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Discussion Paper #928

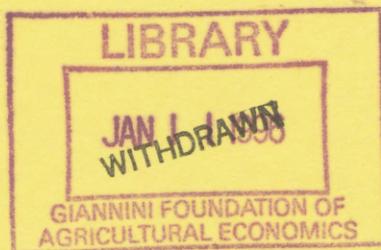
Reexamination of the International Export  
Quota Game through the Theory of Social  
Situations

by

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August 1995



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# Reexamination of the International Export Quota Game through the Theory of Social Situations\*

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July 1995

## Abstract

It is a well-known theorem in international trade that a Nash equilibrium between two countries that set optimal quotas non-cooperatively is the complete elimination of international trade. Yet we know that countries do by quotas on one another and that trade is not eliminated. This paper explores the hypothesis that the discrepancy lies in the weakness of Nash equilibrium concept. Specifically, we agree that the replacement of the Nash equilibrium with Greenberg's (1990) concept of a "standard-of-behavior" yields a much more plausible result. We construct a model of the quota retaliation as an "individual contingent

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\*This paper was written while the author was staying in the Department of Economics of Queen's University as a visiting scholar. The author's stay in Queen's University was financially supported by *Rokkodai-Kowenkai* Foundation. The author would like to express his gratitude both to the Department and to the Foundation. He also would like to thank to Professors Dan Usher and Dan Bernhardt for their comments on an earlier version of this paper.

threats situation." We show the existence of what Greenberg calls a "stable standard-of-behavior" and examine its welfare properties. In a static, essentially non-cooperative setting, we show that every stable standard-of-behavior supports at least one Pareto-efficient combination of quotas and vice versa. Free trade can be "rationalized" by a stable standard-of-behavior.

## 1 Introduction

The purpose of this paper is to reexamine the international export quota game, when the Nash equilibrium concept is replaced by the theory of social situations, as developed by Greenberg (1990). On the international "quota retaliation," Rodriguez (1974) and Tower (1975) are the classics.<sup>1</sup> In a two country, two commodity, competitive framework, Rodriguez has studied the consequence of alternating quota retaliation, where one country uses an export quota and the other uses an import quota. He showed that, as retaliation continues, trade shrinks to zero. With the same framework, Tower has considered other patterns for retaliation: import quota versus export quota; export quota versus export quota; import quota versus import quota; import quota versus import quota with an alternative adjustment process; import tariff versus export quota; and the case where one country is a Stackelberg leader. In the first three cases, Tower showed that retaliation gradually eliminates trade. Although Rodriguez and Tower have not presented their models in a fully game theoretical framework, it can be easily verified that no-trade is a unique "Nash equilibrium" of a quota game in normal form. The story of the quota retaliation by Rodriguez and Tower can be seen as an explanation or interpretation of the Nash equilibrium of a quota game. The notion of quota retaliation, however, includes something more than the Nash equilibrium.

To see this, let us examine briefly the retaliation process proposed by Rodriguez and Tower. Their retaliation process goes as follows. Initially, both countries are in the free trade equilibrium (or, in a non-autarkic trade equilibrium). Then, one of two countries levies the optimal quota believing that the rival country will not retaliate (i.e., will keep its current quota, if any, unchanged). But the other country does retaliate. Taking the first country's quota as given, the second country levies the optimal retaliatory

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<sup>1</sup>For "tariff retaliation" and "tariff negotiation" cases, see Johnson (1953-54), Mayer (1981), Riezman (1982), and Dixit (1987); see also Hungerford (1991) and Riezman (1991).

quota. Then, still believing that the second country will not respond, the first country levies a new optimal quota, and so on. This process continues until all trade is eliminated. There is something questionable about all this. If a pair of countries found themselves in a situation that was not a Nash equilibrium and if they both know that a sequence of that "optimal" retaliations would plunge them into a situation that is worse for both than no retaliation, then they might not retaliate or could not do so "optimally" in the course of worsening themselves as well off as possible if they did not respond. The Nash equilibrium does not capture the situation appropriately. Greenberg (1990) established a "standard-of-behavior" as an alternative. A standard-of-behavior gives a suggestion or a recommendation about course of actions to the countries in each state, even in an off-Nash equilibrium. When a standard-of-behavior is proposed to the countries, each country may or may not accept it. In general, the countries, considering their own interests, are free to accept or reject a given standard-of-behavior.

So far, nothing has been said about the content of a standard-of-behavior. For example, the implicit standard-of-behavior in the Rodriguez-Tower process is for each country in an off-Nash equilibrium to "take the optimal quota given that the others keep the current levels of quotas." Whether this standard-of-behavior is "reasonable" depends on the context. If it is really true that only one of countries can move in each state, and if it is really true that the others keep the current level of quotas and never retaliate, then the above standard-of-behavior will be "reasonable," in the sense that all countries will accept it voluntarily.<sup>2</sup> If a standard-of-behavior makes inconsistent suggestions from one state to another, the countries will not accept it. For a standard-of-behavior to be accepted by all countries, it should be consistent. The consistency requirement *on a standard-of-behavior* is called its "stability" in the theory of social situations. A stable standard-of-behavior is a "solution concept" in the theory of social situations. With a stable standard-of-behavior (if it exists at all), the countries can consistently "justify" or "rationalize" what they do and what they do not do. If a stable standard-of-behavior recommends the countries to take certain actions (which may or may not be an Nash equilibrium), then we can say that *the recommended state is rationalized (or, is supported) by the standard-of-behavior*. In this paper, we do not consider the origin of a standard-of-behavior, who propose it, and how countries choose among different standards-of-behavior. We seek,

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<sup>2</sup>We discuss the standard-of-behavior in the Rodriguez-Tower process in a later section.

instead, to show that there may be a consistent solution to the international quota retaliation game.

Our main concern in this paper is to find a stable standard-of-behavior for the international quota retaliation game in which the countries are utility maximizers who can understand the ingredients and the consequences of the stable standard-of-behavior. Another concern is to investigate the characteristics of the stable standard-of-behavior (if it exists), in particular, to investigate what kinds of states (trade equilibria) will be rationalized by the stable standard-of-behavior. As we take into account of actions of the countries even in off-Nash equilibrium states, it is expected that at least one non-autarkic trade equilibrium can be rationalized by a stable standard-of-behavior—indeed, we can show this is true. We can even show that the free trade equilibrium can be rationalized by a stable standard-of-behavior.

