Trade agreements when profits matter*

[Job market paper]

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November 25, 2010

Abstract

This paper shows that oligopolistic markets provide new insights into GATT/WTO trade agreements. First, there is a rationale for banning export subsidies: in a repeated game, an import-tariff-only regime is more self-enforcing. Second, when only tariffs are available, there is a new rationale for trade agreements: unilaterally set tariffs are inefficiently high, for profit-shifting reasons as well as for familiar terms-of-trade reasons. Trade agreements neutralize both these externalities and help countries to reach efficient tariff levels. Third, when governments are politically motivated rather than social welfare maximizers, trade agreements allow countries to reach efficiency only if governments have similar preferences.

KEYWORDS: GATT/WTO, trade liberalization, multilateralism.

JEL CLASSIFICATION NUMBERS: F02, F13, F15.

*I thank Kyle Bagwell, Richard Baldwin, Rick Bond, Paola Conconi, Doireann Fitzgerald, Lionel Fontagné, Nuno Limão, Peter Neary, Dennis Novy, Emanuel Ornelas, Ralph Ossa, Kamal Saggi, Alan Sykes, Robert Staiger, Mathias Thoenig, David Vines and Ben Zissimos for helpful comments and discussions on this paper. I am also grateful for comments from seminar participants at the London School of Economics, the Ludwig Maximilian University of Munich, Stanford University, University of Nottingham, University of Oxford, Vanderbilt University, the SITE Summer Workshop at Stanford University and the Workshop in International Trade in Villars.

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‡This work has been supported by the Economic and Social Research Council [grant numbers PTA-026-27-2479, PTA-030-2005-00825]. Financial support for travel from the George Webb Medley Fund, Balliol College, and Oriel College is also gratefully acknowledged.

1 Introduction

The postwar era has witnessed a spectacular liberalization of international trade: average ad valorem tariffs on industrial goods have been reduced from over 40 percent to less than 4 percent. It is generally acknowledged that the General Agreement on Tariffs and Trade (GATT), and later its successor, the World Trade Organization (WTO), played a key role in achieving these historically low tariff levels through a series of eight trade negotiation rounds (the ninth round - Doha Development Round - is still in progress).[1,2] This past success stands in contrast to recent difficulties in multilateral trade negotiations.[3] In order to understand the reasons for these difficulties, it is important to understand the reasons for the past success.

The GATT/WTO is a forum for governments to negotiate trade agreements according to a pre-agreed set of rules. Although these rules have attracted a significant amount of attention from economists, many of them are still puzzling. For example, the ban of export subsidies remains to a large extent unexplained. This paper derives a rationale for the ban of export subsidies in an oligopolistic framework where governments use trade policy not only to improve their terms of trade, but also to shift profits from foreign to domestic firms. The same internationally efficient outcome can be achieved by any combination of the import and export instruments as only net instruments matter in equilibrium. The cost of trade instruments thus makes it beneficial to use only one trade instrument. The profit-shifting motive introduces an asymmetry between the two trade instruments which has consequences for the incentives to deviate from the agreement. I show that the tariff-only agreement is more self-enforcing, because it makes the punishment for deviation from the agreement harsher. Moreover, I also show that the use of a single instrument is self-enforcing in the tariff-only agreement, while it may not be in a subsidy-only agreement.

The paper further contributes to the trade agreements literature by identifying a new

[1]The GATT was signed in 1947 by 23 contracting parties as an interim agreement in expectation of the creation of the much more ambitious International Trade Organization (ITO). The ITO was never ratified while the GATT survived and became the platform for multilateral trade agreements until January 1, 1995, when it was superseded by the WTO as the result of the Marrakech Agreement, the final act of the Uruguay Round. The GATT still continues to exist as the WTO's umbrella treaty for trade in goods and it has been supplemented by a set of additional agreements that extend the GATT to new areas (services, intellectual property etc.). I will therefore refer to the agreement as GATT/WTO.

[2]Rose (2004a,b) suggests that there may be no correlation between GATT/WTO membership and more liberal trade policies 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 an important role played by the GATT/WTO in trade liberalization.

[3]The next to last Uruguay Round took seven and a half years, almost twice the original schedule. The current Doha Round, started in November 2001 and was set to be concluded in four years, but as of 2010, 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.

rationale for the foundational principles of reciprocity and non-discrimination. When the set of available trade instruments is restricted to import tariffs only, and markets are oligopolistic, unilateral trade policy is inefficient for two reasons: a standard terms-of-trade reason (countries use tariffs to improve their terms of trade at the expense of other countries) and a profit-shifting reason (countries use tariffs to shift profits from foreign firms to domestic firms). It is shown that the rules of reciprocity and non-discrimination enable countries to neutralize both the terms-of-trade and profit-shifting externalities and to reach the internationally efficient outcome. This is however true only when governments do not differ too much in their political preferences. If governments value export profits of their firms differently, the principle of reciprocity has to be augmented to take these preference differences into account. This may suggest an explanation for why the GATT was so successful in the past and why more recent trade negotiations are proving more difficult. Indeed, the membership of the GATT has grown from 23 countries (mainly developed) to over 150 (both developed and developing) countries.[4] Given that the heterogeneity of political preferences of WTO members has increased over time, the rules of reciprocity and non-discrimination may not be sufficient anymore.

There are few formal models in the literature that rationalize the ban of export subsidies. As Bagwell and Staiger (2009a) point out, there are two challenges to the formalization of the GATT/WTO treatment of export subsidies. The first challenge is to find a situation where governments would actually *want* to use export subsidies. The second challenge is to show that, in such situations, it would be beneficial to ban them. It is generally pointed out that export subsidies give rise to inefficiencies by distorting market forces and therefore should be banned. Indeed, it is easy to show that two export-competing governments would benefit from an export subsidy restriction that would prevent harmful export subsidy wars (see for example Bagwell and Staiger (2002, ch. 10) for a discussion of this argument). However, this reasoning does not take into account the welfare of the importing country. Consumers in the importing country benefit from export subsidies of other countries and it can be shown that, from the world's perspective, export subsidies are welfare increasing due to their trade-expanding nature.[5] As Bagwell and Staiger (2009a) summarize this argument: the ban of export subsidies seems to represent the inefficient victory of exporting governments coming at the cost of importing governments.[6]

In a recent paper, Bagwell and Staiger (2009a) give a new interpretation of the export subsidy ban in a Cournot delocation model. In this model, governments would want

[4] As of today, the WTO has 153 members.

[5] In the absence of cooperation, the volume of trade is inefficiently low, and subsidies, by at least partially neutralizing the imposed trade barriers, help to alleviate this inefficiency.

[6] Under additional assumptions, it is possible to show that the ban of export subsidies may increase world welfare. Bagwell and Staiger (1997) show that export subsidies can create inefficiencies when they affect entry into a natural monopoly export market. Collie (1997) shows that export subsidies can create inefficiencies when they are financed by distortionary taxation.

to tax exports at Nash equilibrium. However, at the efficient cooperative level they have an incentive to deviate from the agreement with an export subsidy. Bagwell and Staiger argue that this provides a compelling rationale for the GATT/WTO treatment of export subsidies for example in agriculture: the original GATT was permissive towards subsidies of primary products (these were subject mostly to a reporting requirement), but the restriction on subsidies has been gradually tightened until they were prohibited by the Agreement on Subsidies and Countervailing Measures (SCM) during the Uruguay Round. This approach, however, does not provide a rationale for the treatment of export subsidies in other areas such as aircraft industry or automotive industry. Export subsidies on non-primary products were banned by Article XVI of the original GATT.[7] The focus of this paper is to provide a rationale for the treatment of export subsidies in the latter areas.

Having established the rationale for the ban of export subsidies, the paper asks what is the purpose of the trade negotiating principles of reciprocity and non-discrimination [also called the Most-Favored-Nation (MFN) principle]? Broadly speaking, the principle of reciprocity requires countries to exchange reciprocal concessions in trade barrier reductions. The principle of non-discrimination, as the name suggests, forbids discrimination between GATT/WTO members. These principles have initially been thought not to have any economic rationale.[8] By building on the work of Johnson (1953-54),[9] in their seminal paper, Bagwell and Staiger (1999) show that the principles of reciprocity and non-discrimination help countries to neutralize a terms-of-trade externality and reach an efficient outcome. In the absence of trade agreements, countries set tariffs inefficiently high because they want to improve their terms of trade at the expense of other countries. Because all countries do so, they end up in a Prisoner's Dilemma situation. By freezing the terms of trade, trade agreements help countries to come out of this Prisoner's Dilemma situation. More recently, Ossa (2010) provides an alternative and novel 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 this production relocation externality.[10]

[7]The original intention for the treatment of export subsidies in the ITO was much more ambitious. As Hudec (1975, p. 13) notes, in the 1943 outline of the code of conduct: "All forms of non-tariff trade restriction were to be prohibited absolutely, the only exception being the authorization to use quantitative restrictions in times of balance-of-payments crisis. Other distortions of normal market forces such as export subsidies were to be eliminated, [...] Tariffs would remain, but they were to be progressively reduced by negotiations."

[8]See for example Krugman (1992).

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

[10]Another strand of literature rationalizes trade agreements as a commitment device: governments sign trade agreements to tie their hands ex ante and eliminate the possibility of being influenced by ex post lobbying. This approach is orthogonal to the beggar-thy-neighbor approach adopted in this paper and I will therefore not discuss it. See for example Maggi and Rodriguez-Clare (1998), or Bagwell and

The present paper contributes to the study of the role of the principles of reciprocity and non-discrimination by deriving a new rationale for these principles distinct from the terms-of-trade and production-relocation rationales: a profit-shifting rationale. The terms-of-trade rationale has been criticized for its empirical irrelevance.[11] Although several recent empirical studies - including Broda, Limão, and Weinstein (2008), Bagwell and Staiger (2006) and Ludema and Mayda (2010) - have found support for terms-of-trade manipulation, some skepticism still prevails. Ethier (2004, 2007) criticizes the terms-of-trade theory from a theoretical perspective. He points out that, 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, there is no trade agreement forbidding or limiting the use of export 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. Hence, according to Ethier, the terms-of-trade theory presents a two-fold puzzle: first, trade agreements do not prevent countries from manipulating their terms of trade; second, in reality countries do not seem to use export taxes to manipulate their terms of trade.[12,13] On the other hand, Bagwell and Staiger (2010) argue that because Ossa (2010) does not address the export subsidy ban and assumes that subsidies are not available, his "interpretation falls short of delivering a fundamental rationale for a trade agreement, because it appeals to the existence of a trade agreement (on export subsidies) to explain the purpose of a trade agreement." This paper does not rebut the existing theories. Instead it provides a complementary explanation: through both the terms-of-trade and profit-shifting externalities, it rationalizes the ban of export subsidies and it provides a new interpretation of the principles of reciprocity and non-discrimination. Note that this interpretation is not subject to the critique by Ethier: the profit-shifting rationale identified in this paper would make countries subsidize their exports, which is prohibited by the GATT/WTO.

The remainder of this paper proceeds as follows. Section 2 presents the basic underlying oligopolistic multi-country model of international trade and derives some preliminary results on trade policy. In particular, it shows that efficiency can be achieved by any combination of the import and export instruments yielding the appropriate net instrument, and that the presence of oligopoly introduces an asymmetry between the trade instruments. Section 3 shows that when it is costly to administer several trade instru-

Staiger (2010) for an overview.

[11] See, for example, Krugman (1997).

[12] In recent years, several countries have imposed export taxes, including China on selected raw materials, Argentina on wheat and Russia on aluminium. This practice is however not widespread.

[13] Another issue pointed out by the critics of the terms-of-trade theory is that terms of trade are never mentioned in trade negotiations. Regan (2006, p. 972) 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." Bagwell and Staiger (2002) explain this by reinterpreting the terms-of-trade rationale in terms of market access.

ments, it is optimal to ban export subsidies as an import-tariff-only agreement is more self-enforcing. Section 4 analyses trade agreements when the set of trade instruments is restricted to import tariffs only. It derives a new rationale for trade agreements: a profit-shifting externality, and it shows how the GATT/WTO fundamental principles of reciprocity and non-discrimination help countries reach a superior cooperative outcome, but only when governments have similar political preferences. Section 5 concludes. All proofs are presented in the Appendix.

2 The model

2.1 Preferences, technology and industry equilibrium

The model I use is an adaptation of Yi's (1996) extension of the Brander (1981) model of trade with oligopoly.[14] There are n symmetric countries. Each country has one firm producing one good. As I am interested in the role of profits for trade agreements, I assume that the number of firms per country is fixed and invariant to trade policy so that firms make abnormal profits.[15] Consumers have quasilinear-quadratic preferences of the form

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

where q_{ij} is country i's consumption of country j's product, $\mathbf{q_i} = (q_{i1}, q_{i2}, \ldots, q_{in})$ is country i's consumption vector, $Q_i \equiv \sum_{j=1}^{n} q_{ij}$ 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. The parameter γ is the substitution index between goods, which ranges from 0 to 1: when $\gamma = 0$, goods are independent and when $\gamma = 1$, they are homogeneous. Consumers have a taste for variety depending on the substitution index. When $\gamma = 1$ consumers do not care about variety, whereas, for lower values of γ, utility is higher the more balanced is the consumption bundle, for a given total consumption Q_i. Maximizing utility, country i's inverse demand function for firm j's good is

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

[14] This framework is standard in the trade agreements' literature. For other variations of this model in different contexts see for example Freund (2000), Fujiwara (2008), Krishna (1998) or Ornelas (2005a,b, 2007).

[15] For ease of exposition, I assume that there is only one firm in each country. The extension to k firms per country is discussed in Appendix D.

There are no transportation costs in this model. Countries can impose specific tariffs on their imports (τ) and subsidies on their exports (σ). Tariffs and subsidies are country-specific: τ_{ij} designates the tariff imposed by country i on imports from country j, while σ_{ij} designates the export subsidy imposed by country j on exports to country i. Because I am interested in the implications of oligopoly for trade agreements, I assume that there are no domestic instruments that could directly target the oligopolistic distortion. In particular, neither tariffs nor subsidies are imposed on home sales of domestic firms: $\tau_{ii} = 0$ and $\sigma_{ii} = 0$. This assumption may seem restrictive, as in reality, countries can use production subsidies or other instruments to address the oligopolistic distortion directly. However, these direct instruments are often not perfectly available, and trade policies are used for second-best objectives.[16] My model highlights the role of trade policy as a second-best policy to diminish the oligopolistic distortion.

All firms produce at the same marginal cost c in terms of the numeraire good. For country j's firm, the effective marginal cost of serving country i's market is therefore $c_{ij} = c+\tau_{ij}-\sigma_{ij}$. Markets are segmented and firms compete by choosing quantities in each country. Note that the strategic interaction between firms depends on the substitution index γ: the higher γ, the more direct is the competition between firms; when $\gamma = 0$, every firm is a monopolist in its own market. In country i, country j's firm solves $\max_{\{q_{ij}\}} \pi^{ij} = (p_{ij} - c_{ij})q_{ij}$. The first-order condition for this maximization problem is

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

In the Cournot equilibrium,

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

where $\Gamma(.)$ is defined as $\Gamma(n,\gamma) \equiv 2 - \gamma + n\gamma$; T_i is the sum of tariffs imposed by country i on all imported goods, $T_i \equiv \sum_{j=1}^{n} \tau_{ij}$; S_i is the sum of subsidies for all products exported to country i, $S_i \equiv \sum_{j=1}^{n} \sigma_{ij}$; and I have normalized $a - c = 1$. $\Gamma(n,\gamma)$ can be interpreted as a measure of the degree of competition in the world. The higher γ (the more goods are substitutable) and the higher n (the more firms there are), the higher the degree of competition.

The equilibrium quantities have standard properties: if country i increases its tariff on imports from country j, the consumption of imports from country j and the total consumption in country i fall, but the consumption of all other goods increases. If

[16] Grossman and Helpman (1995, p. 680) for example argue: "In reality, governments appear to have difficulty in using direct and transparent instruments to transfer income, so they resort to less direct means instead." Rodrik (1995, p. 1476) also points out that the use of trade policy for redistribution purposes is "a universal phenomenon".

country j increases its subsidy to exports to country i, the consumption of imports from country j and the total consumption in country i rise, but the consumption of all other goods falls. Note that, as for example Grossman and Helpman (1995) and Bagwell and Staiger (2001) show in other contexts, what matters for the equilibrium quantities is the *net trade instrument*, i.e. the difference between the export subsidy and the import tariff. If country i increases its tariff on imports from country j and country j increases its subsidy to exports to country i by the same amount, the equilibrium quantities in country i will remain unchanged.

