

# Threats and Concessions in Tariff Settings

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## Abstract

The paper analyzes tariff-settings by two large countries, in an alternating move, infinitely repeated game. We find that there always exists a “non-cooperative” Markov perfect equilibrium in which countries continue to select their individual Nash tariffs. If countries are patient, however, there are also multiple “cooperative” Markov perfect equilibria in which countries mix their actions on their tariff space so that the resulting stochastic path indicates gradual tariff reduction with occasional retreats. In such an equilibrium, a country unilaterally lowers its tariff rate, which may be reciprocated by the other country in the future.

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# 1 Introduction

Why do some countries sometimes liberalize trade unilaterally? Trade theory tells us that trade liberalization benefits the country as long as the country is small. But why even large countries sometimes liberalize trade unilaterally? A notable example is Britain's unilateral trade liberalization in 1840s, including the abolition of the Corn Laws in 1847 (Conybeare, 2002). Did Britain act unilaterally because it believed that unilateral trade liberalization itself should benefit Britain? Or did Britain hope that other countries follow suit? Bhagwati (2002) argues that the latter idea occurred to British prime minister Sir Robert Peel who showed leadership in abolishing the Corn Laws.

Why can a country expect other countries to reciprocate its trade liberalization? Krishna and Mitra (1999) show that unilateral trade liberalization induces reciprocal tariff reduction through endogenous lobby formation in the foreign country's export good industry. Coates and Ludema (2001) also show that unilateral trade liberalization helps the foreign country to ratify a trade agreement by reducing lobbying activities in the foreign import-competing sectors that are against the trade agreement. There is no doubt that lobbying activities play important roles in countries' selection of trade policies. It is not difficult to believe that unilateral trade liberalization changes the environment for lobbies, and thereby induces the lobbies to act for foreign countries' trade liberalization in some occasions. In this paper, however, we provide a simpler explanation as to why countries liberalize trade unilaterally: Countries liberalize trade unilaterally, since by doing so they create a position to threaten to raise trade barriers in the case where other countries do not reciprocate. Our theory does not appeal to political factors in particular.

The idea that the threat of sanction induces players' cooperation is not new, of course. In the framework of repeated tariff setting, Dixit (1987) appeals to a trigger strategy to show that countries can sustain liberalized trade with low tariffs. Although his theory succeeds to explain why reciprocal trade liberalization is sustained, it does not give an answer to the

question why unilateral tariff reduction occurs. His theory is also not very realistic since in reality a country's defection often fails to trigger other countries' punishment of setting high tariffs. In this paper, we model two countries' tariff setting as an alternating move, infinitely repeated game. By the assumption of alternating move, we intend to capture the realistic information structure that when countries choose their trade policies they can observe other countries' current trade policies. Moreover, alternating move games are effectively the same as games of endogenous timing of players' moves with short-run commitment, which suits the analysis of countries' tariff settings. We derive Markov perfect equilibria of the game. We find that there always exists a "non-cooperative" equilibrium in which countries continue to select their individual Nash tariffs. If countries are patient, however, there are also multiple "cooperative" equilibria in which countries mix their actions so that the resulting stochastic path indicates gradual tariff reduction with occasional retreats. In such an equilibrium, a country unilaterally lowers its tariff rate, which may be reciprocated by the other country in the future.

Eaton and Engers (1992) analyze a closely related problem in an alternating move game. In their model, the sender may impose a sanction, which is costly to both sender and target, to urge the target to comply. Whereas in our model, two players are symmetric and sanction is costly only to the punished player. In other words, the one-shot game of our model has a structure of the prisoner's dilemma. Moreover, the credibility problem as to whether or not the sender lifts the sanction after the target's compliance can only be a non-trivial problem when the sender benefits from the sanction. Our prediction on this problem is that the sender becomes more likely to lift the sanction if the target complies.

## 2 The Model

We consider a tariff setting game between two large countries, 1 and 2. Each country consumes three goods: Country 1's export good, Country 2's export good, and a numeraire

good. Consumers' preferences are represented by quasi-linear utility functions that are additively separable for the three goods and are linear with respect to the numeraire good. In such situations, we can proceed with the partial equilibrium analysis for the two non-numeraire goods, in which social welfare of each country is represented by the total surplus derived from the markets of the non-numeraire goods.