In the recent literature, the simple model by Rodriguez and Tower has been modified to some extent to examine the non-autarkic trade equilibrium *with quotas* in a game theoretical setting. Copeland (1989) has introduced both tariffs and quotas into his model, and examined various cases: where both tariffs and quotas are chosen non-cooperatively; where either one of them is chosen non-cooperatively, while the other cooperatively. Bernhardt and Enders (1989) have considered the case where some portions of quota rents of a country are transferred to other countries in their quota game model, and showed that, if the fraction of quota rents accruing to a quota-imposing country is not big enough, the Nash equilibrium of the quota game will be free trade. Both Copeland (1989) and Bernhardt and Enders (1989) expand the scope of the policy instruments, and Copeland (1989) incorporates cooperation between countries into the model. We introduce neither other policy instruments nor the notion of cooperation. Instead, we introduce the guideline called the "standard-of-behavior" as discussed in previous paragraphs.

The rest of this paper is organized as follows. Section 2 is preparatory. We develop convenient tools for analyzing the international export quota games: the strategic trade utility function and the strategic trade indifference map. The strategic trade utility function attaches a measure of welfare to every combination of quotas, one for each country. We develop the strategic trade indifference maps that are essential in the proofs of theorems in this paper. In Section 3, we discuss the Rodriguez and Tower's alternating quota retaliation, and its relation to the Nash equilibrium of a simple quota game in normal form. We point out that this retaliation process exhibits arbitrariness and

inconsistency in a static framework. In Section 4, after introducing some basic concepts in the theory of social situations, we construct a formal model of the quota retaliation as an "individual contingent threats situation,"<sup>3</sup> which is free from the defects in the Rodriguez-Tower retaliation process. In Section 5, we show the existence of the stable standard-of-behavior and examine its welfare properties. In a static, essentially non-cooperative setting, we can show that "no-trade" is only one of several trade equilibria supported by a stable standard-of-behavior. With an additional technical condition ("connectedness"), we can prove that every stable standard-of-behavior supports at least one Pareto efficient quota allocation in terms of the strategic trade utility functions and vice versa. Free trade can be "rationalized" by a stable standard-of-behavior. Section 6 contains some concluding remarks.

## 2 The strategic trade utility function and the strategic trade indifference map

In this section we develop useful tools for analyzing the international export quota games: the strategic trade utility function and the strategic trade indifference map. The strategic trade utility function attaches a measure of welfare to every combination of quotas, and it closely relates to the usual trade utility function ("Meade utility function"<sup>4</sup>) that attaches a measure of welfare to every combination of net-import and net-export. The strategic trade indifference map is a graph of contours of a strategic trade utility function on the set of all feasible combinations of quotas, and it is essential in the proofs of the theorems in this paper.

First let us consider a competitive world economy consisting of two countries (1 and 2) and two tradable commodities (1 and 2). We assume that consumer's preference and the production technology of each country are represented intensively by a single (real-valued) trade utility function:

$$V_k(e_k, m_k), \quad k = 1, 2, \quad (1)$$

where  $e_k$  and  $m_k$  are the quantities of exports and imports of country  $k$ , respectively. As usual, we assume that the trade utility function is decreasing in  $e_k$ , increasing in  $m_k$ , and continuous and strictly quasi-concave in  $(e_k, m_k)$ .

<sup>3</sup>The term "individual contingent threats situation" is due to Greenberg (1990).

<sup>4</sup>See Dixit and Norman (1980).

Through the usual optimization procedure, we obtain a single valued offer curve of country  $k$ :

$$e_k = F_k(m_k), \quad k = 1, 2, \quad (2)$$

which satisfies  $0 = F_k(0)$ . We assume  $F_k$  is increasing and concave in  $m_k$ .<sup>5</sup> This assumption implies that each country's offer curve is elastic in its whole domain. Without loss of generality, we can assume that country 1 exports commodity 1 and country 2 exports commodity 2.<sup>6</sup> In Figure 1, we illustrate the offer curves of both countries. The quantity of country 1's exports is measured horizontally and the quantity of country 2's exports is measured vertically. The unique free trade equilibrium occurs at point  $e^f$  in the figure. Let us denote the quantity of country 1's (country 2's) exports at the free trade equilibrium as  $e_1^f$  ( $e_2^f$ , respectively).

Next let us consider the export quota policy such that the government of each country levies the upper limit  $q_k$  of its exports (that is,  $e_k \leq q_k$ ,  $k=1, 2$ ), and assume that the quota licenses of a country are auctioned off competitively only to the residents of the country. If the quota level of a country is greater than its exports at the free trade equilibrium ( $e_k^f < q_k$ ), then the export quota of this country becomes ineffective *regardless of the other country's export quota*. Therefore a meaningful quota of country  $k$  lies between 0 and  $e_k^f$ . Let us denote the interval  $0 \leq q_k \leq e_k^f$  as  $X_k$  ( $k=1, 2$ ) and define  $X := X_1 \times X_2$ , which is the set of all feasible combinations of quotas  $(q_1, q_2)$ . We write a typical element of  $X$  as  $x$  (or  $y, z$ , etc.), and call it a "quota allocation." When we refer to the components of  $x$ , we write them  $q_1(x)$  and  $q_2(x)$ , that is,  $x = (q_1(x), q_2(x))$  (or  $y = (q_1(y), q_2(y))$ ,  $z = (q_1(z), q_2(z))$ , etc.). We can partition  $X$  into five disjoint subsets  $\{o\}$ ,  $\{f\}$ ,  $A$ ,  $B$ , and  $C$  defined as follows:

$$\begin{aligned} o &:= (q_1(o), q_2(o)) \in X \text{ such that } q_k(o) = 0, k=1, 2, \\ f &:= (q_1(f), q_2(f)) \in X \text{ such that } q_k(f) = e_k^f, k=1, 2, \\ A &:= \{(q_1, q_2) \in X \setminus \{o, f\} | q_2 \geq F_2(q_1)\}, \\ B &:= \{(q_1, q_2) \in X \setminus \{o, f\} | q_1 \geq F_1(q_2)\}, \\ C &:= \{(q_1, q_2) \in X | q_2 < F_2(q_1) \text{ and } q_1 < F_1(q_2)\}. \end{aligned}$$

<sup>5</sup>If  $F_k$  is well defined, the continuity of  $F_k$  is assured.

<sup>6</sup>If we assume the differentiability of the offer curves, this assumption on the trade pattern implies that  $F^1(0) \cdot F^2(0) > 1$ , where  $F^{k'}(0)$  is the derivative of country  $k$ 's offer curve at zero. For our analysis, however, neither the differentiability of the offer curves nor that of the trade utility functions are necessary.

