamma}{2}Q_iq_{ij}$, so $CS^i = \sum_{j=1}^{N} CS^{ij} = \frac{\gamma}{2}Q_i^2+\frac{1-\gamma}{2}\sum_{j=1}^{N} q_{ij}^2$. Furthermore, note that

$$v(\mathbf{q}_i) - cQ_i - \sum_{j\notin K_i}\pi^{ij} = aQ_i - \frac{\gamma}{2}Q_i^2 - \frac{1-\gamma}{2}\sum_{j=1}^{N} q_{ij}^2 - cQ_i - \sum_{j=1}^{N}\pi^{ij} + \sum_{j\in K_i}\pi^{ij}$$
$$= \frac{\gamma}{2}Q_i^2 + \frac{1-\gamma}{2}\sum_{j=1}^{N} q_{ij}^2 + \sum_{j=1}^{N}\tau_{ij}q_{ij} + \sum_{j\in K_i}\pi^{ij} = CS^i + TR^i + \sum_{j\in K_i}\pi^{ij}$$

So

$$W^i = v(\mathbf{q}_i) - cQ_i - \sum_{j\notin K_i}\pi^{ij} + \sum_{\substack{l=1\\ l\neq i}}^{n}\sum_{j\in K_i}\pi^{lj} \tag{58}$$

The result directly follows from combining (58) with (15), (16) and (17). □

Proof of Proposition 5. Assume that there are more firms in country i than in country l: $k_i > k_l$. In Nash equilibrium, $\Gamma(k_i)\tau_e(k_i)$ is an increasing function of k_i: $\frac{d[\Gamma(k_i)\tau_e(k_i)]}{dk_i} = \frac{\gamma\Gamma(0)\Gamma(N)}{D(k_i)^2}\{[2(2-\gamma)+1+4k_i\gamma](2-\gamma)^2+2(1-\gamma)k_i^2\gamma^2\} > 0$. And so $\Gamma(0)-\Gamma(k_i)\tau_e(k_i) \leq \Gamma(0)-\Gamma(k_l)\tau_e(k_l)$. Also, $k_i\Gamma(k_l) \geq k_l\Gamma(k_i)$ and so (25) implies $d\tau(k_i) \geq d\tau(k_l)$. □

Proof of Proposition 6. Efficiency in a two-country world: Assume that the second order condition is satisfied (see below). If the two countries are liberalising simultaneously, the effect of a change in the tariff vector $\boldsymbol{\tau} = (\tau_{il}, \tau_{li})$ on welfare of country i is

$$\begin{aligned} dW^i = &\sum_{j\in K_i} q_{lj}dp^*_{lj} - \sum_{j\in K_l} q_{ij}dp^*_{ij} - \Big(\sum_{j\in K_i}\tau_{lj}dq_{lj} - \sum_{j\in K_l}\tau_{ij}dq_{ij}\Big) \\ &+ \sum_{j\in K_i}(p_{lj}-c)dq_{lj} + \sum_{j\in K_i}(p_{ij}-c)dq_{ij} \end{aligned} \tag{59}$$

A reciprocal tariff change satisfies (22). Combining the two gives

$$dW^i = \sum_{j\in K_l}(p_{ij}-c)dq_{ij} + \sum_{j\in K_i}(p_{ij}-c)dq_{ij} = \sum_{j=1}^{N}(p_{ij}-c)dq_{ij}$$

which is the first order condition of joint welfare maximisation.

Welfare variations with tariff change: The effect of a reciprocal trade liberalisation on welfare can be decomposed using (18) into the effect on the net benefits from consumption and into the effect on the profit balance. The profit balance is kept constant by the principle of reciprocity and so we have

$$\frac{dW^i}{d\boldsymbol{\tau}} = \frac{dNS^i}{d\tau(k_i)} = -\frac{N-k_i}{(\Gamma(0)\Gamma(N))^2}\{\lambda + \mu\tau(k_i)\} \tag{60}$$

where $\lambda \equiv \Gamma(0)^2 > 0$ and $\mu \equiv \Gamma(0)^2\gamma(N-k_i)+(1-\gamma)k_i\gamma^2(N-k_i)+(1-\gamma)\Gamma(k_i)^2 > 0$. So the welfare function is a decreasing function of the tariff vector and welfare unambiguously increases as the two countries liberalise according to the principle of reciprocity. □