Each country imposes a tariff only on the non-numeraire good that the country imports. Let  $t_i$ , for  $i = 1, 2$ , denote Country  $i$ 's tariff rate, and let  $M_i(t_i)$  and  $X_i(t_j)$ , where  $j \neq i$ , denote Country  $i$ 's surplus from import and surplus from export, respectively. Each country's surplus from import is a function of its own tariff rate. The function  $M_i$  is increasing where  $t_i$  is small and decreasing where  $t_i$  is large reflecting the optimal tariff theory. We assume for simplicity that  $M_i$  has a single peak at  $t_i^N > 0$ . On the other hand, each country's surplus from export is a decreasing function of the other country's tariff rate. Then, Country  $i$ 's payoff is written as

$$\tilde{u}_i(t_i, t_j) = M_i(t_i) + X_i(t_j), \quad j \neq i. \quad (1)$$

It is immediate to see that a unique one-shot Nash equilibrium is  $(t_1^N, t_2^N)$ . We restrict Country  $i$ 's tariff space to  $[0, t_i^N]$  since Country  $i$  has no incentive to select a tariff rate outside of this range. Moreover, we normalize the payoff function by subtracting  $\tilde{u}_i(t_i^N, t_j^N)$  from (1). Letting

$$\begin{aligned} x_i(t_j) &\equiv X_i(t_j) - X_i(t_j^N), \\ m_i(t_i) &\equiv M_i(t_i^N) - M_i(t_i), \end{aligned}$$

we write Country  $i$ 's (normalized) payoff function as

$$u_i(t_1, t_2) = x_i(t_j) - m_i(t_i).$$

Notice that both  $x_i$  and  $m_i$  are non-negative decreasing functions that take strictly positive values on  $[0, t_j^N]$  and  $[0, t_i^N]$ , respectively. We assume that  $u_i(0, 0) > u_i(t_1^N, t_2^N)$  for both  $i = 1$  and 2, i.e., mutual tariff elimination is beneficial to both countries.

We examine two countries' tariff setting in the context of an alternating-move, discrete-time model with infinitely many periods. Two countries alternate in setting their individual tariffs; Country 1 moves in odd periods and Country 2 moves in even periods. Since we assume only one country moves in each period, once a country selects a particular tariff rate, it is fixed for two periods. We do not impose which country moves first *a priori*. We derive a Markov perfect equilibrium for each of two games where Country 1 moves first with an arbitrary committed tariff rate of Country 2 and where Country 2 moves first with a committed tariff rate of Country 1. Country  $i$ 's discount factor is given by  $\delta_i$ .

We focus only on the Markov perfect equilibrium. The payoff-relevant histories can be summarized by the state that specifies (i) which country has moved in the last period and (ii) the tariff rate that the country has selected in the last period. The tariff rate that was specified in the last period is obviously relevant information since that tariff rate continues to be valid in the current period.

Mixed strategy of Country  $i$  is defined by a family of cumulative distribution functions over  $[0, t_i^N]$ . Let  $\{F_{t_2}(t_1)\}_{t_2 \in [0, t_2^N]}$  and  $\{G_{t_1}(t_2)\}_{t_1 \in [0, t_1^N]}$  denote mixed strategies of Country 1 and Country 2, respectively. The cumulative distribution function  $F_{t_2}(t_1)$ , for example, specifies the probability distribution of country 1's tariff rate over  $[0, t_1^N]$  when Country 2 has selected  $t_2 \in [0, t_2^N]$  in the last period.