The equilibrium export profit in country i of country j's firm can be obtained using the first-order condition (3):

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

so a change in trade instruments in country i that decreases country j's sales in country i, also decreases country j's profits in country i.

There are two sources of gains from trade in this setting: increased variety of goods and reduced market power of the domestic industry. The variety effect is more important for low values of the substitution index γ, when consumers greatly value variety and the strategic interaction among firms is limited. For high values of γ, the pro-competitive effect is relatively more important.

2.2 Trade policy preliminaries

In this subsection, I present some preliminary results on trade-policy setting which will serve as a starting point for the following sections. Why do countries sign trade agreements? To answer this question, I follow the literature on trade agreements (for an overview see for example Bagwell and Staiger (2010)) and start by exploring whether, in the absence of a trade agreement (when countries do not cooperate and set their trade policy unilaterally), there is any "problem" in the unilateral trade-policy setting that a trade agreement might solve. The answer is yes, there is a problem: unilateral trade policies are inefficient. Before analyzing why they are inefficient, I define what efficiency means.

2.2.1 Internationally efficient trade policy: joint welfare maximization

Country i's welfare W^i is the sum of five components: domestic consumer surplus (CS^i), the domestic firm's profits in the home market (π^{ii}), tariff revenue (TR^i), minus subsidy

expenditure (SE^i), and the domestic firm's export profits (π^{ji} for $j \neq i$)

$$W^i = CS^i + \pi^{ii} + TR^i - SE^i + \sum_{\substack{j=1 \\ j \neq i}}^{n} \pi^{ji}. \tag{6}$$

We can now define international efficiency as the outcome of choosing tariffs and subsidies to maximize the sum of national welfares with domestic policies constrained to be equal to zero:

Definition 1. Internationally efficient trade instruments maximize world welfare (the sum of all countries' welfare): $\max_{\{\tau_{jl},\sigma_{jl}\}_{j=1,l=1}^{n,\ n}} \sum_{i=1}^{n} W^i$, where $\tau_{ii} = 0$ and $\sigma_{ii} = 0$ for $i = 1 \dots n$, and where W^i is the welfare of country i.

The first-order conditions for internationally efficient instruments in country i are for all $l \neq i$,

$$\frac{d}{d\tau_{il}}\left(\sum_{j=1}^{n} W^j\right) = \sum_{j=1}^{n}(p_{ij} - c)\frac{dq_{ij}}{d\tau_{il}} = 0 \quad \text{and} \quad \frac{d}{d\sigma_{il}}\left(\sum_{j=1}^{n} W^j\right) = \sum_{j=1}^{n}(p_{ij} - c)\frac{dq_{ij}}{d\sigma_{il}} = 0.$$

As shown in Appendix B, the two equations above are actually one and the same equation characterizing the efficient net instrument. This is the consequence of the fact that equilibrium quantities depend only on the net instrument. There is thus an infinity of efficient import tariffs and export subsidies such that the difference between them satisfies the first-order condition above. As Appendix B shows, the net instrument is a subsidy. In the presence of oligopolistic markets, firms produce suboptimal quantities and it is therefore efficient to subsidize them.

2.2.2 Unilateral trade policy

Now I come back to the question whether there is any problem in trade policy in the absence of trade agreements. When countries do not cooperate, they set tariffs on imports and subsidize exports to maximize their own individual welfare, so country i solves $\max_{\{\tau_{ij},\sigma_{ji}\}_{j\neq i}} W^i$ with $\tau_{ii} = 0$ and $\sigma_{ii} = 0$. For ease of exposition, I assume in this subsection that countries set their import tariffs in a non-discriminatory way, so for any $j \neq i$, $\tau_{ij} = \tau_i$.[17] Similarly, country i's firm receives the same subsidy to all markets, so for any $j \neq i$, $\sigma_{ji} = \sigma_i$. As discussed for example in Baldwin and Venables (1995), the effect on welfare of an increase in the import tariff and in the export subsidy can be decomposed in a standard way into a terms-of-trade effect (ToT), a volume-of-trade effect (VoT) and

[17] As shown in the Appendix, this assumption is without loss of generality as the symmetry of the model implies that non-discrimination is an equilibrium outcome.

a profit-shifting effect (PS)[18]

$$\frac{dW^i}{d\tau_i} = \underbrace{-\sum_{\substack{j=1\\ j\neq i}}^{n} q_{ij}\frac{dp^*_{ij}}{d\tau_i}}_{ToT\geq 0} \qquad \underbrace{+\sum_{\substack{j=1\\ j\neq i}}^{n} \tau_i \frac{dq_{ij}}{d\tau_i}}_{VoT\leq 0} \qquad \underbrace{+(p_{ii}-c)\frac{dq_{ii}}{d\tau_i}}_{PS\geq 0}, \text{ and} \tag{7}$$

$$\frac{dW^i}{d\sigma_i} = \underbrace{\sum_{\substack{j=1\\ j\neq i}}^{n} q_{ji}\frac{dp^*_{ji}}{d\sigma_i}}_{ToT\leq 0} \qquad \underbrace{-\sum_{\substack{j=1\\ j\neq i}}^{n} \sigma_i \frac{dq_{ji}}{d\sigma_i}}_{VoT\leq 0} \qquad \underbrace{+\sum_{\substack{j=1\\ j\neq i}}^{n} (p_{ji}-c-\tau_j+\sigma_i)\frac{dq_{ji}}{d\sigma_i}}_{PS\geq 0}, \tag{8}$$

where p^*_{ij} is the mill price (the pre-tariff price) of country j's good sold in country i, $p^*_{ij} = p_{ij} - \tau_i$. As markets are segmented, there is no unique world price as such for any given variety and the terms-of-trade effect of trade policy is the variation in the pre-tariff price that a firm receives for its exports: qdp^*. An increase in the import tariff improves country i's terms of trade (pre-tariff price of imports falls $\frac{dp^*_{ij}}{d\tau_i} \leq 0$), reduces its volume of trade ($\frac{dq_{ij}}{d\tau_i} \leq 0$) and, by reducing foreign firms' market access, increases domestic output ($\frac{dq_{ii}}{d\tau_i} \geq 0$). Through this last effect, the import tariff moves the domestic firm towards the Stackelberg leader output level and shifts profits from foreign to domestic firms. Note that this effect is due entirely to the oligopolistic distortion. In perfect competition, prices are equal to marginal cost and so the last term of (7) would be zero. Also, if there were no strategic interaction between the firms ($\gamma = 0$ and every firm would be a monopolist in its own market), $\frac{dq_{ii}}{d\tau_i} = 0$ and the last term would also be zero. When firms are monopolists, there is no profit-shifting motive for trade policy. But when oligopoly matters ($\gamma > 0$), there are two ways in which the import tariff can improve domestic welfare: by improving the terms of trade and by shifting profits from foreign to domestic firms.

An increase in the export subsidy, on the other hand, deteriorates country i's terms of trade (the pre-tariff price of exports falls $\frac{dp^*_{ji}}{d\sigma_i} \leq 0$), increases the volume of trade ($\frac{dq_{ji}}{d\sigma_i} \geq 0$) and thus increases the subsidy expenditure, and it commits the domestic firm to a higher export volume which in turn induces the foreign firms to produce less and thus the subsidy shifts profits from foreign to domestic firms. So again, due to the presence of oligopolistic industries, there is both a profit-shifting and a terms-of-trade rationale for unilateral trade policy intervention, but the profit-shifting motivation for the export subsidy goes in the opposite direction to the terms-of-trade motivation. This observation will be crucial for the arguments in this paper: *oligopoly introduces an asymmetry between the two trade instruments.*

Note that the welfare gain to country i from it's trade policy comes at the expense of other countries: other countries' terms of trade deteriorate and/or profits are shifted

[18]The derivation of this decomposition is given in Appendix A.

away from their firms. Hence unilateral trade-policy setting in the presence of oligopolistic markets gives rise to two international externalities: a terms-of-trade and a profit-shifting externality. It is easy to show, and not surprising given the presence of international externalities, that unilateral trade policy is inefficient.[19] Thus there is a problem that a trade agreement may solve: the inefficiency of unilateral trade policy caused by the presence of international externalities.

In Section 4, I will come back to the exact nature of this problem, i.e. which of the two identified externalities is responsible for the inefficiency of unilateral trade policy and what a trade agreement must do to enable countries to reach the efficient trade policy outcome. But for the moment, I will just assume that countries will sign an agreement that leads them to impose internationally efficient instrument levels. As noted above, there is an infinity of efficient instrument levels, so which levels should countries choose?

2.2.3 Cost of trade policy

Any combination of the export and import instruments yielding the efficient net instrument leads to international efficiency. The only thing that changes, when the absolute levels of trade instruments change, are the transfers between individual countries, but as long as the difference between the trade instruments is the efficient net instrument, world welfare is maximized. In the case of symmetric countries considered in this paper, countries export as much as they import and thus they are indifferent between the efficient outcomes resulting from different combinations of the trade instruments.[20]

An important theme in recent work on political economy (see especially Besley and Persson (2009, 2010)) is that policy choices in market regulation and taxation are constrained by investments in legal and fiscal capacity. In the context of international trade policy, this insight implies that the use of trade instruments is also constrained by investments in institutional capacity. Moreover, export or import trade instruments require the existence of different kinds of administrative infrastructure: customs officials in the import tariff case, inspectors and payment centers in the export subsidy case. Hence, it is more costly to have both instruments than only one. Given that the same efficient equilibrium can be achieved by any combination of the two trade instruments yielding the efficient net instrument, it would be beneficial to agree to use only one trade instrument. The question then arises whether there is a difference between using the export or the import instrument? And if yes, which instrument is better? As I have just argued, there is no difference between the two instruments in terms of what countries can achieve by using one or the other instrument, but the presence of oligopoly introduces an asymme-

[19] Appendix B determines both the efficient and unilateral Nash instruments and shows that they are different. For further discussion see for example Bagwell and Staiger (2009b, 2010).

[20] In a world with asymmetric countries, given that any internationally efficient trade instruments maximize world welfare, there could always be a transfer making all countries better off.

try between the two trade instruments which will have implications for the incentives to deviate from the agreement.[21] Thus there will be a difference in the self-enforceability of the two agreements. The following section explores which trade agreement is more self-enforcing.

3 Explaining the ban of export subsidies

I assume that countries choose between a *tariff-only* agreement, where they agree not to use the export instrument and set the import instrument at the efficient level, and a *subsidy-only* agreement, where they agree not to use the import instrument and set the export instrument at the efficient level. Then they play an infinitely repeated game where at each period, they have the choice between continuing to cooperate or deviating to get a one period gain followed by punishment. The punishment considered here is a permanent Nash-reversion: if a country deviates from the agreement, the multilateral agreement breaks down and countries revert to setting their trade policies unilaterally.[22] For ease of exposition, I start by presenting a simple case where, once countries agree on a certain type of agreement, they can only use (cooperate, deviate or punish with) the "legal instrument": using the second instrument is prohibitively costly. This case has the merit of simply illustrating the basic mechanism. In the following subsection, I relax the assumption of prohibitive costs of the second instrument and show that even if the second instrument is not prohibitively costly, the base case remains the relevant case for a wide range of parameters. Also, when the base case is not the relevant case, the results continue to hold in the extended case where countries can deviate and punish with both instruments.

3.1 Base case: deviation with one instrument only

The goal here is to determine which of the two agreements, tariff-only or subsidy-only, is more self-enforcing given the assumption that both on and off the equilibrium path,

[21] Note that in perfect competition, there would not be a difference between the two instruments: there would not be any profit-shifting rationale for trade policy and as we can see from (7) and (8), the two instruments would be symmetric.

[22] Nash reversion punishment seems to be a plausible benchmark punishment for the case of trade agreements. The threat of the break-down of the GATT has for example been used in the dispute over the illegal imposition of U.S. dairy quotas in 1951. According to Hudec (1975, p. 167), "the Contracting Parties had brought out their biggest guns against the dominant partner. They had threatened everything that could be threatened, including the collapse of the Agreement itself." Maggi (1999) points out that "GATT commentators often argue that countries are deterred from violating trade agreements not just by the prospect of bilateral retaliation, but by the fear that the whole trading system may unravel as a consequence, or in other words, by the fear of a multilateral breakdown of cooperation." To support his claim, Maggi (1999) quotes John Croome, referring to a speech by the ex-Director-General of GATT, Arthur Dunkel: "Dunkel... concluded that governments are being restrained from a substantial slippage towards protectionism only by 'a kind of balance of terror': a fear that if they resorted to trade restrictions these would evoke retaliation, as well as undermining the trading system as a whole."

	Tariff-only agreement ($\sigma = 0$)	Subsidy-only agreement ($\tau = 0$)
Cooperation (C)	$W_C = W(\tau_E, 0; \tau_E, 0)$	$W_C = W(0, \sigma_E; 0, \sigma_E)$
Deviation (D1)	$W_{D1\tau} = W(\tau_{D1}, 0; \tau_E, 0)$	$W_{D1\sigma} = W(0, \sigma_{D1}; 0, \sigma_E)$
Punishment (N1)	$W_{N1\tau} = W(\tau_{N1}, 0; \tau_{N1}, 0)$	$W_{N1\sigma} = W(0, \sigma_{N1}; 0, \sigma_{N1})$

Table 1: On- and off-equilibrium payoffs for the tariff-only and subsidy-only agreements.

countries can only use the legal instrument. The self-enforcement of the two agreements depends on the on- and off-equilibrium-path payoffs which are summarized in Table 1. At each period, the payoff is the welfare level derived from the imposed set of trade instruments by all countries. In this simple case, because of symmetry, I can write the welfare of the deviator as a function of four arguments: his own instruments (import tariff τ^d and export subsidy σ^d) and other countries' instruments (import tariff τ^o and export subsidy σ^o): $W(\tau^d, \sigma^d; \tau^o, \sigma^o)$. I will always write the arguments in the same order. The on-equilibrium-path payoff is the cooperation welfare W_C: the internationally efficient welfare level. By construction, both agreements yield the same cooperation payoff. Therefore, to determine which agreement is more self-enforcing, I need to compare the welfare level of the deviator in the deviation and punishment periods for the two types of agreement to see under which agreement it is more tempting to deviate. In the case of the tariff-only agreement, the deviator gets a one period gain from deviating with the import tariff while other countries cooperate with the import instrument. Then from the next period onwards, countries revert to Nash tariffs. In the case of the subsidy-only agreement, the deviator gets a one period gain from deviating with the export subsidy while other countries cooperate with the export instrument. Then from the next period onwards, countries revert to Nash subsidies. The following lemma compares the deviation welfare levels of the two agreements.

Lemma 1 (One-instrument deviation)**.**

1. *When goods are independent* ($\gamma = 0$) *or perfect substitutes* ($\gamma = 1$)*, the one-instrument deviation from a tariff-only agreement yields a higher welfare than the one-instrument deviation from a subsidy-only agreement:* $W_{D1\tau} \geq W_{D1\sigma}$.
2. *When goods are partially substitutable* ($\gamma \in (0, 1)$)*, there is a threshold number of countries in the world above which the one-instrument deviation from a tariff-only agreement yields a lower welfare than the one-instrument deviation from a subsidy-only agreement:* $W_{D1\tau} < W_{D1\sigma}$.

This result is a consequence of the asymmetry between the two instruments stemming from the presence of oligopoly. When deviating with the import instrument, the deviator

increases the import tariff ($\tau_{D1} > 0 > \tau_E$) and thus gets a terms-of-trade gain and a profit-shifting gain. When deviating with the export instrument, the deviator decreases the export subsidy ($\sigma_{D1} < \sigma_E$) and thus gets a terms-of-trade gain and a profit-shifting loss. So broadly speaking, the gain from deviating with the import tariff is larger.

When goods are independent ($\gamma = 0$), there is no strategic interaction between firms, each firm is a monopolist in its own market and there is no profit-shifting reason for trade policy (each firm already extracts rents as much as it can). Both deviation with the import tariff and the export subsidy yield a terms-of-trade gain, but the gain from the import tariff is larger, because the import tariff is used to extract rents from foreign firms whereas there is no point in extracting rents from export profits of domestic firms (as monopolists, they already extract rents from foreign consumers fully).

When goods are perfect substitutes ($\gamma = 1$), it is not possible to deviate too much with the export subsidy, because a too large deviation would result in zero export sales whereas important deviation with the import tariff is possible and yields high gains (variety is unimportant to consumers).