Proof of Proposition 7. Consider a bilaterally reciprocal trade liberalisation between Country i and Country l in a many country world. In what follows, $\tau(k_i)$ will denote the tariff imposed by Country i on imports from Country l and $\bar{\tau}(k_i)$ will denote the tariff imposed by Country i on imports from all other countries. In the bilateral trade liberalisation, tariffs $\bar{\tau}(k_i)$ will remain constant (trade on other countries is not being liberalised). I will now determine the impact of a variation in $\tau(k_i)$ and the tariffs imposed by Country l on imports from Country i ($\tau(k_l)$) such that they satisfy the condition of reciprocity on welfare of Country i. For Country i we have

$$Q(k_i) = \frac{N - (N - k_i - k_l)\bar{\tau}(k_i) - k_l\tau(k_i)}{\Gamma(N)} \tag{61}$$

and

$$q_D(k_i) = \frac{\Gamma(0) + \gamma(N - k_i - k_l)\bar{\tau}(k_i) + \gamma k_l\tau(k_i)}{\Gamma(0)\Gamma(N)} \tag{62}$$

Exports to Country i from firms based in Country l are

$$q_{F_l}(k_i) = \frac{\Gamma(0) + \gamma(N - k_i - k_l)\bar{\tau}(k_i) - \Gamma(N - k_l)\tau(k_i)}{\Gamma(0)\Gamma(N)} \tag{63}$$

and exports to Country i from firms based in other countries are

$$q_{F_{-l}}(k_i) = \frac{\Gamma(0) - \Gamma(k_i + k_l)\bar{\tau}(k_i) + \gamma k_l\tau(k_i)}{\Gamma(0)\Gamma(N)} \tag{64}$$

The welfare of Country i is

$$\begin{aligned} W^i(\mathbf{k}) = Q(k_i) - \frac{\gamma}{2}Q(k_i)^2 \\ - \frac{1-\gamma}{2}\left\{k_i\left[q_D(k_i)\right]^2 + (N - k_i - k_l)\left[q_{F_{-l}}(k_i)\right]^2 + k_l\left[q_{F_l}(k_i)\right]^2\right\} \\ - (N - k_i - k_l)\left[q_{F_{-l}}(k_i)\right]^2 - k_l\left[q_{F_l}(k_i)\right]^2 + k_i\left[q_F(k_l)^2 + \sum_{\substack{h=1 \\ h\neq i \\ h\neq l}}^{n} q_F(k_h)^2\right] \end{aligned}$$

Other countries than i and l keep their tariffs constant. Furthermore, the variation of tariffs imposed by Country i on imports from Country l and of tariffs imposed by Country l on imports from Country i is bilaterally reciprocal, so we have

$$\begin{aligned} \frac{dW^i}{d\boldsymbol{\tau}} = \frac{dQ(k_i)}{d\tau(k_i)} - \gamma\frac{dQ(k_i)}{d\tau(k_i)}Q(k_i) \\ - (1-\gamma)\left[k_i\frac{dq_D(k_i)}{d\tau(k_i)}q_D(k_i) + (N - k_i - k_l)\frac{dq_{F_{-l}}(k_i)}{d\tau(k_i)}q_{F_{-l}}(k_i) + k_l\frac{dq_{F_l}(k_i)}{d\tau(k_i)}q_{F_l}(k_i)\right] \\ - 2(N - k_i - k_l)\frac{dq_{F_{-l}}(k_i)}{d\tau(k_i)}q_{F_{-l}}(k_i) \end{aligned}$$

Substituting expressions (61), (62), (63) and (64) and rearranging terms gives

$$\frac{dW^i}{d\boldsymbol{\tau}} = \frac{k_l}{\Gamma(0)^2\Gamma(N)^2}\left[-\lambda_B + \xi_B\bar{\tau}(k_i) - \mu_B\tau(k_i)\right]$$

with

$$\lambda_B \equiv \Gamma(0)\Gamma\left[2(N-k_i-k_l)\right] > 0$$
$$\xi_B \equiv \gamma(N-k_i-k_l)\left[(1-\gamma)\Gamma(N)+\Gamma(2(k_i+k_l))\right] \geq 0$$
$$\mu_B \equiv \gamma k_l\left[\Gamma(0)^2+(1-\gamma)(N-k_l)\gamma+2(N-k_i-k_l)\gamma\right]+(1-\gamma)\Gamma(N-k_l)^2 \geq 0$$

So $dW^i/d\boldsymbol{\tau}$ is decreasing linear function of $\tau(k_i)$ and an increasing linear function of $\bar{\tau}(k_i)$. For a sufficiently high $\bar{\tau}(k_i)$, bilaterally reciprocal trade liberalisation may be welfare decreasing. (Note that when $k_i + k_l = N$, we are in the two-country world case where reciprocal trade liberalisation is unambiguously welfare increasing). □

Proof of Proposition 10. The effect on welfare of a trade liberalisation following the principles of reciprocity and non-discrimination can be decomposed using (18) into the effect on the net benefits from consumption and into the effect on the profit balance. The profit balance is kept constant by the principles of reciprocity and non-discrimination and so we have similarly to the two-country world case (see proof of Proposition 6 equation (60))

$$\frac{dW^i}{d\boldsymbol{\tau}} = \frac{dNS^i}{d\tau(k_i)} = -\frac{N-k_i}{(\Gamma(0)\Gamma(N))^2}\{\lambda+\mu\tau(k_i)\} \tag{65}$$

And so the welfare function is a decreasing function of the tariff vector and welfare unambiguously increases as all countries liberalise according to the GATT/WTO principles.