### 3 “Non-cooperative” Equilibrium

In this section, we show that there always exists a “non-cooperative” Markov perfect equilibrium in which each country selects its Nash tariff whenever it moves. In terms of cumulative distribution functions, this equilibrium can be expressed by

$$F_{t_2}(t_1) = \begin{cases} 0 & \text{if } t_1 \in [0, t_1^N) \\ 1 & \text{if } t_1 = t_1^N, \text{ for any } t_2 \in [0, t_2^N], \end{cases}$$

$$G_{t_1}(t_2) = \begin{cases} 0 & \text{if } t_2 \in [0, t_2^N) \\ 1 & \text{if } t_2 = t_2^N, \text{ for any } t_1 \in [0, t_1^N]. \end{cases}$$

According to this strategy, the current choice of tariff does not affect the other country's choice of tariff in the next period and all consequent choices of tariffs by both countries in the future. Thus, it is the country's best interest to select its Nash tariff rate that maximizes its current one-shot payoff for any selected tariff rate of the other country given the separability of the utility function. Therefore, we have shown the following.

**Proposition 1** *There always exists a “non-cooperative” Markov perfect equilibrium in which each country selects its Nash tariff whenever it moves.*

In this equilibrium, each country has no incentive to lower its tariff rate from its Nash tariff given that the other country continues to select its Nash tariff in any occasion. Each country may lower its tariff rate, however, if the country expects that the other country would follow suit. As we show in the next section, such a “cooperative” equilibrium exists indeed if countries are so patient that current sacrifice of the import surplus resulting from a unilateral tariff reduction is well compensated by an increase in the export surplus in the next period that is caused by the other country's induced tariff reduction.

## 4 “Cooperative” Equilibrium

In this section, we show that if  $\delta_i x_i(0) \geq m_i(0)$  for both  $i = 1$  and  $2$ , then there exist multiple mixed-strategy Markov perfect equilibria in which both countries' tariff rates gradually decrease with occasional retreats.

To derive a mixed-strategy Markov perfect equilibrium, we define the average discounted value function when Country  $i$  moves in the current period and the one when the country has moved in the last period. Let  $V_i(t_j)$  denote the average discounted continuation payoff

for Country  $i$  at the beginning of a period where Country  $i$  moves given that Country  $j$  has selected  $t_j$  in the last period. Also let  $W_i(t_i)$  denote the average discounted continuation payoff for Country  $i$  at the beginning of a period where Country  $j$  moves given that Country  $i$  has selected  $t_i$  in the last period.

We focus on completely-mixed strategies such that the supports of the corresponding probability density functions of  $F_{t_2}$  (for any  $t_2$ ) and  $G_{t_1}$  (for any  $t_1$ ) are  $[0, t_1^N]$  and  $[0, t_2^N]$ , respectively. Given  $\{F_{t_2}(t_1)\}_{t_2 \in [0, t_2^N]}$  and  $\{G_{t_1}(t_2)\}_{t_1 \in [0, t_1^N]}$ , Country 1's continuation payoff at the beginning of an odd period is given by

$$V_1(t_2) = \int_0^{t_1^N} [(1 - \delta_1)u_1(t_1, t_2) + \delta_1 W_1(t_1)] dF_{t_2}(t_1). \quad (2)$$

Since Country 1 is indifferent between an arbitrary  $t_1$  and  $t_1^N$ , we have

$$\begin{aligned} (1 - \delta_1)u_1(t_1, t_2) + \delta_1 W_1(t_1) &= (1 - \delta_1)u_1(t_1^N, t_2) + \delta_1 W_1(t_1^N) \\ W_1(t_1) &= W_1(t_1^N) + \frac{1 - \delta_1}{\delta_1} m_1(t_1). \end{aligned} \quad (3)$$

In addition, we use the observation that any choice of  $t_1$  gives the same continuation payoff to Country 1 to rewrite (2) as

$$V_1(t_2) = (1 - \delta_1)u_1(t_1^N, t_2) + \delta_1 W_1(t_1^N) \quad (4)$$

$$= (1 - \delta_1)x_1(t_2) + \delta_1 W_1(t_1^N), \quad (5)$$

where we have used  $m_1(t_1^N) = 0$ . Then we can write  $W_1(t_1^N)$  as the following.