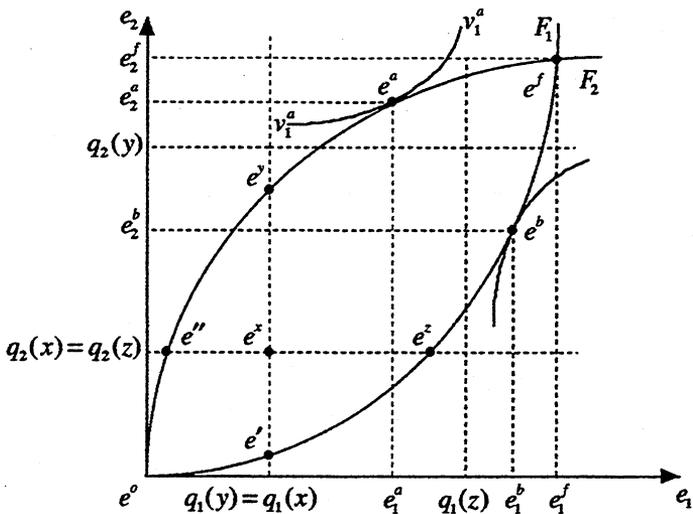


Figure 1: Trade equilibria under various quotas.

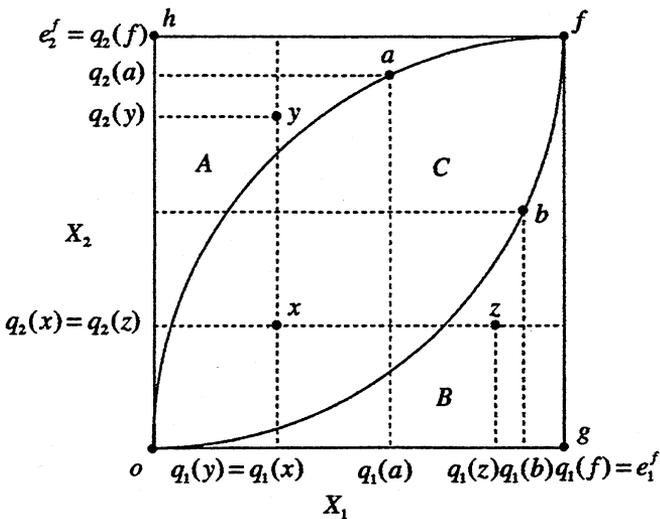


Figure 2: Quota allocations.

We illustrate  $X$  and its partition on the quota space (the  $X_1$ - $X_2$  space) in Figure 2.

To see the meaning of the partition of  $X$ , let us examine the trade equilibria under various quota allocations. If a quota allocation is given by  $f$ , the trade equilibrium occurs at point  $e^f$  in Figure 1, which is the free trade equilibrium. If a quota allocation is given by  $o$ , or more generally, if either one of quotas is equal to zero, then the actual international transaction of commodities does not take place at all: the no-trade equilibrium ( $e^o = (0, 0)$ ) in Figure 1). Consider the case where a quota allocation  $y$  is included in  $A$  as in Figure 2.<sup>7</sup> In this case country 1's offer curve becomes a kinked curve  $e^o e^x e^y$  in Figure 1 and the quota  $q_2(y)$  by country 2 becomes ineffective, then the trade equilibrium under  $y$  occurs at  $e^y = (q_1(y), F_2[q_1(y)])$  in Figure 1. Note that point  $e^y$  is on the non-distorted offer curve of country 2, and that only country 1's export quota is strictly binding (effective).  $A$  is a set of all quota allocations such that only country 1's export quota is strictly binding. Similarly, if a quota allocation  $z$  is included in  $B$  as in Figure 2, country 2's offer curve becomes a kinked curve  $e^o e'' e^z$  in Figure 1 and the quota  $q_1(z)$  by country 1 becomes ineffective, then the trade equilibrium under  $z$  occurs at  $e^z = (F_1[q_2(z)], q_2(z))$  in Figure 1, which is on the non-distorted offer curve of country 1.  $B$  is a set of all quota allocations such that only country 2's quota is strictly binding. Lastly, if a quota allocation  $x$  is included in  $C$  as in Figure 2, the offer curves of both countries become kinked curves  $e^o e' e^x e^y$  and  $e^o e'' e^x e^z$  in Figure 1, respectively, and the trade equilibrium occurs at  $e^x = (q_1(x), q_2(x))$  in Figure 1.  $C$  is a set of all quota allocations with non-zero trade such that both countries quotas are strictly binding.

Using the above results, we can construct the strategic trade utility function  $U_1 : X \rightarrow \Re$  for country 1 as follows:

$$U_1(x) = \begin{cases} V_1(q_1(x), F_2[q_1(x)]), & \text{if } x \in A, \\ V_1(F_1[q_2(x)], q_2(x)), & \text{if } x \in B, \\ V_1(q_1(x), q_2(x)), & \text{if } x \in C \cup \{o\} \cup \{f\}. \end{cases} \quad (3)$$

Similarly, we have the strategic trade utility function  $U_2 : X \rightarrow \Re$  for country 2:

$$U_2(x) = \begin{cases} V_2(F_2[q_1(x)], q_1(x)), & \text{if } x \in A, \\ V_2(q_2(x), F_1[q_2(x)]), & \text{if } x \in B, \\ V_2(q_2(x), q_1(x)), & \text{if } x \in C \cup \{o\} \cup \{f\}. \end{cases} \quad (4)$$

<sup>7</sup>Points  $e^o$ ,  $e^b$ ,  $e^f$ ,  $e^z$ ,  $e^y$ , and  $e^x$  in Figure 1 correspond to the trade equilibria under quota allocations  $a$ ,  $b$ ,  $f$ ,  $x$ ,  $y$ , and  $z$  in Figure 2, respectively.

By construction, it is easy to verify that  $U_k$  ( $k=1, 2$ ) is continuous on  $X$ . Since  $X$  is compact and  $U_k$  is continuous,  $U_k$  attains both the maximum and the minimum on  $X$ . The minimum of  $U_k$  corresponds to no-trade, at which at least one of quotas of two countries is equal to zero. On the other hand, the maximum of  $U_k$  corresponds to the trade equilibrium under the unilateral optimal quota by country  $k$ . To see this, let us consider the unilateral optimal quota by country 1. In Figure 1, a usual trade indifference curve  $v_1^a v_1^a$  is tangent to the non-distorted offer curve of country 2 at point  $e^a$ , at which the usual trade utility function of country 1 attains its maximum provided that country 2 levies no strictly binding quota. If we denote the levels of exports of both countries at  $e^a$  as  $e_1^a$  and  $e_2^a$ , respectively, the associated quota allocation  $a = (q_1(a), q_2(a))$  becomes such that  $q_k(a) = e_k^a$  ( $k=1, 2$ ) in Figure 2. It should be noted that the usual trade utility function of country 1 attains its maximum *only* at  $e^a$  in Figure 1, while the strategic trade utility function of country 1 can attain its maximum as long as a given quota allocation  $(q_1, q_2)$  satisfies that  $q_1 = q_1(a)$  and  $q_2 \geq q_2(a)$ . Similarly, we can find the trade equilibrium  $e^b = (e_1^b, e_2^b)$  under the unilateral optimal quota by country 2 in Figure 1 and the associated quota allocation  $b = (q_1(b), q_2(b))$  such that  $q_k(b) = e_k^b$  ( $k=1, 2$ ) in Figure 2.<sup>8</sup>