When goods are partial substitutes ($\gamma \in (0, 1)$), variety matters to consumers. For small values of n, the gain from deviating with the import tariff is higher, because the tariff yields both a terms-of-trade gain and a profit-shifting gain, but as n increases, a higher tariff hurts consumers while the deviation with the export subsidy has no downside for domestic consumers. Thus for n sufficiently large, the gain from deviating with the export subsidy becomes greater than the gain from deviating with the import tariff. When $\gamma = \frac{1}{3}$, the deviation with the export subsidy yields a higher gain for $n \geq 48$. When $\gamma = \frac{1}{2}$, the threshold is $n \geq 69$ and when $\gamma = \frac{2}{3}$, the threshold is $n \geq 148$.

Lemma 2 (One-instrument Nash reversion)**.** *Nash reversion with tariffs yields a lower welfare than Nash reversion with subsidies:* $W_{N1\tau} < W_{N1\sigma}$.

This result is again a consequence of the asymmetry between the two trade instruments. An increase in the import instrument imposes a terms-of-trade and profit-shifting loss on other countries while the decrease in the export subsidy imposes only a terms-of-trade loss (and a profit-shifting gain). Thus a tariff war is worse than a subsidy war.

The question is which of the two agreements (tariff-only or subsidy-only agreement) is more self-enforcing? As the punishment in the tariff-only case is always harsher than in the subsidy-only case, it is obvious that for cases where the deviation from the tariff-only agreement yields also a lower gain than deviation from the subsidy-only agreement (goods partially substitutable and a many-country world), the tariff-only agreement will be more self-enforcing. But as stated by Lemma 1, there are cases where the deviation from the tariff-only agreement yields a higher gain. For these cases, we cannot conclude easily as the deviation gain makes it more tempting to deviate, but at the same time, the punishment makes it less tempting to deviate from the tariff-only agreement.

For an agreement to be self-enforcing, the discounted welfare from cooperation, $\frac{W_C}{1-\delta}$, where δ is the discount factor, must be no less than the discounted welfare achieved by deviating and thereafter reverting to the punishment phase, $W_{D1} + \frac{\delta W_{N1}}{1-\delta}$. Comparison of these discounted welfare values defines a critical threshold discount factor above which cooperation is sustained. To determine which agreement is more self-enforcing, I will calculate this critical threshold discount factor for both the tariff-only and subsidy-only agreements (δ_τ and δ_σ respectively) and compare them. The agreement with lower critical threshold discount factor will be more self-enforcing. The critical threshold discount factors for the two agreements are defined by

$$\delta_\tau = \frac{W_{D1\tau} - W_C}{W_{D1\tau} - W_{N1\tau}} \text{ and } \delta_\sigma = \frac{W_{D1\sigma} - W_C}{W_{D1\sigma} - W_{N1\sigma}} \tag{9}$$

Evaluating the welfare function at the appropriate instrument levels (derived in Appendix B) yields after simplification

$$\delta_\tau = \frac{D(n,\gamma)}{2\left[D(n,\gamma) - 4\right]} \text{ and } \delta_\sigma = \frac{\Phi(n,\gamma)^2}{\Theta(n,\gamma) + \Phi(n,\gamma)^2} \tag{10}$$

where $D(n,\gamma) \equiv 4(3-\gamma)+\gamma(4-3\gamma)(n-1) > 0$, $\Xi(n,\gamma) \equiv 4(1-\gamma)+\gamma(4-3\gamma)(n-1) > 0$, $\Upsilon(n,\gamma) \equiv 2\Gamma(n-1,\gamma)\left[(1-\gamma)\Gamma(n,\gamma)+\gamma\right] \geq 0$, $\Phi \equiv \Upsilon(n,\gamma) + (n-2)\gamma^2\left[\Gamma(n,\gamma) - 2\right] \geq 0$ and $\Theta(n,\gamma) \equiv \Xi(n,\gamma)\Upsilon(n,\gamma) \geq 0$.

The following proposition evaluates the difference between the two threshold discount factors, $\Delta \equiv \delta_\sigma - \delta_\tau$, and determines when $\Delta > 0$, i.e. when the tariff-only agreement is more self-enforcing.

Proposition 1.

1. *For $\gamma > 0$, δ_σ is an increasing function of n with $\lim_{n\to\infty} \delta_\sigma = 1$, δ_τ is a decreasing function of n with $\lim_{n\to\infty} \delta_\tau = \frac{1}{2}$, and so $\Delta \equiv \delta_\sigma - \delta_\tau$ is an increasing function of n with $\lim_{n\to\infty} \Delta = \frac{1}{2}$.*
2. *For any $\gamma > 0$, there is a threshold number of countries in the world n_τ above which $\Delta > 0$, i.e. the tariff-only agreement is more self-enforcing. For $\gamma = 1$, the tariff-only agreement is more self-enforcing for a world with three or more countries.*
3. *For $\gamma = 0$, $\delta_\tau = \frac{3}{4}$, $\delta_\sigma = \frac{2}{3}$ and $\Delta = -\frac{1}{12}$.*

Given the study of the deviation and punishment payoffs above, the intuition for these results is simple: the deviation gain from the tariff-only agreement may or may not be higher than the deviation gain from the subsidy-only agreement, but the punishment is always harsher in the tariff-only case. When $\gamma > 0$, as the number of countries in the world n increases, the deviation from the tariff-only agreement becomes relatively less

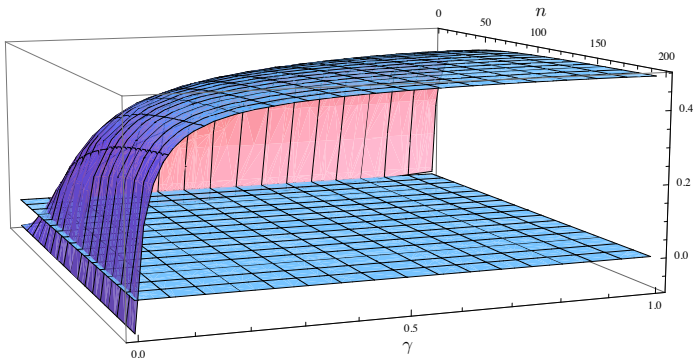

Figure 1: Δ for $\gamma \in [0, 1]$ and $n \in [3, 200]$.

appealing (imports become more important and so an increase in the import tariff hurts more domestic consumers) while the punishment becomes relatively harsher (exports become more important and so facing higher tariffs on exports in the punishment phase hurts more domestic firms). On the other hand a deviation with the export subsidy becomes more appealing while the punishment less threatening. So for any $\gamma > 0$, there is a threshold number of countries in the world above which the asymmetry between the two instruments makes the punishment in the tariff-only case so strong that it deters deviation and the tariff-only agreement is more self-enforcing. The general closed form solution for this threshold is slightly unwieldy (solution of a fourth-degree polynomial equation), but Table 2 indicates values of this threshold for selected values of γ. We can see that, for example when goods are perfect substitutes ($\gamma = 1$), the tariff-only agreement is more self-enforcing for any $n \geq 3$.

γ	1	0.75	0.5	0.25	0.1	0.05	0.01
n_τ	3	4	4	6	10	17	76

Table 2: Integer threshold number of countries in the world n_τ at and above which the tariff-only agreement is more self-enforcing.

For $\gamma = 0$, we are in the monopoly case and there is no profit-shifting rationale for trade policy. The deviation gain from the tariff-only agreement is so much larger than from the subsidy-only agreement and the punishment not harsh enough in the tariff-only case to deter deviation and thus the subsidy-only agreement is more self-enforcing when oligopoly does not matter. For γ close to zero, firms are almost monopolists and their interaction is limited and so the tariff-only agreement is more self-enforcing only for higher values of n as indicated in Table 2.

Figure 1 illustrates the difference between the critical threshold discount factors Δ. We can see that when oligopoly matters, the critical threshold discount factor in the

tariff-only agreement is lower than in the subsidy-only agreement and so a tariff-only agreement is more self-enforcing. Thus the presence of oligopoly together with the high costs of using trade instruments provides a rationale for banning export subsidies and negotiating on import tariffs.[23]

3.2 Extended case: two-instruments deviation

Assume now that the use of trade instruments is costly, but not prohibitively costly. Countries again agree to use either the import instrument or the export instrument only, to save the cost of the additional instrument, but now it is possible to deviate with both instruments on the off-equilibrium path. That said, if a country wants to deviate with both instruments, it has to invest and build the necessary infrastructure for the second instrument first: a customs infrastructure has to be set up at the border, customs officials hired etc. in the case of the import instrument, and a subsidization program has to be created in the case of the export instrument. It takes one period to build the necessary infrastructure for the second instrument and this investment is observable by other countries. Therefore, in the following period, when the deviator actually deviates with two instruments, it gets immediately punished by other countries.[24] However, the other countries can only punish the deviator with the "legal" instrument first, because they have not made the necessary investment at the same time as the deviator. So the deviator may get a one-period gain from playing Nash with two instruments against other countries who only have one instrument available. But would the deviator actually gain from having two instruments when other countries only have one? Would he ever want to deviate with two instruments?

Notice that as the deviation with both instruments requires a prior investment in the second instrument, it is not possible to deviate with both instruments and take the other countries by surprise. Thus, if a country was thinking of deviating, it would never start by deviating with the two instruments as it could get a higher gain from deviating with the 'legal' instrument first and taking the other countries by surprise. The question is

[23]The result can be easily extended, as discussed in Appendix D, to the case of k firms per country. When goods are perfectly substitutable ($\gamma = 1$) and the number of firms per country increases, the industry becomes more competitive and the asymmetry between the two trade instruments disappears. In perfect competition, there is no difference in self-enforceability of the tariff-only and subsidy only agreements.

[24]A recent example of such a development is the 2009 US stimulus plan including a "Buy American" requirement: only U.S.-made iron, steel and manufactured goods would have been allowed to be used in public works projects funded by the bill. As soon as this project became public, it draw fire from other countries, in particular the EU. On February 4, 2009, *The Times* wrote in an article entitled "President Obama to water down 'Buy American' plan after EU trade war threat": "The European Union warned the US yesterday against plunging the world into depression by adopting a planned "Buy American" policy, intensifying fears of a trade war. The EU threatened to retaliate if the US Congress went ahead with sweeping measures in its $800 billion (£554 billion) stimulus plan to restrict spending to American goods and services. [...] Last night Mr Obama gave a strong signal that he would remove the most provocative passages from the Bill."

whether, once the deviator deviates with the legal instrument, he would want to invest in the second instrument so that in the following period he plays Nash with two instruments instead of Nash with one instrument (let us denote this period (D2)). To answer this question, we need to compare the payoffs from playing Nash with two instruments against countries who only have one instrument with the one-instrument Nash reversion payoffs.

When the deviator has two instruments while other countries have only one in period D2, a given punisher will not necessarily impose the same instruments on the deviator and on the other countries. Therefore, with a slight abuse of notation, I will now write the welfare function as a function of six variables: the import and export instruments of the deviator (τ^d and σ^d respectively), the import instrument imposed by the punishers on the deviator τ^p and the export instrument imposed by the punishers in the deviator's market σ^p, and the import and export instruments of the punishers on other punishers (τ^o and σ^o respectively). I will always write the arguments in the same order: $W(\tau^d, \sigma^d; \tau^p, \sigma^p; \tau^o, \sigma^o)$.

The following lemma compares the two-instrument-deviation payoffs with one-instrument Nash reversion payoffs.

Lemma 3 (Two-instrument deviation)**.**

1. *The two-instrument deviation from the tariff-only agreement yields a lower welfare than the one-instrument Nash reversion:* $W_{D2\tau} < W_{N1\tau}$.
2. *For* $\gamma \leq 2 - \sqrt{2}$*, the two-instrument deviation from the subsidy-only agreement yields a higher welfare than the one-instrument Nash reversion:* $W_{D2\sigma} > W_{N1\sigma}$.

   For $\gamma > 2 - \sqrt{2}$*, there is a threshold number of countries in the world* n_1 *above which the two-instrument deviation from the subsidy-only agreement yields a lower welfare than the one-instrument Nash reversion:* $W_{D2\sigma} \leq W_{N1\sigma}$.

This result may seem slightly surprising at first sight: how is it possible that a country with the full set of trade instruments playing Nash against countries with only one trade instrument may have a lower welfare than if it only had one trade instrument? The answer is related to the earlier discussion of the effects of the two instruments: in the tariff-only case, the deviator's export subsidy shifts profits from other countries' firms to the deviator's firm, but other countries can neutralize this effect by raising their import tariff ($\tau_P^\tau \geq \tau_{N1}$). The deviator will thus just suffer a terms-of-trade loss from his subsidy and the other-countries import tariff: the increase in the deviator's export subsidy and the other countries' import tariff will create a transfer from the deviator to the other countries. Thus the deviator would be better off not to have the export subsidy.[25]

[25]Notice that when countries set their trade instruments simultaneously, the deviator cannot commit not to use the export subsidy. The other countries know that the deviator is able to use the export subsidy and they take this information into account when choosing their optimal trade policy. Hence they will set a higher import tariff than when the deviator does not have the export subsidy available and

For the subsidy-only agreement, Lemma 3 tells us that depending on the parameters of the model, the deviator may benefit from having two instruments while other countries have only an export subsidy. This is because the import tariff is a "stronger" instrument. It brings a double gain, a terms-of-trade and a profit-shifting gain, and the other countries cannot neutralize both these effects of the import tariff fully with export subsidies only. However, whether the deviator actually benefits from having the two instruments depends on the parameters of the model. To counter the effect of the deviator's tariff, the other countries will reduce their export subsidy to the deviator which will have a positive profit-shifting effect on the deviator and a negative terms-of-trade effect. When goods are closely substitutable (high γ) and there are many countries (high n), competition among firms is tougher and firms make smaller profits. The profit-shifting gain to the deviator will thus be relatively small, while the negative terms-of-trade effect will be large (when n is large, imports are important for consumers).

The expression for the threshold value of n_1, above which the two-instrument deviation from the subsidy-only agreement yields a lower welfare than the one-instrument Nash reversion, is slightly unwieldy, but the following table indicates values of this threshold for selected values of γ.

γ	1	0.95	0.9	0.85	0.8	0.75	0.7	0.65	0.6
n_1	5	5	6	8	10	13	20	38	180

Table 3: Integer threshold number of countries in the world n_1 at and above which $W_{D2\sigma} \leq W_{N1\sigma}$.

Lemma 3 tells us that when other countries have import tariffs only, the deviator would prefer to play Nash also only with an import tariff rather than with both instruments. On the other hand, when other countries have export subsidies only, the deviator may prefer, depending on the parameters of the model, to play Nash with both instruments. To determine whether two instruments would ever arise in equilibrium, Proposition 2 characterizes the deviator's best response to other countries' strategies.

Proposition 2.

1. *In a trade war of the tariff-only agreement, the use of two instruments is a strictly dominated strategy.*

2. *In a trade war of the subsidy-only agreement, the use of two instruments is a strictly dominated strategy for $\gamma > 2 - \sqrt{2}$ and $n \geq n_1$. For $\gamma \leq 2 - \sqrt{2}$, the use of the export-subsidy only is a strictly dominated strategy.*

the deviator has to impose an export subsidy to partially counter this tariff rise. Collie (1991) showed that when countries set their instruments sequentially (the punisher chooses his countervailing import tariff once the deviator has set his export instrument), the deviator would set an export tax and would then face a lower import tariff from his trading partner.

Proposition 2 has an interesting consequence for trade agreements: countries would never want to deviate with two instruments from a tariff-only agreement while they may want to deviate with two instruments from a subsidy-only agreement.

Corollary 1. *The use of a single instrument is self-enforcing in the tariff-only agreement while it is not in the subsidy-only agreement for* $\gamma \leq 2 - \sqrt{2}$.

This result does not tell us anything about which of the two agreements is more self-enforcing, but it provides a different motivation for choosing the tariff-only agreement: one of the objectives of the GATT/WTO is to limit the proliferation of trade instruments and with the tariff-only agreement, there would not be any temptation to introduce export subsidies while this would not be necessarily the case with the subsidy-only agreement.

A consequence of Proposition 2 is that for the tariff-only agreement, the relevant off-equilibrium path is the base-case path. For the subsidy-only agreement, the base-case off-equilibrium path is relevant for high values of γ (and sufficiently high values of n), but not for lower values of γ. From Proposition 2 we know that for $\gamma \leq 2 - \sqrt{2}$, the relevant off-equilibrium path for the subsidy-only agreement is:

(D1) The deviating country deviates with the export subsidy (because it is readily available and it can take the other countries by surprise) and invests in the import tariff at the same time. Other countries cooperate.

(D2) The deviating country deviates with both instruments and gets punished by the other countries with export subsidies.

(N2) All countries revert to Nash with both instruments.