$$\begin{aligned} W_1(t_1^N) &= \int_0^{t_2^N} [(1 - \delta_1)u_1(t_1^N, t_2) + \delta_1 V_1(t_2)] dG_{t_1^N}(t_2) \\ &= \int_0^{t_2^N} \left\{ (1 - \delta_1)x_1(t_2) + \delta_1 [(1 - \delta_1)x_1(t_2) + \delta_1 W_1(t_1^N)] \right\} dG_{t_1^N}(t_2) \\ &= (1 - \delta_1^2) \int_0^{t_2^N} x_1(t_2) dG_{t_1^N}(t_2) + \delta_1^2 W_1(t_1^N) \end{aligned}$$

Thus, we obtain

$$W_1(t_1^N) = \int_0^{t_2^N} x_1(t_2) dG_{t_1^N}(t_2). \quad (6)$$

Then it follows from (3), (5), and (6) that

$$V_1(t_2) = (1 - \delta_1)x_1(t_2) + \delta_1 \int_0^{t_2^N} x_1(t_2)dG_{t_1^N}(t_2), \quad (7)$$

$$W_1(t_1) = \int_0^{t_2^N} x_1(t_2)dG_{t_1^N}(t_2) + \frac{1 - \delta_1}{\delta_1}m_1(t_1). \quad (8)$$

Since  $\int_0^{t_2^N} x_1(t_2)dG_{t_1^N}(t_2)$  is a constant,  $V_1$  and  $W_1$  have similar shapes to  $x_1$  and  $m_1$ , respectively. In particular, both  $V_1$  and  $W_1$  are decreasing functions, which is quite intuitive.

Similarly to (7) and (8), Country 2's value functions are given by

$$V_2(t_1) = (1 - \delta_2)x_2(t_1) + \delta_2 \int_0^{t_1^N} x_2(t_1)dF_{t_2^N}(t_1), \quad (9)$$

$$W_2(t_2) = \int_0^{t_1^N} x_2(t_1)dF_{t_2^N}(t_1) + \frac{1 - \delta_2}{\delta_2}m_2(t_2). \quad (10)$$

Now, let us derive the conditions for  $\{F_{t_2}(t_1)\}_{t_2 \in [0, t_1^N]}$  and  $\{G_{t_1}(t_2)\}_{t_1 \in [0, t_2^N]}$  to be Markov perfect equilibrium. First, we use (7) to rewrite  $W_1(t_1)$  as

$$\begin{aligned} W_1(t_1) &= \int_0^{t_2^N} [(1 - \delta_1)u_1(t_1, t_2) + \delta_1 V_1(t_2)] dG_{t_1}(t_2) \\ &= \int_0^{t_2^N} \left\{ (1 - \delta_1) [x_1(t_2) - m_1(t_1)] + \delta_1 \left[ (1 - \delta_1)x_1(t_2) + \delta_1 \int_0^{t_2^N} x_1(t_2)dG_{t_1^N}(t_2) \right] \right\} dG_{t_1}(t_2) \\ &= (1 - \delta_1^2) \int_0^{t_2^N} x_1(t_2)dG_{t_1}(t_2) - (1 - \delta_1)m_1(t_1) + \delta_1^2 \int_0^{t_2^N} x_1(t_2)dG_{t_1^N}(t_2) \end{aligned}$$

Then it follows from (8) that

$$\int_0^{t_2^N} x_1(t_2)dG_{t_1^N}(t_2) + \frac{1 - \delta_1}{\delta_1}m_1(t_1) = (1 - \delta_1^2) \int_0^{t_2^N} x_1(t_2)dG_{t_1}(t_2) - (1 - \delta_1)m_1(t_1) + \delta_1^2 \int_0^{t_2^N} x_1(t_2)dG_{t_1^N}(t_2),$$

which gives us

$$\int_0^{t_2^N} x_1(t_2)dG_{t_1}(t_2) = \int_0^{t_2^N} x_1(t_2)dG_{t_1^N}(t_2) + \frac{m_1(t_1)}{\delta_1}. \quad (11)$$

Similarly, we have

$$\int_0^{t_1^N} x_2(t_1)dF_{t_2}(t_1) = \int_0^{t_1^N} x_2(t_1)dF_{t_2^N}(t_1) + \frac{m_2(t_2)}{\delta_2}. \quad (12)$$