Now we can draw the strategic trade indifference map entirely, which is a graph of contours of a trade utility function. In Figure 3, we illustrate some of the strategic trade indifference curves of both countries: bold curves are for country 1 and thin curves are for country 2 (two curves, which together form a lens-shaped area of  $C$ , correspond to the offer curves of both countries). Let us examine the characteristics of the strategic trade indifference map of country 1. To begin with, let us look at some "bench mark curves." A kinked line  $goh$  corresponds to no-trade, and hence it corresponds to the minimum of  $U_1$ . A line segment  $aa'$  corresponds to the maximum of  $U_1$ . A curve  $ff'f''$  corresponds to the welfare level at the free trade equilibrium. A strategic trade indifference curve that lies between  $goh$  and  $ff'f''$ , such as  $vv'v''v'''$ , has three portions: one vertical portion in  $A$ , one horizontal portion in  $B$ , and one curve portion in  $C$  that coincides with a part of a usual trade indifference curve. In general, if a part of a strategic indifference curve goes through  $C$ , this part coincides with a part of a usual trade indifference curve.

<sup>8</sup>Without the assumption on the differentiability of the usual trade utility functions, points of trade equilibria  $e^a$  and  $e^b$  may coincide with the free trade equilibrium point  $e^f$  in Figure 1. This fact, however, does not alter the results of the following analysis at all in an essential way.

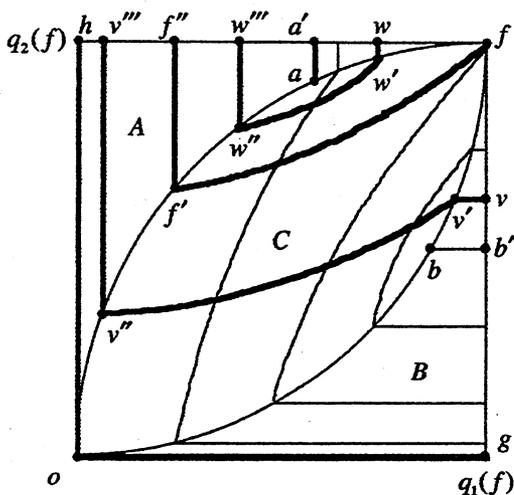


Figure 3: The strategic trade indifference maps.

On the other hand, a strategic trade indifference curve that lies between  $aa'$  and  $ff'f''$ , such as  $ww'w''w'''$ , has three portions: two vertical portions both in  $A$  and one curve portion in  $C$ . Naturally, the closer to  $aa'$  a strategic trade indifference curve lies, the higher the corresponding welfare level of country 1 is.

Turning to the relationship between the strategic trade indifference maps of both countries, it is immediately recognized that, in both  $A$  and  $B$ , both countries' maps coincide with each other. With this property, we can partition  $A$  (as well as  $B$ ) into the indifference classes  $\{A_i\}$  ( $\{B_i\}$ , respectively) such that  $x, y \in A_i$  implies  $U_k(x) = U_k(y)$ ,  $k=1, 2$ . The partition of  $A$ , of course, satisfies that  $A = \cup_{i \in J} A_i$ ,  $A_i \cap A_j = \emptyset$  for  $i, j \in J$ ,  $i \neq j$ , where  $J$  denotes an index set.<sup>9</sup> We can choose the index set so as to satisfy that  $i \leq j$  if and only if  $proj_2(A_i) \subset proj_2(A_j)$  ( $proj_1(B_i) \subset proj_1(B_j)$ , for the partition of  $B$ ), where  $proj_k(\cdot)$  denotes the projection onto  $X_k$  ( $k=1, 2$ ). By  $i(x)$ , we denote the index number of an element of the partition (either of

<sup>9</sup>The same properties hold for the partition of  $B$ .

A or of B) that includes the quota allocation  $x$ . At any quota allocation in  $C$ , the strategic trade indifference curves of both countries intersect, never be tangent to each other; the slope of country 2's strategic trade indifference curve is steeper than that of country 1's.

In relation to the strategic trade indifference maps, we define two subsets of  $X$ :  $I_k(x)$  and  $P$ .  $I_k(x)$  is a set of all quota allocations that are indifferent to a given  $x$  for country  $k$  defined as follows:

$$I_k(x) := \{y \in X | U_k(y) = U_k(x)\}, k=1, 2. \quad (5)$$

Of course,  $I_k(x)$  corresponds to the strategic trade indifference curve of country  $k$  passing through  $x$ .  $P$  is the set of *Pareto-efficient quota allocations in terms of the strategic trade utility functions* defined as follows:

$$P := \{x \in X | \text{there is no } y \in X \text{ s.t. } U_k(y) > U_k(x), k=1, 2\}. \quad (6)$$

In Figure 3, the graph of  $P$  is represented by two triangular areas  $faa'$  and  $fbf'$ , which consist of the graphs of  $A_i$  for all  $i \leq i(a)$ , of  $B_i$  for all  $i \leq i(b)$ , and of  $\{f\}$ .<sup>10</sup>

We have shown that, for example, a strategic trade indifference curve of country 1 that lies between  $aa'$  and  $ff'f''$  has two vertical portions. As it is easily seen from the figure, one of those portions is necessarily in the graph of  $P$ . With notations defined above, we can state this fact formally:

$$I_k(x) \cap P \neq \emptyset \text{ for } x \in X \text{ such that } U_k(x) \geq U_k(f). \quad (7)$$

### 3 The Rodriguez-Tower alternating retaliation and the Nash equilibrium

In this section we discuss the Rodriguez-Tower alternating retaliation and its relation to the Nash equilibrium of the quota game in normal form. First, let us examine in detail the Rodriguez-Tower alternating retaliation along the line with our export quota versus export quota case. This alternating retaliation is illustrated in Figure 4. Suppose that both countries are in the free trade equilibrium  $e^f$  initially and that country 1 moves first (country 1 launches the quota war). country 1 levies the optimal export quota  $q_1(a)$

<sup>10</sup>That is,  $P = \{\cup_{i \leq i(a)} A_i\} \cup \{\cup_{i \leq i(b)} B_i\} \cup \{f\}$ .