Efficiency: When countries are changing their tariffs multilaterally, the variation of welfare of country i with the tariff vector $\boldsymbol{\tau}$ can be written as

$$\begin{aligned} dW^i = & -\sum_{j\notin K_i} q_{ij}dp^*_{ij} + \sum_{j\in K_i}(p_{ij}-c)dq_{ij} + \sum_{j\notin K_i}\tau_{ij}dq_{ij} + d\left[\sum_{\substack{l=1\\l\neq i}}^{n}\sum_{j\in K_i}(p_{lj}-c-\tau_{lj})q_{lj}\right] \\ = & \sum_{\substack{l=1\\l\neq i}}^{n}\sum_{j\in K_i} q_{lj}dp^*_{lj} - \sum_{j\notin K_i} q_{ij}dp^*_{ij} - \left[\sum_{\substack{l=1\\l\neq i}}^{n}\sum_{j\in K_i}\tau_{lj}dq_{lj} - \sum_{j\notin K_i}\tau_{ij}dq_{ij}\right] + \sum_{\substack{l=1\\l\neq i}}^{n}\sum_{j\in K_i}(p_{lj}-c)dq_{lj} \\ & + \sum_{j\in K_i}(p_{ij}-c)dq_{ij} \end{aligned} \tag{66}$$

The reciprocity and non-discrimination conditions require

$$\boxed{\sum_{\substack{l=1\\l\neq i}}^{n}\sum_{j\in K_i} q_{lj}dp^*_{lj} - \sum_{j\notin K_i} q_{ij}dp^*_{ij}}_{ToT} - \boxed{\left[\sum_{\substack{l=1\\l\neq i}}^{n}\sum_{j\in K_i} \tau_{lj}dq_{lj} - \sum_{j\notin K_i} \tau_{ij}dq_{ij}\right]}_{VoT}$$
$$+\boxed{\sum_{\substack{l=1\\l\neq i}}^{n}\sum_{j\in K_i} (p_{lj}-c)dq_{lj} - \sum_{j\notin K_i} (p_{ij}-c)dq_{ij}}_{MA} = 0$$

Substituting this condition into the welfare decomposition (66) yields

$$dW^i = \sum_{j\in K_i}(p_{ij}-c)dq_{ij} + \sum_{j\notin K_i}(p_{ij}-c)dq_{ij} = \sum_{j=1}^{N}(p_{ij}-c)dq_{ij}$$

which is the joint welfare maximisation first order condition. So multilateral liberalisation according to the profit reciprocity condition yields the efficient outcome. □

Proof of Proposition 11. Substituting the inverse demand (2) and the profit maximising first order condition (3) into (31) gives

$$\frac{dW^i}{d\sigma_{hk}} = -\sum_{j\in K_i} q_{hj}\Big(\frac{dq_{hj}}{d\sigma_{hk}} + \gamma\sum_{\substack{f=1\\f\neq j}}^{N}\frac{dq_{hf}}{d\sigma_{hk}}\Big) + \sum_{j\in K_i}(q_{hj}-\sigma_{hj})\frac{dq_{hj}}{d\sigma_{hk}} \tag{67}$$

Country i has k_i firms and I assume that it will subsidise all its firms in the same way, so I am really looking for the subsidy σ_{hi} to export from country i to country h. All country i's firms will have the same exports to country h which I will denote q_{F_i}

$$q_{F_i} = \frac{\Gamma(0) - \gamma S_h + \Gamma(N)\sigma_{hi}}{\Gamma(0)\Gamma(N)} \tag{68}$$

where S_h is the sum of all the subsidies by all countries to export to country h. I will denote by q_{F_j} exports from firms from other countries than country i to country h and by q_D domestic sales in country h

$$q_{F_j} = \frac{\Gamma(0) - \gamma S_h + \Gamma(N)\sigma_{hj}}{\Gamma(0)\Gamma(N)}$$
$$q_D = \frac{\Gamma(0) - \gamma S_h}{\Gamma(0)\Gamma(N)}$$

With this new notation, (67) becomes

$$\frac{dW^i}{d\sigma_{hi}} = k_i q_{F_i}\left[-\frac{dq_{F_i}}{d\sigma_{hi}} - \gamma(k_i-1)\frac{dq_{F_i}}{d\sigma_{hi}} - \gamma k_h\frac{dq_D}{d\sigma_{hi}} - \gamma(N-k_i-k_h)\frac{dq_{F_j}}{d\sigma_{hi}}\right] + k_i(q_{F_i}-\sigma_{hi})\frac{dq_{F_i}}{d\sigma_{hi}}$$