Condition (11), for example, implies that if Country 1 lowers its tariff, its expected surplus from export in the next period increases by the comparable amount of the loss in



the import surplus in the current period. This observation gives a restriction on the above condition. As  $t_1$  decreases,  $\int_0^{t_2^N} x_1(t_2)dG_{t_1}(t_2)$  increases. However, this expected surplus from export cannot exceed  $x_1(0)$  for  $x_1(0)$  is the highest possible surplus from export. Therefore, we have from (11) that

$$\begin{aligned}\int_0^{t_2^N} x_1(t_2)dG_{t_1^N}(t_2) + \frac{m_1(0)}{\delta_1} &\leq x_1(0) \\ \int_0^{t_2^N} x_1(t_2)dG_{t_1^N}(t_2) &\leq x_1(0) - \frac{m_1(0)}{\delta_1}.\end{aligned}$$

Since the left-hand side of the last inequality is non-negative, however,  $\delta_1 x_1(0) \geq m_1(0)$  must hold. Similarly, we must have  $\delta_2 x_2(0) \geq m_2(0)$  for (12) to be valid for all  $t_2$ .

Now, since  $x_1$  is a decreasing function, condition (11) means that Country 2 will put more probabilities on low tariffs in the next period if Country 1 lowers its tariff. Thus, we have shown that unilateral tariff reduction induces the other country to follow suit if the above restrictions are satisfied. If  $\delta_1$  is large, i.e., Country 1 is patient, however, Country 1's reduction its tariff will not change Country 2's probability mixture significantly, since Country 1 values Country 2's future concession more in such cases. Therefore, patience may reduce the expected speed of trade liberalization if  $F_{t_2^N}$  and  $G_{t_1^N}$  put high probabilities on high tariffs. Of course, low variation of  $\{F_{t_2}(t_1)\}_{t_2 \in [0, t_2^N]}$  and  $\{G_{t_1}(t_2)\}_{t_1 \in [0, t_1^N]}$  does not mean that the expected speed of trade liberalization is slow. If  $F_{t_2^N}$  and  $G_{t_1^N}$  put high probabilities on low tariff, trade liberalization is expected to be quick.

**Proposition 2** *If  $\delta_i x_i(0) \geq m_i(0)$  for both  $i = 1$  and  $2$ , there exists a Markov perfect equilibrium in which unilateral tariff reduction induces the other country to select a low tariff rate with a higher probability. The Markov perfect equilibrium must satisfy*

$$\begin{aligned}\int_0^{t_2^N} x_1(t_2)dG_{t_1}(t_2) &= \int_0^{t_2^N} x_1(t_2)dG_{t_1^N}(t_2) + \frac{m_1(t_1)}{\delta_1}, \\ \int_0^{t_1^N} x_2(t_1)dF_{t_2}(t_1) &= \int_0^{t_1^N} x_2(t_1)dF_{t_2^N}(t_1) + \frac{m_2(t_2)}{\delta_2}.\end{aligned}$$

*In equilibrium, tariff rates gradually decrease with occasional retreats.*

The analysis so far suggests that there are infinitely many Markov perfect equilibria of this game. A pair of strategies is Markov perfect equilibrium if (11) and (12) are satisfied and if  $\delta_i x_i(0) \geq m_i(0)$  for both  $i = 1$  and  $2$ . However, many of them are Pareto dominated by another Markov perfect equilibrium. In the rest of this section, we derive Pareto optimal Markov perfect equilibrium of the game.

It is straightforward from (7)–(10) that increases in  $\int_0^{t_2^N} x_1(t_2) dG_{t_1^N}(t_2)$  and  $\int_0^{t_1^N} x_2(t_1) dF_{t_2^N}(t_1)$  are Pareto improving. As we have seen in the above, however,  $\int_0^{t_2^N} x_1(t_2) dG_{t_1^N}(t_2)$  cannot exceed  $x_1(0) - [m_1(0)/\delta_1]$  as the expected export surplus for Country 1 when it has selected  $t_1 = 0$  cannot exceed  $x_1(0)$ , i.e.,  $\int_0^{t_2^N} x_1(t_2) dG_0(t_2) \leq x_1(0)$ . Thus, any Pareto optimal Markov perfect equilibrium must satisfy

$$\int_0^{t_2^N} x_1(t_2) dG_0(t_2) = x_1(0), \quad (13)$$

i.e.,  $G(t_2) = 1$  for any  $t_2 \in [0, t_2^N]$ . In any Pareto optimal Markov perfect equilibrium, once a country completely eliminate its tariff rate, the other country follows suit and free trade lasts perpetually thereafter.