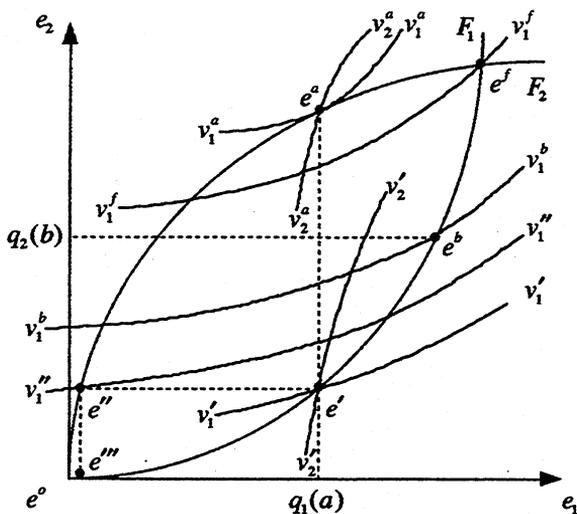


Figure 4: The Rodriguez-Tower quota retaliation.

so that the trade equilibrium occurs at  $e^a$ , where a usual trade indifference curve  $v_1^a v_1^a$  is tangent to the non-distorted offer curve of country 2. Country 1's quota-distorted offer curve becomes a kinked curve  $e^o e' e^a$ . Given country 1's quota, country 2 imposes the optimal retaliatory quota so that the trade equilibrium occurs at  $e'$ . Country 2 obtains a higher welfare level  $v_2' v_2'$  than  $v_2^a v_2^a$ , whereas country 1 obtains a lower welfare level  $v_1' v_1'$  than  $v_1^a v_1^a$ . Given country 2's quota, country 1 levies new optimal quota so that the trade equilibrium occurs at  $e''$ , and so on. As retaliation continues, trade equilibrium point moves from  $e^f$  through  $e^a$ ,  $e'$ ,  $e''$ , ..., and eventually approaches to  $e^o$ , that is, no-trade. The characteristics of the Rodriguez-Tower retaliation are summarized as follows: (a) both countries can be in some non-zero trade equilibria in the course of retaliation; (b) each country levies optimal quota given that the other keeps the current quota; (c) countries move alternately; (d) the final situation is no-trade.

To contrast, let us examine the Nash equilibrium of a quota game in normal form, in which the players are countries 1 and 2; country  $k$  uses an export quota in  $X_k$  ( $k=1, 2$ ) as its strategy; and country  $k$ 's payoff function is

$U_k$  ( $k=1, 2$ ).<sup>11</sup> A quota allocation  $(q_1^*, q_2^*)$  is a Nash equilibrium if it satisfies both

$$U_1(q_1^*, q_2^*) \geq U_1(q_1, q_2^*) \text{ for all } q_1 \in X, \quad (8)$$

and a similar condition for country 2. To find a Nash equilibrium, the best reply mapping is a convenient analytical device. The best reply mapping for country 1 is defined as follows:

$$R_1 := \{q_1 \in X \mid \arg \max U_1(q_1, q_2), q_2: \text{ given}\}. \quad (9)$$

Similarly, we can define the best reply mapping  $R_2$  for country 2. In Figure 3, the graph of  $R_1$  is the kinked curve  $a'aw''f'v''og$  and that of  $R_2$  is the kinked curve  $b'boh$ .<sup>12</sup> Both curves intersect only at the origin  $o$ . No-trade is the unique Nash equilibrium of this quota game.

The Rodriguez-Tower retaliation and the Nash equilibrium of the quota game are similar in some respects, but different in others. They share the same final situation, that is, no-trade. How each country takes its action (point [b] above) in a given situation in the Rodriguez-Tower retaliation can be seen as reflection of the definition of the best reply mapping. Note, however, that point (b) does not reflect the definition of the Nash equilibrium. The Nash equilibrium does not require each country to take an "optimal" action given the others' off-Nash equilibrium actions, it only tells each country to take *the equilibrium strategy that maximizes its own utility given that the others are taking the equilibrium strategies*. In the Rodriguez-Tower retaliation, some non-zero trade equilibria that are off-Nash equilibria can be realized at least temporarily (point [a]). On the other hand, as far as the countries (players) are simple utility maximizers as usually assumed in a normal form game, the no-trade Nash equilibrium is the only state that can be realized in the quota game. In the quota game in normal form, since the countries choose their equilibrium strategies simultaneously, alternating actions by the countries (point [d]) are not necessary, and therefore there is no room for "retaliation." Despite some similarities, the notion of retaliation is not captured appropriately by the Nash equilibrium of the quota game. To examine the notion of retaliation meaningfully, it is necessary to take fully account of actions by the countries in off-Nash equilibrium states.

<sup>11</sup>We denote this quota game as  $T = \{N, \{X_k\}_{k=1,2}, \{U_k\}_{k=1,2}\}$ .

<sup>12</sup>The derivation of the graph of the best reply mapping is quite obvious from the strategic trade indifference map. For details and for other applications of the strategic trade indifference map, see Nakanishi (1994-a, -b).

Now let us examine whether the Rodriguez-Tower alternating retaliation describes consistently the notion of "quota retaliation" in general. Unfortunately, it is suffering from two defects. One is its alternating nature of the Rodriguez-Tower retaliation. Although we have chosen country 1 as the first mover in the above discussion, country 2 would do as well. The first mover is chosen *ad hoc*. In a static framework, there is no reason to assume that one country moves first and the other second. It is natural to assume both countries can move at every state. The other, more serious, defect is the implicit standard-of-behavior in the Rodriguez-Tower retaliation, as discussed above. It tells each country to take the optimal quota given that the other keeps the current action unchanged. If each country believes that all countries (including itself) follow this implicit standard-of-behavior at every state and knows the consequence of the alternating retaliation, the country never follows this standard-of-behavior. This is a contradiction. To see the point, let us look at Figure 4 again. By launching the quota war, country 1 can attain a higher welfare level  $v_1^a v_1^a$  at  $e^a$  than  $v_1^f v_1^f$  at  $e^f$ . After country 2's retaliation, country 1 counter-retaliates and obtains  $v_1^b v_1^b$ . But it can not recover its welfare level up to  $v_1^a v_1^a$ , nor can it recover up to  $v_1^f v_1^f$ .<sup>13</sup> If country 1 does not launch the quota war and keeps free trade, it can retain the welfare level  $v_1^b v_1^b$ , which is higher than  $v_1^c v_1^c$ , even when country 2 levies its optimal quota (the corresponding trade equilibrium is  $e^b$ ). It is not "reasonable" for country 1 to follow the above standard-of-behavior at the initial trade equilibrium.<sup>14</sup> the same argument applies to country 2. Since the implicit standard-of-behavior described in the Rodriguez-Tower retaliation is inconsistent, the countries will cease to follow it in later rounds of retaliation, and consequently, the alternating process will break down. Hence, the final situation may not be no-trade.

