Limited Cross-retaliation and Lengthy Delays in International Dispute Settlement

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Abstract

Although politicians and the popular press often express the desire to link retaliation in trade agreements to non-trade issues, the WTO discourages and usually disallows cross-retaliation even among its own agreements. In this paper we analyze the WTO’s reticence to embrace cross-retaliation. We employ a dynamic mechanism design approach and compare the welfare effects of same and cross-sector retaliation and we show that a same-sector retaliation mechanism generates greater welfare and supports a higher self-enforcing level of cooperation than does a cross-sector retaliation mechanism. We also consider the optimality of the WTO’s often revealed preference for sanctioning retaliation only after a lengthy delay and we provide conditions on when such a delay is optimal. Still, whether or not retaliation is better delayed, limiting cross-retaliation is always the preferred mechanism.

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1 Introduction

Amid continual calls to link trade agreements to environmental policy, labour concerns, nuclear disarmament, and even the occasional whims of political leaders, the World Trade Organization (WTO) has remained steadfast in choosing a different tack. Article 22.3 of the WTO’s dispute settlement understanding (DSU) agreements generally opposes cross-agreement even among its own agreements unless (as stated in DSU article 22.3 paragraph (c)) same agreement retaliation is not viable. In its own ruling it has rejected eleven out of fourteen requests for cross retaliation (even when it has permitted same-agreement retaliation) and it has only allowed it when there is a stark differences in economic size and also export composition between the complainant and defendant country (see table 2). We take these stylized facts as our point of departure and analyze the WTO’s reluctance to permit cross-retaliation when other forms of retaliation are possible. Utilizing a dynamic mechanism design framework we show that same-sector, or same-agreement, retaliation is preferred to cross-retaliation for similar countries in an environment where trade disputes occur with strictly positive probability at each point in time.

In contrast to the WTO, Preferential Trade Agreements (PTAs) generally have no such restrictions against cross-retaliation. Furthermore, as shown in table 2, in the three cases where cross-sector retaliation has been permitted by the WTO the allowable retaliation was smaller than the same-sector amounts. The largest sanctioned cross-retaliation was $191.4 million. On the other hand cross-retaliation is common in larger PTAs such as the North American Free Trade Agreement (NAFTA) and the southern common market (MERCOSUR) and the amount of permitted cross-retaliation in the PTAs is much larger than that allowed by the WTO. For example, in the Mexico-US trucking dispute, the dispute panel of NAFTA authorized Mexico to impose retaliatory import tariffs on ninety US goods ranging from strawberries to Christmas trees in retaliation for the US’s ban on Mexican trucks (see Alexander-Soukup [1]). The total amount of this cross-sector retaliation is approximately $2.4 billion. Our results also help to analyze whether the WTO was prescient in precluding cross-retaliation or if PTAs are not amiss in allowing its unmitigated use.

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1 The WTO encompasses the general agreements on tariffs and trade (GATT), trade in services (GATS), trade related aspects of intellectual property (TRIPS), investment measures (TRIMS), the annexes of the above agreements, and the plurilateral agreements on government procurement and civil aircraft. Article 22.3 paragraph (g) does not include TRIMS as a covered agreement for cross-retaliation and Article 22.5 states that there can be no cross-retaliation if the other covered agreement does not allow for a suspension of concessions. Although TRIMS does not prohibit a suspension of concessions for any violation of the agreements, none of the TRIMS disputes have so far resulted in sanctions. In a recent case, however, the USA, as a complainant, has requested sanctions against India for their domestic content requirement in solar cells and has cited violation of the GATT, the subsidies and countervailing agreement and also TRIMS in their complaint.

2 The dispute settlement procedures of PTAs are much less developed than those in the WTO and punitive stages, or trade wars, filed under PTAs are generally longer lasting and more arbitrary than those filed under the WTO (see Chisik, 2012).

3 NAFTA and MERCOSUR are the second and third largest PTAs in the world. A new NAFTA agreement, known as the Canada-United States-Mexico Agreement, or CUSMA has not yet been approved by the US Congress.
Although we focus on international trade between similar economies our model can also shed light on wider issues in international relations. For example, emissions of pollution that damage the global commons can be analyzed in a similar manner to an international trade agreement whereby the tariff violations would be replaced by the amount of pollution emitted by each country. To some extent international agreements covering labour standards, nuclear non-proliferation, chemical weapons, cyber security, among others could also be analyzed by a variation of our framework. Hence, our results could be considered as more general than applying only to international trade agreements.

International trade agreements are self-enforcing contracts between two or more trading parties. There are, however, two important aspects of international agreements that differ from domestic tort and criminal laws. First, in domestic tort law, the injured party is expected to receive compensation soon after the court has made its decision to support the complainant and, in criminal law, a guilty defendant is usually sent to jail without delay. Nevertheless, following a reported violation in international trade agreement, the Dispute Settlement Body (DSB) of the WTO is slow to produce a panel report and even slower to permit retaliation (see table 1). Second, in both contract and criminal law, it is usually awkward or impracticable to charge

Of course, the parameters could differ across agreements. Hence, in addition to the channels identified results in this paper, it would not be optimal to use chemical weapons to retaliate against trade restrictions, but trade restrictions might serve as a means of retaliating against the use of chemical weapons. As the point of our paper is to identify why there is so little linking in practice, we leave the analysis of optimal linking in asymmetric cases for future research.
the defendant by exactly the same harm or crime that they have inflicted upon the plaintiff. For example, if a medical injury is caused by a physician’s negligence, the patient will be compensated by a cash payment and not by ordering the physician to suffer the same damage. Similarly, criminals are usually sent to jail and are not required to suffer as a victim of the crime that they committed. As noted above, however, the WTO prefers for punishment and compensation to be paid in the same sector in which the violation occurred.  

To analyze these issues, we adopt a dynamic mechanism design approach and analyze the welfare effects of same-sector and cross-sector retaliation under both no-delayed and delayed retaliation mechanisms. We consider a two-country two-sector tariff-setting political economy framework where there is information asymmetry about the varying levels of political pressure that a country may face. This pressure is the country’s private information and might induce the governments to increase its import tariffs to protect its domestic industry. The political pressure fluctuates between high and low values and evolves according to a Markov process over time.

When political pressure is high a government may wish to grant temporary protection to a domestic

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5 Article 22.3 paragraph (a) of the WTO’s DSU stipulates that retaliation in the form of a suspension of a previously granted concession should occur in the same sector(s) whereby the violation took place. In DSU article 22.3 paragraph (b) it concedes that if same sector retaliation is not practicable, then cross-sector retaliation in the same agreement could be permitted. Paragraph (c) states that only if within agreement retaliation is not practicable or effective, and if the violation and its effects are highly serious, then may cross-retaliation be considered.

6 Our model combines elements of a political economy model with incomplete information as in Bagwell-Staiger [4], Bagwell [5] and Beshkar [7], and of a multi-sector tariff setting model as in [?].
industry by raising import tariffs in a sensitive sector. These temporary suspensions of concession are provided for in the GATT articles VI, XII, XVIII, XIX, XX, and XXI. These escape valves exist in order to maintain the viability of the trade agreement. Of course, their existence could invite abuse. To prevent a government from continually claiming that political pressure for temporary protection is high the GATT, and its successor the WTO, allow for a reciprocal suspension of concessions by the trading partner. For example, article 22.4 of the DSU states that “The level of the suspension of concessions or other obligations authorized by the DSB shall be equivalent to the level of the nullification or impairment.” Reciprocity as an upper bound on retaliation is also evidenced throughout the GATT as well. For instance, article XIX paragraph (c) states that “the affected contracting party is free to suspend...substantially equivalent concessions or other obligations under this Agreement...”

We start by allowing for an announced temporary suspension of concessions within a sector that is reciprocated an equivalent tariff increase by the trading partner. We term these violations as on-schedule deviations and we show that this reciprocity induces truthful revelation of the state of political pressure.

The most important assumption in our framework is that tariffs are strategic substitutes within a sector, or agreement, and are strategically neutral across the sectors. In a traditional two-good general equilibrium framework (see, for example Johnson (1953-54, Mayer (1981), or Dixit (1987)) an increase in the foreign import tariff lowers home income and, therefore, reduces the home import demand. The home country then has less benefit from raising its own import tariff. For this reason tariffs are strategic substitutes in a traditional framework. Our analysis requires at least four goods and two sectors and does not afford a closed form solution in a traditional general equilibrium framework. We show that if the goods within a sector, or agreement, are substitutes in consumption, then the tariffs within that sector are strategic substitutes.

Without strategic substitutability of tariffs combined with incomplete information there is no difference between same- and cross-sector retaliation. It is only when these two aspects are combined that they produce different outcomes between same- and cross-sector retaliation. The information revelation mechanism we employ uses safeguards whose cost to the country applying the safeguard is tied to the level of the safeguard. A larger safeguard tariff implies a larger retaliation. Crucially, the cost of the reciprocating tariff to the respondent (and the benefit to the complainant) is less when tariffs are strategic substitutes. For this reason the size of the safeguard tariff and the retaliatory tariff that it generates are lower when tariffs are strategic substitutes.

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7 Article VI provides for antidumping and countervailing duties. Although this provision, may at first glance, appear to sanction retaliation its continual abuse has allowed it serve as one of the main forms of temporary protection used by GATT signatories (see Prusa, 1992 and Blonigen and Prusa, 2015). The remaining allow escape valves for balance of payments concerns (article XII), infant industry protection in developing countries(XVIII), protection against import surges that damage domestic industries (XIX), health and safety reasons (XX), and national security (XXI).
substitutes. Hence, tariffs are lower and welfare is higher when retaliation is same-sector as opposed to cross-sector (where tariffs are strategically neutral).

Although, as noted above, the GATT/WTO allows for equivalent retaliation, this full reciprocity is excessively strict and generates slack in the incentive compatible constraints. We, therefore, consider, weaker forms of reciprocity that still elicit truthful revelation of the level of political pressure. Although our main result would obtain with any retaliatory tariff that is an increasing function of the violation, we again look at GATT/WTO practice in developing this alternative mechanism. In particular, we consider equal retaliation but with the delayed implementation noted above and we show that same sector-retaliation generates greater welfare than does cross-sector even when retaliation is delayed. On the other hand, the optimality of delayed retaliation depends on the length of delay, the Markov-transition probability, and the government’s rate of time preference.

Finally, we consider the viability of the trade agreement. We term an abrogation of the trade agreement as an off-schedule violation. Such a violation implies that a country will ignore the tariff bindings and available safeguards and set unilaterally optimal tariffs in both sectors with the knowledge that all tariff concessions will be removed in the following and all future periods. The ability of these non-abrogation or voluntary participation constraints to prevent off-schedule violations depends in part on the sector of retaliation for on-schedule violations. In particular, the future cost of violating the agreement is larger with same-sector retaliation so that these voluntary participation constraints are slack for a wider parameter range under same-sector retaliation. Even when these constraints are binding under both the same- and cross-sector mechanism the induced distortion in the tariff is less under the same sector mechanism.

In the next section we describe the economic framework and in the third section we analyze the perfect information outcome. In section 4 we consider same sector-retaliation and we extend this analysis to cross-sector in section 5 where we also make our first comparisons. We consider alternative delayed retaliation mechanisms in section 6 and analyze trade agreement abrogation in section 7. Our conclusions are contained in section 8.

2 Economic Environment

We are interested in analyzing the potential for linking punishments in international agreements where unilateral actions generate an international externality that has elements of a prisoners’ dilemma. Tariffs

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8Beshkar [6] also demonstrates that reciprocal retaliation can be excessive and shows that the probability of less than one that the WTO correctly supports the complainant can improve welfare even when the retaliation is equivalent, but is randomly sanctioned.
are an obvious example of this type of action, in that each country may benefit from levying a tariff on imports, but the losses to the partner country exceed the gains to the country setting the tariff. A reduced form of the welfare function such an environment would generate could be written as \( \vartheta(\tau, \tau^*, \theta) \), where \( \tau \) and \( \tau^* \) are the home and foreign tariffs. The parameter \( \theta \) depicts the fluctuating elements of the state of the world (such as the current economic environment and any political pressure faced by the governments). In a two-good, two-country, traditional general equilibrium environment the tariffs are considered to be strategic substitutes, because the country facing a tariff will have less income to buy its partner’s exports and less benefit from levying its own tariff. We will also allow the tariffs to be strategic substitutes within a sector, but our multi-sector framework does not permit a closed form solution of the chosen tariffs using a traditional general equilibrium framework (i.e. without a numeraire good to absorb all income effects). Still, as shown below, strategic substitutability of tariffs within a sector is provided as long as the goods are substitutes in consumption.

Emissions of pollution that damage the global commons are a related example, whereby the variables \( \tau \) and \( \tau^* \) could indicate the amount of pollution emitted by each country. In the environmental literature each country is assumed to have some benefit from polluting more (avoiding abatement costs) but they also suffer from global environmental damage, which is usually modeled as a convex function of the sum of the emission levels. If this damage function is strictly convex, then the choice variables would also be strategic substitutes. In a similar vein, international agreements covering intellectual property, trade in services, government procurement, nuclear non-proliferation, chemical weapons, cyber security, among others could also be described by a similar reduced form function. Hence, our model could be considered as more general than applying only to international trade agreements. Still, for analytical tractability, we will proceed to describe an environment of two sectors of traded goods.

2.A Fundamentals

We analyze trade policy in the following environment. There are two countries, Home (no star) and Foreign (*), two sectors, defined as \( i \in \{a, b\} \), two goods in each sector, represented by \( j_i \in \{x_i, y_i\} \), and a numeraire good, denoted by \( z \). Time is infinite and discrete (i.e. \( t = 0, 1, \ldots \)). Preferences of Home’s consumers are represented by:

\[
U(\cdot) = \sum_{t=0}^{\infty} \delta^t \left[ \sum_{i=a,b} u_{it}(\cdot) + z_t \right],
\]
where \( u_{it} (\cdot) \) and \( z_t \) are the home utility from sector \( i \) and the numeraire sector in period \( t \), respectively, and \( \delta < 1 \) is the common factor by which consumers, firms and governments discount future consumption.

The sector \( i \) sub-utility, \( u_{it} (\cdot, \cdot) \), takes the following quadratic form:

\[
\begin{align*}
    u_{it} (q^d_{x_i,t}, q^d_{y_i,t}) &= \frac{1}{1-D^2} [A(1+D)(q^d_{x_i,t} + q^d_{y_i,t}) - \frac{1}{2}(q^d_{x_i,t})^2 - \frac{1}{2}(q^d_{y_i,t})^2 - Dq^d_{x_i,t}q^d_{y_i,t}],
\end{align*}
\]

where \( q^d_{x_i,t} \) and \( q^d_{y_i,t} \) are Home’s demand of goods \( x_i \) and \( y_i \) in period \( t \), \( A > 0 \) is a taste parameter which measures the intensity of preferences (and it would also be the demand choke price if the goods are neither substitutes or complements), and \( D \in (0, 1) \) indicates the extent of substitutability between the goods. Foreign preferences, denoted by \( U^* (\cdot) \) and \( u^*_t (\cdot) \) are given by identical expressions.

Labour (\( \ell, \ell^* \)), the only factor of production, is assumed sufficiently large so that there is positive numeraire production in both countries. The numeraire good is produced with the same constant-returns-to-scale technology in Home and Foreign and we can, therefore, normalize the price of the numeraire good and the wage to unity in both countries.

Technology for the sector \( a \) and sector \( b \) goods can be represented by the following cost functions:

\[
\begin{align*}
    C_{x_i}(q^s_{x_i,t}) &= \frac{(q^s_{x_i,t})^2}{2}; \quad C_{y_i}(q^s_{y_i,t}) = f q^s_{y_i,t} + \frac{(q^s_{y_i,t})^2}{2},
    \\
    C_{x_a}(q^s_{x_a,t}) &= f q^s_{x_a,t} + \frac{(q^s_{x_a,t})^2}{2}; \quad C_{y_b}(q^s_{y_b,t}) = \frac{(q^s_{y_b,t})^2}{2};
\end{align*}
\]

where \( q^s_{x_i,t} \) and \( q^s_{y_i,t} \) are the quantities supplied by Home and Foreign in period \( t \), respectively, and \( f > 0 \) is an exogenous parameter. So that all quantities are positive we assume that \( A > \frac{2}{f} \). Since \( f > 0 \), the marginal cost of producing either \( x \) good (\( x_a \) and \( x_b \)) in Home is lower than in Foreign. Hence, Home has a comparative advantage in, and is the natural exporter of, the \( x \) goods. Similarly, Foreign has a comparative advantage in \( y_a \) and \( y_b \). Ownership of the firms that produce the goods is shared equally by the by the inhabitants of their country of production and these inhabitants use their share of the profits and their labour income to purchase goods.

Government preferences in Home, but not Foreign, assign an added value to the numeraire consumption that is provided by profits from the import competing industry in the \( a \) sector. This extra value appears as a weight, \( \theta_t \geq 1 \), on sector \( a \) import-competing profits in the Home government’s indirect utility, or political welfare, function \( \vartheta_a (\tau_{at}, \tau_{at}^*, \theta_t) \) which is derived below.

We make the following assumptions about this political weight, \( \theta_t \). First, to capture the idea that the government may face fluctuating political pressure, we allow \( \theta_t \) to take two values, \( \theta_t = \{ \theta_L, \theta_H \} \). High
pressure is given by $\theta_H > 1$ and low pressure by $\theta_L = 1$. Second, after an initial period where $\theta_i = \theta_L$ with probability $\lambda$ and $\theta_i = \theta_H$ with probability $1 - \lambda$, $\theta_i$ evolves according to a Markov process over time:

$$\text{prob}(\theta_{t+1} = \theta_L|\theta_t = \theta_L) = \text{prob}(\theta_{t+1} = \theta_H|\theta_t = \theta_H) = \beta;$$

$$\text{prob}(\theta_{t+1} = \theta_H|\theta_t = \theta_L) = \text{prob}(\theta_{t+1} = \theta_L|\theta_t = \theta_H) = 1 - \beta,$$

where $\beta \in [0, 1]$ is the transition probability. To avoid autarky, we assume that $\theta_H < \bar{\theta}(A, f, D, \beta, \delta)$, where $\bar{\theta} > 1$ will be derived below. Finally, we assume that this political pressure is private information of Home’s government.