Now, it follows from (11) and (13) that

$$\begin{aligned} \int_0^{t_2^N} x_1(t_2) dG_{t_1^N}(t_2) + \frac{m_1(0)}{\delta_1} &= x_1(0) \\ \int_0^{t_2^N} x_1(t_2) dG_{t_1^N}(t_2) &= x_1(0) - \frac{m_1(0)}{\delta_1}. \end{aligned}$$

Then we use (11) again to obtain

$$\int_0^{t_2^N} x_1(t_2) dG_{t_1}(t_2) = x_1(0) - \frac{m_1(0) - m_1(t_1)}{\delta_1}. \quad (14)$$

Similarly, we have

$$\int_0^{t_1^N} x_2(t_1) dF_{t_2}(t_1) = x_2(0) - \frac{m_2(0) - m_2(t_2)}{\delta_2}. \quad (15)$$

We can derive value functions in any Pareto optimal Markov perfect equilibrium from (7)–(10) as

$$V_1(t_2) = (1 - \delta_1)x_1(t_2) + \delta_1 x_1(0) - m_1(0),$$

$$\begin{aligned}
W_1(t_1) &= x_1(0) - \frac{m_1(0) - (1 - \delta_1)m_1(t_1)}{\delta_1}, \\
V_2(t_1) &= (1 - \delta_2)x_2(t_1) + \delta_2x_2(0) - m_2(0), \\
W_2(t_2) &= x_2(0) - \frac{m_2(0) - (1 - \delta_2)m_2(t_2)}{\delta_2}.
\end{aligned}$$

**Proposition 3** *Any Pareto optimal Markov perfect equilibrium must satisfy*

$$\begin{aligned}
\int_0^{t_2^N} x_1(t_2)dG_{t_1}(t_2) &= x_1(0) - \frac{m_1(0) - m_1(t_1)}{\delta_1}, \\
\int_0^{t_1^N} x_2(t_1)dF_{t_2}(t_1) &= x_2(0) - \frac{m_2(0) - m_2(t_2)}{\delta_2}.
\end{aligned}$$

*In particular, countries continue to set their tariff rates at 0 once a country completely eliminate its tariff rate.*

## 5 An Example of Pareto optimal Markov perfect equilibrium

In order to visualize Pareto optimal Markov perfect equilibrium, we consider linear families of  $\{F_{t_2}(t_1)\}_{t_2 \in [0, t_2^N]}$  and  $\{G_{t_1}(t_2)\}_{t_1 \in [0, t_1^N]}$ . That is, we concentrate on probability distributions whose cumulative distribution functions are linear. A typical distribution attaches a point mass on either endpoint and uniformly distribute the rest of the probability on the tariff space.

The previous section indicates that in any Pareto optimal Markov perfect equilibrium,  $G_{t_1}$  is such that  $\int_0^{t_2^N} x_1(t_2)dG_{t_1}(t_2)$  equals  $x_1(0) - [m_1(0)/\delta_1]$  when  $t_1 = t_1^N$  and  $G_{t_1}(t_2) = 1$  for any  $t_2 \in [0, t_2^N]$  when  $t_1 = 0$ . As Figure 1 indicates,  $G_{t_1}$  shifts up as  $t_1$  decreases from  $t_1^N$  to 0, keeping (14) satisfied. An intermediate  $G_{t_1}$  in Figure 1, for example, depicts the probability distribution that  $t_2 = 0$  with probability 1/2 and  $t_2$  falls in  $(0, t_2^N]$  with probability 1/2 such that all points in  $(0, t_2^N]$  are equally likely.