<sup>13</sup>The same argument can not be applied to the "tariff retaliation." In the tariff retaliation case, one country may attain a higher welfare level at the Nash equilibrium than at the free trade equilibrium. This possibility was pointed out by Johnson (1953-54); Mayer (1981) and Riezman (1982) called this the "Johnson's case."

<sup>14</sup>At least, it becomes "unreasonable" for each country to follow that standard-of-behavior within first several rounds of retaliation.

## 4 The quota retaliation as an individual contingent threats situation

Since the notion of retaliation involves the possibility that off-Nash equilibrium states are realized, a precise description of every possible state (the Nash as well as off-Nash equilibria) becomes necessary. In the theory of social situations, this can be handled by using the notions of a "position," an "outcome," and the "inducement correspondence."

Before proceeding further, we now introduce formally some basic concepts in the theory of social situations.<sup>15</sup> A "position," denoted by  $G$ , describes the players in this position, all feasible actions that the players in  $G$  can take, the payoff functions of the players in  $G$ . Put formally,  $G = (N(G), X(G), \{u_k(G)\}_{k \in N(G)})$ , where  $N(G)$  is the set of players in  $G$ ,  $X(G)$  is the set of all feasible actions (an element in  $X(G)$  is called an "outcome" in the theory of social situations), and  $u_k(G) : X(G) \rightarrow \mathfrak{R}$  is a real-valued payoff function in  $G$  for player  $k$  defined over  $X(G)$ . We denote the set of all positions as  $\Gamma$ . The "inducement correspondence," denoted by  $\gamma$ , describes how a player or a group of players can change the current position. When a group  $S$  of players can change the current position  $G$  to a new position  $H$ , we say that the group  $S$  can "induce" a position  $H$ . Formally, given a position  $G$  and a proposed outcome  $x \in X(G)$ , the inducement correspondence  $\gamma$  describes a subset of  $\Gamma$  that can be induced by a non-empty coalition  $S \subset N(G)$ ; we denote this subset as  $\gamma(S|G, x)$ . A pair of the inducement correspondence and the set of all positions  $\Gamma$ ,  $(\gamma, \Gamma)$ , is called a "social situation."

Next, we introduce the most important building block in the theory of social situations, that is, a "standard-of-behavior" and its "stability." A subset  $\sigma(G)$  of  $X(G)$  is called a "solution for position  $G$ ." A mapping  $\sigma$  that assigns to each position  $G \in \Gamma$  a solution  $\sigma(G)$  is called a "standard-of-behavior" for  $\Gamma$ . A standard-of-behavior gives the players a suggestion or a recommendation ( $\sigma(G)$ ) about course of actions in every position. At this point, a standard-of-behavior can be arbitrary. For example, a standard-of-behavior such that  $\sigma(G) = \emptyset$  for all  $G$  satisfies the definition. Such a standard-of-behavior, however, is meaningless, and then the players will not accept it. To be accepted by all players, a standard-of-behavior should be meaningful and consistent. The consistency requirement on a standard-of-behavior is

<sup>15</sup>For details of the theory of social situations, see Greenberg (1990).

called its "stability." Greenberg (1990) has developed two stability concepts: the optimistic stability and the conservative stability.

**The optimistic stability:** A standard-of-behavior  $\sigma$  is called "optimistic internally stable" for  $(\gamma, \Gamma)$  if for all  $G \in \Gamma$ ,  $x \in \sigma(G)$  implies that there do not exist a coalition  $S \subset N(G)$ , a position  $H \in \gamma(S|G, x)$ , and an outcome  $y \in \sigma(H)$  such that  $u_k(H)(y) > u_k(G)(x)$  for all  $k \in S$ ; and  $\sigma$  is called "optimistic externally stable" for  $(\gamma, \Gamma)$  if for all  $G \in \Gamma$ ,  $x \in X(G) \setminus \sigma(G)$  implies that there exist coalition  $S \subset N(G)$ ,  $H \in \gamma(S|G, x)$ , and  $y \in \sigma(H)$  such that  $u_k(H)(y) > u_k(G)(x)$  for all  $k \in S$ . If a standard-of-behavior  $\sigma$  is both optimistic internally stable and optimistic externally stable, then  $\sigma$  is an "optimistic stable standard-of-behavior" for  $(\gamma, \Gamma)$ .

**The conservative stability:** A standard-of-behavior  $\sigma$  is called "conservative internally stable" for  $(\gamma, \Gamma)$  if for all  $G \in \Gamma$ ,  $x \in \sigma(G)$  implies that there exists no  $S \subset N(G)$ ,  $H \in \gamma(S|G, x)$  such that  $\sigma(H) \neq \emptyset$ , and for all  $y \in \sigma(H)$ ,  $u_k(H)(y) > u_k(G)(x)$  for all  $k \in S$ ; and it is called "conservative externally stable" if for all  $G \in \Gamma$ ,  $x \in X(G) \setminus \sigma(G)$  implies that there exist coalition  $S \subset N(G)$ ,  $H \in \gamma(S|G, x)$  such that  $\sigma(H) \neq \emptyset$ , and for all  $y \in \sigma(H)$ ,  $u_k(H)(y) > u_k(G)(x)$  for all  $k \in S$ . If a standard-of-behavior  $\sigma$  is both conservative internally and conservative externally stable, then  $\sigma$  is a "conservative stable standard-of-behavior" for  $(\gamma, \Gamma)$ .

Given a position  $G$  and an outcome  $x \in \sigma(G)$ , if a standard-of-behavior is not "internally stable," there exists at least one coalition  $S$  that can induce another position  $H \in \gamma(S|G, x)$  and an outcome  $y \in \sigma(H)$  such that  $u_k(H) > u_k(G)(x)$  for all  $k \in S$ . The players in  $S$  will, according to  $\sigma$  itself, refuse to accept the outcome  $x$  in position  $G$ , then the outcome  $x$  fails to be a solution for  $G$ . In this case, the standard-of-behavior  $\sigma$  gives inconsistent suggestions to the players. This explains the motivation for the "internal stability." On the other hand, if a standard-of-behavior  $\sigma$  is not "externally stable," a solution  $\sigma(G)$  for a certain position  $G$  would include an outcome that will be rejected by at least one coalition  $S$  in  $G$  according to  $\sigma$ . That is, the "internal stability" of  $\sigma$  would be violated. A standard-of-behavior that assigns empty set to every position (we showed above) is automatically "internally stable," but not "externally stable." Hence, it is not a stable standard-of-behavior. Note, however, that the stability of a standard-of-behavior  $\sigma$  does not require

that  $\sigma(G) \neq \emptyset$  for all  $G$ . Even if  $\sigma$  is a stable standard-of-behavior, it is quite possible that  $\sigma(G) = \emptyset$  for some (not all) positions. When we have  $\sigma(G) = \emptyset$  for a position  $G$ , this means that there is no solution for *this position*, but there should be another position  $H$  that has a solution ( $\sigma(H) \neq \emptyset$ ) by the external stability. The stability is the only one "consistency" requirement in the theory of social situations.