In every period $t$, consumer maximization yields the following demand functions, where $p_{j,t}$ is the equilibrium price of good $j_i$ in Home:

$$q_{x,t}^d = A - p_{x,t} + Dp_{y,t}; \quad q_{y,t}^d = A - p_{y,t} + Dp_{x,t}. \quad (3)$$

Letting $p_{j,t}^*$ denote prices in Foreign, the Foreign demand functions, $q_{j,t}^d$, are similar to those in Home.

Profit maximization generates the following Home and Foreign supply functions:

$$q_{x,t}^s = p_{x,t}; \quad q_{y,t}^s = p_{y,t} - f; \quad q_{x,t}^* = p_{x,t} - f; \quad q_{y,t}^* = p_{y,t}. \quad (4)$$

Each government chooses a sequence of per-unit tariffs, $\tau_i = \{\tau_{it}\}_{t=0}^\infty$ and $\tau_i^* = \{\tau_{it}^*\}_{t=0}^\infty$, to maximize their political welfare function. The relationship between the Home and Foreign prices is described by:

$$p_{x,t}^* = p_{x,t} + \tau_{it}; \quad p_{y,t} = p_{y,t}^* + \tau_{it}^*.$$

Political welfare is a weighted sum of the country’s producer surplus, consumer surplus and tariff revenues in that period, where the sequence of weights on producer surplus in sector $a$ in Home is $\theta = \{\theta_t\}_{t=0}^\infty$. 10 The critical $\bar{\theta}$ will depend on whether or not reciprocal retaliation is immediate, as in sections 4 and 5, or is delayed, as in section 6. When retaliation is not delayed we require $\theta_H < \bar{\theta}^{ND} = \frac{A+7f/4}{A+7f/8} > 1$. This expression is decreasing in $D$, therefore $\theta_H < \bar{\theta}^{ND} = \frac{A+7f/4}{A+7f/8}$ is sufficient to avoid autarky. When reciprocal retaliation is delayed the critical upper bound on $\theta$ also depends on the discount factor, $\delta$, and the state-transition probability, $\beta$, and we require $\theta_H < \bar{\theta}^D = \frac{(D+6)(1+\delta)(2D+f+2A-3f)+(2-D)(5+8\delta+3\delta+4D\delta)}{(1+\delta)(2A+2f+2A-3f)+(2-D)(5+8\delta+3\delta+4D\delta)} > 1$. This expression is also decreasing in $D$, therefore $\theta_H < \bar{\theta}^D = \frac{(D+6)(1+\delta)(2D+f+2A-3f)+(2-D)(5+8\delta+3\delta+4D\delta)}{(1+\delta)(2A+2f+2A-3f)+(2-D)(5+8\delta+3\delta+4D\delta)}$ is sufficient to avoid autarky in the delayed retaliation case.

10Magee-Brock-Young [15] provide the earliest micro-foundation for the above politically weighted measure of welfare. In their framework two parties compete in an election and a third party, known as the “lobby groups”, makes campaign contributions to the political parties. In order to gain support and win the election, the two competing parties commit to trade policies that
political welfare of Home in sector $a$ is defined as:

$$
\vartheta_a(\tau_a, \tau_a^*, \theta) = \sum_{t=0}^{\infty} \delta t \vartheta_{at}(\tau_{at}, \tau_{at}^*, \theta_t)
$$

$$
= \sum_{t=0}^{\infty} \delta t \int_{p_{xat}(\tau_{at})}^{A} \int_{p_{yat}(\tau_{at})}^{A} u_{at}[q_{xat}^d, q_{yat}^d] dp_{xat} dp_{yat} 
+ \int_{0}^{p_{xat}(\tau_{at})} q_{xat}^s dp_{xat} + \theta_t \int_{0}^{p_{yat}(\tau_{at})} q_{yat}^s dp_{yat} + \tau_{at}[q_{xat}^d - q_{xat}^s] ,
$$

where the chosen quantities depend on the equilibrium prices as in equations (3) and (4). The term on the second line of equation (5) is consumer surplus. The first two terms on the third line are producer surplus and the third term is tariff revenue. The welfare of Home sector $b$ and each Foreign sector are the same as Home sector $a$ except that the weights on producer surplus are always 1. Home welfare can then be written as $V(\tau_a, \tau_a^*, \theta) = \vartheta_a(\tau_a, \tau_a^*, \theta) + \vartheta_b(\tau_b, \tau_b^*) + \ell$ and Foreign welfare as $V^*(\tau_a, \tau_a^*, \tau_b, \tau_b^*) = \vartheta_a^*(\tau_a, \tau_a^*) + \vartheta_b^*(\tau_b, \tau_b^*) + \ell^*$.

The two most important elements of our model are given by the parameters $D$ and $\theta$. As we show below, if $D > 0$, then the tariffs are strategic substitutes as in the classic analyses of Johnson (1953-54) and Mayer (1981). On the other hand if $D = 0$, then the tariffs would be strategically independent. These results are illustrated in Figure 1 below and are derived formally in lemma 1. For completeness, in Figure 1 we also include the case where $D < 0$.

only benefit the “lobby group”. In Grossman-Helpman [12] lobbies have more power in that they can directly influence the level of the trade policies. The earliest work that recognizes the influence of lobbyists on trade policy is provided by Hillman [14]. Our welfare function is most closely related to Baldwin [2] who uses a reduced form of the social welfare function in Hillman [14].

$^{11}$The parameter $D$ is assumed to be zero in all of the literature on trade agreements under incomplete information that are cited in the introduction as well as in the wider group of literature on trade agreements that have a partial equilibrium intuition (where a numeraire good is utilized to close the model).
Lemma 1. If the utility functions are as given in (1) and the cost functions are as given in equation (2), then:

(i) the political welfare in each sector is strictly concave and initially strictly increasing in the domestic tariff while it is strictly convex and monotonically decreasing in the foreign tariff,

• (ii) for all $\theta < \bar{\theta}$ there is a unique Nash equilibrium in tariffs,

(iii) the best response tariffs within the sectors are strategic substitutes.

All the proof are relegated to Appendix A.

2.B Timing

The timing of the interaction is as follows. Each period consists of five stages. In the first stage, nature moves. It chooses a level of political pressure, or a type, for Home. In the second stage, Home moves. It announces its import tariff in sectors $a$ and $b$ based on the realization of its type. In the third stage, Foreign observes Home’s announcement and announces its own import tariffs in sectors $a$ and $b$. In the fourth stage
tariffs are chosen simultaneously. In the fifth stage, production and consumption take place and markets clear.

The home and foreign actions in period $t$ are their tariff choices $\tau_t \equiv (\tau_{at}, \tau_{bt})$ and $\tau_t^* \equiv (\tau_{at}^*, \tau_{bt}^*)$. The public history at the beginning of period $t$ is the sequence of tariffs through $t-1$, denoted as $T^{t-1} \times T^{*t-1}$, where $T^{t-1} = \tau_1, ..., \tau_{t-1}$ and $T^{*t-1} = \tau_1^*, ..., \tau_{t-1}^*$. In the perfect information benchmark the public history also includes the complete history of realizations of the political economy parameter: $\theta^{t-1} \times \theta_t$, where $\theta^{t-1} = \theta_1, ..., \theta_{t-1}$, but under asymmetric information the realizations of this parameter are the private information of Home. A strategy for each country, in the asymmetric information version of model, is then $s = (s_t)_{t=1}^\infty$ and $s^* = (s_t^*)_{t=1}^\infty$ with

$$s_t : T^{t-1} \times \theta^{t-1} \times T^{*t-1} \times \theta_t \rightarrow \mathbb{R}^2$$

and

$$s^*_t : T^{*t-1} \times T^{t-1} \times \tau_t \rightarrow \mathbb{R}^2.$$ 

A strategy for each country maps the public history and any private information into the current period actions. Although, as written, strategies are history dependent, in the next several sections we ignore the history of past outcomes and assume that countries will abide by outlines of the trade agreement and only consider “on-schedule” violations. Hence, actions are conditioned only on the current period state (although the previous period outcome may provide information about the current state realization). After deriving what the trade agreement can accomplish when there is incomplete information about the current state we will consider the ability of history-dependent strategies to limit “off-schedule” violations.

## 3 Perfect-Information Benchmark

In this section we analyze the jointly-optimal tariffs when there is perfect information about Home’s type. These tariffs are chosen to maximize the sum of Home’s and Foreign’s political welfare functions:

$$\Omega = V(\tau_a, \tau_a^*, \theta, \tau_b, \tau_b^*) + V^*(\tau_a^*, \tau_a, \tau_b, \tau_b^*).$$  \hspace{1cm} (6)

12As long as Home adheres to the trade agreement, the game is as if home announces its type and then the tariffs are chosen simultaneously. We think that is more realistic for home to choose a tariff to reveal their type. The careful reader may note that Home, by choosing its tariff first, has a first-mover advantage. The reason that Home could never use this advantage is that the trade agreement, to be described below, specifies allowable tariffs for each state. The first-mover tariff would most likely be an “off-schedule” violation and trigger a severe punishment. If, on the other hand, the first-mover tariff for the low state were the same as the allowable high-state tariff, then the incentive compatibility condition would prevent Home from using their first-mover advantage in the low state. As long as the incentive compatible (covering on-schedule violations) and voluntary participation (covering off-schedule violations) constraints are satisfied Home would never utilize its first-mover advantage in equilibrium.
We use three observations to simplify this optimization problem. First, because each country’s welfare is separable in the sectors, we solve each sector’s optimization problem separately. Second, the per-period jointly-optimal actions are independent of past realizations of the state variable, so we omit the time subscript, \( t \), to unclutter notation. Finally, given that the state is revealed before tariffs are chosen, we divide the sector \( a \) welfare maximization problem into a low-state, \( \theta_L \), and high-state, \( \theta_H \), case. The perfect-information optimization problem can then be written as:

\[
\begin{align*}
\max_{\tau_a^L, \tau_a^*} & \quad \Omega_a(\tau_a^L, \tau_a^*, \theta_L) = \max_{\tau_a^L, \tau_a^*} \vartheta_a(\tau_a^L, \tau_a^*, \theta_L) + \vartheta_a^*(\tau_a^L, \tau_a^*); \\
\max_{\tau_a^H, \tau_a^*} & \quad \Omega_a(\tau_a^H, \tau_a^*, \theta_H) = \max_{\tau_a^H, \tau_a^*} \vartheta_a(\tau_a^H, \tau_a^*, \theta_H) + \vartheta_a^*(\tau_a^H, \tau_a^*);
\end{align*}
\]

and

\[
\max_{\tau_b^L, \tau_b^*} \Omega_b(\tau_b^L, \tau_b^*) = \max_{\tau_b^L, \tau_b^*} \vartheta_b(\tau_b^L, \tau_b^*) + \vartheta_b^*(\tau_b^L, \tau_b^*).
\]

Using superscript letter “\( E \)” to represent “politically efficient” and solving the above maximization problems yields the following proposition:

**Proposition 1.** The joint-welfare-maximizing tariffs under perfect information are

\[
\begin{align*}
\tau_a^E &= \tau_a^*E = \tau_b^*E = 0; \\
\tau_a^*E &= \frac{D (\theta_H - 1)(2Df - 3f + 2A)}{2(D - 2)(D^2 + \theta_H - 5)} < 0 < \tau_a^*E = \frac{(\theta_H - 1)(2Df + 2A - 3f)}{(D - 2)(D^2 + \theta_H - 5)}.
\end{align*}
\]

The essence of proposition 1 is shown in Figure 2 where we illustrate the two possible states for sector \( a \). The non-cooperative outcome for the low state is given by point A in Figure 2 where there is a unique intersection of each country’s tariff best-response function. We also illustrate the iso-welfare for each country that passes through point A. From these iso-welfare curves we can draw the contract curve in tariff space as curve CC. Note that this contract curve passes through the origin. Both countries prefer any outcome on CC to that at point A. The joint welfare optimization chooses point O, where \( \tau_a^L = \tau_a^*E = 0 \) as the unique solution for sector \( a \) in the low state (and also in sector \( b \)).
In the high state, Home’s best-response is more responsive to a foreign tariff. The non-cooperative outcome for the high state is given by point B. While the iso-welfare for Foreign passing through point B has the same shape as that through point A, the iso-welfare curve for Home (labeled H’) is steeper reflecting the fact that in a high state Home increases its desire for a larger protective tariff and is less affected by Foreign’s tariff. From these two iso-welfare curves passing through point B we can construct the high state contract curve C’C’ and the joint optimum is given on that curve at point E. At point E the optimum Home tariff is positive and the Foreign tariff is negative. That is, at the high-state perfect-information optimum Foreign should subsidize imports to reduce Home’s import tariff. This interesting result occurs because the tariffs are strategic substitutes. From proposition 1 we see that if \( D = 0 \), then Foreign’s tariff would be zero.
regardless of the Home’s state. We also see there that Home’s tariff is increasing in θ and is zero if θ = 1.

We now consider the more interesting case whereby Foreign does not know the realization of θ.

4 Incomplete Information with Same-sector Retaliation

From this point on we assume that foreign does not know Home’s type, but it perfectly observes Home’s action. Hence, if Home adheres to the tariff schedule given by the trade agreement, then Foreign can infer its type in any period. In this section, we also restrict retaliation to be in the same sector.

If Home announces their type, then it must be induced to announce truthfully, otherwise Home would always announce a high state. We begin with a simple revelation mechanism suggested by the GATT article XXVIII, which allows Foreign to reciprocate by matching the Home tariff in any period.\textsuperscript{13} This concept of equivalent retaliation is also evidenced in many areas of international diplomacy.

With same sector retaliation we can solve for the (constrained) welfare maximizing tariffs in each sector separately. For sector a, since θ takes two values we consider a Home tariff schedule that also takes on two values: τ\textsubscript{aL}(θ\textsubscript{L}) and τ\textsubscript{aH}(θ\textsubscript{H}). Given our assumption of reciprocity we impose that τ\textsubscript{*aH}(τ\textsubscript{aH}) = τ\textsubscript{aH}.

The negotiators’ maximization problem in sector b is the same as in the perfect-information benchmark

\[
\max_{\tau_b, \tau_b^*} \Omega_b(\tau_b, \tau_b^*) = \max_{\tau_b, \tau_b^*} \theta_b(\tau_b, \tau_b^*) + \theta_b^*(\tau_b, \tau_b^*),
\]

and has the same solution, τ\textsubscript{bE} = τ\textsubscript{bE} = 0 as in proposition 1. The negotiators’ maximization problem in sector a is given by:

\[
\max_{\tau_aL, \tau_aH, \tau_aL^*} \lambda \Omega_a(\tau_aL, \tau_aL^*, \theta_L) + (1 - \lambda) \Omega_a(\tau_aH, \tau_aH, \theta_H)
\]

subject to

\[
\tau_aL \geq 0, \tau_aL^* \geq 0, \tau_H \geq 0,
\]

\[
\theta_a(\tau_aL, \tau_aL^*, \theta_L) \geq \theta_a(\tau_aH, \tau_aH, \theta_L),
\]

\textsuperscript{13}In addition to Article XXVIII, which specifically addresses reciprocity as necessary when modifying tariff schedules, Articles XVIII, XIX, XX, and XXI all require an equivalent concession or reciprocity for the temporary withdrawal of any previous granted tariff concession for balance of payments, emergency actions to protect domestic producers, phytosanitary or national security reasons.
and

\[ \vartheta_a(\tau_{aH}, \tau_{aH}, \theta_H) \geq \vartheta_a(\tau_{aL}, \tau_{aL}^*, \theta_H) \]  

(12)

where we have used the constraint \( \tau_{aH}^* = \tau_{aH} \) in writing the problem.

Problem (9) is the unconstrained maximization problem. The tariff non-negativity constraint is given by equation (10). To ensure truthful revelation of \( \theta \), the tariff scheme needs to be incentive compatible. Equation (11) is the incentive compatibility condition for the low state and equation (12) is that for the high state. The voluntary participation constraints for this type of framework are given by the incentive constraints for the infinitely repeated game. In particular, if either country chooses not to abide by the tariff schedule, then they would commit an “off-schedule” deviation and both countries would revert to the non-cooperative Nash tariffs forevermore. We analyze these voluntary participation constraints in section 7.

We use the term incentive-unconstrained to denote the solution to a welfare maximization problem subject only to the reciprocity and non-negativity constraints. For (9) we write these incentive-unconstrained solutions as \( (\tau_{aL}^S, \tau_{aH}^S, \tau_{aL}^S) \), where the superscript “S” represents “same-sector”. We then have the following proposition.