The per-period payoffs for the two agreements are as shown in Table 4. The cooperation welfare is again the same for both regimes. The first deviation D1 is exactly the same in the base case: if a country deviates with the legal instrument, it gets the deviation welfare $W_{D1\tau}$ in the tariff-only agreement and $W_{D1\sigma}$ in the subsidy-only agreement. We know from the study of the base case that the one instrument deviation D1 from the tariff-only agreement may or may not yield a higher welfare than the deviation from the subsidy-only agreement. We also know that for $\gamma \leq 2 - \sqrt{2}$, $W_{D2\sigma} > W_{N1\sigma}$ and from Lemma 2 we know that $W_{N1\sigma} > W_{N1\tau}$ which implies that the payoff in phase D2 is higher in the subsidy-only agreement than in the tariff-only agreement: $W_{D2\sigma} > W_{N1\tau}$. We need to compare the welfare in Nash reversion with tariffs only and in Nash reversion with the full set of trade instruments.

Lemma 4. *The trade war with the full set of trade instruments yields a higher welfare than a trade war with import tariffs only.*

	Tariff-only agreement (initially $\sigma = 0$)	Subsidy-only agreement (initially $\tau = 0$)
Cooperation (C)	$W_C = W(\tau_E, 0; \tau_E, 0; \tau_E, 0)$	$W_C = W(0, \sigma_E; 0, \sigma_E; 0, \sigma_E)$
Deviation (D1)	$W_{D1\tau} = W(\tau_{D1}, 0; \tau_E, 0; \tau_E, 0)$	$W_{D1\sigma} = W(0, \sigma_{D1}; 0, \sigma_E; 0, \sigma_E)$
Deviation (D2)	$W_{N1\tau} = W(\tau_{N1}, 0; \tau_{N1}, 0; \tau_{N1}, 0)$	$W_{D2\sigma} = W(\tau^{\sigma}_{D2}, \sigma^{\sigma}_{D2}; 0, \sigma^{\sigma}_{P}; 0, \sigma^{\sigma}_{O})$
Punishment (N2)	$W_{N1\tau} = W(\tau_{N1}, 0; \tau_{N1}, 0; \tau_{N1}, 0)$	$W_{N2} = W(\tau^{f}_{N}, \sigma^{f}_{N}; \tau^{f}_{N}, \sigma^{f}_{N}; \tau^{f}_{N}, \sigma^{f}_{N})$

Table 4: Actual on- and off-equilibrium payoffs with two-instrument deviation for the tariff-only and subsidy-only agreements for $\gamma \leq 2 - \sqrt{2}$.

The intuition for this result is simple and goes back to the argument mentioned in the introduction that export subsidies should be encouraged rather than banned: in a non-cooperative world with trade barriers, subsidies partly neutralize the effect of import tariffs and thus increase welfare.

Finally, we want to determine which agreement is more self-enforcing in this extended case where countries can deviate with both instruments. Notice that both periods D2 and N2 yield a lower welfare in the tariff-only agreement so for cases where the one instrument deviation D1 also yields a lower welfare in the tariff-only agreement ($\gamma \in (0, 1)$ and sufficiently large n), this agreement is obviously more self-enforcing. For the other cases, we have to, as in the base case, determine the critical threshold discount factors for these two agreements. The tariff-only off-equilibrium path is identical to the base case and so the critical threshold discount factor is the same: δ_τ. For the subsidy-only agreement, the critical threshold discount factor $\tilde{\delta}_\sigma$ makes countries indifferent between cooperation $\frac{W_C}{1-\delta}$ and deviation followed by punishment $W_{D1\sigma} + \delta W_{D2\sigma} + \frac{\delta^2}{1-\delta} W_{N2}$. The critical threshold discount factor $\tilde{\delta}_\sigma$ is the positive root of

$$\delta^2 + \delta \frac{W_{D1\sigma} - W_{D2\sigma}}{W_{D2\sigma} - W_{N2}} - \frac{W_{D1\sigma} - W_C}{W_{D2\sigma} - W_{N2}} = 0 \tag{11}$$

Given the complexity of $\tilde{\delta}_\sigma$ (solution of a second degree equation with coefficients being rational functions of n and γ of high degrees), it is hard to sign the difference between the critical discount factors $\tilde{\Delta} \equiv \tilde{\delta}_\sigma - \delta_\tau$ analytically, however, we can study this expression numerically. When $\gamma = 0$, $\tilde{\Delta} = -\frac{3}{20}$, the difference between the critical threshold discount factors is negative for the same reasons as in the base case: when $\gamma = 0$, each firm is a monopolist and oligopoly does not matter. However, for $\gamma > 0$, $\tilde{\Delta}$ is positive for a wide range of parameters as shown in Figure 2. Indeed, for any $\gamma > 0$, there is again a threshold number of countries in the world above which the tariff-only agreement is more self-enforcing. Furthermore, for $\gamma \in (0, 1)$, we have $\lim_{n\to\infty} \tilde{\Delta} = \frac{1}{2}$. The following table indicates the values of n above which the tariff-only agreement is more self-enforcing for

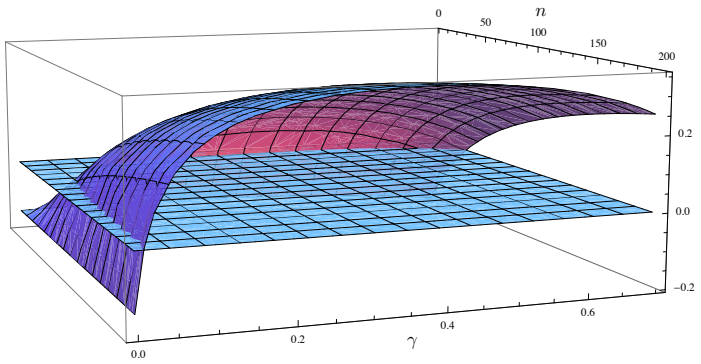

Figure 2: $\tilde{\Delta}$ for $\gamma \in [0, 0.7]$ and $n \in [3, 200]$.

selected values of γ. We can see that the tariff-only agreement is more self-enforcing

γ	0.1	0.2	0.3	0.4	0.5	0.6
n_c	30	18	16	15	17	23

Table 5: Integer threshold number of countries in the world n_c at and above which $\tilde{\Delta} > 0$.

for a wide range of parameters even in the extended case and the presence of oligopoly thus provides a rationale for the ban of export subsidies in multilateral agreements of the GATT/WTO.

4 Trade agreements with import tariffs only

So far, I have assumed that countries sign an agreement which enables them to set trade instruments at the efficient levels. When the use of trade instruments is costly, it would be beneficial to ban one of the two instruments and I have shown that banning the export subsidy provides a more self-enforcing agreement. Let us now come back to the question foreshadowed in Subsection 2.2: how can an agreement help countries to reach efficiency? To answer this question, we need first to determine what are the sources of the inefficiency. I have shown that in the presence of oligopolistic industries, unilateral trade policy gives rise to two international externalities. Do both these externalities cause the international inefficiency?

Bagwell and Staiger (2009b) answer this question assuming that countries have at their disposal the full set of trade instruments: they show that it is only the terms-of-trade externality that leads to the inefficiency of unilateral trade policy, as countries are able to internalize (from the world's perspective) the profit-shifting externality through the import and export instruments. Broadly speaking, when country i raises its import tariff on imports from country j, country j suffers a terms-of-trade and a profit-shifting

loss. But if country j increases its export subsidy on exports to country i by the same amount, the profit-shifting effect is neutralized (the net trade instrument is the same and so the equilibrium is the same). The only difference is that now there is a transfer from country j to country i: country j suffers a terms-of-trade loss that it cannot neutralize. So when markets are oligopolistic and countries have both trade instruments available, the only potential role for a trade agreement is to neutralize the terms-of-trade externality as is the case in perfectly competitive markets (see Bagwell and Staiger (1999, 2002) for a discussion of rationales for trade agreements under perfect competition).

However, I have shown in the previous section that it may be optimal to ban export subsidies and negotiate on import tariffs only, and indeed the GATT/WTO bans export subsidies so countries do not have both instruments at their disposal. Therefore this section looks at the rationales for trade agreements when the set of trade instruments is restricted to import tariffs only.[26]

4.1 Potential role for trade agreements

To determine whether there is any other potential role for a trade agreement beyond neutralizing the inefficiency-inducing terms-of-trade externality, I follow the approach adopted by Bagwell and Staiger (1999) for competitive markets and Bagwell and Staiger (2009b) for oligopolistic markets with the full set of trade instruments. I consider the following hypothetical experiment: if countries did not value the terms-of-trade effects of their trade policy, would they set efficient import tariffs?

Lemma 5. *Nash equilibrium tariffs in the absence of terms-of-trade effects are inefficient:*

$$\tilde{\tau}_N = \frac{\gamma\Gamma(0,\gamma)}{2\Gamma(0,\gamma)\Gamma(n,\gamma) - \gamma^2(n-1)} \geq 0 \text{ while } \tau_E = -\frac{\Gamma(0,\gamma)^2}{\Xi(n,\gamma)} < 0.$$

So even if governments did not want to manipulate their terms of trade and only the import tariff was available, they would impose inefficiently high tariffs because they would use them to shift profits from foreign to domestic firms.[27] When the set of trade instruments is restricted, it is not possible to neutralize the profit-shifting externality of import tariffs and efficiency cannot be reached by neutralizing terms of trade only. Hence the presence of oligopoly provides potentially a new rationale for trade agreements: a profit-shifting externality, which is distinct from the terms-of-trade externality. The question is how can a trade agreement neutralise both externalities?

[26]Note that similar results about the rationales for trade agreements of this section would arise if the set of instruments were restricted to export instruments only instead of import instruments only. However, this case is not discussed here as this is not a feature of the GATT/WTO, and as the previous section showed it is optimal to choose import instruments.

[27]Note that when $\gamma = 0$, $\tilde{\tau}_N = 0$: firms are monopolists and there is no room for profit-shifting.

For ease of exposition, assume first that there are only two countries: i and j. (I will relax this assumption later.) Country i imposes an import tariff τ_{ij} on country j and country j imposes an import tariff τ_{ji} on country i. Recall that the internationally-efficient import tariff of country i must satisfy

$$\frac{d}{d\tau_{ij}}\left(W^i + W^j\right) = (p_{ii} - c)\frac{dq_{ii}}{d\tau_{ij}} + (p_{ij} - c)\frac{dq_{ij}}{d\tau_{ij}} = 0. \tag{12}$$

When countries change their tariffs simultaneously, the change in country i's tariff $d\tau_{ij}$ affects country i's welfare arising at home and the change in country j's tariff $d\tau_{ji}$ affects country i's export profits, so country i's welfare is affected by the simultaneous change in tariffs $d\boldsymbol{\tau} = (d\tau_{ij}, d\tau_{ji})$ as follows:[28]

$$\frac{dW^i}{d\boldsymbol{\tau}} = \underbrace{-q_{ij}\frac{dp^*_{ij}}{d\tau_{ij}} + \tau_{ij}\frac{dq_{ij}}{d\tau_{ij}} + (p_{ii} - c)\frac{dq_{ii}}{d\tau_{ij}}}_{\text{change in domestic welfare induced by } d\tau_{ij}} + \underbrace{\frac{d}{d\tau_{ji}}\left[(p_{ji} - c - \tau_{ji})q_{ji}\right]}_{\text{change in export profits induced by } d\tau_{ji}} \tag{13}$$

Comparing (12) with (13), we see that a trade liberalisation $d\boldsymbol{\tau}$ yields international efficiency if and only if it is such that

$$\frac{d}{d\tau_{ji}}\left[(p_{ji} - c - \tau_{ji})q_{ji}\right] = q_{ij}\frac{dp^*_{ij}}{d\tau_{ij}} - \tau_{ij}\frac{dq_{ij}}{d\tau_{ij}} + (p_{ij} - c)\frac{dq_{ij}}{d\tau_{ij}} = \frac{d}{d\tau_{ij}}\left[(p_{ij} - c - \tau_{ij})q_{ij}\right]. \tag{14}$$

This result can be restated in the following way:

Proposition 3. *A bilateral trade liberalisation yields international efficiency if and only if it keeps the profit balance constant $dPB_{ij} = 0$ where*

$$PB_{ij} = (p_{ji} - c - \tau_{ji})q_{ji} - (p_{ij} - c - \tau_{ij})q_{ij}. \tag{15}$$

By keeping the profit balance constant, both the terms-of-trade and profit-shifting externalities are neutralized, or more precisely, countries exchange equivalent terms-of-trade and profit-shifting concessions:

$$\frac{dPB_{ij}}{d\boldsymbol{\tau}} = 0 = \underbrace{q_{ji}\frac{dp^*_{ji}}{d\tau_{ji}} - q_{ij}\frac{dp^*_{ij}}{d\tau_{ij}}}_{ToT} + \underbrace{\left[(p_{ji} - c - \tau_{ji})\frac{dq_{ji}}{d\tau_{ji}}\right] - \left[(p_{ij} - c - \tau_{ij})\frac{dq_{ij}}{d\tau_{ij}}\right]}_{PS} \tag{16}$$

Notice that this result has both a local and global meaning: as shown in the appendix, if countries change reciprocally their tariffs in a marginal way, starting from above the efficient tariffs, they will be unambiguously better off. And this is true all the way along the path until they reach efficiency.[29]

[28] Note that this is independent of the assumption of linear demands.

[29] Note that if countries were asymmetric, depending on the starting point of the trade liberalisation,

The following subsection discusses whether GATT/WTO trade agreements play the role of keeping the profit balance constant.

4.2 Reciprocity in a two-country world

The principle of reciprocity is considered to be one of the foundational principles of the GATT/WTO, but there is no formal definition of reciprocity in the GATT/WTO.[30] Hoda (2001, p. 8) for example points out that "there is no provision on the manner in which reciprocity is to be measured and even the rules of various rounds of negotiations did not spell out any guidelines on the issue. The understanding has always been that governments participating in negotiations should retain complete freedom to adopt any method for evaluating the concessions."

Broadly speaking, reciprocity requires countries to exchange reciprocal concessions when negotiating trade liberalization. Keohane (1986, p. 7) explains that "reciprocity is not defined in the General Agreement on Tariffs and Trade, but the director-general of GATT [referring to Arthur Dunkel's lecture at the Chinese University of Hong Kong] defines it as 'the equivalence of concessions'." Given that firms' profits seem to on the mind of real-world trade negotiators, I define reciprocity as follows:

Definition 2. A tariff change $d\boldsymbol{\tau} = (d\tau_{ij}, d\tau_{ji})$ is bilaterally reciprocal if it keeps the bilateral profit balance constant: $dPB_{ij} = 0$.

It immediately follows that a bilaterally reciprocal trade liberalization enables countries to reach international efficiency.

Notice however, that the literature usually defines 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 (see for example Bagwell and Staiger (1999, 2001, 2002)). This definition is equivalent to my definition under perfect competition and under oligopoly with linear demands.[31] But when markets are oligopolistic and demands are not linear, these two definitions are different and reciprocity as defined by Bagwell and Staiger

they would not necessarily both reach efficiency.

[30]The only mention of reciprocity in the GATT is that trade negotiations should be done on a"reciprocal and mutually advantageous basis" and the only way in which reciprocity is actually encoded in the GATT is that countries are allowed 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.

[31]Following Bagwell and Staiger (2001), in the context of quasi-linear preferences, a tariff change $d\boldsymbol{\tau} = (d\tau_{ij}, d\tau_{ji})$ is bilaterally reciprocal if it is such that $p^*_{ij}dq_{ij} + d\tilde{M}_i - p^*_{ji}dq_{ji} = 0$, where $\tilde{M}_i$ denotes country i's imports of the numeraire good ($\tilde{M}_i = M_i - M_i^p$ with M_i (M_i^p) being the consumption (production) of the numeraire good). Trade is balanced and so we have $TB_{ij} = p^*_{ij}q_{ij} + \tilde{M}_i - p^*_{ji}q_{ji} = 0$. Total differentiation of this gives $dTB_{ij} = q_{ij}dp^*_{ij} - q_{ji}dp^*_{ji} + p^*_{ij}dq_{ij} + d\tilde{M}_i - p^*_{ji}dq_{ji} = 0$. And hence reciprocity interpreted by Bagwell and Staiger yields $q_{ji}dp^*_{ji} - q_{ij}dp^*_{ij} = 0$: it ensures an equivalent exchange of terms-of-trade concessions. When demands are linear, we have $q_{ij}dp^*_{ij} = (p_{ij} - c - \tau_{ij})dq_{ij}$ and so reciprocity also implies an equivalent exchange of profit concessions.