Substituting and rearranging terms yields

$$\frac{dW^i}{d\sigma_{hi}} = \frac{k_i}{\Gamma(0)^2\Gamma(N)^2}\{\Gamma(0)\gamma\left[\Gamma(N) - 2k_i\right] + \sigma_{hi}\Gamma(N)\left[\gamma(\Gamma(N) - 2k_i) - \Gamma(N - k_i)\Gamma(0)\right] - S_h\gamma^2\left[\Gamma(N) - 2k_i\right]\}$$

So the first order condition for the optimal subsidy $\frac{dW^i}{d\sigma_{hi}} = 0$ can be rewritten as

$$a(k_i)\sigma_{hi} + \sum_{\substack{l=1 \\ l\neq i \\ l\neq h}}^{n} k_l\sigma_{hl} = c(k_i) \tag{69}$$

with $a(k_i) \equiv \frac{2\Gamma(N-k_i)[(1-\gamma)\Gamma(N)+k_i\gamma]}{\gamma^2[\Gamma(N)-2k_i]}$ and $c(k_i) \equiv \frac{\Gamma(0)}{\gamma}$. The optimal subsidy of country i to export to country h depends on the subsidies of all other exporting countries into country h. We have a system of (n-1) simultaneous equations. In matrix form $AS_h = C$, with

$$A = \begin{pmatrix} a(k_1) & k_2 & k_3 & \cdots & k_n \\ k_1 & a(k_2) & k_3 & \cdots & k_n \\ k_1 & k_2 & a(k_3) & \cdots & k_n \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ k_1 & k_2 & k_3 & \cdots & a(k_n) \end{pmatrix}, S_h = \begin{pmatrix} s_{h1} \\ s_{h2} \\ s_{h3} \\ \cdots \\ s_{hn} \end{pmatrix} \text{ and } C = \begin{pmatrix} c(k_1) \\ c(k_2) \\ c(k_3) \\ \cdots \\ c(k_n) \end{pmatrix}$$

Subtracting from all the first $(n-2)$ equations the last one gives

$$A' = \left(\begin{array}{cccc|c} a(k_1) - k_1 & 0 & 0 & \cdots & k_n - a(k_n) \\ 0 & a(k_2) - k_2 & 0 & \cdots & k_n - a(k_n) \\ 0 & 0 & a(k_3) - k_3 & \cdots & k_n - a(k_n) \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ \hline k_1 & k_2 & k_3 & \cdots & a(k_n) \end{array}\right) \text{ and } C' = \begin{pmatrix} 0 \\ 0 \\ 0 \\ \cdots \\ \frac{\Gamma(0)}{\gamma} \end{pmatrix}$$

where the top left bloc of A' is diagonal and the bottom right bloc is a scalar so this matrix can be easily inverted using blockwise inversion. Furthermore, given the form of C', to solve the system, we really only need the last column of A'^{-1}. With the blocs of A' denoted $A' = \left(\begin{array}{c|c} \alpha & \beta \\ \hline \omega & \delta \end{array}\right)$ the inverse of A' is given by $A'^{-1} = \left(\begin{array}{c|c} \cdots & -\alpha^{-1}\beta(\delta-\omega\alpha^{-1}\beta)^{-1} \\ \hline \cdots & (\delta-\omega\alpha^{-1}\beta)^{-1} \end{array}\right)$ which yields the formula.

Sign of $\sigma_{e_{hi}}$: $a(k_i) - k_i = \frac{Num}{Denum}$ with $Num \equiv \Gamma(N)\left[2(1-\gamma)\Gamma(N-k_i) + k_i\gamma\Gamma(0)\right] \geq 0$ and $Denum \equiv \gamma^2\left[\Gamma(N) - 2k_i\right]$. $Denum$ can be both positive or negative depending on k_i and the parameters of the model. For $k_i < \Gamma(N)/2$, $a(k_i) - k_i \geq 0$ and for $k_i > \Gamma(N)/2$,