**Proposition 2.** Under a same-sector retaliation mechanism,

(i) the incentive-unconstrained joint-welfare-maximizing import tariffs are as follows:

\[ \tau_{aL}^S = \tau_{aL}^* = 0 < \tau_{aH}^S = \frac{(\theta_H - 1)(2Df - 3f + 2A)}{(D - 2)(-4D + \theta_H - 9)}. \]

(ii) the incentive-unconstrained joint-welfare-maximizing import tariff in a high state is smaller than the politically efficient tariff: \( \tau_{aH}^S < \tau_{aH}^E \).
The essence of proposition 2 is illustrated in Figure 3 (and the proof is in the appendix). As in Figure 2, the non-cooperative Nash tariffs are given by point B. The reciprocity condition, however, requires Foreign to match Home’s tariff and is shown by the forty-five degree line passing through the origin. The non-cooperative reciprocal tariffs when Home is in a high state are then given by point D. Drawing iso-welfare curves through point D, we can then construct the contract curve, which is depicted as curve C”C”. The reciprocity condition requires equivalent tariffs (on the forty-five degree line) and the solution is given by point S. As shown formally in proposition 2, this tariff is increasing in $\theta_H$ and larger than that in the low state (unless $\theta_H = 1$), but it is less than the politically-efficient high-state Home tariff. It is straightforward to see that the unconstrained optimum also satisfies the non-negative tariff constraint.

In solving for the optimal tariffs in proposition 2 we ignore the incentive compatibility constraints. The next proposition shows that these constraints are slack under the same-sector retaliation mechanism. Therefore, the incentive-unconstrained solutions also satisfy the constrained maximization problem.

**Proposition 3.** Under a same-sector retaliation mechanism with incentive-unconstrained solutions the incentive compatibility conditions (11) and (12) are slack.
The idea of proposition 3 is illustrated (for the low state) in Figure 4. In the low state both countries prefer free trade to any positive reciprocated tariff, therefore Home is on a higher iso-welfare curve if it does not misrepresent its type in the low state. The proof to proposition 3 also demonstrates that the high-state incentive-constraint is slack, however, as this result is expected (Home in a high state would not wish to claim it is in a low state) it is not shown graphically in figure 4. Given that neither of the incentive-compatibility constraints are binding, it indicates that these equivalent retaliation strategies are too strict. In section 6 we, therefore, consider a less severe punishment mechanism. Before turning to a more efficient truth telling mechanism, we first analyze cross retaliation.

5 Incomplete Information with Cross-sector Retaliation

In this section, we consider cross-retaliation, or linked agreements. Cross-retaliation requires that when Home raises its tariff in sector $a$ Foreign is constrained to reciprocally cross-retaliate in sector $b$.\footnote{Although we impose cross-retaliation as a requirement, we could just as easily allow the foreign country to choose its sector of retaliation. Given such a choice, the foreign country would always choose cross-sector over same sector retaliation because the tariffs are strategic substitutes within a sector.} For on-schedule deviations we continue to impose reciprocity on the size of the retaliatory measure (and we again
address the inefficiency of equivalent retaliation).

The “on-schedule” requirements in this cross-sector retaliation mechanism are as follows. When Home chooses a low-state tariff, \( \tau_{aL} \), in sector \( a \), Foreign must match Home’s tariffs in both sectors, i.e., \( \tau_a^*(\tau_{aL}) = \tau_{aL} \), \( \tau_b^*(\tau_{aL}) = \tau_b \). On the other hand, when Home sets a high-state tariff, \( \tau_{aH} \), then Foreign can impose a retaliatory tariff in sector \( b \): \( \tau_b^*(\tau_{aH}) = \tau_{aH} \). Foreign must still choose the low-state tariff in sector \( a \).

Although the politically-efficient high-state tariff for Foreign is negative, as shown in proposition 1, our non-negativity constraint implies that they impose the low-state efficient tariff, which is zero. Our reasoning is as follows. An import subsidy would reduce foreign welfare, therefore, Foreign would never levy a negative import tax unless it were compensated by some other benefit such as a side payment, or a Home import subsidy in sector \( b \). Furthermore, import subsidies are not observed in international commerce and are not discussed in trade negotiations. Finally, although it would mildly complicate the analysis to incorporate “on-schedule” import subsidies it would have no qualitative effect on the results. Hence, we proceed with the more realistic (if slightly less efficient) cross-sector mechanism whereby Foreign is only required to set a non-negative tariff in sector \( a \) when Home chooses a high tariff in the previous stage. With respect to Home, because the state does not change they will always levy the same low-state tariff in sector \( b \) and, given the non-negative tariff requirement, the optimal low state tariff for Home in sector \( b \) will be a zero tariff.

We continue to defer the voluntary-participation constraints until section 7 and only consider “on-schedule” violations in this section. The negotiators problem is to choose tariffs, \( (\tau_{aL}, \tau_{aH}, \tau_b) \), to maximize the expected joint political welfare, or,

\[
\max_{\tau_{aL}, \tau_{aH}, \tau_b} \lambda[\Omega_a(\tau_{aL}, \tau_{aL}, \theta_L) + \Omega_b(\tau_b, \tau_b)] + (1 - \lambda)[\Omega_a(\tau_{aH}, \tau_{aL}, \theta_L) + \Omega_b(\tau_b, \tau_{aH})]
\]

subject to

\[
\tau_{aL} \geq 0, \tau_b \geq 0, \tau_{aH} \geq 0,
\]

\[
\varphi_a(\tau_{aL}, \tau_{aL}, \theta_L) + \varphi_b(\tau_b, \tau_b) \geq \varphi_a(\tau_{aH}, \tau_{aL}, \theta_L) + \varphi_b(\tau_b, \tau_{aH}),
\]

19
Problem (13) is the unconstrained maximization problem. The first bracketed term of problem (13) is the low-state joint political welfare, weighted by the probability of a low state, \( \lambda \). The second bracketed term payoff in a high state. The incentive compatible conditions for each state are given by eqs.(15) and (16).

The incentive-unconstrained maximization problem can be rewritten as three optimization problems to be solved simultaneously, however, the non-negativity constraint indicates that we can solve for the optimal low-state, \( \tau_{aL}^C \), and sector \( b \), \( \tau_{b}\), tariffs and then substitute these solutions into the problem for the high state tariff. Hence we can rewrite the incentive-unconstrained maximization problem as:

\[
\tau_{aL}^C = \tau_{aL} \arg \max \Omega_a(\tau_{aL}, \tau_{aL}, \theta_L); \\
\tau_{aH}^C = \tau_{aH} \arg \max \Omega_a(\tau_{aH}, \tau_{aL}, \theta_H) + \Omega_b(\tau_{b}, \tau_{aH}), \\
\tau_{b}^C = \tau_{b} \arg \max \Omega_b(\tau_{b}, \tau_{b}) + \vartheta^*_b(\tau_{b}, \tau_{b}),
\]

where the superscript letter “\( C \)” denotes “cross-sector”.

By solving the incentive-unconstrained maximization problem, we have the following proposition.

**Proposition 4.** (i) The incentive-unconstrained welfare-maximizing tariffs under a cross-sector retaliation mechanism are as follows:

\[
\tau_{aL}^C = \tau_{b}^C = 0 = \tau_{aL}^E < \tau_{aH}^C = \frac{(\theta_H - 1)(2bf + 2A - 3f)}{(b - 2)(\theta_H - 9)}. 
\]

(ii) The incentive-unconstrained welfare-maximizing tariff in a high state under a cross-sector retaliation mechanism is greater than under a same-sector retaliation mechanism while smaller than the politically efficient tariff: \( \tau_{aH}^S < \tau_{aH}^C < \tau_{aH}^E \).
The idea of proposition 4 is illustrated in Figure 5 (the full proof is in the appendix), where we try to capture cross-retaliation across two sectors in a single two-dimensional figure. In order to make comparisons and also to help explain the illustration in figure 5, we have included information from figure 2, which depicts the perfect-information benchmark, and figure 3, which shows same-sector retaliation. If Home chooses a high-state tariff in sector \( a \) it treats the foreign tariff as given, therefore, it no longer considers the tariffs in sector \( a \) as strategic substitutes. For this reason, Home’s best response is shown by the vertical line labeled \( \tau_a^R \). Foreign’s reciprocal tariff in sector \( b \) is given by the forty-five degree line labeled \( \tau_b^{Reciprocal}(\tau_a) \). The intersection between these (constrained) best-response functions at point G indicates the Nash equilibrium outcome. All three of Foreign’s iso-welfare curves have the same shape because Foreign is always in a low state in both sectors, but Home’s iso-welfare curves have three shapes. The low state is shown by curve H, the high state by the two \( H' \) curves, and the combination low state in sector \( b \) and high state in sector \( a \) is approximated by curve \( H'' \) (the graphical depiction of proposition 4 does not depend on the shape of the Home best response functions but rather on the location of the Nash equilibrium). From the iso-welfare curves passing through the Nash equilibrium we can construct the new contract curve \( C''C''' \). This contract curve passes through the forty-five degree line at point CR, yielding the high-state cross-sector retaliation.
tariffs and these tariffs are larger than those under same-sector retaliation as shown by point S.\footnote{If we plug the high-state tariffs, $\tau^C_{aH}$ and $\tau^S_{aH}$ into the demand and supply functions we can then find an upper bound on $\theta_H$ so that imports are positive if and only if $\theta_H$ is less than this upper bound. For same-sector retaliation, this upper bound is $\theta_H < \frac{4A + 2AD - f(12 + 2D^2)}{4A + f(12 - 2D)}$. For cross-sector retaliation, it is $\theta_H < \frac{4A + f(12 - 2D)}{4A + f(3D - 4)}$. Because $D < 1$ and $A > 3f/2$, both of these expressions are greater than one and comparison shows that the cross sector upper bound is lower. Evaluating it at its minimum value, when $D = 1$, yields $\theta_H < \hat{\theta}^{ND} = \frac{4A + 2f}{A - f/2}$ as in footnote 9.}

Similar to the same-sector retaliation case, the solution to the incentive-unconstrained cross-sector problem satisfies the incentive compatibility constraints, therefore, the optimal tariffs described in proposition 4 also solve the constrained problem given by equations (13, 15 and 16).

**Proposition 5.** Under a cross-sector retaliation mechanism with incentive-unconstrained solutions the incentive compatibility conditions (15) and (16) are slack.

Proposition 5 is illustrated (again, only for the more interesting low-state) in figure 6 (the proof is in the appendix), which is similar to figure 4.

From propositions 3 and 5, we know that the unconstrained tariffs given in propositions 2 and 4 also satisfy the incentive constraints, therefore, we can compare the welfare implications of the two mechanisms by analyzing the unconstrained optimal tariffs. The following proposition, which is our first main result, compares welfare under incomplete information with same-sector and cross-sector retaliation:
Proposition 6. The joint-welfare-maximizing incentive-compatible negotiated import tariffs under a same-sector retaliation mechanism generate higher welfare than do the joint-welfare-maximizing incentive-compatible negotiated tariffs under a cross-sector retaliation mechanism.

There are two cases considered in the proof to proposition 6 (shown in the appendix). In a low state the two mechanisms deliver the same efficient tariffs. The more interesting case is the high state. Although same-sector retaliation potentially imposes additional inefficiencies in sector $a$ this potentiality generates lower sector $a$ tariffs, $\tau_{aH}^S < \tau_{aH}^C$. Furthermore, there are no tariff-generated inefficiencies in sector $b$.

As shown in propositions 3 and 5 these same-sector and cross-sector retaliation mechanism are too strong because they require an excessive amount of retaliation. In the next section we consider a more efficient, asymmetric retaliation mechanism and we compare the welfare effects of cross-sector and same-sector retaliation in this asymmetric mechanism.

6 Delayed Retaliation

In this section we introduce a less-restrictive type-revealing mechanism. We continue to focus on “on-schedule” deviations and defer the analysis of “off-schedule” violations until the next section. In order to analyze delayed retaliation, the mechanism must consist of at least two-periods, however, given that $\beta$ follows a Markov process a two-period analysis is not sufficient. We, therefore, introduce the full dynamic game (but without history dependent strategies) for our analysis of “on-schedule” deviations in this section and use it as a building block for the study of “off-schedule” deviations in the next.

6.A Same-sector Retaliation with Delay

In this section we extend the analysis of same-sector retaliation (from section 4) to include reciprocal retaliation with delay. Delayed punishment has no effect on sector $b$ when retaliation is limited to the same sector as the transgression. Hence, as in section 4, Home and Foreign will choose the politically efficient tariff in sector $b$. We, therefore, only need to analyze the negotiators’ problem in sector $a$.

We follow the idea of reciprocity as described in the GATT and the WTO. In particular, an “on-schedule” retaliation is applied to an ongoing deviation and is removed once the trade restriction is reduced. On the other hand, given a delay in punishment a country could always raise their tariff for only one period and never suffer any retaliation. For that reason we consider reciprocity in two period increments. If Home claims it is a high state and raises their tariff, then Foreign will set the low tariff in the current period and retaliate.
in the next period. Home is allowed to maintain their high tariff during the retaliatory period. After these two periods Foreign will again set a low tariff and only raise it following an additional “on-schedule” Home deviation. Given that Home’s (on-schedule) action during the retaliatory period does not affect Foreign’s action in the following period, Home will continue to levy a high tariff during the retaliatory period even if the state reverts to low. Delayed retaliation in sector \( a \) can be described as follows.

\[
\tau_{at} = \begin{cases} 
\tau_{aL} & \text{if } \theta_t = \theta_L \\
\tau_{aH} & \text{if } \theta_t = \theta_H \end{cases}
\]

\[
\tau_{a,t+1} = \begin{cases} 
\tau_{aL} & \text{if } \tau_{at} = \tau_{aL} \\
\tau_{aH} & \text{if } \tau_{at} = \tau_{aH} \text{ or if } \theta_{t+1} = \theta_H. 
\end{cases}
\]

\[
\tau_{a}^* = \begin{cases} 
\tau_{aL} & \text{if } \tau_{at} = \tau_{aL} \\
\tau_{aH} & \text{if } \tau_{at} = \tau_{aH}. 
\end{cases}
\]

The joint political welfare in sector \( a \) under a same-sector retaliation with delay mechanism is captured by the following two Bellman equations:

\[
\omega_{S}^a(\theta_L) = \Omega_{a}(\tau_{aL}, \tau_{aL}^*, \theta_L) + \delta \beta \omega_{S}^a(\theta_L) + \delta (1 - \beta) \omega_{S}^a(\theta_H)
\]

\[
\omega_{S}^a(\theta_H) = \Omega_{a}(\tau_{aH}, \tau_{aL}^*, \theta_H) + \delta \beta \Omega_{a}(\tau_{aH}, \tau_{aH}, \theta_H) + \delta^2 \beta^2 \omega_{S}^a(\theta_H) + \delta (1 - \beta) \Omega_{a}(\tau_{aH}, \tau_{aH}, \theta_L) + 2 \delta^2 (1 - \beta) \omega_{S}^a(\theta_L) + \delta^2 (1 - \beta)^2 \omega_{S}^a(\theta_H)
\]

where \( \omega_{S}^a(\theta_L) = \omega_{S}^a(\theta_L, \tau, \tau^*) \) captures the case when the state was low last period and is again low in the current period and \( \omega_{S}^a(\theta_H) = \omega_{S}^a(\theta_H, \tau, \tau^*) \) captures the first period after the state has transitioned to high. Solving the two Bellman equations simultaneously yields:

\[
\omega_{S}^a(\theta_L) = \frac{1}{\gamma_1} \left\{ \Omega_{a}(\tau_{aH}, \tau_{aL}^*, \theta_H) + \delta \beta \Omega_{a}(\tau_{aH}, \tau_{aH}, \theta_H) + \delta (1 - \beta) \Omega_{a}(\tau_{aH}, \tau_{aH}, \theta_L) + (1 - \delta^2 + 2 \beta \delta^2 (1 - \beta)) \Omega_{a}(\tau_{aL}, \tau_{aL}^*, \theta_L) \right\}
\]

\(^{16}\text{As long as } \theta_H < \theta^D \text{ as described in footnote 9, the high-state tariff is low enough so that the best response (when } \theta = 1 \text{) to the same sector mechanism tariff when } \theta = \theta_H \text{ is greater than that allowed tariff so that Home would choose to maintain their high tariff in the retaliatory period even when } \theta = 1. \text{ This critical upper bound on } \theta \text{ is lower (more restrictive) than that required so that autarky is not an outcome. We, therefore, only report this minimum critical upper bound on } \theta \text{ for the delayed case.}\)
\[ \omega_a^S(\theta_H) = \frac{1}{\gamma_1} \{(1 - \delta\beta)\Omega_a(\tau_{aH}, \tau_{aL}^*, \theta_H) + (1 - \delta\beta)\delta\beta\Omega_a(\tau_{aH}, \tau_{aH}, \theta_H) \\
+ (1 - \delta\beta)\delta (1 - \delta)\Omega_a(\tau_{aH}, \tau_{aH}, \theta_L) + 2\beta^2 (1 - \delta)\Omega_a(\tau_{aL}, \tau_{aL}^*, \theta_L)\} \]

where \( \gamma_1 \equiv (1 - \delta) (1 - 2\beta\delta + \delta) (\beta\delta + 1) \).