Equilibrium families of  $\{F_{t_2}(t_1)\}_{t_2 \in [0, t_2^N]}$  and  $\{G_{t_1}(t_2)\}_{t_1 \in [0, t_1^N]}$  look different depending on

the values of  $x_2(0) - [m_2(0)/\delta_2]$  and  $x_1(0) - [m_1(0)/\delta_1]$ , respectively. Let us define  $\bar{x}_i$ , for  $i = 1, 2$ , by

$$\bar{x}_i = \frac{1}{t_j^N} \int_0^{t_j^N} x_i(t_j) dt_j, \quad j \neq i,$$

which expresses the expected export surplus for Country  $i$  when the probability for Country  $j$ 's tariff rate is uniformly distributed on  $[0, t_j^N]$ , e.g.,  $\int_0^{t_2^N} x_1(t_2) dG_{t_1}(t_2) = \bar{x}_1$  if  $G_{t_1}$  is the uniform distribution on  $[0, t_2^N]$ .

If  $x_1(0) - [m_1(0)/\delta_1] = \bar{x}_1$ , then  $\int_0^{t_2^N} x_1(t_2) dG_{t_1^N}(t_2) = \bar{x}_1$  so that  $G_{t_1^N}$  is the uniform distribution on  $[0, t_2^N]$ . As  $t_1$  decreases, Country 2 puts a higher probability on  $t_2 = 0$ . Then Country 2 selects  $t_2 = 0$  for sure when  $t_1 = 0$ . If  $x_1(0) - [m_1(0)/\delta_1] > \bar{x}_1$ , the expected export surplus under the uniform distribution on  $[0, t_2^N]$  is strictly less than the expected export surplus when  $t_1 = t_1^N$ . Thus, Country 2 puts a positive probability, namely the difference between  $x_1(0) - [m_1(0)/\delta_1]$  and  $\bar{x}_1$ , on  $t_2 = 0$ . Indeed, Figure 1 depicts such a case. Finally, if  $x_1(0) - [m_1(0)/\delta_1] < \bar{x}_1$ , Country 2 puts the positive probability  $\bar{x}_1 - \{x_1(0) - [m_1(0)/\delta_1]\}$  on  $t_2 = t_2^N$  when  $t_1 = t_1^N$ . Obviously, a similar result obtains for  $\{F_{t_2}(t_1)\}_{t_2 \in [0, t_2^N]}$ . Figure 2 shows  $\{F_{t_2}(t_1)\}_{t_2 \in [0, t_2^N]}$  in the last case of the above.

The strategy profile described in Figure 1 and Figure 2 shows that free trade will eventually prevail with a positive probability. The process toward free trade is stochastic involving occasional retreats.

## 6 Concluding Remarks

We have analyzed a tariff-setting game between two large countries, in which countries alternate in setting their individual tariffs. Although there always exists a “non-cooperative” Markov perfect equilibrium in which both countries continue to select their individual Nash tariffs, there also exist equilibria in which they mix their actions so that tariffs gradually decrease with occasional retreats. Unilateral tariff reduction creates the threat of retreats,

thereby induces the other country's concession in such "cooperative" equilibrium. We have derived a Pareto optimal Markov perfect equilibrium in which free trade is reached with a positive probability, and once free trade is reached it is sustained perpetually.

In order for unilateral tariff reduction to be reciprocated, there must be room to retreat since otherwise unilateral tariff reduction would not create a threat to the other country. This observation suggests that safeguards and antidumping actions, for example, play important roles in international cooperation under the auspices of WTO.