$a(k_i) - k_i \leq 0$. To determine the sign of $\sigma_{e_{hi}}$, we need to study $\sum_{\substack{l=1 \\ l \neq h}}^{n} \frac{k_l}{a(k_l) - k_l}$. Each term of this sum can be both positive or negative depending on k_l, but we can note that for any k_l, $\frac{k_l}{a(k_l)-k_l} > -\frac{k_l}{N}$

$$\frac{k_l}{a(k_l) - k_l} + \frac{k_l}{N} = \frac{k_l \left[\Gamma(N)\gamma^2(N - k_l) + 2k_l\gamma\Gamma(0) + 2\Gamma(N)(1-\gamma)\Gamma(N - k_l)\right]}{N\Gamma(N)\left[2(1-\gamma)\Gamma(N - k_l) + k_l\gamma\Gamma(0)\right]} \geq 0$$

so

$$1 + \sum_{\substack{l=1 \\ l \neq h}}^{n} \frac{k_l}{a(k_l) - k_l} \geq 1 - \sum_{\substack{l=1 \\ l \neq h}}^{n} \frac{k_l}{N} > 0$$

So the sign of $\sigma_{e_{hi}}$ depends only on the sign of $\Gamma(N) - 2k_i$. □

Proof of Proposition 12. Substituting the profit maximising first order condition (3) into (33), the optimal subsidy without terms-of-trade effects satisfies

$$\frac{d\tilde{W}^i}{d\sigma_{hk}} = \sum_{j \in K_i} (q_{hj} - \sigma_{hj}) \frac{dq_{hj}}{d\sigma_{hk}} = 0 \tag{70}$$

Assuming again that all firms in country i receive the same subsidy to export to country h and using the notation introduced in proof of Proposition 11 (see above)

$$\frac{d\tilde{W}^i}{d\sigma_{hi}} = k_i(q_{F_i} - \sigma_{hi}) \frac{dq_{F_i}}{d\sigma_{hi}} = \frac{k_i\Gamma(N - k_i)}{\Gamma(0)^2\Gamma(N)^2} \left[\Gamma(0) - \gamma S_h + \Gamma(N)\sigma_{hi} - \Gamma(0)\Gamma(N)\sigma_{hi}\right]$$

So the first order condition (70) can be rewritten as

$$\tilde{a}(k_i)\sigma_{hi} + \sum_{\substack{l=1 \\ l \neq i \\ l \neq h}}^{n} k_l\sigma_{hl} = c(k_i) \tag{71}$$

with $\tilde{a}(k_i) \equiv \frac{\Gamma(0)\Gamma(N) - \Gamma(N-k_i)}{\gamma} \geq 0$ and $c(k_i)$ defined in the proof of Proposition 11. Using the same solution method as in the proof of Proposition 11 yields the formula.

Sign of $\tilde{\sigma}_{e_{hi}}$: Now $\tilde{a}(k_i)$ is unambiguously positive.

$$\tilde{a}(k_i) - k_i = \frac{\Gamma(0)\Gamma(N) - \Gamma(N - k_i) - \gamma k_i}{\gamma} = \frac{(1-\gamma)\Gamma(N)}{\gamma} \geq 0$$

and so the optimal subsidy is a subsidy $\tilde{\sigma}_{e_{hi}} \geq 0$. □

Proof of Proposition 13. Substituting the inverse demand (2) into (35), the optimal subsidy without market-access effects satisfies

$$\frac{d\hat{W}^i}{d\sigma_{hk}} = -\sum_{j\in K_i} q_{hj}\Big(\frac{dq_{hj}}{d\sigma_{hk}} + \gamma\sum_{\substack{f=1\\f\neq j}}^{N}\frac{dq_{hf}}{d\sigma_{hk}}\Big) - \sum_{j\in K_i}\sigma_{hj}\frac{dq_{hj}}{d\sigma_{hk}} = 0 \tag{72}$$

Assuming again that all firms in country i receive the same subsidy to export to country h and using the notation introduced in proof of Proposition 11 (see above)

$$\begin{aligned}\frac{d\hat{W}^i}{d\sigma_{hi}} &= k_i q_{F_i}\left[-\frac{dq_{F_i}}{d\sigma_{hi}} - \gamma(k_i-1)\frac{dq_{F_i}}{d\sigma_{hi}} - \gamma k_h\frac{dq_D}{d\sigma_{hi}} - \gamma(N-k_i-k_h)\frac{dq_{F_j}}{d\sigma_{hi}}\right] - k_i\sigma_{hi}\frac{dq_{F_i}}{d\sigma_{hi}}\\ &= \frac{k_i}{\Gamma(0)^2\Gamma(N)^2}\{[\gamma\Gamma(N)-\Gamma(N+k_i)]\left[\Gamma(0)-\gamma S_h+\Gamma(N)\sigma_{hi}\right]-\Gamma(0)\Gamma(N)\Gamma(N-k_i)\sigma_{hi}\}\end{aligned}$$