Based on the strategies explained before, the negotiators choose the import tariff scheme, \((\tau_{aL}, \tau_{aL}^*, \tau_{aH})\), to maximize the discounted joint political welfare, or,

\[
\max_{\tau_{aL}, \tau_{aH}, \tau_{aL}^*} \omega_a^S(\theta_L);
\]

\[
\max_{\tau_{aL}, \tau_{aH}, \tau_{aL}^*} \omega_a^S(\theta_H)
\]

subject to the non-negative tariff constraint

\[
\tau_{aL} \geq 0, \tau_{aL}^* \geq 0, \tau_{aH} \geq 0
\]

and the two incentive compatibility conditions:

\[
\vartheta_a(\tau_{aL}, \tau_{aL}^*, \theta_L) + \delta\beta \vartheta_a(\tau_{aL}, \tau_{aL}^*, \theta_L) + \delta (1 - \beta) \vartheta_a(\tau_{aH}, \tau_{aL}^*, \theta_H) \geq \vartheta_a(\tau_{aH}, \tau_{aH}, \theta_L) + \delta (1 - \beta) \vartheta_a(\tau_{aH}, \tau_{aH}, \theta_H)
\]

(21)

\[
(1 + \delta\beta) \vartheta_a(\tau_{aL}, \tau_{aL}^*, \theta_H) + \delta (1 - \beta) \vartheta_a(\tau_{aL}, \tau_{aL}^*, \theta_L) \geq
\]

(22)

Denote the incentive-unconstrained solution to problem (20) as \((\tau_{aL}^{DS}, \tau_{aL}^{*DS}, \tau_{aH}^{DS})\), where the superscript “D” represents “delayed” and the superscript “S” denotes “same-sector”. Ignoring the incentive compatibility conditions for now the incentive-unconstrained optimal delayed same-sector retaliation mechanism tariffs are:

\[
\tau_{aL}^{DS} = \tau_{aL}^{*DS} = 0; \quad \tau_{aH}^{DS} = \frac{(\beta\delta + 1) (\theta_H - 1)}{D - 2} \frac{(2A - 3f + 2Df)}{(D - 2)(\beta\delta\theta_H - 4D\delta - \beta\delta - 8\delta + \theta_H - 5)}.
\]

(23)
6.B Cross-sector Retaliation with Delay

In this section we extend the analysis of cross-sector retaliation (from section 5) to include reciprocal retaliation with delay. The two-period structure and timing are the same as the same-sector retaliation but now the delayed reciprocal retaliation by Foreign is in sector $b$. Home is again allowed to maintain their high tariff in sector $a$ while being retaliated against in sector $b$. The strategies of home and foreign under a cross-sector retaliation with delay mechanism can be written as:

\[
\tau_{at} = \begin{cases} 
\tau_{aL} & \text{if } \theta_t = \theta_L \\
\tau_{aH} & \text{if } \theta_t = \theta_H;
\end{cases}
\]

\[
\tau_{a,t+1} = \begin{cases} 
\tau_{aL} & \text{if } \tau_{at} = \tau_{aL} \\
\tau_{aH} & \text{if } \tau_{at} = \tau_{aH} \text{ or if } \theta_{t+1} = \theta_H; \\
\tau_{bL} & \text{if } \tau_{at} = \tau_{aL}; \\
\tau_{bH} & \text{if } \tau_{at} = \tau_{aH}.
\end{cases}
\]

The main difference in writing the Bellman equations for the joint political welfare under a cross-sector retaliation mechanism is that, unlike same-sector retaliation, we must consider both sectors simultaneously:

\[
\omega^C(\theta_L) = \Omega_a(\tau_{aL}, \tau_{aL}, \theta_L) + \Omega_b(\tau_{bL}, \tau_{bL}, \theta_L) + \delta \beta \omega^C(\theta_L) + \delta (1 - \beta) \omega^C(\theta_H)
\]

\[
\omega^C(\theta_H) = \Omega_a(\tau_{aH}, \tau_{aL}, \theta_H) + \Omega_b(\tau_{bH}, \tau_{bL}, \theta_H) + \delta \beta \omega^C(\theta_L) + \delta (1 - \beta) \omega^C(\theta_H)
\]

\[
+ \delta (1 - \beta) [\Omega_a(\tau_{aH}, \tau_{aL}, \theta_L) + \Omega_b(\tau_{bH}, \tau_{aH}, \theta_L)] + 2 \delta^2 (1 - \beta) \beta \omega^C(\theta_L) + \delta^2 (1 - \beta)^2 \omega^C(\theta_H)
\]

where $\omega^C(\theta)$ now describes welfare in both sectors. Solving these two Bellman equations simultaneously yields:

\[
\omega^C(\theta_L) = \frac{1}{\gamma_1} \left[ \Omega_a(\tau_{aH}, \tau_{aL}, \theta_H) + \Omega_b(\tau_{bH}, \tau_{bL}, \theta_L) + \delta \beta [\Omega_a(\tau_{aH}, \tau_{aL}, \theta_H) + \Omega_b(\tau_{bH}, \tau_{aL}, \theta_H)] 
+ \delta (1 - \beta) [\Omega_a(\tau_{aH}, \tau_{aL}, \theta_L) + \Omega_b(\tau_{bH}, \tau_{aH}, \theta_L)] + (1 - \delta^2 + 2 \delta^2 (1 - \beta)) [\Omega_a(\tau_{aH}, \tau_{aL}, \theta_L) + \Omega_b(\tau_{bH}, \tau_{bL}, \theta_L)] \right]
\]

As in the previous footnote Home will wish to maintain the high tariff in sector $a$ even when the state reverts to low as long as the high-state tariff is not too high. This limit on the high-state tariff can be written as a limit on the upper bound of $\theta_H$. Given that tariffs are strategic substitutes the best response to a low tariff is greater than that to a high tariff. Hence, if home would be willing to maintain the high tariff in sector $a$ when the state reverts to low and Foreign is reciprocally retaliating in sector $a$, then it would certainly wish to do so Foreign keeps a low tariff in sector $a$ (but retaliates in sector $b$). Hence, the $\bar{\theta}^D$ we derived in footnote 16 is more than sufficient to guarantee that Home will levy a high tariff in the retaliatory period for any value of the state variable.
\[
\omega^C(\theta_H) = \frac{1}{\gamma_1} \{ (1 - \delta \beta) [\Omega_a(\tau_{aH}, \tau_{aL}, \theta_H) + \Omega_b(\tau_b, \tau_{aH})] + (1 - \delta \beta) \delta \beta [\Omega_a(\tau_{aH}, \tau_{aL}, \theta_H) + \Omega_b(\tau_b, \tau_{aH})] \\
+ (1 - \delta \beta) \delta (1 - \beta) [\Omega_a(\tau_{aH}, \tau_{aL}, \theta_H) + \Omega_b(\tau_b, \tau_{aH})] + 2 \beta \delta^2 \delta (1 - \beta) [\Omega_a(\tau_{aL}, \tau_{aL}, \theta_L) + \Omega_b(\tau_b, \tau_{aH})].
\]

Under a delayed cross-sector retaliation mechanism the negotiators choose the tariff scheme, \((\tau_{aL}, \tau_{aH}, \tau_b)\), to maximize the discounted joint political payoffs, or,

\[
\max_{\tau_{aL}, \tau_{aH}, \tau_b} \omega^C(\theta_L); \\
\max_{\tau_{aL}, \tau_{aH}, \tau_b} \omega^C(\theta_H)
\]

subject to the non-negativity constraint

\[
\tau_{aL} \geq 0, \tau_{aH} \geq 0, \tau_b \geq 0
\]

and the two incentive compatibility conditions:

\[
(1 + \delta \beta) [\vartheta_a(\tau_{aL}, \tau_{aL}, \theta_L) + \vartheta_b(\tau_b, \tau_{aL})] + \delta (1 - \beta) [\vartheta_a(\tau_{aH}, \tau_{aL}, \theta_H) + \vartheta_b(\tau_b, \tau_{aH})] \\
\geq (1 + \delta \beta) [\vartheta_a(\tau_{aH}, \tau_{aL}, \theta_H) + \vartheta_b(\tau_b, \tau_{aH})] + \delta (1 - \beta) [\vartheta_a(\tau_{aH}, \tau_{aL}, \theta_H) + \vartheta_b(\tau_b, \tau_{aH})]
\]

and

\[
(1 + \delta \beta) [\vartheta_a(\tau_{aH}, \tau_{aL}, \theta_H) + \vartheta_b(\tau_b, \tau_{aL})] + \delta (1 - \beta) [\vartheta_a(\tau_{aL}, \tau_{aL}, \theta_L) + \vartheta_b(\tau_b, \tau_{aL})] \\
\geq (1 + \delta \beta) [\vartheta_a(\tau_{aH}, \tau_{aL}, \theta_H) + \vartheta_b(\tau_b, \tau_{aL})] + \delta (1 - \beta) [\vartheta_a(\tau_{aH}, \tau_{aL}, \theta_L) + \vartheta_b(\tau_b, \tau_{aL})].
\]

Denote the incentive-unconstrained solutions to problem (24) as \((\tau_{aL}^{DC}, \tau_{aH}^{DC}, \tau_b^{DC})\), where the superscripts “D” and “C” represent “delayed” and “cross-sector”, respectively. Then, by following similar steps as in deriving Proposition 4, we can verify that:

\[
\tau_{aL}^{DC} = \tau_{aH}^{DC} = 0; \quad \tau_b^{DC} = \frac{(\beta \delta + 1)(\theta_H - 1)(2A - 3f + 2Df)}{(D - 2)(\beta \delta \theta_H - \beta \delta - 8\delta + \theta_H - 5)}.
\]

Comparing the incentive-unconstrained solutions for the same-sector delayed retaliation problem as given in equation (23) to those in the cross-sector problem given above we have the following result.

**Proposition 7.** The joint-welfare-maximizing import tariffs in a low state under delayed same-sector and delayed cross-sector retaliation mechanisms are both politically efficient and the joint-welfare-maximizing
incentive-unconstrained tariffs in a high state under a cross-sector retaliation mechanism is greater than under a same-sector retaliation mechanism: \( \tau_{aL}^{DS} = \tau_{aL}^{DC} = \tau_{aL}^{E} \) and \( \tau_{aH}^{DS} < \tau_{aH}^{DC} < \tau_{aH}^{E} \).

We now demonstrate that the incentive compatibility constraints can bind in both delayed same-sector and cross-sector retaliation mechanisms if the discount factor is relatively small or the transition probability is relatively large. This result is contrary to the case of retaliation-without-delay mechanisms and it is rather intuitive. If the discount factor is small, then delayed retaliation has little deterrence effect and the Home country would choose to misrepresent the low state as high. Similarly, if the transition probability is large, then when Home misrepresents a low-state the reciprocal retaliation is more likely to occur when the state changes to high and Home would prefer to continue levying a high tariff when the state is high. The following proposition develops these points formally.

**Proposition 8.** (i) For every \( \beta \) there exists a \( \delta'(\beta) \in (0, 1) \) such that for any \( \delta \in [\delta'(\beta), 1] \), the incentive compatibility conditions (21) and (22) are slack. The critical \( \delta'(\beta) \) is decreasing in \( \beta \).

(ii) For every \( \beta \) there exists a \( \delta''(\beta) \in (0, 1) \) such that for any \( \delta \in [\delta''(\beta), 1] \), the incentive compatibility conditions (21) and (22) are slack. The critical \( \delta''(\beta) \) is decreasing in \( \beta \).

When the transition probability is small (so \( \beta \) is large) the critical discount factor is smaller and it is more likely that the incentive compatibility conditions are satisfied. We can rewrite the discount factor as \( \delta = he^{-\rho \lambda} \) where \( h \) is the hazard rate, \( \rho \) is the rate of time preference and \( \lambda \) is the period length. Staiger (1995b, pp. 1520–1521) explains that the period length can be thought of as the time required for observing and responding to the trading partner’s policies. In this vein, proposition 8 could be restated as there is a critical value of \( \lambda(\beta) \) such that if \( \lambda < \lambda(\beta) \) then the incentive compatibility conditions are slack, where \( \lambda(\beta) \) is increasing in \( \beta \).

If the incentive compatibility conditions are slack, then, as we show below, a same-sector delayed-retaliation mechanism generates greater welfare than does a a cross-sector delayed mechanism. The reasoning here is the same as in proposition 6. On the other hand, if the incentive constraints are binding, then the same-sector delayed mechanism is binding at a lower (less-distortionary) high-state tariff than is the cross-sector delayed mechanism and the same-sector delayed-retaliation mechanism also generates greater welfare in this case as well. Finally, there is a range of \( \delta \) and \( \beta \) such that the cross-sector low state incentive constraint is binding and the same sector one is slack. A binding constraint requires a larger (more distortionary reciprocated) tariff than does a slack constraint, therefore, the same-sector mechanism generates greater welfare in this third case as well. Hence, as the proposition below formally demonstrates, the
The best incentive compatible tariffs are always more efficient under a same-sector delayed-retaliation mechanism irrespective of whether the incentive compatibility conditions are binding.

**Proposition 9.** The joint-welfare-maximizing incentive-compatible negotiated import tariffs under a same-sector delayed-retaliation mechanism generate higher expected welfare than do the joint-welfare-maximizing incentive-compatible negotiated import tariffs under a cross-sector delayed-retaliation mechanism.

Taken together propositions 9 and 6 are our key result: same-sector reciprocal retaliation is more efficient than cross-sector and the architects of the GATT and the WTO were prescient in trying to limit cross-retaliation.

Our second most important set of results concerns the optimality of delayed retaliation. The discount factor and transition probability again play a key role in determining the efficiency of the delayed mechanism. For example, if Home is extremely impatient, then delayed reciprocal retaliation is a less effective deterrent to type misrepresentation. Similarly, the transition probability determines the likelihood of suffering reciprocal retaliation while still in the low state. It is interesting to note that the intuition for the optimality of delayed retaliation is identical to that of whether the incentive constraints are binding. In fact, the conditions are identical: if and only if the delayed-retaliation mechanism incentive-compatibility conditions are slack, does the delay mechanism generate greater welfare. On the other hand, if the constraints are binding, then retaliation without delay is optimal. The proposition below also shows that this result holds irrespective of whether retaliation is in the same sector or cross sector.

**Proposition 10.** (i) For every \( \beta \) there exists a \( \delta'(\beta) \in (0,1) \), which is decreasing in \( \beta \), such that for any \( \delta \in [\delta'(\beta),1] \), the same-sector delayed-retaliation mechanism generates higher welfare than does the same-sector retaliation-without-delay mechanism. If \( \delta < \delta'(\beta) \), retaliation-without-delay generates greater welfare.

(ii) For every \( \beta \) there exists a \( \delta''(\beta) \in (0,1) \), which is decreasing in \( \beta \), such that for any \( \delta \in [\delta''(\beta),1] \), the cross-sector delayed-retaliation mechanism generates higher welfare than does the same-sector retaliation-without-delay mechanism. If \( \delta < \delta''(\beta) \), retaliation-without-delay generates greater welfare.

From proposition 9 we know that \( \delta'(\beta) < \delta''(\beta) \) because the cross-sector incentive constraints are slack for a narrower range of \( \delta \) and \( \beta \) and from propositions 9 and 6 we know that same-sector retaliation is always preferred to cross-sector retaliation. Hence, we can restate the last result as: there exists a critical value for
the time required for observing and responding to the trading partner’s policies, $\lambda(\beta)$, which is increasing in $\beta$ such that if $\lambda < \lambda(\beta)$, then same-sector delayed retaliation is the joint welfare maximizing mechanism and if $\lambda > \lambda(\beta)$, then the same-sector retaliation-without-delay is optimal.

7 Dynamic Setup: “Off-schedule” Violation

In this section, we consider the possibility that one of the countries will disregard the constraints of the trade agreement and choose a tariff that is not permitted by the previously described mechanisms. This more egregious violation is “off-schedule” and, it is considered to be a breaking of a trade agreement. To deter such an “off-schedule” violation, we consider history-dependent strategies. Following Bagwell-Staiger [3], we use infinite Nash reversion as the punishment for this type of violation. That is, if Home deviates from the trade agreement and chooses any arbitrary tariffs, Foreign will punish home by imposing the Nash tariff in both sectors and they will enter a trade war forevermore.

7.A Nash Tariffs

In the absence of cooperation, Home and Foreign choose the import tariff schedules, $(\tau_{as}, \tau_b)$ and $(\tau_{as}^*, \tau_b^*)$, to maximize their own payoffs, respectively. The Nash tariff scheme, $(\tau_{as}^N, \tau_b^N, \tau_{as}^*N, \tau_b^*N)$, which is described in 1(ii), is given by

$$
\tau_{as}^N = \arg\max_{\tau_{as}} \vartheta_a(\tau_{as}, \tau_{as}^*, \theta_s); \quad \tau_{as}^*N = \arg\max_{\tau_{as}} \vartheta_a^*(\tau_{as}, \tau_{as}^*); \\
\tau_b^N = \arg\max_{\tau_b} \vartheta_b(\tau_b, \tau_b^*); \quad \tau_b^*N = \arg\max_{\tau_b} \vartheta_b^*(\tau_b, \tau_b^*).
$$

Given that all off-schedule deviations generate the same punishment, the optimal deviations are given by

$$
\tau_{as}^{Sd} = \arg\max_{\tau_a} \vartheta_a(\tau_a, \tau_{aL}^*, \theta) \quad \text{for a same-sector mechanism and} \quad \tau_{as}^{Cd} = \arg\max_{\tau_a} \vartheta_a(\tau_a, \tau_{aL}^*, \theta) \quad \text{for cross-sector.}
$$

Note that although $\theta$ is home private information, Foreign still has an expectation over the true state and this expectation depends on the tariff that Home imposes in their initial deviation and the value of the Markov transition probability. That is, during Nash-reversion, for sector $a$, Home will levy a Nash-tariff based on the current state and Foreign will levy a Bayes-Nash tariff $\tau_{as}^{BN}(\theta_{ds})$ that depends on the inferred state in the deviation period. The sector $b$ Nash tariffs do not depend on the state.
7.B Bellman Equations

If Home sticks to the trade agreement, the future values under a same-sector retaliation mechanism can be captured by the following two Bellman equations:

\[
V^S(\theta_L) = \vartheta_a(\tau^S_a, \tau^S_a, \theta_L) + \vartheta_b(\tau^S_b, \tau^S_b) + \delta[\beta V^S(\theta_L) + (1 - \beta)V^S(\theta_H)]
\]

(28)

and

\[
V^S(\theta_H) = \vartheta_a(\tau^S_a, \tau^S_a, \theta_H) + \vartheta_b(\tau^S_b, \tau^S_b) + \delta[\beta V^S(\theta_H) + (1 - \beta)V^S(\theta_L)],
\]

(29)

where \(V^S(\theta)\) represents the Bellman equation for Home under a same-sector retaliation mechanism with the three control variables, \(\tau^S_a, \tau^S_a\) and \(\tau^S_b\), and the state variable, \(\theta\). Eq.(28) is the Bellman equation when the state is low and eq.(29) is that when the state is high.