(1999) does not yield efficiency. Therefore, when profits matter, it seems appropriate to use my definition above.

4.3 Non-discrimination: a many-country world

The previous two subsections showed that reciprocal liberalization in a two-country world unambiguously increases both countries' welfare and enables countries reach efficiency. But what if there are more then two countries in the world? It is easy to show that if two countries liberalize trade between themselves, outsiders are made unambiguously worse off. Indeed, in this model, country l is affected by country i's tariffs only through its exports to country i. As we have seen in the preliminary section, when country i lowers its tariffs on country j (without changing its tariffs on country l), country l's export sales (and therefore also export profits) in country i decrease. This phenomenon is well known in the literature since Viner (1950) as trade diversion.

Lemma 6. *A discriminatory liberalization harms countries that are not involved in it.*

Thus the bilateral principle of reciprocity is not sufficient to ensure a monotonic increase in welfare of all countries in a many-country world. The role of the non-discrimination principle will be to prevent discriminatory trade liberalization.

4.4 Reciprocity and non-discrimination

In this subsection, I determine the impacts on welfare of a trade liberalization that follows both the reciprocity and non-discrimination principles. The principle of non-discrimination requires that countries impose the same tariff on all their trading partners. Furthermore, I follow Bagwell and Staiger (1999) and Ossa (2010) in interpreting the principle of non-discrimination as a way to 'multilateraze' the principle of reciprocity and define the two principles together in the following way:

Definition 3. A tariff change $d\boldsymbol{\tau}$ is multilaterally reciprocal if it keeps the multilateral profit balance constant: $dPB_i = 0$, where

$$PB_i = \sum_{\substack{j=1 \\ j\neq i}}^{n} (p_{ji} - c - \tau_j) q_{ji} - \sum_{\substack{j=1 \\ j\neq i}}^{n} (p_{ij} - c - \tau_i) q_{ij}. \tag{17}$$

The following proposition determines the effects of multilaterally-reciprocal trade liberalisation:

Proposition 4. *Trade liberalization following both the principle of reciprocity and non-discrimination, starting from above the efficient import tariff levels, unambiguously increases the welfare of all countries until they reach internationally efficient tariff levels.*

So the presence of oligopoly provides a new rationale for trade agreements: a profit-shifting externality. Trade agreements ensure a balanced exchange of profit concessions by keeping the profit balance fixed. Hence they undo both the terms-of-trade and profit-shifting externalities and unambiguously raise countries' welfare.

4.5 Politically motivated governments

The previous study showed that when countries are restricted in their use of trade instruments to import tariffs only, in the presence of oligopolistic markets, there are two inefficiency-inducing international externalities: the traditional terms-of-trade externality and a profit-shifting externality. The rules of reciprocity and non-discrimination help countries to neutralize both these externalities and to reach the internationally efficient outcome. In all the analysis, I assumed that governments are social welfare maximizers. Do the previous results hold when governments have politically motivated preferences? Will the rules of reciprocity and non-discrimination still be sufficient to achieve international efficiency?

In what follows, I allow governments to place a higher weight on profits in their objective function:

$$\begin{aligned} W^i &= CS^i + TR^i + \theta_i \pi^{ii} + \omega_i \sum_{\substack{j=1 \\ j\neq i}}^{n} \pi^{ji} \\ &= \sum_{j=1}^{n} \frac{1}{2}(a - p_{ij})q_{ij} + \sum_{\substack{j=1 \\ j\neq i}}^{n} \tau_i q_{ij} + \theta_i (p_{ii} - c)q_{ii} + \omega_i \sum_{\substack{j=1 \\ j\neq i}}^{n} (p_{ji} - c - \tau_j)q_{ji}, \end{aligned}$$

where θ_i and ω_i are the weights that country i attaches to its firm's profits in the home and foreign markets respectively. Both θ_i and ω_i may be greater than one.[32]

Internationally efficient tariffs maximize joint welfare. The first-order condition for country i's import tariff is

$$\begin{aligned} \frac{d}{d\tau_i}\left(\sum_{j=1}^{n} W^j\right) = & -\sum_{\substack{j=1 \\ j\neq i}}^{n} (1-\omega_j) q_{ij} \frac{dp^*_{ij}}{d\tau_i} + \sum_{\substack{j=1 \\ j\neq i}}^{n} (1-\omega_j)\tau_i \frac{dq_{ij}}{d\tau_i} + (2\theta_i - 1)(p_{ij} - c)\frac{dq_{ij}}{d\tau_i} \\ & + \sum_{\substack{j=1 \\ j\neq i}}^{n} \omega_j (p_{ij} - c)\frac{dq_{ij}}{d\tau_i} = 0. \end{aligned} \tag{18}$$

[32] As Baldwin (1987) points out this representation of governments preferences is quite general as it can encompass many different political economy models of trade policy. It is standard to assume that the weights on home and export profits are equal. I allow them to be different in order to be able to identify the origin of the effects discussed below.

When countries liberalize simultaneously, the welfare of country i is affected

$$\begin{aligned}\frac{dW^i}{d\boldsymbol{\tau}} = &\sum_{\substack{j=1\\j\neq i}}^{n} - q_{ij}\frac{dp^*_{ij}}{d\tau_i} + \sum_{\substack{j=1\\j\neq i}}^{n}\tau_i\frac{dq_{ij}}{d\tau_i} + (2\theta_i - 1)(p_{ij} - c)\frac{dq_{ij}}{d\tau_i} \\ &+ \omega_i\sum_{\substack{j=1\\j\neq i}}^{n}\left[q_{ji}\frac{dp^*_{ji}}{d\tau_j} + (p_{ji} - c - \tau_j)\frac{dq_{ji}}{d\tau_j}\right],\end{aligned} \tag{19}$$

where the first line represents the variation of the part of welfare arising in the home market (variation induced by the change in country i's own import tariff) and the second line represents the change in country i's export profits induced by the change in other countries' tariffs. Now suppose that countries liberalize trade following the principles of reciprocity and non-discrimination. The multilateral reciprocity condition tells us that the change in country i's export profits has to be equal to the change in export profits that other countries make in country i. Using this condition to substitute for the change in country i's export profits in (19) in order to obtain the change in country i's welfare only in terms of its own tariff yields

$$\begin{aligned}\frac{dW^i}{d\boldsymbol{\tau}} = &-(1-\omega_i)\sum_{\substack{j=1\\j\neq i}}^{n} q_{ij}\frac{dp^*_{ij}}{d\tau_i} + (1-\omega_i)\sum_{\substack{j=1\\j\neq i}}^{n}\tau_i\frac{dq_{ij}}{d\tau_i} + (2\theta_i - 1)(p_{ij} - c)\frac{dq_{ij}}{d\tau_i} \\ &+ \omega_i\sum_{\substack{j=1\\j\neq i}}^{n}(p_{ij} - c)\frac{dq_{ij}}{d\tau_i}.\end{aligned} \tag{20}$$

Comparing (20) with (18), we can see that when countries attach different weights to their firm's export profits ($\omega_i \neq \omega_j$), even if they are completely symmetric otherwise, the multilateral reciprocity condition will not yield efficiency.

Proposition 5. *When governments are politically motivated, the rules of reciprocity and non-discrimination only yield efficiency if countries value their export profits in the same way.*

This is an intuitively appealing result. Reciprocity requires countries to exchange mutual profit concessions on a one-for-one basis; if countries value their export profits differently, reciprocity cannot yield international efficiency. Moreover, this result points to an explanation of why the GATT/WTO was successful in the past and why trade negotiations are now proving more difficult. In the early days of the GATT, there were only 23 members, most of which were relatively homogeneous developed countries with similar political preferences. The few developing countries that were members of the GATT were allowed to free ride on the agreement and were not required to make any substantial concessions (see for example Irwin (1995), Rose (2007) or Subramanian and Wei (2007)). Hence, the

rule of reciprocity was an appropriate rule. Contrasting the early success of the GATT with the failure of the much broader ITO, Hudec (1975, p. 51) for example points out that "it was comforting to have one place (one might almost say a club) where like-minded people could get together and do their work in peace." With the expansion of the GATT/WTO, the membership became much wider and more heterogeneous: the WTO currently has 153 members of which many are developing countries. There can be little doubt that the political preferences of the current WTO members differ substantially and so the principle of reciprocity is no longer an adequate negotiating rule.

The natural question is how should the rule of reciprocity be changed so that it enables countries with different political preferences to reach international efficiency? The rule of reciprocity could indeed be generalized to take into account countries' different weights on profits.

Definition 4. A tariff change $d\boldsymbol{\tau}$ satisfies the 'generalized' multilateral reciprocity condition if it keeps the profit balance weighted by the different coefficients of the different countries $\tilde{PB}_i$ constant:

$$d\tilde{PB}_i = d\left[\omega_i \sum_{\substack{j=1 \\ j\neq i}}^{n}(p_{ji} - c - \tau_j)q_{ji} - \sum_{\substack{j=1 \\ j\neq i}}^{n}\omega_j(p_{ij} - c - \tau_i)q_{ij}\right] = 0.$$

It is easy to show that trade liberalization satisfying this generalized multilateral reciprocity would unambiguously increase welfare of liberalizing countries and would enable countries to reach the internationally efficient outcome. The generalized multilateral reciprocity condition would imply that countries which value more the export profits of their firms would make smaller concessions. How to make this criterion operational remains an open question. The difficulty is that this criterion depends on countries' preferences. Antràs and Staiger (2008) find a similar result in a completely different framework of trade agreements in the presence of offshoring. They show that, when governments are politically motivated, offshoring makes the role of trade agreements more complicated in that the problem, that trade agreements have to solve, depends on governments' preferences. Their result and the result above are in contrast to the predictions of the terms-of-trade theory of trade agreements (see Bagwell and Staiger (1999, 2002)) where the fact whether governments are politically motivated or not, does not change anything to the nature of the problem that a trade agreement should solve.

5 Conclusion

This paper has identified three new insights into trade agreements arising from the presence of oligopolistic markets. First, the presence of oligopolistic markets provides a

rationale for banning export subsidies. The internationally efficient equilibrium depends only on the net instrument, i.e. the difference between the export subsidy and the import tariff. The absolute levels of the two instruments do not matter. Therefore, if the use of trade instruments is costly, it may be beneficial to ban one of the two instruments and negotiate only on the other one. The question then is whether it is better to ban export subsidies and negotiate on tariffs only or the other way round. When cooperation is sustained, both agreements yield the same, internationally efficient outcome. But a country may be tempted to deviate from the agreement and cooperation may fail. Under perfect competition, the off-equilibrium path payoffs would be the same for both agreements, because the two instruments are symmetric. But the presence of oligopolistic markets introduces an asymmetry between the two instruments and so the off-equilibrium paths for the two agreements differ. An increase in the import tariff both improves the terms of trade of the importing country and shifts profits from foreign to domestic firms. A change in the export subsidy either shifts profits from foreign to domestic firms or improves the terms of trade of the exporting country, but not both. So in the case of the import tariff, the terms-of-trade and the profit-shifting effects go in the same direction whereas in the case of the export subsidy, they go in opposite directions. This makes the import tariff a 'stronger' instrument. In the situation where both instruments are not readily available (because one of them has been banned and it takes time and resources to build up the necessary infrastructure for using the other instrument), the import tariff is a more effective punishment instrument which makes deviation more costly and thus less likely. Therefore, banning export subsidies and negotiating on import tariffs only is a more self-enforcing agreement than banning import tariffs and negotiating on export subsidies.

Second, when the set of available trade instruments is restricted to import tariffs only, as it is in the GATT/WTO, the presence of oligopolistic markets gives rise to a new rationale for the rules of reciprocity and non-discrimination: a profit-shifting externality. Governments use import tariffs not only to improve their terms of trade, but also as a second-best policy to increase domestic production and shift profits from foreign to domestic firms. This profit-shifting externality cannot be internalized with the restricted set of trade instruments and leads to inefficiently high import tariffs even in the absence of terms-of-trade effects. Therefore, neutralizing the terms of trade would not be sufficient to achieve the internationally efficient equilibrium. Interpreting the principle of reciprocity as keeping the profit balance constant, I show that reciprocity and non-discrimination neutralize both the terms-of-trade and the profit-shifting externalities and enable countries to reach the internationally efficient equilibrium.

Third, when the set of instruments is restricted to import tariffs only and governments are politically motivated, i.e. attach different weights to consumers and producers, the rules of reciprocity and non-discrimination only yield efficiency if governments have

similar political preferences in the sense that they attach the same weights to their export profits. The rule of reciprocity requires a balanced exchange of export profit concessions. If one country values its export profits more than a partner country, the rule of reciprocity which does not take this difference in political preferences into account, will not yield international efficiency. However, the rule of reciprocity could be generalized to take the difference in political preferences into account: a trade liberalization keeping constant the profit balance weighted by the weights that countries attach to their export profits, would unambiguously increase the welfare of all countries and enable them to reach the internationally efficient tariff levels.

In order to compare welfare levels under different trade instrument regimes and prove the first result on the desirability to ban export subsidies, I have made two assumptions. I have assumed that preferences are quasi-linear, thereby assuming away any income effects of trade policy, and that the break-down of negotiations corresponds to a Nash reversion. Further work is needed to establish the robustness of this result with different demand systems and with different punishment strategies. However, the mechanisms uncovered in this paper are clearly direct implications of oligopolistic behavior and are likely to remain robust to relaxing other assumptions made. Given the importance of large firms in the world economy and especially their major role in political economy, it seems very desirable to explore further consequences of oligopolistic behavior for international trade agreements.

Appendix

A Effect of a change in trade policy on welfare

A.1 Import tariff case: derivation of equation (7)

By definition, from (6) we have

$$W^i = \sum_{j=1}^{n} \frac{1}{2}(a - p_{ij})q_{ij} + (p_{ii} - c)q_{ii} + \sum_{\substack{j=1 \\ j\neq i}}^{n} \tau_i q_{ij} - \sum_{\substack{l=1 \\ l\neq i}}^{n} \sigma_i q_{li} + \sum_{\substack{l=1 \\ l\neq i}}^{n} (p_{li} - c - \tau_l + \sigma_i)q_{li}.$$

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

$$\frac{dW^i}{d\tau_i} = \sum_{j=1}^{n} -\frac{1}{2}\frac{dp_{ij}}{d\tau_i}q_{ij} + \sum_{j=1}^{n} \frac{1}{2}(a - p_{ij})\frac{dq_{ij}}{d\tau_i} + (p_{ii} - c)\frac{dq_{ii}}{d\tau_i} + \frac{dp_{ii}}{d\tau_i}q_{ii} + \sum_{\substack{j=1 \\ j\neq i}}^{n} q_{ij} + \sum_{\substack{j=1 \\ j\neq i}}^{n} \tau_i \frac{dq_{ij}}{d\tau_i}, \tag{21}$$

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

$$\frac{dp_{ij}}{d\tau_i} = -\Big(\frac{dq_{ij}}{d\tau_i} + \gamma \sum_{\substack{k=1 \\ k\neq j}}^{n} \frac{dq_{ik}}{d\tau_i}\Big). \tag{22}$$

Substituting (2) and (22) in (21), noting that $\sum_{j=1}^{n} q_{ij} \sum_{\substack{k=1 \\ k\neq j}}^{n} \frac{dq_{ik}}{d\tau_i} = \sum_{j=1}^{n} \frac{dq_{ij}}{d\tau_i} \sum_{\substack{k=1 \\ k\neq j}}^{n} q_{ik}$, pure transfers cancel out and we obtain

$$\frac{dW^i}{d\tau_i} = -\sum_{\substack{j=1 \\ j\neq i}}^{n} q_{ij}\frac{dp_{ij}}{d\tau_i} + (p_{ii} - c)\frac{dq_{ii}}{d\tau_i} + \sum_{\substack{j=1 \\ j\neq i}}^{n} q_{ij} + \sum_{\substack{j=1 \\ j\neq i}}^{n} \tau_i \frac{dq_{ij}}{d\tau_i},$$

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

A.2 Export subsidy case: derivation of equation (8)

Similarly to the case with import tariffs, the effect of country i's export subsidy on its welfare is

$$\frac{dW^i}{d\sigma_i} = \frac{d}{d\sigma_i}\left[\sum_{\substack{j=1 \\ j\neq i}}^{n} (p_{ji} - c - \tau_j)q_{ji}\right] = \sum_{\substack{j=1 \\ j\neq i}}^{n} \left[q_{ji}\frac{dp^*_{ji}}{d\sigma_i} + (p_{ji} - c - \tau_j)\frac{dq_{ji}}{d\sigma_i}\right],$$

which yields (8). □

B Optimum instruments for the repeated game

B.1 Cooperation instruments

I start by assuming that countries have both instruments to determine the first-order conditions for the cooperation instrument levels. I will then solve for the cooperation instruments in the tariff-only and subsidy-only case.