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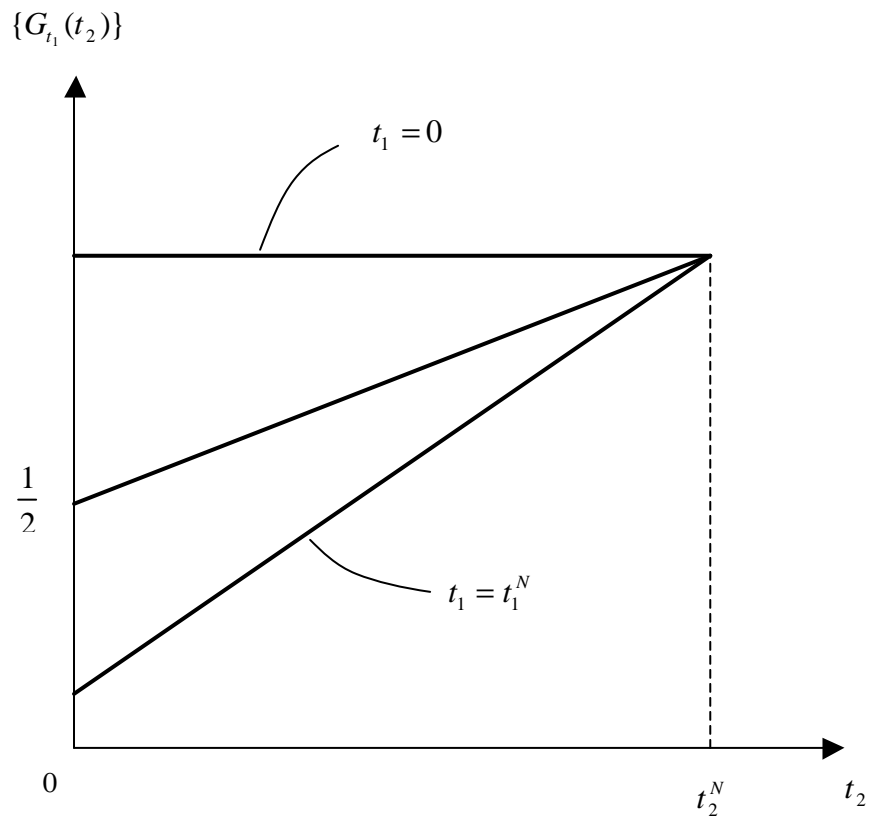


Figure 1. Country 2's equilibrium strategy

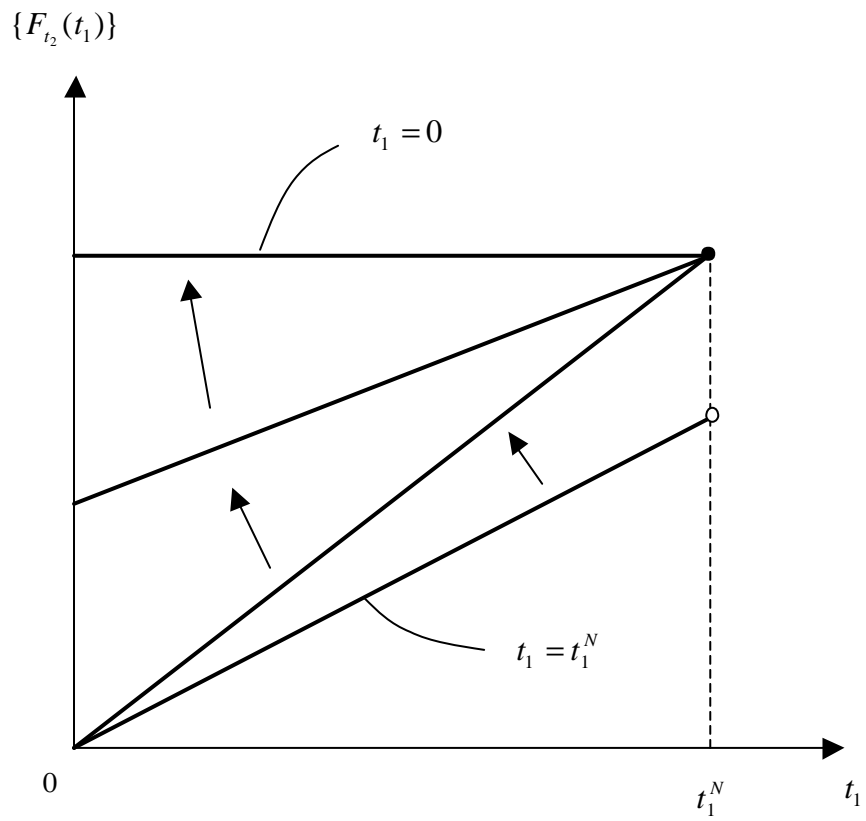


Figure 2. Country 1's equilibrium strategy