So the first order condition (72) can be rewritten as

$$\hat{a}(k_i)\sigma_{hi} + \sum_{\substack{l=1\\l\neq i\\l\neq h}}^{n} k_l\sigma_{hl} = c(k_i) \tag{73}$$

with $\hat{a}(k_i) \equiv -\frac{\Gamma(N-k_i)[2(1-\gamma)\Gamma(N)+\Gamma(N+k_i)]}{\gamma[\Gamma(N+k_i)-\gamma\Gamma(N)]} \leq 0$ and $c(k_i)$ defined in the proof of Proposition 11. Using the same solution method as in the proof of Proposition 11 yields the formula.
Sign of $\hat{\sigma}_{e_{hi}}$: Now $\hat{a}(k_i)$ is unambiguously negative and so $\hat{a}(k_i) - k_i$ is negative. It can also be shown that for any k_l,

$$\frac{k_l}{\hat{a}(k_l)-k_l} > -\frac{k_l}{N}$$

$$\frac{k_l}{\hat{a}(k_l)-k_l} + \frac{k_l}{N} = \frac{k_l\left[N-k_l+\hat{a}(k_l)\right]}{N\left[\hat{a}(k_l)-k_l\right]}$$

so we need to show that $N - k_l + \hat{a}(k_l) \leq 0$.

$$N-k_l+\hat{a}(k_l) = -\frac{2(1-\gamma)\Gamma(N-k_l)\Gamma(N)+(N-k_l)\gamma^2\Gamma(N)+\Gamma(N+k_l)\Gamma(0)}{\gamma\left[\Gamma(N+k_l)-\gamma\Gamma(N)\right]} \leq 0$$

Hence

$$1+\sum_{\substack{l=1\\l\neq h}}^{n}\frac{k_l}{\hat{a}(k_l)-k_l} \geq 1-\sum_{\substack{l=1\\l\neq h}}^{n}\frac{k_l}{N} > 0$$

and $\hat{\sigma}_{e_{hi}} \leq 0$. In the absence of the market-access effect, the optimal subsidy would be unambiguously an export tax. □

Proof of Proposition 14. Substituting the profit maximising first order condition (3) into (37), the efficient subsidy satisfies the following first order condition

$$\frac{d}{d\sigma_{hk}}\sum_{l=1}^{n} W^l = \sum_{j=1}^{N}(q_{hj} - \sigma_{hj})\frac{dq_{hj}}{d\sigma_{hk}} = 0 \tag{74}$$

Assuming all firms from country i are subsidised in the same way and using the notation introduced in proof of Proposition 11 (see above)

$$\frac{d}{d\sigma_{hi}}\sum_{l=1}^{n} W^l = k_i(q_{F_i} - \sigma_{hi})\frac{dq_{F_i}}{d\sigma_{hi}} + k_h q_D \frac{dq_D}{d\sigma_{hi}} + \sum_{\substack{l=1\\ l\neq i\\ l\neq h}}^{n}(q_{hl} - \sigma_{hl})\frac{dq_{hl}}{d\sigma_{hi}} = 0$$

with

$$\sum_{\substack{l=1\\ l\neq i\\ l\neq h}}^{n}(q_{hl}-\sigma_{hl})\frac{dq_{hl}}{d\sigma_{hi}} = -\frac{\gamma k_i}{\Gamma(0)^2\Gamma(N)^2}\{(N-k_i-k_h)\left[\Gamma(0)-\gamma S_h\right]-\Gamma(N)\left[\Gamma(0)-1\right]\sum_{\substack{l=1\\ l\neq i\\ l\neq h}}^{n} k_l\sigma_{hl}\}$$

so

$$\begin{aligned}\frac{d}{d\sigma_{hi}}\sum_{l=1}^{n} W^l = \frac{k_i}{\Gamma(0)^2\Gamma(N)^2}\{&\Gamma(0)^2 + \sigma_{hi}\left[\Gamma(N)\Gamma(N-k_i)(1-\Gamma(0)) - k_i\gamma\Gamma(0)\right]\\ &+\gamma\left[\Gamma(N)(1-\gamma)-\Gamma(0)\right]\sum_{\substack{l=1\\ l\neq i\\ l\neq h}}^{n} k_l\sigma_{hl}\}\end{aligned}$$

So the first order condition (74) can be rewritten as

$$a_J(k_i)\sigma_{hi} + \sum_{\substack{l=1\\ l\neq i\\ l\neq h}}^{n} k_l\sigma_{hl} = c_J(k_i) \tag{75}$$

with $a_J(k_i) \equiv -\frac{\Gamma(N)\Gamma(N-k_i)(1-\gamma)+k_i\gamma\Gamma(0)}{\gamma^2[\Gamma(N)-N]}$ and $c_J(k_i) \equiv \frac{\Gamma(0)^2}{\gamma^2[\Gamma(N)-N]}$. Using the same solution method as in the proof of Proposition 11 yields the formula.