In addition, we introduce the connectedness of a standard-of-behavior.

**Connectedness:** A standard-of-behavior  $\sigma$  is called "(arcwise-) connected," if  $\sigma(G)$  is (arcwise-) connected for every  $G \in \Gamma$  such that  $X(G)$  is (arcwise-) connected in terms of an appropriate topology introduced into the outcome space.

Although the connectedness is a rather technical requirement, economic intuition behind it can be explained as follows. Suppose that two distinct outcomes  $x$  and  $y$  are included in the solution  $\sigma(G)$  for position  $G$ , then the connectedness implies that there should always exist an alternative "mild" outcome  $z$  between the extremes  $x$  and  $y$  in the solution for position  $G$ .

Let us introduce the "individual contingent threats situation" by Greenberg (1990, Chapter 7) into our international quota retaliation. The individual contingent threats situation is associated with a quota game in normal form, and is constructed so as to represent satisfactorily the following "open negotiation" process. Suppose that a quota allocation  $(q_1, q_2)$  is proposed to both countries 1 and 2. If both countries openly consent to follow  $(q_1, q_2)$ , then it will be adopted as a solution. If, say, country 1 objects to  $(q_1, q_2)$ , it has to declare that if country 2 will stick to the specified quota level  $q_2$ , then country 1 will employ the quota  $q'_1$  instead of  $q_1$ . The quota  $q'_1$  is not necessarily an "optimal" response to country 2's quota  $q_2$ . Anyway, the newly proposed quota allocation becomes  $(q'_1, q_2)$ . Country 2 may object to  $(q'_1, q_2)$ , then it can threaten country 1 to deviate from  $(q'_1, q_2)$  by declaring to adopt the quota  $q'_2$  instead of  $q_2$ . The revised quota allocation becomes  $(q'_1, q'_2)$ . The "open negotiation" process continues in a similar way as the Rodriguez-Tower alternating retaliation. But, unlike the Rodriguez-Tower retaliation, each country can revise its quota level at any point of the negotiation process, therefore a simultaneous revision of quotas by both countries is possible. It should be noted that, though we use the term "negotiation," this process does not imply any binding-agreement between countries and any coalition-formation by countries at all. In other words, there is no *a priori* cooperation between countries in the individual contingent threats situation.

Let us construct a formal model of the quota retaliation as an individual contingent threats situation. First, we define the position  $G_T$  that corresponds to the normal form quota game  $T = (N, \{X_k\}_{k=1,2}, \{U_k\}_{k=1,2})$  as follows:<sup>16</sup>

$$G_T := (N, X, \{U_k\}_{k=1,2}), \quad (10)$$

where  $N$  is the set of countries  $\{1, 2\}$ ,  $X$  is the set of all quota allocations  $X_1 \times X_2$ , and  $U_k$  is the strategic trade utility function for country  $k$ . The only difference between  $G_T$  and  $T$  lies in the specifications of the set of outcome  $X$  and the strategy spaces  $\{X_k\}$ . Next, we define position  $G_x$  in which the set of players  $N(G_x)$  is  $N$ , the set of outcome  $X(G_x)$  consists of a single outcome  $x \in X$ , and the payoff function  $u_k(G_x)$  for country  $k$  is  $U_k$ :

$$G_x := (N, \{x\}, \{U_k\}_{k=1,2}). \quad (11)$$

Then we have the set of positions  $\Gamma$  for the quota retaliation as an individual contingent threats situation, that is,

$$\Gamma := \{G_T\} \cup \{G_x | x \in X\}. \quad (12)$$

Both countries 1 and 2 are always included in the set of players in every position, hence both of them can take actions in every position. (One country does not have to wait the other's action.)

Turn to the definition of the inducement correspondence  $\gamma$ . First, we define a subset  $L_k(x)$  of  $X$ :

$$L_k(x) := \{(q_1, q_2) \in X | q_k \in X_k, q_l = q_l(x) \text{ for all } l \neq k\}. \quad (13)$$

$L_1(x)$  ( $L_2(x)$ ) corresponds to a horizontal line segment (vertical line segment, respectively) passing through a given quota allocation  $x$  on the  $X_1$ - $X_2$  plane. With  $L_k$ , we can define  $\gamma$  as follows: for all  $G \in \Gamma$ ,  $x \in X$ , and  $S \subset N$ ,

$$\gamma(S|G, x) := \begin{cases} \{G_y | y \in L_k(x)\}, & \text{if } S = \{k\}, k=1, 2, \\ \emptyset, & \text{if } S = \{1, 2\}. \end{cases} \quad (14)$$

The first line implies that no country can induce the position  $G_T$  from any given position  $G$  and any proposed outcome  $x$ . In a sense,  $G_T$  is the "initial position" of the quota retaliation. From a given position  $G$  and a proposed

<sup>16</sup>See footnote 11.

quota allocation  $x$ , a single country can induce another position by changing its own quota level. The second line captures the fact that the formation of non-trivial coalition is not allowed. Our framework is essentially non-cooperative.

Regarding the stable standard-of-behavior for the individual contingent threats situation associated with a normal form game in general, Greenberg (1990) has shown the following two facts.

**Fact 1 (Greenberg 1990, Theorem 7.4.1)** *Let  $(\gamma, \Gamma)$  be the individual contingent threats situation associated with a normal form game  $T$ . A standard-of-behavior  $\sigma$  for  $(\gamma, \Gamma)$  is "optimistic stable" if and only if it is "conservative stable." Moreover, we have  $NE(T) \subset \sigma(G_T)$ , where  $NE(T)$  and  $G_T$  denote the set of Nash equilibria of  $T$  and the position that corresponds to  $T$ , respectively.*

**Fact 2 (Greenberg 1990, Claim 7.4.3)** *Let  $\sigma$  be an optimistic (conservative) stable standard-of-behavior for the individual contingent threats situation  $(\gamma, \Gamma)$  associated with a normal form game  $T$ . Then,  $\sigma(G_T) \neq \emptyset$ . Furthermore, for all  $G \in \Gamma$ ,  $\sigma(G) = \sigma(G_T) \cap X(G)$ .*

Due to Fact 1, we can omit the words "optimistic" and "conservative" from the expression of the stability of a standard-of-behavior. Hereafter, we use the simple term "stable standard-of-behavior."