When countries cooperate, they maximize their joint welfare. The first-order conditions of this optimization problem for trade instruments in country i are: $\forall l \neq i$,

$$\frac{d(W^1 + W^2 + \ldots + W^n)}{d\tau_{il}} = \sum_{j=1}^{n}(p_{ij} - c)\frac{dq_{ij}}{d\tau_{il}} = 0 \tag{23}$$

$$\frac{d(W^1 + W^2 + \ldots + W^n)}{d\sigma_{il}} = \sum_{j=1}^{n}(p_{ij} - c)\frac{dq_{ij}}{d\sigma_{il}} = 0 \tag{24}$$

Because equilibrium quantities depend only on the net instruments, (23) and (24) are actually the same equation. From (4), we have $\forall l \neq i$,

$$\frac{dQ_i}{d\tau_{il}} = -\frac{1}{\Gamma(n,\gamma)} \quad \text{and} \quad \frac{dQ_i}{d\sigma_{il}} = \frac{1}{\Gamma(n,\gamma)} \tag{25}$$

$$\frac{dq_{ij}}{d\tau_{ij}} = \frac{\gamma - \Gamma(n,\gamma)}{\Gamma(0,\gamma)\Gamma(n,\gamma)} \quad \text{and} \quad \frac{dq_{ij}}{d\sigma_{ij}} = -\frac{\gamma - \Gamma(n,\gamma)}{\Gamma(0,\gamma)\Gamma(n,\gamma)} \tag{26}$$

$$\forall l \neq j, \frac{dq_{ij}}{d\tau_{il}} = \frac{\gamma}{\Gamma(0,\gamma)\Gamma(n,\gamma)} \quad \text{and} \quad \frac{dq_{ij}}{d\sigma_{il}} = -\frac{\gamma}{\Gamma(0,\gamma)\Gamma(n,\gamma)} \tag{27}$$

Substituting the inverse demand (2), the Cournot equilibrium quantities (4) and the derivatives above into either (23) or (24) yields

$$-\Gamma(0,\gamma)^2 + \gamma\left[\Gamma(n,\gamma)(1-\gamma) - \Gamma(0,\gamma)\right](T_i - S_i) - \Gamma(n,\gamma)^2(1-\gamma)(\tau_{il} - \sigma_{il}) = 0 \tag{28}$$

Now invoking symmetry: $\tau_{il} = \tau$, $T_i = (n-1)\tau$, $\sigma_{il} = \sigma$ and $S_i = (n-1)\sigma$, we have

$$\sigma - \tau = \frac{\Gamma(0,\gamma)^2}{\Xi(n,\gamma)} = \frac{(2-\gamma)^2}{4(1-\gamma) + \gamma(4-3\gamma)(n-1)} > 0 \tag{29}$$

where $\Xi(n,\gamma) \equiv 2\Gamma(0,\gamma)\Gamma(n,\gamma) - \gamma^2(n-1) - 4 = 4(1-\gamma) + \gamma(4-3\gamma)(n-1)$. So there is an infinity of internationally efficient instruments such that their difference is a net subsidy given by (29).

In the tariff-only agreement, the subsidy σ is zero and the cooperation tariff is $\tau_E = -\frac{\Gamma(0,\gamma)^2}{\Xi(n,\gamma)}$ (it is an import subsidy) while in the subsidy-only agreement, the import tariff

τ is zero and the cooperation subsidy is $\sigma_E = \frac{\Gamma(0,\gamma)^2}{\Xi(n,\gamma)}$.

B.2 Nash equilibrium instruments

I start again by determining the first-order conditions for the full-instrument Nash equilibrium from which I will then deduce the Nash instruments in the tariff-only and subsidy-only cases as well as the full instrument case. Each country chooses its trade instruments to maximize its welfare. The first-order conditions for trade instruments in country i are, $\forall l \neq i$,

$$\frac{dW^i}{d\tau_{il}} = -\sum_{\substack{j=1 \\ j\neq i}}^{n} q_{ij}\frac{dp^*_{ij}}{d\tau_{il}} + \sum_{\substack{j=1 \\ j\neq i}}^{n} \tau_{ij}\frac{dq_{ij}}{d\tau_{il}} + (p_{ii} - c)\frac{dq_{ii}}{d\tau_{il}} = 0 \tag{30}$$

$$\frac{dW^l}{d\sigma_{il}} = \frac{d}{d\sigma_{il}}\left[(p_{il} - c - \tau_{il})q_{il}\right] = 0 \tag{31}$$

Substituting the inverse demand, the Cournot equilibrium quantity expressions and the derivatives into (30) yields the import-tariff first-order condition

$$\begin{aligned}\Gamma(0,\gamma)\Gamma(2,\gamma) + \gamma\{\Gamma(2,\gamma) + \Gamma(n,\gamma)\left[\Gamma(0,\gamma)+1\right]\}T_i - \gamma\left[\Gamma(n,\gamma) + \Gamma(2,\gamma)\right]S_i \\ -\Gamma(n,\gamma)^2\left[\Gamma(0,\gamma)+1\right]\tau_{il} + \Gamma(n,\gamma)^2\sigma_{il} = 0\end{aligned} \tag{32}$$

Substituting the inverse demand, the Cournot equilibrium quantity expressions and the derivatives into (31) yields the export-subsidy first-order condition

$$\begin{aligned}\Gamma(0,\gamma)\gamma^2(n-1) + \gamma^3(n-1)(T_i - S_i) \\ -\Gamma(n,\gamma)\gamma^2(n-1)\tau_{il} - \Gamma(n,\gamma)\left[2\Gamma(n,\gamma)(1-\gamma) + \gamma^2\right]\sigma_{il} = 0\end{aligned} \tag{33}$$

Invoking symmetry and using (32) to substitute τ in (33) yields the Nash export subsidy in the full instrument case

$$\sigma_N^f = \frac{(4-3\gamma)\gamma^2(n-1)}{\tilde{D}(n,\gamma)} \geq 0 \tag{34}$$

where $\tilde{D}(n,\gamma) \equiv D(n,\gamma)\Gamma(n-1,\gamma) - 4\gamma^2(n-1)$, $D(n,\gamma) \equiv \Psi(\gamma)\Gamma(n,\gamma) + \Gamma(1,\gamma)\Gamma(2,\gamma) = 4(3-\gamma) + \gamma(4-3\gamma)(n-1)$ and $\Psi(\gamma) \equiv 4 - 3\gamma$. Substituting the Nash export subsidy back into (32) gives the Nash equilibrium tariff for the full instrument case

$$\tau_N^f = \frac{\Gamma(0,\gamma)\Gamma(2,\gamma)\Gamma(n-1,\gamma) - \gamma^3(n-1)}{\tilde{D}(n,\gamma)} > 0 \tag{35}$$

Furthermore, setting the subsidies to zero in the Nash tariff first-order condition (32)

gives the Nash tariff in the tariff-only case

$$\tau_N^\tau = \frac{\Gamma(0,\gamma)\Gamma(2,\gamma)}{D(n,\gamma)} = \frac{(2-\gamma)(2+\gamma)}{4(3-\gamma)+\gamma(4-3\gamma)(n-1)} > 0 \tag{36}$$

and similarly setting the tariff to zero in the Nash subsidy first-order condition (33) gives the Nash export subsidy in the subsidy-only case

$$\sigma_N^\sigma = \frac{\gamma^2\Gamma(0,\gamma)(n-1)}{\hat{D}(n,\gamma)} \geq 0 \tag{37}$$

where $\hat{D}(n,\gamma) \equiv \Gamma(n,\gamma)\left[2\Gamma(n,\gamma)(1-\gamma)+\gamma^2\right]+\gamma^3(n-1)^2$.

B.3 D1 deviation instruments: one-instrument deviation

The deviator sets his instruments to maximize his own welfare knowing that other countries cooperate and set internationally efficient instruments. The first-order conditions for the deviator's D1 optimization problem are therefore the Nash first-order conditions (32) and (33) applied to the one-instrument case where the instruments of other countries are at their efficient levels.

Deviation tariff: Notice that the first-order condition for Nash equilibrium tariffs (32) is independent of the other countries' tariffs (i.e. there is no strategic interdependence between tariffs which is consequence of the segmented markets and identical constant marginal costs assumptions). The D1 deviation tariff is thus the Nash equilibrium tariff for the tariff-only case given by (36).

Deviation subsidy: The deviator's subsidy is given by equation (33) applied to the one instrument case (tariffs are zero) where the subsidies of other countries are at their efficient levels $\sigma_E = \frac{\Gamma(0,\gamma)^2}{\Xi(n,\gamma)}$. Solving the equation yields

$$\sigma_{D1}^\sigma = \frac{\gamma^2\Gamma(0,\gamma)(n-1)\left[\Xi(n,\gamma)-\gamma(n-2)\Gamma(0,\gamma)\right]}{2\Gamma(n-1,\gamma)\left[(1-\gamma)\Gamma(n,\gamma)+\gamma\right]\Xi(n,\gamma)} \geq 0. \tag{38}$$

B.4 D2 deviation instruments: two-instrument deviation

B.4.1 Tariff-only-agreement instruments

In the D2 deviation phase of the tariff-only agreement, the deviator has both an import tariff and an export subsidy while the punishers have import tariffs only.

In the deviator's market: The only trade instrument in the deviator's market is the deviator's own import tariff. As this tariff is independent of instruments in other markets, the deviator's tariff is just the one-instrument Nash tariff given by (36).

In the punishers' markets: The trade instruments in a given punisher's market are the punisher's own import tariff and the export subsidy of the deviator. Because

only the deviator has an export subsidy, he will be potentially facing a different import tariff than the other punishers in a given punisher's market. Let us denote by σ_{D2}^{τ} the subsidy of the deviator in a given punisher's market (in the tariff-only agreement), by τ_P^{τ} the "punishment" Nash tariff of the punisher on the deviator and by τ_O^{τ} the Nash tariff on the other punishers. The punisher is setting τ_P^{τ} and τ_O^{τ} to maximize his welfare. The first-order conditions for these tariffs are thus given by (32) with $T_i = \tau_P^{\tau} + (n-2)\tau_O^{\tau}$ and $S_i = \sigma_{D2}^{\tau}$. The deviator is choosing the export subsidy to maximise his welfare and so the first-order condition is given by (33). This yields a system of three equations in three unknowns

$$\begin{aligned}
\Gamma(0,\gamma)\Gamma(2,\gamma) &+ \{\Gamma(n,\gamma)\left[\Gamma(0,\gamma)+1\right]\left[\gamma-\Gamma(n,\gamma)\right] + \gamma\Gamma(2,\gamma)\}\tau_P^{\tau} \\
&+ \gamma(n-2)\{\Gamma(n,\gamma)\left[\Gamma(0,\gamma)+1\right] + \Gamma(2,\gamma)\}\tau_O^{\tau} \\
&+ \{\Gamma(n,\gamma)^2 - \gamma\left[\Gamma(n,\gamma)+\Gamma(2,\gamma)\right]\}\sigma_{D2}^{\tau} = 0 \qquad (39) \\
\Gamma(0,\gamma)\Gamma(2,\gamma) &+ \gamma\{\Gamma(n,\gamma)\left[\Gamma(0,\gamma)+1\right] + \Gamma(2,\gamma)\}\tau_P^{\tau} \\
&+ \{\gamma(n-2)\left[\Gamma(n,\gamma)\left[\Gamma(0,\gamma)+1\right]+\Gamma(2,\gamma)\right] - \Gamma(n,\gamma)^2\left[\Gamma(0,\gamma)+1\right]\}\tau_O^{\tau} \\
&- \gamma\left[\Gamma(n,\gamma)+\Gamma(2,\gamma)\right]\sigma_{D2}^{\tau} = 0 \qquad (40) \\
\gamma^2\Gamma(0,\gamma)(n-1) &+ \gamma^2(n-1)\left[\gamma-\Gamma(n,\gamma)\right]\tau_P^{\tau} \\
&+ \gamma^3(n-1)(n-2)\tau_O^{\tau} \\
&- \left\{\Gamma(n,\gamma)\left[2\Gamma(n,\gamma)(1-\gamma)+\gamma^2\right] + \gamma^3(n-1)\right\}\sigma_{D2}^{\tau} = 0 \qquad (41)
\end{aligned}$$

Solving the system yields

$$\tau_P^{\tau} = \frac{\left[\Gamma(0,\gamma)+1\right]\left[2(1-\gamma)(4-\gamma)+\gamma^3+2\gamma(2-\gamma^2)n\right]}{B(n,\gamma)} > 0 \qquad (42)$$

$$\tau_O^{\tau} = \frac{\Gamma(0,\gamma)\Gamma(2,\gamma)\left[6-8\gamma+3\gamma^2+\gamma(3-2\gamma)n\right]}{B(n,\gamma)} > 0 \qquad (43)$$

$$\sigma_{D2}^{\tau} = \frac{\left[\Gamma(0,\gamma)+1\right]\gamma^2(4-3\gamma)(n-1)}{B(n,\gamma)} \geq 0 \qquad (44)$$

where $B(n,\gamma) \equiv \alpha_0^B + \alpha_1^B n + \alpha_2^B n^2 > 0$ and $\alpha_0^B \equiv 2(36-72\gamma+59\gamma^2-26\gamma^3+6\gamma^4) > 0$, $\alpha_1^B \equiv \gamma(60-98\gamma+65\gamma^2-18\gamma^3) \geq 0$ and $\alpha_2^B \equiv \gamma^2(3-2\gamma)(4-3\gamma) \geq 0$.

Note that $\tau_P^{\tau} - \tau_O^{\tau} = \frac{\gamma^2(4-3\gamma)(n-1)}{B(n,\gamma)} \geq 0$.

B.4.2 Subsidy-only-agreement instruments

In the D2 deviation phase of the subsidy-only agreement, the deviator has both an import tariff and an export subsidy while the punishers have export subsidies only.

In the deviator's market: the deviator imposes an import tariff while all the punishers impose export subsidies. The instruments in the deviator's market are thus the full-instrument Nash equilibrium instruments determined by (35) and (34).

In the punishers' markets: both the deviator and the punishers impose a Nash subsidy. This subsidy corresponds to the Nash-equilibrium subsidy in the subsidy-only case given by (37).

B.5 Summary of trade instruments

Tables B.5 and B.5 summarize the trade instrument values at different stages of the repeated game.