Sign of $\sigma_{J_{hi}}$: Note that

$$a_J(k_i) - k_i = \frac{\Gamma(N)^2(1-\gamma)}{\gamma^2\left[\Gamma(N)-N\right]}$$

so $a_J(k_i) - k_i$ does not depend on k_i and furthermore $a_J(k_i) - k_i$ and $c_J(k_i)$ are of the same sign.

$$\frac{k_i}{a_J(k_i)-k_i} + \frac{k_i}{N} = \frac{k_i\Gamma(0)\left[N\gamma^2 + (1-\gamma)\Gamma(2N)\right]}{\Gamma(N)\Gamma(N-k_i)(1-\gamma)+k_i\gamma\Gamma(0)} \geq 0$$

and so the optimal subsidy is a subsidy $\sigma_{J_{hi}} \geq 0$.

So is there a reason for trade agreements to restrict export subsidies if they are efficient? To answer this question, let us compare the efficient subsidy with the subsidy without terms-of-trade effects. Note that the efficient subsidy can be rewritten as

$$\sigma_{J_{hi}} = \frac{\Gamma(0)^2}{\Gamma(N)^2(1-\gamma) + \gamma^2 \left[\Gamma(N) - N\right](N - k_h)}$$

On the other hand, the subsidy without terms-of-trade effects can be rewritten as

$$\tilde{\sigma}_{e_{hi}} = \frac{\Gamma(0)}{(1-\gamma)\Gamma(N) + \gamma(N - k_h)}$$

It is straightforward to show that $\sigma_{J_{hi}} \leq \tilde{\sigma}_{e_{hi}}$.

$$\Gamma(N)^2(1-\gamma) + \gamma^2 \left[\Gamma(N) - N\right](N - k_h) - \Gamma(0)\left[(1-\gamma)\Gamma(N) + \gamma(N - k_h)\right] \geq 0$$
$$(1-\gamma)\Gamma(N)\gamma k_h \geq 0$$

So in the absence of terms-of-trade effects, the market-access effect would make countries chose inefficiently high subsidies. □

Proof of Proposition 15. From (39) by differentiating with respect to tariff $\tau(k_i)$, we have for Country i

$$\frac{dCS(k_i)}{d\tau(k_i)} = \frac{(N - k_i)}{\Gamma(0)^2\Gamma(N)^2}(-\lambda_{CS} + \mu_{CS}\tau(k_i)) \tag{76}$$

with

$$\lambda_{CS} \equiv \Gamma(0)^2(1 - \gamma + \gamma N) > 0$$
$$\mu_{CS} \equiv \gamma(N - k_i)\Gamma(0)^2 + (1-\gamma)k_i\gamma^2(N - k_i) + \Gamma(k_i)^2(1-\gamma) = D(k_i) - 2\Gamma(k_i)^2 > 0$$

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

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

with $Num = D(k_i)\left[\Gamma(0)(1 - \gamma + \gamma N) - \Gamma(2k_i)\right] + 2\Gamma(k_i)^2\Gamma(2k_i)$.
$\tau_{CSmin} - \tau_e$ is of the same sign as Num. To determine the sign of Num, I study its

variations with k_i. $\frac{d^2}{dk_i^2}Num = 4\gamma^2\Gamma(N) \geq 0$ and so the derivative of Num with respect to k_i is a monotonically increasing function of k_i. Furthermore, we have $\frac{d}{dk_i}Num(k_i = 1) = \gamma\Gamma(N)\left[\gamma(1-\gamma)(2-\gamma)N + 4 - 2\gamma + 4\gamma^2 - \gamma^3\right] \geq 0$ and so for any number of firms k_i, $\frac{d}{dk_i}Num$ is positive. Hence Num is a monotonically increasing function of k_i. Finally, $Num(k_i = 1) = 8(2+\gamma) + \gamma\left[\gamma(4-3\gamma)N + 12 - 8\gamma + 3\gamma^2\right]\left[\Gamma(0)(N-1) - 2\right] \geq 0$ and so we have $\tau_{CSmin} \geq \tau_e$ and the consumer surplus is a decreasing function of the tariff for any tariff between 0 and τ_e. □

Proof of Proposition 16.

$$\frac{d\Pi^i(\mathbf{k})}{d\boldsymbol{\tau}} = 2k_i\frac{dq_D(k_i)}{d\tau(k_i)}q_D(k_i) + 2k_i\sum_{\substack{l=1\\l\neq i}}^{n}\frac{dq_F(k_l)}{d\tau(k_l)}q_F(k_l)$$