Note that by simplifying the above two equations and combing them together, we can rewrite the Bellman equations as follows:

\[
V^S(\theta_L) = \gamma_2 \vartheta_a(\tau^S_a, \tau^S_a, \theta_L) + \gamma_3 \vartheta_a(\tau^S_a, \tau^S_a, \theta_H) + (1 - \delta)\vartheta_b(\tau^S_b, \tau^S_b);
\]

\[
V^S(\theta_H) = \gamma_3 \vartheta_a(\tau^S_a, \tau^S_a, \theta_L) + \gamma_2 \vartheta_a(\tau^S_a, \tau^S_a, \theta_H) + (1 - \delta)\vartheta_b(\tau^S_b, \tau^S_b);
\]

(30)

where \(\gamma_2 \equiv \frac{1 - \delta}{(1 - \delta)(1 + \delta - 2\beta)}\) and \(\gamma_3 \equiv \frac{\delta(1 - \beta)}{(1 - \delta)(1 + \delta - 2\beta)}\).

Similarly, under a cross-sector retaliation mechanism, the future values of adhering to the trade agreement when the state is low and high are

\[
V^C(\theta_L) = \vartheta_a(\tau^C_a, \tau^C_a, \theta_L) + \vartheta_b(\tau^C_b, \tau^C_b) + \delta[\beta V^C(\theta_L) + (1 - \beta)V^C(\theta_H)]
\]

and

\[
V^C(\theta_H) = \vartheta_a(\tau^C_a, \tau^C_a, \theta_H) + \vartheta_b(\tau^C_b, \tau^C_a) + \delta[\beta V^C(\theta_H) + (1 - \beta)V^C(\theta_L)],
\]
respectively.\(^{18}\) Solving the above two equations simultaneously, we have:

\[
V^C(\theta_L) = \gamma_2 \theta_a (\tau_{aL}^S, \tau_{aL}^C, \theta_L) + \gamma_3 \theta_a (\tau_{aH}^C, \tau_{aL}^E, \theta_H) + \gamma_2 \theta_b (\tau_{b}^C, \tau_{aH}^C) + \gamma_3 \theta_b (\tau_{b}^E, \tau_{aH}^C);
\]

\[
V^C(\theta_H) = \gamma_3 \theta_a (\tau_{aL}^S, \tau_{aL}^C, \theta_L) + \gamma_2 \theta_a (\tau_{aH}^C, \tau_{aL}^E, \theta_H) + \gamma_3 \theta_b (\tau_{b}^C, \tau_{aH}^C) + \gamma_2 \theta_b (\tau_{b}^E, \tau_{aH}^C).
\]

The future values for home’s “off-schedule” violation under the two mechanisms are the same (they both generate Nash reversion in sector \(b\)) and can be represented by the following two Bellman equations:

\[
V^N(\theta_L, \theta_{ds}) = \theta_a (\tau_{aL}^N, \tau_{aL}^{*BN}(\theta_{ds}), \theta_L) + \theta_b (\tau_{b}^N, \tau_{b}^{*N}) + \delta [\beta V^N(\theta_L, \theta_{ds}) + (1 - \beta) V^N(\theta_H, \theta_{ds})];
\]

\[
V^N(\theta_H, \theta_{ds}) = \theta_a (\tau_{aH}^N, \tau_{aL}^{*BN}(\theta_{ds}), \theta_H) + \theta_b (\tau_{b}^N, \tau_{b}^{*N}) + \delta [\beta V^N(\theta_H, \theta_{ds}) + (1 - \beta) V^N(\theta_L, \theta_{ds})],
\]

Solving the two equations yields:

\[
V^N(\theta_L, \theta_{ds}) = \gamma_2 \theta_a (\tau_{aL}^N, \tau_{aL}^{*BN}(\theta_{ds}), \theta_L) + \gamma_3 \theta_a (\tau_{aH}^N, \tau_{aL}^{*BN}(\theta_{ds}), \theta_H) + (1 - \delta) \theta_b (\tau_{b}^N, \tau_{b}^{*N});
\]

\[
V^N(\theta_H, \theta_{ds}) = \gamma_3 \theta_a (\tau_{aH}^N, \tau_{aL}^{*BN}(\theta_{ds}), \theta_L) + \gamma_2 \theta_a (\tau_{aH}^N, \tau_{aL}^{*BN}(\theta_{ds}), \theta_H) + (1 - \delta) \theta_b (\tau_{b}^N, \tau_{b}^{*N}).
\]

### 7.C “Off-schedule” Violation

We can now write the incentive rational (voluntary participation) constraints and compare the self-enforcing levels of cooperation under a same-sector and cross-sector retaliation mechanism.

The incentive-rational constraints under a same-sector retaliation mechanism are:

\[
\begin{align*}
&\partial_a (\tau_{aL}^S, \tau_{aL}^C, \theta_L) + \partial_b (\tau_{b}^S, \tau_{b}^C) + \delta [\beta V^S(\theta_L) + (1 - \beta) V^S(\theta_H)] \geq \\quad (33) \\
&\partial_a (\tau_{aL}^{Sd}, \tau_{aL}^E, \theta_L) + \partial_b (\tau_{b}^{Sd}, \tau_{b}^E) + \delta [\beta V^N(\theta_L, \theta_{ds}) + (1 - \beta) V^N(\theta_H, \theta_{ds})]
\end{align*}
\]

and

\[
\begin{align*}
&\partial_a (\tau_{aH}^S, \tau_{aH}^C, \theta_H) + \partial_b (\tau_{b}^S, \tau_{b}^C) + \delta [\beta V^S(\theta_H) + (1 - \beta) V^S(\theta_L)] \geq \\quad (34) \\
&\partial_a (\tau_{aH}^{Sd}, \tau_{aL}^E, \theta_H) + \partial_b (\tau_{b}^{Sd}, \tau_{b}^E) + \delta [\beta V^N(\theta_H, \theta_{ds}) + (1 - \beta) V^N(\theta_L, \theta_{ds})].
\end{align*}
\]

Eq.(33) describes the voluntary-participation condition when the state is low. The left hand side is the benefit of sticking to the trade-agreement. It is the sum of the one period current payoff and the discounted expected future value. The right hand side is the payoff if Home deviates. It is the current benefit if Home

\(^{18}\)Remember that \(\Omega^C(\theta)\) represents the discounted joint political welfare in a dynamic setup under a cross-sector retaliation with delay mechanism. Therefore, we have \(\Omega^C(\theta) = V^C(\theta) + V^C^*\), where \(V^C^*\) denotes the corresponding discounted political welfare of foreign.
chooses any arbitrary tariff and is then punished by the Nash tariff in the next period plus the payoff stream of a Bayesian-Nash reversion strategies. Eq.(34) is the incentive-rational constraint in a high state and it has a similar interpretation. Substituting Eqs.(30) and (32) into the above two equations yields:

$$
\gamma_4 \vartheta_a(\tau_a^S, \tau_a^S, \theta_L) + \gamma_6 \vartheta_a(\tau_a^S, \tau_a^S, \theta_H) + \delta(1 - \delta) \vartheta_b(\tau_b^E, \tau_b^S) \\
\geq \vartheta_a(\tau_a^S, \tau_a^S, \theta_L) + \gamma_4 \vartheta_a(\tau_a^E, \tau_a^E, \theta_L) + \gamma_5 \vartheta_a(\tau_a^N, \tau_a^N, \theta_L) + \gamma_6 \vartheta_a(\tau_a^E, \tau_a^E, \theta_L) + \delta(1 - \delta) \vartheta_b(\tau_b^N, \tau_b^E) \\
$$

and

$$
\gamma_6 \vartheta_a(\tau_a^S, \tau_a^S, \theta_L) + \gamma_4 \vartheta_a(\tau_a^S, \tau_a^S, \theta_H) + \delta(1 - \delta) \vartheta_b(\tau_b^E, \tau_b^S) \\
\geq \vartheta_a(\tau_a^S, \tau_a^S, \theta_L) + \gamma_4 \vartheta_a(\tau_a^E, \tau_a^E, \theta_L) + \gamma_5 \vartheta_a(\tau_a^N, \tau_a^N, \theta_L) + \gamma_6 \vartheta_a(\tau_a^E, \tau_a^E, \theta_L) + \delta(1 - \delta) \vartheta_b(\tau_b^N, \tau_b^E),
$$

where

$$
\gamma_4 \equiv 1 + \beta \gamma_2 + \delta(1 - \beta) \gamma_3; \quad \gamma_5 \equiv \beta \gamma_2 + \delta(1 - \beta) \gamma_3; \quad \gamma_6 \equiv \beta \gamma_3 + \delta(1 - \beta) \gamma_2.
$$

The voluntary-participation conditions under a cross-sector retaliation mechanism are:

$$
\vartheta_a(\tau_a^C, \tau_a^C, \theta_L) + \vartheta_b(\tau_b^C, \tau_b^C) + \delta[\beta V^C(\theta_L) + (1 - \beta) V^C(\theta_H)] \\
\geq \vartheta_a(\tau_a^C, \tau_a^C, \theta_L) + \vartheta_b(\tau_b^C, \tau_b^C) + \delta[\beta V^C(\theta_L) + (1 - \beta) V^C(\theta_H)] \\
\geq \vartheta_a(\tau_a^C, \tau_a^C, \theta_L) + \vartheta_b(\tau_b^C, \tau_b^C) + \delta[\beta V^C(\theta_L) + (1 - \beta) V^C(\theta_H)]
$$

(35)

and

$$
\vartheta_a(\tau_a^E, \tau_a^E, \theta_H) + \vartheta_b(\tau_b^E, \tau_b^E) + \delta[\beta V^E(\theta_H) + (1 - \beta) V^E(\theta_L)] \\
\geq \vartheta_a(\tau_a^E, \tau_a^E, \theta_L) + \vartheta_b(\tau_b^E, \tau_b^E) + \delta[\beta V^E(\theta_H) + (1 - \beta) V^E(\theta_L)]
$$

(36)

We can interpret the above two equations by following a similar argument as in explaining Eq.(33). Substituting Eqs.(31) and (32) into them yields:

$$
\gamma_4 \vartheta_a(\tau_a^C, \tau_a^C, \theta_L) + \gamma_6 \vartheta_a(\tau_a^C, \tau_a^C, \theta_H) + \gamma_5 \vartheta_b(\tau_b^E, \tau_b^C) + \gamma_6 \vartheta_b(\tau_b^E, \tau_b^C) \\
\geq \vartheta_a(\tau_a^E, \tau_a^E, \theta_L) + \gamma_5 \vartheta_a(\tau_a^N, \tau_a^N, \theta_L) + \gamma_6 \vartheta_a(\tau_a^E, \tau_a^E, \theta_L) + \delta(1 - \delta) \vartheta_b(\tau_b^N, \tau_b^E) \\
$$

and

$$
\gamma_6 \vartheta_a(\tau_a^C, \tau_a^C, \theta_L) + \gamma_4 \vartheta_a(\tau_a^C, \tau_a^C, \theta_H) + \gamma_7 \vartheta_b(\tau_b^E, \tau_b^E) + \gamma_4 \vartheta_b(\tau_b^E, \tau_b^C) \\
\geq \vartheta_a(\tau_a^E, \tau_a^E, \theta_H) + \gamma_5 \vartheta_a(\tau_a^N, \tau_a^N, \theta_L) + \gamma_6 \vartheta_a(\tau_a^E, \tau_a^E, \theta_L) + \delta(1 - \delta) \vartheta_b(\tau_b^N, \tau_b^E),
$$
where $\gamma_7 \equiv \gamma_6 - 1$.

When comparing the incentive-rational constraints for each mechanism the first thing to notice is that the deviation and future Nash reversion payoff are the same in either mechanism. On the other hand, the cooperative payoffs are larger in the same-sector mechanism. Hence, the same-sector voluntary-participation constraint is slack for wider range of discount factors than is the cross-sector one. Furthermore, and for the same reasoning, even if the constraints are binding for both mechanism so that a higher tariff than that prescribed by the mechanism is required to satisfy the incentive-rational constraints, then a less-distortionary tariff would be required by same-sector mechanism. We establish these points formally in the following proposition, which along with propositions 2 and 4 allow us to demonstrate that a same-sector mechanism generates more cooperation and greater welfare than does a cross-sector retaliation mechanism.

**Proposition 11.** (i) For any value of the discount factor the joint-welfare-maximizing incentive-compatible and incentive-rational negotiated import tariffs under a same-sector non-delayed-retaliation mechanism generate higher expected welfare than do the joint-welfare-maximizing incentive-compatible and incentive-rational negotiated import tariffs under a cross-sector non-delayed-retaliation mechanism.

(ii) For any value of the discount factor the joint-welfare-maximizing incentive-compatible and incentive-rational negotiated import tariffs under a same-sector delayed-retaliation mechanism generate higher expected welfare than do the joint-welfare-maximizing incentive-compatible and incentive-rational negotiated import tariffs under a cross-sector delayed-retaliation mechanism.

8 Conclusion

In this paper, we aim to provide a compelling explanation as to why the WTO prefers same-sector retaliation. In particular, we take a dynamic mechanism design approach and compare two different mechanisms in a two-country two-sector tariff setting political economy model with incomplete information. In a same-sector retaliation mechanism, a violation of the international trade agreement will be punished by an equivalent retaliation in the sector where the initial deviation takes place. In a cross-sector retaliation mechanism, when a violation happens, the retaliatory actions will be taken in another sector.

We show that the best negotiated import tariffs under a same-sector retaliation mechanism generate higher welfare and support a higher self-enforcing level of cooperation than under a cross-sector retaliation mechanism, irrespective of whether there is a time lag between the initial violation and the corresponding retaliatory action. In addition whether the retaliation is same-sector or cross-sector, delayed retaliation
generates greater joint political welfare as long as the incentive compatibility conditions are slack and they are more likely to be slack under same-sector retaliation.

9 Appendix A

Lemma 1. Suppose that the social welfare functions are defined by equation (5) with the demand functions given in equation (3), the supply functions given in equation (4) and the political pressure given in equation (5). Then

(i) the social welfare in each sector is concave and monotonically increasing in domestic tariff while it is convex and monotonically decreasing in foreign tariff.

(ii) the optimal import tariffs within the sectors are strategic substitutes.

Proof. (i) Since now our analysis is confined to a one-period game, we will drop the subscript letter \( t \). Given that trade is balance in equilibrium, i.e.,

\[
q^*_{y_a} - q^{d}_{y_a} = q^*_{y_a} - q^*_{s_a}; \quad q^*_{x_a} - q^{d}_{x_a} = q^*_{x_a} - q^*_{s_a},
\]

and the import tariff creates a wedge between domestic and foreign prices, i.e.,

\[
p^*_x = p_x + \tau^*_a; \quad p_y = p^*_y + \tau_a,
\]

and the import tariff creates a wedge between domestic and foreign prices, i.e.,

\[
p^*_y = p_y + \tau^*_a + \frac{2A + f}{4 - 2D};
\]

and

\[
q^*_{y_a} = \frac{1}{2} \tau_a + \frac{2A - 3f + 2Df}{4 - 2D}.
\]
Note that the per period indirect utility function of home in sector \( a \) is defined as follows:

\[
\vartheta_a(\tau_a, \tau^*_a, \theta) = u[q^d_a(p_{xa}, p_{ya}), q^e_a(p_{ya}, p_{xa})] - p_{xa}(\tau^*_a)q^d_{xa}(p_{xa}, p_{ya}) - p_{ya}(\tau_a)q^d_{ya}(p_{ya}, p_{xa}) + p_{xa}(\tau^*_a)q^e_{xa}(p_{xa}) - c_{xa}(q^e_{xa}(p_{xa})) + \theta[p_{ya}(\tau_a)q^e_{ya}(p_{ya}) - c_{ya}(q^e_{ya}(p_{ya}))]
\]

Taking the partial derivative of \( \vartheta_a \) with respect to \( \tau_a \), using the first order conditions from the producer and consumer maximization problem and the Envelope Theorem and plugging Eq.(4) into it, together with Eq.(37) which implies that \( \frac{\partial \vartheta_a}{\partial \tau_a} = \frac{1}{2} \), derives

\[
\frac{\partial \vartheta_a(\tau_a, \tau^*_a, \theta)}{\partial \tau_a} = \left( \frac{1}{2} \theta - 1 \right)(p_{ya} - f) + \frac{1}{2} q^d_{ya}(p_{ya}, p_{xa}) - \tau_a.
\] (39)

By following similar arguments, we can verify that:

\[
\frac{\partial \vartheta_a(\tau_a, \tau^*_a, \theta)}{\partial \tau^*_a} = \frac{1}{2} M^*_a - \frac{1}{2} D_{\tau_a}, \quad \frac{\partial \vartheta^*_a(\tau^*_a, \tau^*_i)}{\partial \tau^*_i} = \frac{1}{2} M^*_i - \tau^*_i;
\]

\[
\frac{\partial \vartheta^*_i(\tau^*_i, \tau^*_i)}{\partial \tau^*_i} = \frac{1}{2} M^*_i - \frac{1}{2} D_{\tau^*_i}, \quad \frac{\partial \vartheta_b(\tau_b, \tau^*_b)}{\partial \tau^*_b} = \frac{1}{2} M^*_b - \frac{1}{2} D_{\tau^*_b}, \quad \frac{\partial \vartheta_b(\tau_b, \tau^*_b)}{\partial \tau^*_b} = \frac{1}{2} M^*_b - \frac{1}{2} D_{\tau^*_b}.
\] (40)

where \( M^*_a \equiv q^d_{ya}(p_{ya}, p_{xa}) - q^e_{ya}(p_{ya}) \) and \( M^*_i \equiv q^e_{xa}(p_{xa}, p_{ya}) - q^e_{xa}(p_{xa}) \).