	Tariff-only agreement ($\sigma = 0$)		Subsidy-only agreement ($\tau = 0$)	
	Deviator	Punisher	Deviator	Punisher
C	$\tau_E = -\frac{\Gamma(0,\gamma)^2}{\Xi(n,\gamma)}$		$\sigma_E = \frac{\Gamma(0,\gamma)^2}{\Xi(n,\gamma)}$	
D1	$\tau_{D1} = \tau_N^\tau$	τ_E	$\sigma_{D1} = \frac{\gamma^2\Gamma(0,\gamma)(n-1)[\Xi(n,\gamma)-\gamma(n-2)\Gamma(0,\gamma)]}{2\Gamma(n-1,\gamma)[(1-\gamma)\Gamma(n,\gamma)+\gamma]\Xi(n,\gamma)}$	σ_E
N1	$\tau_N^\tau = \frac{\Gamma(0,\gamma)\Gamma(2,\gamma)}{D(n,\gamma)}$		$\sigma_N^\sigma = \frac{\gamma^2\Gamma(0,\gamma)(n-1)}{\hat{D}(n,\gamma)}$	

Table 6: Summary table of trade instruments for the base case

		Deviator	Punisher
$D2^\tau$	in D	$\tau_{D2}^\tau = \tau_N^\tau$	
	in P	$\sigma_{D2}^\tau = \frac{[\Gamma(0,\gamma)+1]\gamma^2(4-3\gamma)(n-1)}{B(n,\gamma)}$	$\tau_P^\tau = \frac{[\Gamma(0,\gamma)+1]\left[2(1-\gamma)(4-\gamma)+\gamma^3+2\gamma(2-\gamma^2)n\right]}{B(n,\gamma)}$
			$\tau_O^\tau = \frac{\Gamma(0,\gamma)\Gamma(2,\gamma)\left[6-8\gamma+3\gamma^2+\gamma(3-2\gamma)n\right]}{B(n,\gamma)}$
$D2^\sigma$	in D	$\tau_{D2}^\sigma = \tau_N^f$	$\sigma_P^\sigma = \sigma_N^f$
	in P	$\sigma_{D2}^\sigma = \sigma_N^\sigma$	$\sigma_O^\sigma = \sigma_N^\sigma$
N^f		$\tau_N^f = \frac{\Gamma(0,\gamma)\Gamma(2,\gamma)\Gamma(n-1,\gamma)-\gamma^3(n-1)}{\tilde{D}(n,\gamma)}$	
		$\sigma_N^f = \frac{(4-3\gamma)\gamma^2(n-1)}{\tilde{D}(n,\gamma)}$	

Table 7: Summary table of trade instruments for the extended case

C Proofs

Proof of Lemma 1 (One-instrument deviation)**.** The goal of this proof is to compare the gain from deviating in the tariff-only and subsidy-only agreement. Evaluating welfare at the respective instrument levels yields

$$\begin{aligned} W_{D1\tau} - W_{D1\sigma} &= W(\tau_{D1}, 0; \tau_E, 0) - W(0, \sigma_{D1}; 0, \sigma_E) \\ &= \frac{(n-1)g(n,\gamma)}{4\Gamma(n-1,\gamma)\left[(1-\gamma)\Gamma(n,\gamma)+\gamma\right]D(n,\gamma)\Xi(n,\gamma)^2} \end{aligned} \tag{45}$$

with $g(n,\gamma) = \alpha_0^g(\gamma) + \alpha_1^g(\gamma)n + \alpha_2^g(\gamma)n^2 + \alpha_3^g(\gamma)n^3$ and

$$\begin{aligned} \alpha_0^g(\gamma) &= 1280 - 3584\gamma + 2368\gamma^2 + 3008\gamma^3 - 6672\gamma^4 + 5536\gamma^5 - 2488\gamma^6 + 620\gamma^7 - 75\gamma^8 \gtreqless 0 \\ \alpha_1^g(\gamma) &= \gamma(1024 - 1344\gamma - 2816\gamma^2 + 8448\gamma^3 - 8880\gamma^4 + 4820\gamma^5 - 1416\gamma^6 + 195\gamma^7) \geq 0 \\ \alpha_2^g(\gamma) &= 8(1-\gamma)\gamma^2(8 + 112\gamma - 282\gamma^2 + 256\gamma^3 - 111\gamma^4 + 21\gamma^5) \geq 0 \\ \alpha_3^g(\gamma) &= -16(1-\gamma)^4\gamma^3(4-3\gamma) \leq 0 \end{aligned}$$

From (45) we see that the welfare difference is of the same sign as $g(n,\gamma)$. $g(n,\gamma)$ is a polynomial function of n with coefficients depending on γ. When $\gamma = 0$, $g(n,\gamma) = 1280 > 0$. When $\gamma = 1$, $\alpha_2^g(\gamma) = \alpha_3^g(\gamma) = 0$ and g is a linear function of n with a positive coefficient on n and we have $g(n,1) > 0$ for any $n \geq 2$.

When $\gamma \in (0,1)$, g is a third degree polynomial of n with a negative coefficient on the third degree term. By successive differentiation, it can be shown that g is initially an increasing function of n with $g(2,\gamma) > 0$ and becomes a decreasing function of n ($\lim_{n\to\infty} g(n,\gamma) = -\infty$). By the intermediate value theorem, there exists a threshold n above which the difference in welfare $W_{D1\tau} - W_{D1\sigma}$ is negative. □

Proof of Lemma 2 (One-instrument Nash reversion)**.** Evaluating the welfare function at the Nash reversion instrument levels for the tariff-only and subsidy-only case respectively yields

$$\begin{aligned} W_{N1\tau} - W_{N1\sigma} &= W(\tau_N^\tau, 0; \tau_N^\tau, 0) - W(0, \sigma_N^\sigma; 0, \sigma_N^\sigma) \\ &= -\frac{(n-1)\tilde{g}(n,\gamma)\hat{g}(n,\gamma)}{2D(n,\gamma)^2\hat{D}(n,\gamma)^2} \end{aligned} \tag{46}$$

with $\tilde{g}(n,\gamma) = 8 - 8\gamma - 6\gamma^2 + 5\gamma^3 + 4\gamma(1+\gamma-\gamma^2)n > 0$ and $\hat{g}(n,\gamma) = \alpha_0^r(\gamma) + \alpha_1^r(\gamma)n + \alpha_2^r(\gamma)n^2$ where

$$\begin{aligned} \alpha_0^{\hat{g}} &= 224 - 608\gamma + 704\gamma^2 - 396\gamma^3 + 106\gamma^4 - 15\gamma^5 > 0 \\ \alpha_1^{\hat{g}} &= \gamma(208 - 504\gamma + 420\gamma^2 - 154\gamma^3 + 27\gamma^4) \gtreqless 0 \\ \alpha_2^{\hat{g}} &= 4\gamma^2(4-3\gamma)(3-3\gamma+\gamma^2) \geq 0 \end{aligned}$$

The function $\hat{g}$ is increasing with n and $\hat{g}(1,\gamma) = 4(2-\gamma)^2(14-11\gamma+\gamma^2) > 0$ so $\hat{g}(n,\gamma) > 0$ and thus $W_{N1\tau} - W_{N1\sigma} < 0$. □

Proof of Proposition 1. Study of δ_τ: when $\gamma > 0$,

$$\frac{\partial \delta_\tau}{\partial n}(n,\gamma) = \frac{-8\frac{\partial D}{\partial n}(n,\gamma)}{4\left[D(n,\gamma)-4\right]^2} = -\frac{8\gamma(4-3\gamma)}{4\left[D(n,\gamma)-4\right]^2} \leq 0$$

and so δ_τ is decreasing with n with $\lim_{n\to\infty}\delta_\tau = \lim_{n\to\infty}\frac{D(n,\gamma)}{2D(n,\gamma)} = \frac{1}{2}$. When $\gamma = 0$, $\delta_\tau = \frac{3}{4}$.

Study of δ_σ: when $\gamma > 0$,

$$\frac{\partial \delta_\sigma}{\partial n}(n,\gamma) = \frac{\Phi(n,\gamma)h(n,\gamma)}{\left[\Theta(n,\gamma)+\Phi(n,\gamma)^2\right]^2}$$

where $h(n,\gamma) \equiv 2\frac{\partial \Phi}{\partial n}(n,\gamma)\Theta(n,\gamma) - \Phi(n,\gamma)\frac{\partial \Theta}{\partial n}(n,\gamma)$. Thus the derivative of δ_σ with respect to n is of the sign of $h(n,\gamma)$.

$$h(n,\gamma) = 2\gamma^2\left[\alpha_0^h(\gamma) + \alpha_1^h(\gamma)n + \alpha_2^h(\gamma)n^2 + \alpha_3^h(\gamma)n^3 + \alpha_4^h(\gamma)n^4\right]$$

with

$$\begin{aligned}
\alpha_0^h(\gamma) &\equiv -2(48-144\gamma+168\gamma^2-108\gamma^3+48\gamma^4-16\gamma^5+3\gamma^6)\\
\alpha_1^h(\gamma) &\equiv 64-352\gamma+640\gamma^2-588\gamma^3+328\gamma^4-116\gamma^5+21\gamma^6\\
\alpha_2^h(\gamma) &\equiv 3\gamma(32-112\gamma+156\gamma^2-116\gamma^3+48\gamma^4-9\gamma^5)\\
\alpha_3^h(\gamma) &\equiv \gamma^2(48-128\gamma+140\gamma^2-73\gamma^3+15\gamma^4)\\
\alpha_4^h(\gamma) &\equiv \Gamma(0,\gamma)(1-\gamma)\gamma^3(4-3\gamma) \geq 0
\end{aligned}$$

$\frac{\partial^4 h}{\partial n^4}(n,\gamma) = 24\Gamma(0,\gamma)(1-\gamma)\gamma^3(4-3\gamma) \geq 0$ and so the third derivative of h with respect to n is an increasing function of n. Furthermore, $\frac{\partial^3 h}{\partial n^3}(2,\gamma) = 6\gamma^2(48-64\gamma-4\gamma^2+31\gamma^3-9\gamma^4) \geq 0$, and so $\frac{\partial^3 h}{\partial n^3}$ is positive for any $n \geq 2$ and the second derivative of h is an increasing function of n. Also, $\frac{\partial^2 h}{\partial n^2}(2,\gamma) = 6\gamma(32-16\gamma-36\gamma^2+20\gamma^3+6\gamma^4-3\gamma^5) \geq 0$ and so the second derivative is positive for any $n \geq 2$ and the first derivative is an increasing function of n. Finally, $\frac{\partial h}{\partial n}(2,\gamma) = 64+32\gamma-128\gamma^2+4\gamma^3+40\gamma^4-3\gamma^6 \geq 0$ and so the first derivative is positive for any $n \geq 2$ and h is an increasing function of n with $h(2,\gamma) = 16(1-\gamma)(2-\gamma^2) \geq 0$ and so h is positive for any $n \geq 2$. Thus $\frac{\partial \delta_\sigma}{\partial n}(n,\gamma) \geq 0$ for any $\gamma \in [0,1]$ and any $n \geq 2$ and δ_σ is increasing with n. Notice that $\Phi(n,\gamma)^2$ is a polynomial of degree 4 in n while $\Theta(n,\gamma)$ is a polynomial of degree 3 in n and so $\lim_{n\to\infty}\delta_\sigma = \lim_{n\to\infty}\frac{\Phi(n,\gamma)^2}{\Phi(n,\gamma)^2} = 1$. When $\gamma = 0$, $\delta_\sigma = \frac{2}{3}$.

Study of Δ: The difference between the critical threshold discount factors given by (10)

is

$$\Delta = \delta_\sigma - \delta_\tau = \frac{\Xi(n,\gamma) r(n,\gamma)}{2\left[D(n,\gamma)-4\right]\left\{\Theta(n,\gamma)+\Phi(n,\gamma)^2\right\}}$$

with $r(n,\gamma) \equiv \alpha_0^r(\gamma) + \alpha_1^r(\gamma) n + \alpha_2^r(\gamma) n^2 + \alpha_3^r(\gamma) n^3 + \alpha_4^r(\gamma) n^4$ and

$$\begin{aligned}
\alpha_0^r(\gamma) &\equiv 4(-8 + 38\gamma^2 - 56\gamma^3 + 35\gamma^4 - 9\gamma^5 + \gamma^6) \\
\alpha_1^r(\gamma) &\equiv -2\gamma^2(76 - 168\gamma + 140\gamma^2 - 45\gamma^3 + 6\gamma^4) \\
\alpha_2^r(\gamma) &\equiv \gamma^2(40 - 160\gamma + 190\gamma^2 - 80\gamma^3 + 13\gamma^4) \\
\alpha_3^r(\gamma) &\equiv 2\gamma^3(12 - 25\gamma + 15\gamma^2 - 3\gamma^3) \\
\alpha_4^r(\gamma) &\equiv \Gamma(0,\gamma)^2\gamma^4
\end{aligned}$$

From the above, we know that Δ is an increasing function of $n \geq 2$ and it is of the sign of $r(n,\gamma)$. We have $\Delta(2,\gamma) = -\frac{(4+\gamma^2)(4-3\gamma^2)}{2(8-3\gamma^2)(12-7\gamma^2)} < 0$ and $\lim_{n\to\infty} \Delta = \frac{1}{2}$, so there is a threshold value of n above which Δ is positive. This threshold value is the solution of $r(n,\gamma) = 0$. □

Proof of Lemma 3. 1. Two-instrument deviation from the tariff-only agreement

$$\begin{aligned}
W_{D2\tau} - W_{N1\tau} &= W(\tau_{D2}^\tau, \sigma_{D2}^\tau; \tau_P^\tau, 0; \tau_O^\tau, 0) - W(\tau_{N1}, 0; \tau_{N1}, 0; \tau_{N1}, 0) \\
&= -\frac{\gamma^2(4-3\gamma)^2(n-1)^2\tilde{h}(n,\gamma)}{D(n,\gamma)^2 B(n,\gamma)^2}
\end{aligned}$$

where $\tilde{h}(n,\gamma) \equiv \alpha_0^{\tilde{h}}(\gamma) + \alpha_1^{\tilde{h}}(\gamma) n + \alpha_2^{\tilde{h}}(\gamma) n^2 + \alpha_3^{\tilde{h}}(\gamma) n^3$ and

$$\begin{aligned}
\alpha_0^{\tilde{h}}(\gamma) &\equiv 2(432 - 1296\gamma + 1608\gamma^2 - 1200\gamma^3 + 613\gamma^4 - 223\gamma^5 + 57\gamma^6 - 9\gamma^7) \gtreqless 0 \\
\alpha_1^{\tilde{h}}(\gamma) &\equiv \gamma(1008 - 2688\gamma + 3184\gamma^2 - 2184\gamma^3 + 969\gamma^4 - 282\gamma^5 + 45\gamma^6) \geq 0 \\
\alpha_2^{\tilde{h}}(\gamma) &\equiv \gamma^2(4-3\gamma)(96 - 170\gamma + 134\gamma^2 - 57\gamma^3 + 12\gamma^4) \geq 0 \\
\alpha_3^{\tilde{h}}(\gamma) &\equiv \gamma^3(4-3\gamma)^2(3 - 3\gamma + \gamma^2) \geq 0
\end{aligned}$$

$\tilde{h}$ is thus a third degree polynomial in n with all the coefficients (except $\alpha_0^{\tilde{h}}$) positive, so $\tilde{h}$ is an increasing function of n. Furthermore, note that $\tilde{h}(1,\gamma) = 8\Gamma(0,\gamma)(3-\gamma)^2(6 - 4\gamma - \gamma^2) > 0$, so $\tilde{h}(n,\gamma)$ is positive for any $n \geq 1$ and any $\gamma \in [0,1]$ and $W_{D2\tau} - W_{N1\tau} \leq 0$.

2. Two-instrument deviation from the subsidy-only agreement

$$\begin{aligned}
W_{D2\sigma} - W_{N1\sigma} &= W(\tau_{D2}^\sigma, \sigma_{D2}^\sigma; 0, \sigma_P^\sigma; 0, \sigma_O^\sigma) - W(0, \sigma_{N1}; 0, \sigma_{N1}) \\
&= \frac{(n-1)\Gamma(n-1,\gamma)\left[\Gamma(0,\gamma)\Gamma(2,\gamma)\Gamma(n-1,\gamma) - \gamma^3(n-1)\right]\hat{h}(n,\gamma)}{2\hat{D}(n,\gamma)^2\tilde{D}(n,\gamma)^2} \qquad (47)
\end{aligned}$$

where $\hat{h}(n,\gamma) \equiv \alpha_0^{\hat{h}}(\gamma) + \alpha_1^{\hat{h}}(\gamma)n + \alpha_2^{\hat{h}}(\gamma)n^2 + \alpha_3^{\hat{h}}(\gamma)n^3$ with

$$\begin{aligned}
\alpha_0^{\hat{h}} &\equiv 2(96 - 256\gamma + 320\gamma^2 - 244\gamma^3 + 126\gamma^4 - 37\gamma^5 + 3\gamma^6) \\
\alpha_1^{\hat{h}} &\equiv \gamma(256 - 688\gamma + 824\gamma^2 - 568\gamma^3 + 200\gamma^4 - 21\gamma^5) \\
\alpha_2^{\hat{h}} &\equiv \gamma^2(112 - 304\gamma + 332\gamma^2 - 154\gamma^3 + 21\gamma^4) \\
\alpha_3^{\hat{h}} &\equiv 2\gamma^3(4 - 3\gamma)(2 - 4\gamma + \gamma^2)
\end{aligned}$$

The difference in welfare $W_{D2\sigma} - W_{N1\sigma}$ is of the sign of $\hat{h}(n,\gamma)$. To determine the sign of $\hat{h}(n,\gamma)$, I proceed by successive differentiation of $\hat{h}$: $\frac{\partial^3}{\partial n^3}\hat{h}(n,\gamma) = 6\alpha_3^{\hat{h}}$ which is positive for $\gamma \leq 2 - \sqrt{2}$ and negative for $\gamma > 2 - \sqrt{2}$. Thus $\frac{\partial^2}{\partial n^2}\hat{h}(n,\gamma)$ is an increasing function of n for $\gamma \in [0, 2 - \sqrt{2}]$ and a decreasing function of n for $\gamma \in (2 - \sqrt{2}, 1]$.