The trade liberalisation considered satisfies the principles of reciprocity and non-discrimination and so we have

$$k_i\sum_{l\neq i}^{n}2q_F(k_l)dq_F(k_l) = (N-k_i)2q_F(k_i)dq_F(k_i)$$

and so

$$\begin{aligned}\frac{d\Pi^i(\mathbf{k})}{d\boldsymbol{\tau}} &= 2k_i\frac{dq_D(k_i)}{d\tau(k_i)}q_D(k_i) + 2(N-k_i)\frac{dq_F(k_i)}{d\tau(k_i)}q_F(k_i)\\ &= \frac{2(N-k_i)}{\Gamma(0)^2\Gamma(N)^2}\left[-\lambda_\Pi + \mu_\Pi\tau(k_i)\right]\end{aligned}$$

with

$$\begin{aligned}\lambda_\Pi &\equiv \Gamma(0)^2 > 0\\ \mu_\Pi &\equiv k_i\gamma^2(N-k_i) + \Gamma(k_i)^2 > 0\end{aligned}$$

so the derivative of profits is a linear increasing function of the tariff. Set $\tau_{\Pi min}$ the tariff at which the derivative of profits is zero (and profits are minimum).

$$\tau_{\Pi min} = \frac{\lambda_\Pi}{\mu_\Pi} = \frac{\Gamma(0)^2}{k_i\gamma^2(N-k_i) + \Gamma(k_i)^2}$$

So profit is a decreasing function of tariff for $\tau \leq \tau_{\Pi min}$ and it is an increasing function of tariff for $\tau \geq \tau_{\Pi min}$.

$$\frac{d^2\Pi}{d\tau^2} = \frac{2(N-k_i)\left[k_i(N-k_i)\gamma^2 + \Gamma(k_i)^2\right]}{\Gamma(0)^2\Gamma(N)^2} > 0$$

shows that profit function has a minimum at $\tau_{\Pi min}$. The Nash equilibrium tariff τ_e

can be both smaller or greater than $\tau_{\Pi min}$ depending on the parameters of the model. When $\tau_e \leq \tau_{\Pi min}$, the profit function is monotonic with the tariffs and a reciprocal trade liberalisation will increase profits. When $\tau_e > \tau_{\Pi min}$, a reciprocal trade liberalisation from Nash equilibrium will initially decrease profits. Comparison of τ_e and $\tau_{\Pi min}$ gives

$$\tau_{\Pi min} > \tau_e \Leftrightarrow \gamma < 2 + k_i - \sqrt{k_i^2 + 4k_i}$$

□

Proof of Proposition 18. The effect on welfare a reciprocal trade liberalisation with partial participation is given by (45). Substituting the expressions of NS from (18) and of q_F from (15) yields

$$\begin{aligned}\frac{dW(k_i)}{d\alpha} = &\frac{\tau(k_i)}{\Gamma(0)^2\Gamma(N)^2}\{\Gamma(0)\left[N\Gamma(2k_i) + k_i\Gamma(0)\right] \\ &- \alpha\tau(k_i)\{(N-k_i)^2\gamma\left[\Gamma(0)^2 + (1-\gamma)k_i\gamma\right] + \Gamma(k_i)^2\left[(3-\gamma)N - (1-\gamma)k_i\right]\}\} \\ &- \frac{2P\Gamma(k_i)\tau(k_i)}{\Gamma(0)^2\Gamma(N)^2}\left[\Gamma(0) - \alpha\Gamma(k_i)\tau(k_i)\right]\end{aligned}$$

The partial trade liberalisation is welfare increasing if and only if $\frac{dW(k_i)}{d\alpha} \leq 0$. Defining $A(k_i) \equiv \Gamma(0)\left[N\Gamma(2k_i) + k_i\Gamma(0)\right]$ and $B(k_i) \equiv (N-k_i)^2\gamma\left[\Gamma(0)^2 + (1-\gamma)k_i\gamma\right] + \Gamma(k_i)^2\left[(3-\gamma)N - (1-\gamma)k_i\right]$ and rearranging terms yields the result. □

Proof of Proposition 19. The effect on welfare a flat-rate tariff cut with partial participation is given by (49). Substituting the expressions of NS from (18) and of q_F from (15) yields

$$\begin{aligned}\frac{dW(k_i)}{d\alpha} = &\frac{\tau(k_i)}{\Gamma(0)^2\Gamma(N)^2}\{\Gamma(0)\left[N\Gamma(2k_i) + k_i\Gamma(0)\right] \\ &- \alpha\tau(k_i)\{(N-k_i)^2\gamma\left[\Gamma(0)^2 + (1-\gamma)k_i\gamma\right] + \Gamma(k_i)^2\left[(3-\gamma)N - (1-\gamma)k_i\right]\}\} \\ &- \frac{2pk_i}{\Gamma(0)^2\Gamma(N)^2}f_p(\mathbf{k})\end{aligned}$$

The partial trade liberalisation is welfare increasing if and only if $\frac{dW(k_i)}{d\alpha} \leq 0$. Using definitions of A and B from the proof of Proposition 18 above and rearranging terms yields the result. □

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