Therefore, we have \( \vartheta_{i1} > 0, \vartheta_{i11} < 0, \vartheta_{i2} < 0 \) and \( \vartheta_{i22} > 0 \). This completes the proof of part (i).

(ii) From Eqs.(39) and (40), it can be verified that

\[
\frac{\partial^2 \vartheta_i(\tau_i, \tau^*_i)}{\partial \tau^*_i \partial \tau_i} = -\frac{1}{4} D < 0.
\]

Therefore, the import tariffs within the sectors are strategic substitutes, completing the proof of part (ii). \( \square \)

**Proposition 1.** The welfare maximizing tariffs under perfect information are

\[
\tau^E_{aL} = \tau^*_a = \tau^E_b = \tau^*_b = 0;
\]

\[
\tau^E_{aH} = -\frac{D}{2} \frac{(\theta_H - 1)(2Df - 3f + 2A)}{(D - 2)(D^2 + \theta_H - 5)} < 0 < \tau^E_{aH} = \frac{(\theta_H - 1)(2Df + 2A - 3f)}{(D - 2)(D^2 + \theta_H - 5)}.
\]
Proof. Since \((\tau_{as}, \tau^*_{as})\) and \((\tau^E_{b}, \tau^*_{bE})\) are the solutions to the maximization problems (7) and (8), respectively, they can be written as:

\[
\tau_{as}^E = \arg\max_{\tau_{as}} \vartheta_a(\tau_{as}, \tau^*_{as}, \theta_s) + \vartheta^*_a(\tau_{as}, \tau^*_{as}, \theta_s); \quad \tau^*_{as} = \arg\max_{\tau_{as}} \vartheta_a(\tau_{as}, \tau^*_{as}, \theta_s) + \vartheta^*_a(\tau_{as}, \tau^*_{as});
\]

\[
\tau_{b}^E = \arg\max_{\tau_{b}} \vartheta_b(\tau_{b}, \tau^*_{b}) + \vartheta^*_b(\tau_{b}, \tau^*_{b}); \quad \tau^*_{b} = \arg\max_{\tau_{b}} \vartheta_b(\tau_{b}, \tau^*_{b}) + \vartheta^*_b(\tau_{b}, \tau^*_{b}).
\]

From the proof of Lemma 1, we have

\[
\frac{\partial \vartheta_a(\tau_{as}, \tau^*_{as}, \theta)}{\partial \tau_{as}} + \frac{\partial \vartheta^*_a(\tau_{as}, \tau^*_{as})}{\partial \tau_{as}} = \frac{1}{2}(\theta - 1)(p_{ya} - f) - \tau_{as} - \frac{1}{2}D\tau^*_a;
\]

\[
\frac{\partial \vartheta_a(\tau_{as}, \tau^*_{as}, \theta)}{\partial \tau^*_{as}} + \frac{\partial \vartheta^*_a(\tau_{as}, \tau^*_{as})}{\partial \tau^*_{as}} = \frac{1}{2}D\tau_{as} - \tau^*_a;
\]

\[
\frac{\partial \vartheta_b(\tau_{b}, \tau^*_{b})}{\partial \tau^*_{b}} + \frac{\partial \vartheta^*_b(\tau_{b}, \tau^*_{b})}{\partial \tau^*_{b}} = -\tau^*_b - \frac{1}{2}D\tau_{b}.
\]

Solving these equations derives the solutions to problem (??):

\[
\tau_{aL}^E = \tau_{aL}^* = \tau_{b}^E = \tau^*_{b} = 0; \quad \tau_{aH}^E = \frac{2}{4 - 2D^2}(\theta_H - 1)(p_{ya} - f); \quad \tau_{aH}^* = \frac{D}{D^2 - 4}(\theta_H - 1)(p_{ya} - f). \quad (41)
\]

From the proof of lemma 1, we know that

\[
p_{ya} = \frac{1}{2}\tau^E_{aH} + \frac{2A + f}{4 - 2D} = \frac{1}{2}\tau_{aH}^E + \frac{2A + f}{4 - 2D}.
\]

Substituting it into Eq.(41), we have

\[
\tau_{aH}^* = \frac{D}{2}(\theta_H - 1)(2Df - 3f + 2A) \quad ; \quad \tau_{aH}^E = \frac{(\theta_H - 1)(2Df + 2A - 3f)}{(D - 2)(D^2 + \theta_H - 5)}.
\]

Note that

\[
p_{ya} - f = q_{ya}^s > 0,
\]

for all \(\tau, \tau^* \in [0, +\infty)\). Therefore, together with \(b \in (0,1)\), it is obvious that \(\tau_{aH}^E > 0 > \tau_{aH}^*\). \(\Box\)

**Proposition 2.** Under a same-sector retaliation mechanism,
(i) the best negotiated import tariffs are as follows:
\[
\tau^S_{aL} = \tau^S_{aL} = 0 < \tau^S_{aH} = \frac{(\theta_H - 1)(2Df - 3f + 2A)}{(D - 2)(-4D + \theta_H - 9)}.
\]

(ii) the best negotiated import tariff in a high state is smaller than the politically efficient tariff, i.e. \(\tau^S_{aH} < \tau^E_{aH}\).

Proof. (i) The solutions to the unconstrained maximization problem (9) must satisfy the following equations:
\[
\vartheta_{a1}(\tau^S_{aL}, \tau^*_{aL}, \theta_L) + \vartheta^*_{a1}(\tau^S_{aL}, \tau^*_{aL}) = 0;
\]
\[
\vartheta_{a1}(\tau^S_{aH}, \tau^*_{aH}, \theta_H) + \vartheta^*_{a1}(\tau^S_{aH}, \tau^*_{aH}) + \vartheta_{a2}(\tau^S_{aH}, \tau^*_{aH}, \theta_H) + \vartheta^*_{a2}(\tau^S_{aH}, \tau^*_{aH}) = 0;
\]
\[
\vartheta_{a2}(\tau^S_{aL}, \tau^*_{aL}, \theta_L) + \vartheta^*_{a2}(\tau^S_{aL}, \tau^*_{aL}) = 0.
\]
Together with Eqs.(39) and (40), we have
\[
-\tau^S_{aL} - \frac{1}{2}D\tau^*_{aL} = 0;
\]
\[
\frac{1}{2}(\theta_H - 1)\frac{p_{ya} - f}{2} - \tau^S_{aH} - \frac{1}{2}D\tau^S_{aH} - \frac{1}{2}M^* - \frac{1}{2}D\tau^S_{aH} + \frac{1}{2}M^* - \tau^S_{aH} = 0;
\]
\[
-\frac{1}{2}D\tau^S_{aL} - \tau^*_{aL} = 0.
\]
Solving the above equations yields the solution to problem (9):
\[
\tau^S_{aL} = \tau^*_{aL} = 0;
\]
\[
\tau^S_{aH} = \frac{1}{4 + 2D}(\theta_H - 1)(p_{ya} - f).
\] (42)

From the proof of Lemma 1, we have
\[
p_{ya} = \frac{1}{2} \tau + \frac{2A + f}{4 - 2D}.
\]
Substitute $\tau_a = \tau^S_{aH}$ into it:
\[ p_y = \frac{1}{2} \tau^S_{aH} + \frac{2A + f}{4 - 2D}. \]

Together with Eq.(42), we have
\[ \tau^S_{aH} = \frac{(\theta_H - 1)(2Df - 3f + 2A)}{(D - 2)(-4D + \theta_H - 9)}. \]

Next to show that $\tau^S_{aH} > 0$, remember that $2A > 3f$, $1 < \theta_H < 5 - D^2 < 9 + 4D$, and that $D \in (0, 1)$.

(ii) Propositions 1 says that
\[ \tau^E_{aH} = \frac{(\theta_H - 1)(2Df - 3f + 2A)}{(D - 2)(D^2 + \theta_H - 5)} > 0 \]

and Proposition 2(i) shows that
\[ \tau^S_{aH} = \frac{(\theta_H - 1)(2Df - 3f + 2A)}{(D - 2)(-4D + \theta_H - 9)}. \]

Hence, given that $D - 2 < 0$, $2Df - 3f + 2A > 0$ and $\theta_H > 1$, to prove that $\tau^S_{aH} < \tau^E_{aH}$, we need to show that
\[-4D + \theta_H - 9 < D^2 + \theta_H - 5 < 0,\]
which is true since $\theta_H < 5 - D^2 < 9 + 4D$. \[\square\]

**Proposition 3.** Under a same-sector retaliation mechanism, the incentive compatibility conditions (11) and (12) are slack.

**Proof.** To prove this, we compare the solution to the maximization problem (9), i.e., $\tau^S_{aL}$ and $\tau^S_{aH}$, with the optimal tariff $\hat{\tau}^L_a$ and $\hat{\tau}^H_a$ that maximizes the home political welfare when home and foreign impose equal tariffs, i.e.,
\[ \hat{\tau}^L_a = \arg\max_{\tau_a} \vartheta_a(\tau_a, \tau_L); \quad \hat{\tau}^H_a = \arg\max_{\tau_a} \vartheta_a(\tau_a, \tau_a, \theta_H). \]

We will show that $\tau^S_{aL} = \hat{\tau}^L_a < \tau^S_{aH}$, which implies that condition (11) is slack, and show that $\tau^S_{aL} < \tau^S_{aH} < \hat{\tau}^H_a$, which implies that condition (12) is slack.

From Eqs.(39) and (40), we know that
\[ \frac{1}{2} M_a - \hat{\tau}^L_a - \frac{1}{2} M^*_a - \frac{1}{2} D \tau^L_a = 0; \quad (43) \]
When \( \theta = \theta_L \), home and foreign are symmetric. Hence, \( M_a = M_a^* \). Then by Eq.(43), we know that \( \hat{\tau}_{aL} = 0 \).

From Proposition 2, we have \( \hat{\tau}_{aL} = \hat{\tau}_{aL}^s = 0 \neq \tau_{aH}^s \). This indicates that

\[
\partial_a(\tau_{aL}^s, \tau_{aL}^*, \theta_L) = \partial_a(\tau_{aL}, \tau_{aL}, \theta_L) > \partial_a(\tau_{aH}^s, \tau_{aH}^s, \theta_L) .
\]

Thus, condition (11) is not binding.

To show that condition (12) is slack, recall from the proof of Proposition 2, we know that \( \tau_{aH}^s \) must satisfy:

\[
\frac{1}{2}[\theta_H q_y^s(p_y) - q_d^y(p_y, p_x)] + M_a - \frac{1}{2} M_a^* - \frac{1}{2} D\tau_{aH} = 0 .
\]

Let \( G(\tau) = \frac{1}{2}[\theta_H q_y^s(p_y) - q_d^y(p_y, p_x)] + M_a - \tau - \frac{1}{2} M_a^* - \frac{1}{2} D\tau . \)

Then Eqs.(44) and (45) can be rewritten as \( G(\tau) = 0 \) and

\[
G(\tau) = \frac{1}{2} M_a + \frac{1}{2} D\tau + \frac{1}{2} M_a^* + \tau ,
\]

respectively. Since \( \frac{1}{2} M_a + \frac{1}{2} D\tau + \frac{1}{2} M_a^* + \tau > 0 \) and \( \frac{\partial G(\tau)}{\partial \tau} < 0 \), Eqs.(44) and (45) indicate that \( \tau_{aH} > \tau_{aH}^s \).

Hence, given \( \partial_a(\tau_a, \tau, \theta_H) \) is concave, continuous and increasing from 0 to \( \tau_{aH} \), together with Proposition 2 which says that \( \tau_{aH}^s > \tau_{aL}^s = \tau_{aL}^* \), we must have \( \partial_a(\tau_{aH}^s, \tau_{aH}^s, \theta_H) > \partial_a(\tau_{aL}^s, \tau_{aL}^s, \theta_H) \). Thus, condition (12) is slack.

\[
\frac{1}{2}[\theta_H q_y^s(p_y) - q_d^y(p_y, p_x)] + M_a - \frac{1}{2} M_a^* - \frac{1}{2} D\tau_{aH} = 0 .
\]
than under a same-sector retaliation mechanism while smaller than under the first best perfect information, i.e. \( \tau^S_{aH} < \tau^C_{aH} < \tau^E_{aH} \).

Proof. (i) By going through similar steps as in obtaining Propositions 1 and 2, we substitute Eqs. (39) and (40), the price function

\[
p_{ya} = \frac{1}{2} \tau_a + \frac{2A + f}{4 - 2b} = \frac{1}{2} \tau^C_{aH} + \frac{2A + f}{4 - 2b}.
\]

and \( \tau^*_{aL} = \tau^*_b = 0 \) (from Proposition 1) into the following first order conditions derived from the maximization problems (17)-(19):

\[
\begin{align*}
\vartheta_{a1}(\tau_{aL}, \tau_{aL}, \theta_L) + \vartheta^{*}_{a1}(\tau_{aL}, \tau_{aL}) + \vartheta_{a2}(\tau_{aL}, \tau_{aL}, \theta_L) + \vartheta^{*}_{a2}(\tau_{aL}, \tau_{aL}) &= 0; \\
\vartheta_{b1}(\tau_b, \tau_b) + \vartheta^{*}_{b1}(\tau_b, \tau_b) + \vartheta_{b2}(0, \tau_{aL}) + \vartheta^{*}_{b2}(0, \tau_{aL}) &= 0; \\
\vartheta_{b1}(\tau_b, \tau_{aL}) + \vartheta^{*}_{b1}(\tau_b, \tau_{aL}) + \vartheta_{b2}(\tau_b, \tau_b) + \vartheta^{*}_{b2}(\tau_b, \tau_b) &= 0.
\end{align*}
\]

Then, we could yield the optimal import tariffs under a cross-sector retaliation mechanism as follows:

\[
\begin{align*}
\tau^C_{aL} &= 0; \\
\tau^C_{b} &= 0; \\
\tau^C_{aH} &= \frac{1}{4}(\theta_H - 1)(p_{ya} - f) = \frac{(\theta_H - 1)(2bf + 2A - 3f)}{(b - 2)(\theta_H - 9)}.
\end{align*}
\]

Given that the supply function \( q^*_y = (p_{ya} - f) > 0 \), and \( \theta_H > 1 \), it is obvious that \( \tau^C_{aH} > 0 \).

(ii) From Proposition 1, we have

\[
\tau^E_{aH} = \frac{(\theta_H - 1)(2bf + 2A - 3f)}{(b - 2)(b^2 + \theta_H - 5)},
\]

from Proposition 2, we have

\[
\tau^S_{aH} = \frac{(\theta_H - 1)(2bf - 3f + 2A)}{(b - 2)(-4b + \theta_H - 9)}
\]

and from Proposition 4, we have

\[
\tau^C_{aH} = \frac{(\theta_H - 1)(2bf + 2A - 3f)}{(b - 2)(\theta_H - 9)}.
\]
Since \( b \in (0, 1) \), it implies that

\[-4b + \theta_H - 9 < \theta_H - 9 < b^2 + \theta_H - 9.\]

From the proof of Proposition 2, we know that

\[2bf + 2A - 3f > 0.\]

Together with \( \theta_H > 1 \), it is obvious that

\[\tau_{aH}^S < \tau_{aH}^C < \tau_{aH}^E.\]

\[\square\]

**Proposition 5.** Under a cross-sector retaliation mechanism, the incentive compatibility conditions (15) and (16) are slack.

**Proof.** To show that

\[
\vartheta_a(\tau_{aL}, \tau_{aL}^C, \theta_L) + \vartheta_b(\tau_{bL}^C, \tau_{bL}^C) \geq \vartheta_a(\tau_{aH}^C, \tau_{aH}^C, \theta_L) + \vartheta_b(\tau_{bL}^E, \tau_{aH}^C),
\]

substitute \( \tau_{aL}^C = \tau_{bL}^C = 0 \) (from Proposition 4) and \( \tau_{aL}^* = \tau_{bL}^* = 0 \) (from Proposition 1) and rearrange it:

\[
\vartheta_a(0, 0, \theta_L) - \vartheta_a(\tau_{aH}^C, 0, \theta_L) \geq \vartheta_b(0, \tau_{aH}^C) - \vartheta_b(0, 0).
\]

Condition (15) is equivalent to the above equation. From Proposition 1, we know that

\[(0, 0) = \text{argmax} \{ \vartheta_a(\tau_a, \tau_{aL}^*, \theta_L) + \vartheta_a^*(\tau_a, \tau_{aL}^*) \}
\]

and from Proposition 4, we have \( \tau_{aH}^* > 0 \). Therefore,

\[
\vartheta_a(0, 0, \theta_L) + \vartheta_a^*(0, 0) > \vartheta_a(\tau_{aH}^C, 0, \theta_L) + \vartheta_a^*(\tau_{aH}^C, 0).
\]
Rearranging the above equation yields:

$$\vartheta_a(0,0,\theta_L) - \vartheta_a(\tau_{aH},0,\theta_L) > \vartheta_a^*(\tau_{aH},0) - \vartheta_a^*(0,0).$$  (46)

Given that when $\theta = \theta_L$, home and foreign are symmetric and sectors $a$ and $b$ are identical, it implies that

$$\vartheta_a^*(\tau_{aH},0) - \vartheta_a^*(0,0) = \vartheta_a(0,\tau_{aH},\theta_L) - \vartheta_a(0,0,\theta_L) = \vartheta_b(0,\tau_{aH}) - \vartheta_b(0,0).$$

Combined with Eq.(46), we have

$$\vartheta_a(0,0,\theta_L) - \vartheta_a(\tau_{aH},0,\theta_L) > \vartheta_b(0,\tau_{aH}) - \vartheta_b(0,0),$$

completing the proof that condition (15) is slack.