$\frac{\partial^2}{\partial n^2}\hat{h}(1,\gamma) = 2\gamma^2(112 - 256\gamma + 200\gamma^2 - 58\gamma^3 + 3\gamma^4) \geq 0$ for any $\gamma \in [0,1]$. Hence for $\gamma \in [0, 2-\sqrt{2}]$, $\frac{\partial^2}{\partial n^2}\hat{h}(n,\gamma)$ is positive for any n and $\frac{\partial}{\partial n}\hat{h}$ is an increasing function of n. For $\gamma \in (2 - \sqrt{2}, 1]$, $\frac{\partial^2}{\partial n^2}\hat{h}$ is a decreasing function of n with $\lim_{n\to\infty} \frac{\partial^2}{\partial n^2}\hat{h}(n,\gamma) = -\infty$ (negative coefficient on the term with the highest power) and so there exists a threshold value of n above which $\frac{\partial^2}{\partial n^2}\hat{h}(n,\gamma) < 0$. Therefore, for $\gamma \in (2 - \sqrt{2}, 1]$, $\frac{\partial}{\partial n}\hat{h}$ may initially be an increasing function of n, but ultimately decreases with n.

$\frac{\partial}{\partial n}\hat{h}(1,\gamma) = (2 - \gamma)\gamma(128 - 168\gamma + 48\gamma^2 + 6\gamma^3 - 3\gamma^4) \geq 0$ for any $\gamma \in [0,1]$. Hence for $\gamma \in [0, 2 - \sqrt{2}]$, $\frac{\partial}{\partial n}\hat{h}(n,\gamma)$ is positive for any n and $\hat{h}$ is an increasing function of n. For $\gamma \in (2 - \sqrt{2}, 1]$, $\frac{\partial}{\partial n}\hat{h}$ is a decreasing function of n above a certain threshold value of n with $\lim_{n\to\infty} \frac{\partial}{\partial n}\hat{h}(n,\gamma) = -\infty$ (negative coefficient on the term with the highest power) and so there exists a threshold value of n above which $\frac{\partial}{\partial n}\hat{h}(n,\gamma) < 0$. Therefore, for $\gamma \in (2 - \sqrt{2}, 1]$, $\hat{h}$ may initially be an increasing function of n, but ultimately decreases with n.

Finally note that $\hat{h}(1,\gamma) = 4(3-\gamma)(2-\gamma)^3(2+\gamma) > 0$ for $\gamma \in [0,1]$. For $\gamma \in [0, 2-\sqrt{2}]$, $\hat{h}$ is an increasing function of n and so we know that for $\gamma \in [0, 2-\sqrt{2}]$, $\hat{h}(n,\gamma) \geq 0$ for any $n \geq 1$. For $\gamma \in (2-\sqrt{2}, 1]$, $\hat{h}$ is a decreasing function of n above a certain threshold n with $\lim_{n\to\infty} \hat{h}(n,\gamma) = -\infty$ (negative coefficient on the term with the highest power). Therefore, there is a threshold value of n above which $\hat{h}(n,\gamma) < 0$ for $\gamma \in (2 - \sqrt{2}, 1]$. □

Proof of Proposition 2. 1. Tariff-only agreement: to show that the use of two instruments is a dominated strategy, I need to show that no matter which instruments the other countries use, the deviator would always prefer to use an import tariff only. Assume that there are k other countries that have both import tariffs and export subsidies and $(n - k - 1)$ other countries that only have import tariffs. I want to show that the

welfare of the deviator when he has both instruments is lower than when he has an import tariff only for any $k \in [0, n-1]$. (Notice that the case $k = 0$ corresponds to all other countries having import tariffs only which has been proved in the lemma above. When $k = n - 1$, all other countries have both instruments.)

First, I need to determine the equilibrium trade instruments for the two cases, then evaluate the welfare of the deviator. Each country is supposed to maximise its welfare taking the instruments of other countries as given and so we can use the first-order conditions (32) and (33). A country that has (not) an export subsidy is indicated by the subscript s (0).

1. Deviator has an import tariff only: there are k countries in the world that have export subsidies

   - In his home market: k foreign countries are subsidizing exports to the deviator (subsidy $\sigma(k)$) while $(n - k - 1)$ are not. The deviator imposes $\tau_s(k)$ on subsidized imports and $\tau_0(k)$ on non-subsidized imports. The total amount of tariffs in the deviator' market is $T(k) = k\tau_s(k) + (n - k - 1)\tau_0(k)$. The total amount of subsidies in the deviator's market is $S(k) = k\sigma(k)$.
   - In his export markets:
     - in a non-subsidizing country: k foreign countries are subsidizing exports to this market and the trade instruments in a non-subsidizing country are exactly the same as in the deviator's market. The deviator exports are facing the tariff $\tau_0(k)$.
     - in a subsidizing country: $k - 1$ foreign countries are subsidizing exports to this market while $(n - k)$ countries are not. The subsidizing country is imposing a tariff $\tau_s(k - 1)$ on the subsidized imports and $\tau_0(k - 1)$ on non-subsidized imports. The total amount of tariffs in this market is $T(k - 1) = (k - 1)\tau_s(k - 1) + (n - k)\tau_0(k - 1)$. The total amount of subsidies in this market is $S(k - 1) = (k - 1)\sigma(k - 1)$.

2. Deviator has both instruments: there are $k + 1$ countries in the world that have export subsidies

   - In his home market: k foreign countries are subsidizing exports to the deviator (subsidy $\sigma(k)$) while $(n - k - 1)$ are not. The instruments in the deviator's market are exactly the same as in situation 1 above where the deviator does not have export subsidies (deviator's export subsidies are irrelevant for the equilibrium in his market): $\sigma(k)$, $\tau_s(k) =$ and $\tau_0(k)$.
   - In his export markets:

– in a non-subsidizing country: k+1 foreign countries are subsidizing exports to this market while $(n-k-2)$ are not. The total amount of subsidy is $(k+1)\sigma(k+1)$. The deviator (and other subsidizing countries) will be facing the import tariff $\tau_s(k+1)$ while non-subsidizing countries will be facing $\tau_0(k+1)$. The total amount of tariff in this market is $T(k+1) = (k+1)\tau_s(k+1) + (n-k-2)\tau_0(k+1)$.

– in a subsidizing country: k foreign countries are subsidizing exports to this market while $(n-k-1)$ countries are not. The trade instruments in this market are exactly the same as in the deviator's market: $\sigma(k)$, $\tau_s(k) =$ and $\tau_0(k)$.

Solving the system of three equations of three unknowns gives us the set of instruments:

$$\tau_s(k) = \frac{(3-\gamma)\left[8-8\gamma-2\gamma^2+3\gamma^3+2\gamma(2-\gamma^2)n\right]}{\Omega(n,\gamma,k)}$$
$$\tau_0(k) = \frac{\Gamma(0,\gamma)\Gamma(2,\gamma)\left[6-8\gamma+3\gamma^2+\gamma(3-2\gamma)n\right]}{\Omega(n,\gamma,k)}$$
$$\sigma(k) = \frac{(3-\gamma)\gamma^2(4-3\gamma)(n-1)}{\Omega(n,\gamma,k)}$$

where $\Omega(n,\gamma,k) \equiv D(n,\gamma)\left[6-8\gamma+3\gamma^2+\gamma(3-2\gamma)n\right]+\gamma^3(4-3\gamma)(n-1)k$. Now evaluating the welfare at the instrument levels when the deviator has an import subsidy and when he has not yields

$$W_s(k+1) - W_0(k) = -\frac{\gamma^2(4-3\gamma)^2(n-1)^2 w(n,\gamma,k)}{\Omega(n,\gamma,k-1)^2\Omega(n,\gamma,k)^2\Omega(n,\gamma,k+1)^2}$$

where $w(n,\gamma,k)$ is a 9^{th} degree polynomial function of n with coefficients polynomial functions of k and γ. By successive differentiation, it is easy to show that $w(n,\gamma,k) > 0$ for any $n \geq 2$, $\gamma \in [0,1]$ and $k \in [0, n-1]$. Therefore, no matter what other countries do, the deviator would never want to use the export subsidy.

2. Subsidy-only agreement: I want to determine the deviator's best reply to other countries strategies. Assume now that there are k other countries that have both import tariffs and export subsidies and $(n-k-1)$ other countries that only have export subsidies. The equilibrium instruments are the following:

1. Deviator has export subsidies only:

   - In his home market: the only instruments are export subsidies of other countries and thus we have a Nash equilibrium in export subsidies only (σ_N^σ)
   - In his export markets: there are k countries that have both instruments and where we have a full-instrument Nash equilibrium $(\tau_N^f,\ \sigma_N^f)$ and $(n-k-1)$

countries that have export subsidies only and where we have a Nash equilibrium in export subsidies only (σ_N^σ)

2. Deviator has both instruments:

   - In his home market: full-instrument Nash equilibrium (τ_N^f,σ_N^f)
   - In his export markets: there are k countries that have both instruments and where we have a full-instrument Nash equilibrium (τ_N^f, σ_N^f) and $(n-k-1)$ countries that have export subsidies only and where we have a Nash equilibrium in export subsidies only (σ_N^σ)

We can see that whether the deviator has only export subsidies or import tariffs as well does not change anything to what happens in his export markets. The difference between his welfare with two instruments minus his welfare with only export subsidies comes entirely from the part of welfare arising in his home country. Thus it is irrelevant how many other countries have also import tariffs and the difference that we need to sign is the difference given by (47) studied in the proof above. □

Proof of Lemma 4.

$$\begin{aligned} W_{N2} - W_{N1\tau} &= W(\tau_N^f, \sigma_N^f; \tau_N^f, \sigma_N^f; \tau_N^f, \sigma_N^f) - W(\tau_{N1}, 0; \tau_{N1}, 0; \tau_{N1}, 0) \\ &= \frac{\gamma^2(4-3\gamma)^2(n-1)^2\left[D(n,\gamma) + 2\gamma^2(n-1)\right]u(n,\gamma)}{D(n,\gamma)^2\tilde{D}(n,\gamma)^2} \end{aligned}$$

where $u(n,\gamma) \equiv 8 - 8\gamma + 3\gamma^2 + \gamma(4+3\gamma)n > 0$ and so $W_{N2} - W_{N1\tau} > 0$. □

Proof of Lemma 5. If countries did not value the terms-of-trade effects of their trade policy, the first-order condition for the import tariff of country i on country l ($\forall l \neq i$) would be

$$\sum_{\substack{j=1 \\ j\neq i}}^{n} \tau_{ij} \frac{dq_{ij}}{d\tau_{il}} + (p_{ii} - c)\frac{dq_{ii}}{d\tau_{il}} = 0.$$

Substituting the inverse demand (2), imposing symmetry and rearranging terms yields the formula. □

Proof of Proposition 3. To study the effect of a reciprocal trade liberalization on welfare, it is convenient to rewrite the welfare function in the following way:

$$W^i = NS^i + PB^i,$$

where $NS^i \equiv Q_i - \frac{\gamma}{2}Q_i^2 - \frac{1-\gamma}{2}\sum_{j=1}^{n} q_{ij}^2$ is the net benefit from consumption and $PB^i \equiv$

$-\sum_{\substack{j=1\\j\neq i}}^{n}(q_{ij}-\sigma_{ij})q_{ij}+\sum_{\substack{j=1\\j\neq i}}^{n}(q_{ji}-\sigma_{ji})q_{ji}$ is the net profit balance.[33] The net benefit from consumption is a part of welfare arising in the home country, it is thus independent of import tariffs of other countries. The profit balance depends both on home and foreign countries' instruments. Using this definition, we can decompose the effect of a reciprocal liberalization $d\boldsymbol{\tau}=(d\tau_{ij},d\tau_{ji})$ on welfare of country i into effects on the net benefit from consumption and on the profit balance: $\frac{dW^i}{d\boldsymbol{\tau}}=\frac{dNS^i}{d\tau_{ij}}+\frac{dPB^i}{d\boldsymbol{\tau}}$. In a two country world, the profit balance is just the bilateral profit balance. Bilaterally-reciprocal trade liberalization keeps the bilateral profit balance constant and so we have:

$$\frac{dW^i}{d\boldsymbol{\tau}}=\frac{dNS^i}{d\tau_{ij}}=-\frac{1}{\left[\Gamma(0,\gamma)\Gamma(2,\gamma)\right]^2}\{\Gamma(0,\gamma)^2+\Xi(2,\gamma)\tau_{ij}\},\tag{48}$$

The net benefit from consumption is a decreasing function of country i's own tariff (consumers gain from trade liberalization) for tariff higher than $-\frac{\Gamma(0,\gamma)^2}{\Xi(2,\gamma)}$ which is the internationally efficient tariff τ_E. So a bilaterally reciprocal trade liberalization starting from above the efficient tariff unambiguously increases welfare of country i until countries reach efficiency. □

Proof of Lemma 6. From (4), for $j\neq l$, $\frac{dq_{il}}{d\tau_{ij}}=\frac{\gamma}{\Gamma(0,\gamma)\Gamma(n,\gamma)}>0$. □

Proof of Proposition 4. The effect on welfare of a trade liberalisation following the principles of reciprocity and non-discrimination can again be decomposed into the effect on the net benefit from consumption and on the multilateral profit balance. The multilateral 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 equation (48)):

$$\frac{dW^i}{d\boldsymbol{\tau}}=\frac{dNS^i}{d\tau_i}=-\frac{n-1}{\left[\Gamma(0,\gamma)\Gamma(n,\gamma)\right]^2}\left[\Gamma(0,\gamma)^2+\Xi(n,\gamma)\tau_i\right].$$

The effect of the liberalisation on welfare of country i is the effect of the reduction in country i's own tariff on the net benefit from consumption. The net benefit from consumption is again a decreasing function of country i's own tariff, for tariff higher than $-\frac{\Gamma(0,\gamma)^2}{\Xi(n,\gamma)}$ which is the internationally efficient tariff τ_E. So a trade liberalization following the principles of reciprocity and non-discrimination, starting from above the efficient tariff, unambiguously increases welfare of country i until countries reach efficiency. □

Proof of Proposition 5. Follows from the discussion.

[33] See for example Furusawa and Konishi (2004) for a general derivation of this decomposition for quasi-linear economies.

D Base case extension to many firms per country

It is straightforward to extend the results presented in the core of the paper for 1 firm per country to the case of k firms per country. The main intuition prevails with one qualification: with $k > 1$ firms per country, the Nash equilibrium subsidy is not necessarily a subsidy. The sign of the instrument depends on the number of firms per country. For $k \leq \frac{\Gamma(nk,\gamma)}{2}$ the equilibrium export instrument is a subsidy, but for $k > \frac{\Gamma(nk,\gamma)}{2}$, it is an export tax. (This is a generalization of Dixit's (1984) result extended here to many countries and differentiated products.) Note that for $\gamma = 1$, the instrument is always an export subsidy.

With $k \geq 1$ firms per country, the critical threshold discount factors are now

$$\delta_\tau^k = \frac{D^k(k,n,\gamma)}{2\left[D^k(k,n,\gamma) - \Gamma(k,\gamma)^2\right]} \text{ and } \delta_\sigma = \frac{\Phi^k(k,n,\gamma)^2}{\Theta^k(k,n,\gamma) + \Phi^k(k,n,\gamma)^2}, \tag{49}$$

where

$$\begin{aligned}
\Psi^k(k,\gamma) &\equiv \left[\Gamma(0,\gamma)+1\right]\Gamma(k,\gamma) - \Gamma(2k,\gamma),\\
D^k(k,n,\gamma) &\equiv \Psi^k(k,n,\gamma)\Gamma(nk,\gamma) + \Gamma(k,\gamma)\Gamma(2k,\gamma),\\
\Xi^k(k,n,\gamma) &\equiv \Gamma(0,\gamma)^2\gamma(n-1)k + (1-\gamma)\left[\gamma^2k^2(n-1) + \Gamma(k,\gamma)^2\right],\\
\Upsilon^k(k,n,\gamma) &\equiv 2\Gamma((n-1)k,\gamma)\left[(1-\gamma)\Gamma(nk) + k\gamma\right],\\
\Phi^k(k,n,\gamma) &\equiv \Upsilon^k(k,n,\gamma) + (n-2)k\gamma^2\left[\Gamma(nk,\gamma) - 2k\right],\\
\Theta^k(k,n,\gamma) &\equiv \Xi^k(k,n,\gamma)\Upsilon^k(k,n,\gamma).
\end{aligned}$$

It can be shown that the tariff-only agreement is again more self-enforcing for a wide range of parameters. Evaluating the difference between the two discount factors for $\gamma = 1$ and high values of k provides an interesting comparative statics exercise: $\lim_{k\to\infty} \Delta = 0$. As competition increases, the difference between the two discount factors disappears. In the limit, in perfect competition, trade instruments would be perfectly symmetric and thus there would not be any difference between the self-enforceability of a tariff-only and subsidy-only agreement.

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