Now we show that condition (16) is slack. Since $\tau_{aH}^C > \tau_{aH}^S$ (from Proposition 4), $\tau_{aL}^C = \tau_b^C = 0$ (from Proposition 4) and $\tau_{aL}^E = \tau_b^E = 0$ (from Proposition 1), together with Lemma 1(i) which implies that $\vartheta_{a2}(\tau_a,\tau_a^*,\theta_H) < 0$, we have

$$\vartheta_a(\tau_{aH},0,\theta_H) - \vartheta_a(0,0,\theta_H) > \vartheta_a(\tau_{aH},0,\theta_H) - \vartheta_a(0,0,\theta_H)$$

$$> \vartheta_a(\tau_{aH},\tau_{aH},\theta_H) - \vartheta_a(0,0,\theta_H).$$

Recall from Proposition 3, we know that

$$\vartheta_a(\tau_{aH},\tau_{aH},\theta_H) - \vartheta_a(0,0,\theta_H) > 0.$$

Hence,

$$\vartheta_a(\tau_{aH},0,\theta_H) - \vartheta_a(0,0,\theta_H) > 0.$$

Then we have

$$\vartheta_a(\tau_{aH},0,\theta_H) - \vartheta_a(\tau_{aL},0,\theta_H) > 0 > \vartheta_b(0,0) - \vartheta_b(0,\tau_{aH}),$$

because from Lemma 1(i), we have $\vartheta_{b2}(\tau_b,\tau_b^*) < 0$ and from Proposition 4, we have $\tau_{aL}^C = 0 < \tau_{aH}^C$. Therefore, condition (16) is slack. □
Proposition 6. The best incentive-compatible negotiated import tariffs under a same-sector retaliation mechanism generate higher welfare than do the best incentive-compatible negotiated tariffs under a cross-sector retaliation mechanism.

Proof. First, recall from Propositions 3 and 5, the incentive compatibility conditions under these two mechanisms are slack. Therefore, the solutions to the unconstrained maximization problem (9) and (13) are incentive compatible.

To prove that the negotiated tariffs under a same-sector retaliation mechanism generates higher expected political payoff, it is equivalent to show that

\[ \frac{\partial}{\partial \tau_a}(\tau_a^{E}, \tau_a^{E}, \theta_H) + \frac{\partial}{\partial \tau_a}(\tau_a^{S}, \tau_a^{S}) - \frac{\partial}{\partial \tau_a}(\tau_a^{S}, \tau_a^{S}) \]

\[ - \frac{\partial}{\partial \tau_b}(\tau_b^{E}, \tau_b^{E}) + \frac{\partial}{\partial \tau_a}(\tau_a^{E}, \tau_b^{E}) - \frac{\partial}{\partial \tau_a}(\tau_a^{E}, \tau_b^{E}) \]

\[ < \frac{\partial}{\partial \tau_a}(\tau_a^{E}, \tau_a^{E}) + \frac{\partial}{\partial \tau_b}(\tau_b^{E}, \tau_a^{E}) - \frac{\partial}{\partial \tau_a}(\tau_b^{E}, \tau_a^{E}) \]

Substituting \( \tau_a^{E} = \tau_a^{E} = \tau_b^{E} = 0 \) (from Proposition 1) into the above equation and simplifying it, we have

\[ \frac{\partial}{\partial \tau_a}(\tau_a, \tau_a^{*}, \theta) = CS_a(\tau_a, \tau_a^{*}) + PS_a(\tau_a, \tau_a^{*}, \theta) + TR_a(\tau_a, \tau_a^{*}), \quad (48) \]

By the welfare function defined in Eq.(5), we have

\[ \frac{\partial}{\partial \tau_a}(\tau_a, \tau_a^{*}, \theta) = u_a[q_{x_a}(p_{x_a}(\tau_a), p_{y_a}(\tau_a^{*})), q_{y_a}(p_{y_a}(\tau_a^{*}), p_{x_a}(\tau_a))] \]

\[ - p_{x_a}(\tau_a)q_{x_a}(p_{x_a}(\tau_a), p_{y_a}(\tau_a^{*})) - p_{y_a}(\tau_a^{*})q_{y_a}(p_{y_a}(\tau_a^{*}), p_{x_a}(\tau_a)); \]

\[ PS_a(\tau_a, \tau_a^{*}, \theta) = p_{x_a}(\tau_a)q_{x_a}(p_{x_a}(\tau_a)) - c_{x_a}(q_{x_a}(p_{x_a}(\tau_a))) \]

\[ + \theta[p_{y_a}(\tau_a^{*})q_{y_a}(p_{y_a}(\tau_a^{*})) - c_{y_a}(q_{y_a}(p_{y_a}(\tau_a^{*})))]; \]

\[ TR_a(\tau_a, \tau_a^{*}) = \tau_a[q_{y_a}(p_{y_a}(\tau_a^{*}), p_{x_a}(\tau_a)) - q_{y_a}(p_{y_a}(\tau_a))]. \]

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Similarly, we can show that

$$\vartheta_b(\tau_b, \tau_b^*) = CS_b(\tau_b, \tau_b^*) + PS_b(\tau_b, \tau_b^*) + TR_b(\tau_b, \tau_b^*)$$

$$\vartheta_a(\tau_a, \tau_a^*) = CS_a(\tau_a, \tau_a^*) + PS_a(\tau_a, \tau_a^*) + TR_a(\tau_a, \tau_a^*)$$

$$\vartheta_i(\tau_b, \tau_b^*) = CS_b(\tau_b, \tau_b^*) + PS_b(\tau_b, \tau_b^*) + TR_b(\tau_b, \tau_b^*)$$

where $CS_b(\cdot, \cdot)$, $PS_b(\cdot, \cdot)$, $TR_b(\cdot, \cdot)$, $CS_a(\cdot, \cdot)$, $PS_a(\cdot, \cdot)$ and $TR_a(\cdot, \cdot)$ can be expressed in a similar expression of Eq.(48). From the utility function defined in Eq.(1), it is obvious that

$$CS_a(\tau, \tau) = CS_b(\tau, \tau) = CS_a^*(\tau, \tau) = CS(\tau, \tau)$$

and

$$\max \{CS(\tau, \tau)\} = CS(0, 0),$$

for any $\tau \geq 0$. From Proposition 2, we have $\tau_a^S = \frac{(\theta_H - 1)(2f - 3f + 2A)}{(b - 2)(-4b + \theta_H - 9)}$ and from Proposition 4, we have $\tau_a^C = \frac{(\theta_H - 1)(2f + 2A - 3f)}{(b - 2)(\theta_H - 9)}$. Hence, it can be verified that

$$CS(0, 0) - CS(0, \tau_a^C) - CS(\tau_a^C, 0) + CS(\tau_a^S, \tau_a^S)$$

$$= \frac{1}{4} b(2A + (-1 + 2 (b - 1)) f^2 (\theta - 1)^2 (\theta_H - 9)^2 > 0.$$  

Then we substitute Eqs.(48) and (50) into Eq.(47). Since the above inequality is true, to show that Eq.(47) holds, it is equivalent to prove the following inequality:

$$PS_b(0, 0) + TR_b(0, 0) + PS_b^*(0, 0) + TR_b^*(0, 0)$$

$$- PS_b(0, \tau_a^C) - TR_b(0, \tau_a^C) - PS_b^*(0, \tau_a^C) - TR_b^*(0, \tau_a^C)$$

$$- PS_a(\tau_a^C, 0, \theta_H) - TR_a(\tau_a^C, 0) - PS_a^*(\tau_a^C, 0) - TR_a^*(\tau_a^C, 0)$$

$$+ PS_a(\tau_a^S, \tau_a^S, \theta_H) + TR_a(\tau_a^S, \tau_a^S)$$

$$+ PS_a^*(\tau_a^S, \tau_a^S) + TR_a^*(\tau_a^S, \tau_a^S) > 0.$$  

From Proposition 2, we have

$$\tau_a^S = \frac{(\theta_H - 1)(2f - 3f + 2A)}{(b - 2)(-4b + \theta_H - 9)}.$$  

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From Proposition 4, we have
\[ \tau_{aH}^{C} = \frac{(\theta_{H} - 1)(2bf + 2A - 3f)}{(b - 2)(\theta_{H} - 9)}. \]

Substituting the above two equations into Eq.(51), together with \( CS_i \), \( PS_i \) and \( TR_i \) defined in Eq.(49), we obtain
\[
\frac{512 (2bf + 2A - 3f) (\theta_{H} - 1) b}{(4b(-\theta_{H} + 9)(b - 2) + 9 - \theta_{H} (-\theta_{H} + 9)(b - 2))^{8}} \left( f \left( \frac{\theta_{H} - 1}{12} \right) b^{2} + 128 \right) \\
+ \frac{b}{512} \left( 4\theta_{H}^{2} - 22\theta_{H} + 14 \right) A - 2 \left( \theta_{H}^{3} - \frac{25}{2} \theta_{H}^{2} + \frac{87 \theta_{H}}{2} - 24 \right) f \\
- \frac{\theta_{H} - 9}{256} \left( \theta_{H}^{2} - 6\theta_{H} + 1 \right) A - \frac{3}{2} f \left( \theta_{H}^{2} - \frac{20 \theta_{H}}{3} + 7 \right) \right) > 0.
\]

Given that \( A > 0 \), \( b \in (0,1) \), \( \theta_{H} > 1 \), \( f > 0 \) and \( 2bf + 2A - 3f > 0 \) (from the proof of Proposition 2), it implies that
\[
\frac{512 (2bf + 2A - 3f) (\theta_{H} - 1) b}{(4b(-\theta_{H} + 9)(b - 2) + 9 - \theta_{H} (-\theta_{H} + 9)(b - 2))^{8}} > 0.
\]

Then the required condition for this claim can be expressed as:
\[
g(b) = f \left( \frac{\theta_{H} - 1}{12} \right) b^{2} + 128 \\
+ \frac{b}{512} \left( 4\theta_{H}^{2} - 22\theta_{H} + 14 \right) A - 2 \left( \theta_{H}^{3} - \frac{25}{2} \theta_{H}^{2} + \frac{87 \theta_{H}}{2} - 24 \right) f \\
- \frac{\theta_{H} - 9}{256} \left( \theta_{H}^{2} - 6\theta_{H} + 1 \right) A - \frac{3}{2} f \left( \theta_{H}^{2} - \frac{20 \theta_{H}}{3} + 7 \right) > 0. \tag{52}
\]

Recall that \( 1 < \theta_{H} < 5 - b^2 \) (by footnote ??), \( f > 0 \) and \( b \in (0,1) \). Therefore,
\[
\frac{\partial g^2(b)}{\partial^2 b} = f \left( 2\theta^{2} - 13\theta + 11 \right) < 0.
\]

Hence,
\[
\frac{\partial g(b)}{\partial b} = -\frac{\theta^{3} f}{256} + \frac{((8b + 25)f + 4A) \theta^{2}}{512} + \frac{((-52b - 87)f - 22A) \theta}{512} + \frac{(44b + 48)f}{512} - \frac{7A}{256}
\]
is monotonically decreasing in \( b \). Since \( \frac{\partial g(b)}{\partial b} \big|_{b=1} > 0 \), we have \( \frac{\partial g(b)}{\partial b} > 0 \, \text{for all} \, b \in [0,1] \). Therefore, \( g(b) \) is monotonically increasing in \( b \). Then \( g(0) > 0 \) implies that Eq.(52) is satisfied, completing the proof. \( \Box \)

**Proposition 8.**
(i) There exist some parameters \( t' \in [0, +\infty] \) and \( \beta' \in [0, 1] \) such that for any \( \delta \beta \in [\beta', 1] \), the incentive compatibility conditions (21) and (22) are slack, where \( \delta' = he^{-mt'} \) and \( h \) and \( m \) are constants.

(ii) There exist some parameters \( t'' \in [0, +\infty] \) and \( \beta'' \in [0, 1] \) such that for any \( \delta \beta \in [\beta'', 1] \), the incentive compatibility conditions (25) and (26) are slack, where \( \delta'' = he^{-mt''} \) and \( h \) and \( m \) are constants.

Proof. (i) Substituting \( \tau_{aL}^{DS} = 0 \) (from Eq.(23)), \( \tau_{aE}^{*} = 0 \) (from Proposition 1) and \( \tau_{aH} = \tau_{aH}^{DS} \) into Eqs.(21) and (22) yields:

\[
\begin{align*}
\vartheta_a(0, 0, \theta_L) + \delta \beta \vartheta_a(0, 0, \theta_L) + \delta(1 - \beta)\vartheta_a(\tau_{aH}^{DS}, 0, \theta_L) & \geq \vartheta_a(\tau_{aH}^{DS}, 0, \theta_L) + \delta \beta \vartheta_a(\tau_{aH}^{DS}, \tau_{aH}^{DS}, \theta_L) + \delta(1 - \beta)\vartheta_a(\tau_{aH}^{DS}, \tau_{aH}^{DS}, \theta_L) \\
\vartheta_a(\tau_{aH}^{DS}, 0, \theta_L) + \delta \beta \vartheta_a(\tau_{aH}^{*, DS}, \tau_{aH}^{DS}, \theta_L) + \delta(1 - \beta)\vartheta_a(\tau_{aH}^{DS}, \tau_{aH}^{DS}, \theta_L) & \geq (1 + \delta \beta)\vartheta_a(0, 0, \theta_L) + \delta(1 - \beta)\vartheta_a(0, 0, \theta_L).
\end{align*}
\]

Note that

\[
\delta(1 - \beta)\vartheta_a(\tau_{aH}^{DS}, 0, \theta_L) > \delta(1 - \beta)\vartheta_a(\tau_{aH}^{DS}, \tau_{aH}^{DS}, \theta_L).
\]

Therefore, to verify that Eq.(53) holds, it is equivalent to show that

\[
\begin{align*}
\vartheta_a(0, 0, \theta_L) + \delta \beta \vartheta_a(0, 0, \theta_L) & \geq \vartheta_a(\tau_{aH}^{DS}, 0, \theta_L) + \delta \beta \vartheta_a(\tau_{aH}^{DS}, \tau_{aH}^{DS}, \theta_L) \\
\vartheta_a(\tau_{aH}^{DS}, 0, \theta_L) + B\vartheta_a(0, 0, \theta_L) & \geq \vartheta_a(\tau_{aH}^{DS}, 0, \theta_L) + B\vartheta_a(\tau_{aH}^{DS}, \tau_{aH}^{DS}, \theta_L).
\end{align*}
\]

Let \( \delta \beta = B \in [0, 1] \). Then, we have

\[
\begin{align*}
\vartheta_a(0, 0, \theta_L) + B\vartheta_a(0, 0, \theta_L) & \geq \vartheta_a(\tau_{aH}^{DS}, 0, \theta_L) + B\vartheta_a(\tau_{aH}^{DS}, \tau_{aH}^{DS}, \theta_L).
\end{align*}
\]

Let

\[
G(B) = \vartheta_a(0, 0, \theta_L) + B\vartheta_a(0, 0, \theta_L) - \vartheta_a(\tau_{aH}^{DS}, 0, \theta_L) - B\vartheta_a(\tau_{aH}^{DS}, \tau_{aH}^{DS}, \theta_L).
\]

From the previous proof, we know that \( 2bf - 3f + 2A > 0 \). Therefore, given that \( b - 2 < 0 \) and \( \theta_H < 5 - b^2 \), Eq.(23) implies that \( \frac{\partial \tau_{aH}^{DS}}{\partial \Delta \tau} < 0 \). By the welfare function defined in Eq.(1), we have

\[
\vartheta_a(0, 0, \theta_L) - \vartheta_a(\tau_{aH}^{DS} - \Delta \tau, 0, \theta_H) > \vartheta_a(0, 0, \theta_L) - \vartheta_a(\tau_{aH}^{DS} - \Delta \tau, \tau_{aH}^{DS} - \Delta \tau, \theta_H),
\]

47
for any $\Delta \tau \in [0, \tau_{DS}^{aH}]$. Therefore, $\frac{dG}{dH} > 0$. Then $G(0) < 0$ and $G(1) > 0$ indicate that there exists a $\hat{B}$ such that $G(\hat{B}) = 0$. Or, for any given $b \in (0, 1)$ and $\lambda \in (0, 1)$, there exist some parameters $t' \in [0, +\infty]$ and $\beta' \in [0, 1]$ such that if $\delta \beta \in [\delta', \beta']$, conditions (21) is slack, where $\delta' = he^{-mt'}$.

Next we show that condition (22) is slack. Similar to the proof of Proposition 3, it can be verified that $\tau_{aH} = \arg\max_{\tau_a} \vartheta_a(\tau_a, \tau_H) > \tau_{DS}^{aH}$. Then, given that $\vartheta_a(\tau_a, \tau_H)$ is concave, continuous and increasing from 0 to $\tau_{aH}$, we have

$$\vartheta_a(\tau_{DS}^{aH}, \tau_{DS}^{aH}, \theta_H) > \vartheta_a(0, 0, \theta_H).$$

Besides, from the properties of the welfare function, we know that

$$\vartheta_a(\tau_{DS}^{aH}, 0, \theta_H) > \vartheta_a(0, 0, \theta_H).$$

Therefore, notice that

$$\vartheta_a(\tau_{aH}, 0, \theta_H) - \vartheta_a(0, 0, \theta_H) > \delta(1 - \beta)[\vartheta_a(0, 0, \theta_L) - \vartheta_a(\tau_{aH}, \tau_{aH}, \theta_L)].$$

It indicates that condition (21) is slack. We have shown that if $\delta \beta \in [\delta', \beta']$, the two incentive compatibility conditions are slack. This completes the proof of Proposition 8(i).

(ii) Simplify the incentive-compatibility conditions (25) and (26) and substitute $\tau_{aL}^* = \tau_{aL}^{DS} = \tau_b^* = \tau_{aH}^* = 0$ and $\tau_{aH} = \tau_{aH}^{DC}$:

$$\begin{align*}
(1 + \delta \beta)\vartheta_a(0, 0, \theta_L) + \delta(1 - \beta)\vartheta_b(0, 0) \\
\geq (1 + \delta \beta)\vartheta_a(\tau_{aH}^{DC}, 0, \theta_L) + \delta(1 - \beta)\vartheta_b(0, \tau_{aH}^{DC});
\end{align*}$$

$$\begin{align*}
(1 + \delta \beta)\vartheta_a(\tau_{aH}^{DC}, 0, \theta_H) + \delta(1 - \beta)\vartheta_a(\tau_{aH}^{DC}, 0, \theta_L) + \delta\vartheta_b(0, \tau_{aH}^{DC}) \\
\geq (1 + \delta \beta)\vartheta_a(0, 0, \theta_H) + \delta(1 - \beta)\vartheta_a(0, 0, \theta_L) + \delta\vartheta_b(0, 0).
\end{align*}$$

By following similar arguments as in deriving Proposition 8 (i), we can show that Eq.(57) never binds and there exists some parameters $t'' \in [0, 1]$ and $\beta'' \in [0, 1]$ such that Eq.(56) is slack for any $\delta \beta \in [\delta'' \beta'', 1]$, where $\delta'' = he^{-mt''}$. \hfill \Box

**Proposition 9.** The best incentive-compatible negotiated tariffs under a same-sector retaliation with delay mechanism generate higher expected welfare than do the best incentive-compatible negotiated tariffs under a cross-sector retaliation with delay mechanism.
Proof. First, we show that the incentive compatibility conditions under a delayed cross-sector retaliation mechanism are stricter than under a same-sector one. Then we compare the highest joint political welfare generated by the two mechanisms in three possible cases.

Rearrange Eqs. (53) and (56):

\begin{align*}
(1 + \delta \beta) \vartheta_a(0, 0, \theta_L) &\geq \vartheta_a(\tau^{DS}_{aH}, 0, \theta_L) + \delta \beta \vartheta_a(\tau^{DS}_{aH}, \tau^{DS}_{aH}, \theta_L) + \delta (1 - \beta)[\vartheta_a(\tau^{DS}_{aH}, \tau^{DS}_{aH}, \theta_H) - \vartheta_a(\tau^{DS}_{aH}, 0, \theta_H)] \\
&\geq \vartheta_a(\tau^{DC}_{aH}, 0, \theta_L) + \delta \beta \vartheta_a(\tau^{DC}_{aH}, 0, \theta_L) + \delta (1 - \beta)[\vartheta_b(0, \tau^{DC}_{aH}) - \vartheta_b(0, 0)].
\end{align*}

(58)

(59)

Notice that the left hand side of the above two equations are the same. Then to show that Eq. (59) is stricter than Eq. (58), it is equivalent to verify that

\[ \text{the right hand side (r.h.s.) of Eq. (58) < the r.h.s. of Eq. (59)}. \]

From Proposition 7, we know that \( 0 < \tau^{DS}_{aH} < \tau^{DC}_{aH} \). Then from the welfare function defined in 1, it implies that

\[ \vartheta_a(\tau^{DS}_{aH}, 0, \theta_L) < \vartheta_a(\tau^{DC}_{aH}, 0, \theta_L); \]
\[ \delta \vartheta_a(\tau^{DS}_{aH}, \tau^{DS}_{aH}, \theta_L) - \vartheta_a(\tau^{DS}_{aH}, 0, \theta_L) < 0 < \delta \vartheta_b(0, \tau^{DC}_{aH}) - \vartheta_b(0, 0); \]
\[ \delta \beta \vartheta_a(\tau^{DS}_{aH}, \tau^{DS}_{aH}, \theta_L) - \vartheta_a(\tau^{DS}_{aH}, \tau^{DS}_{aH}, \theta_H) < 0; \]
\[ \delta \beta \vartheta_a(\tau^{DS}_{aH}, 0, \theta_L) - \vartheta_a(\tau^{DC}_{aH}, 0, \theta_L) < 0; \]
\[ \delta \beta \vartheta_b(0, \tau^{DC}_{aH}) - \vartheta_b(0, 0) < 0. \]

Therefore,

\[ \text{the right hand side (r.h.s.) of Eq. (58) < the r.h.s. of Eq. (59)}, \]

and Eq. (59) is stricter than Eq. (58). From the previous proof, we know that Eqs. (54) and (57) are slack. Hence, cross-sector retaliation with delay binds for a wider interval of tariffs.

Then we compare the highest expected welfare under same-sector and cross-sector retaliation with delay mechanisms in the following three possible cases:

Case 1: Eqs. (21) and (25) are slack.
The proof was given.

Case 2: Eqs.(21) and (25) are binding.

Let \((\tau_{aL}^{DSB}, \tau_{aH}^{DSB})\) and \((\tau_{aL}^{DCB}, \tau_{aH}^{DCB})\) denote the solutions to maximization problems (20) and (24) when the incentive compatibility conditions (21) and (25) are binding, respectively. Note that even if the two conditions are binding, rather than imposing any arbitrary tariff, it would still be more efficient if the import tariff in the low state is the optimal one. Therefore, without loss of generality, we assume that home sets the optimal tariff in a low state under the two mechanisms, i.e. \(\tau_{aL}^{DSB} = \tau_{aL}^{DCB} = 0\).

From the previous proof, we know that Eq.(21) is more likely to bind. Hence, given that \(\tau_{aL}^{DSB} = \tau_{aL}^{DCB} = 0\), we must have \(\tau_{aH}^{DSB} > \tau_{aH}^{DCB}\). Besides, since \(\tau_{aL}^{DS} < \tau_{aH}^{E}\), it indicates that \(\tau_{aH}^{DCB} < \tau_{aH}^{DSB} < \tau_{aH}^{DS} < \tau_{aH}^{E}\). Thus, a same-sector retaliation with delay mechanism generates higher welfare when the incentive compatibility conditions under both mechanisms are binding.

Case 3: Eq.(21) is slack and Eq.(25) binds.

From Proposition 7, we know that \(\tau_{aH}^{DCB} < \tau_{aH}^{DS} < \tau_{aH}^{E}\). Thus, a same-sector retaliation with delay mechanism has higher joint political welfare in case 3.

Remember it could never be the case such that Eq.(21) is binding and Eq.(25) is slack. Therefore, we could sum up with the result that a delayed same-sector retaliation mechanism generates higher welfare than a delayed cross-sector retaliation mechanism. 

**Proposition 10.**

(i) In comparison to a same-sector retaliation without delay mechanism, if the incentive compatibility conditions under a same-sector retaliation with delay mechanism are slack, then the best incentive-compatible negotiated import tariffs in a same-sector retaliation with delay mechanism generate higher welfare. On the other hand, if the incentive compatibility condition is binding, then the best incentive-compatible negotiated import tariffs in a same-sector retaliation with delay mechanism generate less welfare.

(ii) In comparison to a cross-sector retaliation without delay mechanism, if the incentive compatibility conditions under a cross-sector retaliation with delay mechanism are slack, then the best incentive-compatible negotiated import tariffs in a cross-sector retaliation with delay mechanism generate higher welfare. On the other hand, if the incentive compatibility condition is binding, then the best incentive-compatible negotiated import tariffs in a cross-sector retaliation with delay mechanism generate less welfare.
compatible negotiated import tariffs in a cross-sector retaliation with delay mechanism generate less welfare.

Proof. (i) From Propositions 1, 2 and 7, together with Eq.(23), we know that

\[ \tau_{aL}^S = \tau_{aL}^{DS} = 0 \]

and

\[ \tau_{aL}^* < 0 < \tau_{aH}^S < \tau_{aH}^{DS} < \tau_{aH}^E. \]

Then it is easy to verify that

\[ (1 + \delta \beta) [\vartheta_a(\tau_{aH}^S, \tau_{aH}^S, \theta_H) + \vartheta_a^*(\tau_{aH}^S, \tau_{aH}^S)] 
< \vartheta_a(\tau_{aH}^{DS}, 0, \theta_H) + \vartheta_a^*(\tau_{aH}^{DS}, 0) + \delta \beta [\vartheta_a(\tau_{aH}^S, \tau_{aH}^S, \theta_H) + \vartheta_a^*(\tau_{aH}^S, \tau_{aH}^S)]; \]

\[ \vartheta_a(\tau_{aH}^S, \tau_{aH}^S, \theta_H) + \vartheta_a^*(\tau_{aH}^S, \tau_{aH}^S) < \vartheta_a(\tau_{aH}^{DC}, 0, \theta_H) + \vartheta_a^*(\tau_{aH}^{DC}, 0); \]

\[ \vartheta_a(\tau_{aL}^S, 0, \theta_L) + \vartheta_a^*(\tau_{aL}^S, 0) < \vartheta_a(\tau_{aL}^{DC}, 0, \theta_L) + \vartheta_a^*(\tau_{aL}^{DC}, 0). \]

Hence,

\[ (1 + \delta) \{ \lambda [\vartheta_a(\tau_{aL}^S, \tau_{aL}^S, \theta_L)] + \vartheta_a^*(\tau_{aL}^S, \tau_{aL}^S) \} + (1 - \lambda) [\vartheta_a(\tau_{aH}^S, \tau_{aH}^S, \theta_H) + \vartheta_a^*(\tau_{aH}^S, \tau_{aH}^S)] \]

\[ < \lambda \{ \vartheta_a(\tau_{aL}^{DS}, 0, \theta_L) + \vartheta_a^*(\tau_{aL}^{DS}, 0, \theta_L) \]

\[ + \delta \beta [\vartheta_a(\tau_{aL}^{DS}, 0, \theta_L) + \vartheta_a^*(\tau_{aL}^{DS}, 0, \theta_L)] \}

\[ + (1 - \lambda) \{ \vartheta_a(\tau_{aH}^{DS}, 0, \theta_L) + \vartheta_a^*(\tau_{aH}^{DS}, 0, \theta_L) \]

\[ + \delta \beta [\vartheta_a(\tau_{aH}^{DS}, \tau_{aH}^{DS}, \theta_H) + \vartheta_a^*(\tau_{aH}^{DS}, \tau_{aH}^{DS}, \theta_L)] \]

\[ + (1 - \beta) [\vartheta_a(\tau_{aL}^{DS}, 0, \theta_L) + \vartheta_a^*(\tau_{aL}^{DS}, 0, \theta_L)] \}. \]

Therefore, when the incentive compatibility conditions are slack, a delayed same-sector retaliation mechanism can generate higher welfare. Then by following similar arguments as in the proof of Proposition 11, we can demonstrate that it supports a higher self-enforcing level of cooperation as well.

Now we consider the case where the incentive compatibility condition binds. By a similar line of argument, it can be verified that a same-sector retaliation without delay mechanism supports a higher self-enforcing
level of cooperation when the constraint binds.

(ii) The proof of Proposition 10(ii) follows by similar steps as in deriving Proposition 10(i). \hfill \Box

Proposition 11.

(i) A same-sector retaliation mechanism supports a higher self-enforcing level of cooperation than a cross-sector retaliation mechanism.

(ii) A same-sector retaliation with delay mechanism supports a higher self-enforcing level of cooperation than a cross-sector retaliation with delay mechanism.

Proof. (i) From Propositions 2 and 4, we have \( \tau_{aL}^S = \tau_{aL}^C = \tau_{b}^S = \tau_{b}^C = 0 \), and from Proposition 1, we have \( \tau_{aL}^{*S} = 0 \). Hence, the voluntary participation conditions under same-sector and cross-sector retaliation mechanisms become:

\[
\begin{align*}
\gamma_4 \vartheta_a(0, 0, \theta_L) &+ \gamma_6 \vartheta_a(\tau_{aL}^S, \tau_{aH}^S, \theta_H) + \delta(1 - \delta) \vartheta_b(0, 0) \\
\geq & \ \vartheta_a(\tau_{aL}^{SD}, 0, \theta_L) + \gamma_5 \vartheta_a(\tau_{aL}^N, \tau_{aL}^{*N}, \theta_L) + \gamma_6 \vartheta_a(\tau_{aH}^N, \tau_{aL}^{*N}, \theta_H) + \delta(1 - \delta) \vartheta_b(\tau_{b}^N, \tau_{b}^{*N});
\end{align*}
\]

(60)

\[
\begin{align*}
\gamma_6 \vartheta_a(0, 0, \theta_L) &+ \gamma_4 \vartheta_a(\tau_{aH}^S, \tau_{aH}^S, \theta_H) + \delta(1 - \delta) \vartheta_b(0, 0) \\
\geq & \ \vartheta_a(\tau_{aH}^{SD}, 0, \theta_H) + \gamma_6 \vartheta_a(\tau_{aL}^N, \tau_{aL}^{*N}, \theta_L) + \gamma_5 \vartheta_a(\tau_{aH}^N, \tau_{aL}^{*N}, \theta_H) + \delta(1 - \delta) \vartheta_b(\tau_{aH}^N, \tau_{aL}^{*N})
\end{align*}
\]

(61)

and

\[
\begin{align*}
\gamma_4 \vartheta_a(0, 0, \theta_L) &+ \gamma_6 \vartheta_a(\tau_{aH}^C, \tau_{aH}^C, \theta_H) + \gamma_5 \vartheta_b(0, 0) + \gamma_6 \vartheta_a(0, \tau_{aH}^C) \\
\geq & \ \vartheta_a(\tau_{aL}^{CD}, 0, \theta_L) + \gamma_3 \vartheta_a(\tau_{aL}^N, \tau_{aL}^{*N}, \theta_L) + \gamma_6 \vartheta_a(\tau_{aH}^N, \tau_{aL}^{*N}, \theta_H) + \delta(1 - \delta) \vartheta_b(\tau_{b}^N, \tau_{b}^{*N});
\end{align*}
\]

(62)

\[
\begin{align*}
\gamma_6 \vartheta_a(0, 0, \theta_L) &+ \gamma_4 \vartheta_a(\tau_{aH}^C, 0, \theta_H) + G \vartheta_b(0, 0) + \gamma_4 \vartheta_b(0, \tau_{aH}^C) \\
\geq & \ \vartheta_a(\tau_{aH}^{CD}, 0, \theta_H) + \gamma_6 \vartheta_a(\tau_{aL}^N, \tau_{aL}^{*N}, \theta_L) + \gamma_5 \vartheta_a(\tau_{aH}^N, \tau_{aH}^{*N}, \theta_H) + \delta(1 - \delta) \vartheta_b(\tau_{b}^N, \tau_{b}^{*N}),
\end{align*}
\]

(63)

respectively.

We next show that in a low state, in comparison to a cross-sector retaliation mechanism, the voluntary participation condition under a same-sector retaliation mechanism is less likely to bind. Note that

\[
\tau_{aL}^{SD} = \tau_{aL}^{CD} = \arg\max_{\tau_a} \vartheta_a(\tau_a, 0, \theta_L)
\]

Therefore, when it is a low state, the costs of deviating from the trade agreements under same-sector and
cross-sector retaliation are identical. Namely,

\[ \text{the right hand side (r.h.s.) of Eq.}(60) = \text{the r.h.s. of Eq.}(62). \]

Moreover, from Proposition 4, we know that \( \tau_{aH}^S < \tau_{aH}^C \). Given the utility function defined in Eq.(5), it implies that

\[
\varphi^*(0, \tau_{aH}, \theta) - \varphi^*(0, 0) = \varphi^*(\tau_{aH}, \theta) - \varphi^*(0, 0) > \varphi^*(\tau_{aH}^S, \theta) - \varphi^*(\tau_{aH}^S, 0).
\]

Combined with Eq.(47), we must have

\[
\varphi(0, \tau_{aH}, \theta) - \varphi(0, 0) < \varphi(S, \tau_{aH}, \theta) - \varphi(\tau_{aH}, 0).
\]

Rearrange it,

\[
\varphi(0, \tau_{aH}, \theta) + \varphi(0, \tau_{aH}^C(\theta_H)) < \varphi(S, \tau_{aH}, \theta) + \varphi(0, \tau_{aH}^C(\theta_H)).
\]

Hence, when home faces a high level of political pressure, it will receive a higher payoff under a same-sector retaliation mechanism than under a cross-sector one. In addition, Proposition 6 shows that \( \tau_{aH}^S(\theta_L) = \tau_{aH}^C(\theta_L) = 0 \). Therefore, the home payoffs are identical under the two mechanisms in a low state. Hence, home’s benefits of sticking to the trade agreement in a same-sector retaliation mechanism is greater than in a cross-sector retaliation mechanism. That is,

\[
X^S(\tau_{aH}^S(\theta_H), 0, \theta_L) > X^C(\tau_{aH}^C(\theta_H), 0, \theta_L)
\]

\[
X^S(\tau_{aH}^S(\theta_H), 0, \theta_H) > X^C(\tau_{aH}^C(\theta_H), 0, \theta_H).
\]

Thus,

\[ \text{the left hand side (l.h.s.) of Eq.}(60) > \text{the l.h.s. of Eq.}(62). \]

Therefore, Eq.(60) is less likely to bind than Eq.(62).

By following a similar line of argument, it can be verified that in comparison to Eq.(61), Eq.(63) is more
likely to bind. Hence, home has less incentive to violate the trade agreement in same-sector retaliation. Or, same-sector retaliation supports a higher self-enforcing level of cooperation than cross-sector retaliation.

(ii) The proof follows by similar steps as in deriving Proposition 11 (i) (See online Appendix).
References