Since the set of outcome  $X(G_x)$  is a singleton for any position  $G_x$ , Fact 2 implies that if a stable standard-of-behavior  $\sigma$  exists, then it should take the following form:

$$\sigma(G) = \begin{cases} \sigma(G_T), & \text{if } G = G_T, \\ \{x\}, & \text{if } G = G_x \text{ where } x \in \sigma(G_T), \\ \emptyset, & \text{if } G = G_x \text{ where } x \notin \sigma(G_T). \end{cases} \quad (15)$$

That is,  $\sigma$  is completely characterized by  $\sigma(G_T)$ . Since  $\sigma(G_x)$  is a singleton or empty set,  $\sigma(G_x)$  is connected for every position  $G_x$ ,  $x \in X$ . Therefore, if we require the connectedness of  $\sigma$ , it is sufficient to show that  $\sigma(G_T)$  is a connected subset of  $X$ .

As shown in the previous section, the Nash equilibrium of the international quota game  $T$  associated with our quota retaliation is no-trade. Therefore, due to Fact 2, if there exists a stable standard-of-behavior for the quota retaliation as an individual contingent threats situation,  $\sigma(G_T)$  must include the origin  $o$ .

By definition of position  $G_x$ , we can identify a position  $G_x$  with the outcome  $x$  in this position. Further, taking into account of the definition of the inducement correspondence (i.e., no country can induce the position  $G_T$ ), we can also identify  $\gamma(\{k\}|G, x)$  with  $L_k(x)$ . Therefore, we can say, for example, that "country 1 can induce a quota allocation  $y \in L_1(x)$  from a quota allocation  $x$  and can improve its welfare according to  $\sigma$ " instead of saying that "given a position  $G$  and a proposed quota allocation  $x$ , there exist a position  $G_y \in \gamma(\{1\}|G, x)$  and an outcome  $y \in \sigma(G_y)$  such that  $U_1(y) > U_1(x)$ ." In the following, we will frequently use the former rough expression instead of the latter more accurate one.

## 5 The existence and the characteristics of the stable standard-of-behavior

Since the general existence theorem has not been established,<sup>17</sup> we must show the existence of a stable standard-of-behavior  $\sigma$  for the quota retaliation as an individual contingent threats situation. Due to Fact 2, it is sufficient to find an appropriate subset  $\sigma(G_T)$  of  $X$  (the solution for position  $G_T$ ) to show the existence of  $\sigma$ . This fact highlights the importance of the strategic trade indifference maps, which is drawn on  $X$  (the  $X_1$ - $X_2$  plane). First, assuming the existence, we give some necessary conditions for a standard-of-behavior to be stable, which impose restrictions on the shape of  $\sigma(G_T)$ , and then prove its existence by constructing concrete examples of the graphs of  $\sigma(G_T)$ .

Suppose that there exists a stable standard-of-behavior  $\sigma$  for the quota game as an individual contingent threats situation. Then the graph of  $\sigma(G_T)$  must satisfy the following properties.<sup>18</sup>

**Property 1** *If two distinct quota allocations in  $\sigma(G_T)$ ,  $x$  and  $y$ , are located in horizontal positions each other on the  $X_1$ - $X_2$  plane, then country 1 must be indifferent between them. Similarly, if two distinct quota allocations in  $\sigma(G_T)$ ,  $x$  and  $y$ , are located in vertical positions each other on the  $X_1$ - $X_2$  plane, then country 2 must be indifferent between them.*

**Property 2** *The graph of  $\sigma(G_T)$  must be drawn with lines (in other words, the graph of  $\sigma(G_T)$  does not have any "thick" area on  $X$ ).*

<sup>17</sup>Facts 1 and 2 do not imply the existence of the stable standard-of-behavior, even if there exists a Nash equilibrium of the associated normal form game.

<sup>18</sup>For the formal statements and the proofs of properties 1 through 8, see Appendix A.

**Property 3** *If a part of the graph of  $\sigma(G_T)$  goes through the lens-shaped area  $C$ , it must be an "upward-sloping" curve.*

**Property 4** *If a part of the graph of  $\sigma(G_T)$  goes through  $A$  (or, through  $B$ ), it must be a vertical straight line (a horizontal straight line, respectively).*

**Property 5** *If a quota allocation on the strategic trade indifference curve  $aa'$  ( $bb'$ ), which corresponds to the maximum of  $U_1$  ( $U_2$ , respectively), is included in  $\sigma(G_T)$ , then the curve  $aa'$  ( $bb'$ , respectively) as a whole will be included in the graph of  $\sigma(G_T)$ .*

**Property 6** *If a quota allocation  $x$  in an element of  $A_i$  of the partition of  $A$  is included in  $\sigma(G_T)$  for  $i \leq i(a)$ , then  $A_i$  as a whole will be included in  $\sigma(G_T)$ . Similarly, if  $x$  in  $B_i$  is included in  $\sigma(G_T)$  for  $i \leq i(b)$ , then  $B_i$  as a whole will be included in  $\sigma(G_T)$ .*

The above six properties can be derived without any additional restrictions on the stable standard-of-behavior. With a usual (Euclidean) topology,  $X$  can be considered an arcwise-connected set. If we require the arcwise-connectedness of  $\sigma$ , we can derive two more properties.

**Property 7** *If a quota allocation  $x$  in an element of  $A_i$  of the partition of  $A$  is included in  $\sigma(G_T)$  for  $i > i(a)$ , then all quota allocations in  $A_i$  "below"  $x$  will be included in  $\sigma(G_T)$ . Similarly, if  $x$  in  $B_i$  is included in  $\sigma(G_T)$  for  $i > i(b)$ , then all quota allocations in  $B_i$  to the "left" of  $x$  will be included in  $\sigma(G_T)$ .*

**Property 8** *If an element  $A_i$  of the partition of  $A$  is included entirely in  $\sigma(G_T)$  for  $i > i(a)$ , then the strategic trade indifference curve of country 1 that includes  $A_i$  will be included entirely in the graph of  $\sigma(G_T)$ . Similarly, if  $B_i$  is included entirely in  $\sigma(G_T)$  for  $i > i(b)$ , then the strategic trade indifference curve of country 2 that includes  $B_i$  will be included entirely in the graph of  $\sigma(G_T)$ .*

In Figures 5 and 6, we give two examples of  $\sigma(G_T)$  that satisfy all properties above (bold curves in the figures), and we denote them as  $\sigma^*(G_T)$  and  $\sigma^{**}(G_T)$ , respectively. They are the candidates for the stable standards-of-behavior for the quota retaliation as an individual contingent threats situation.  $\sigma^*(G_T)$  in Figure 5 starts from the origin  $o$  (Fact 2), goes upward

through  $C$  (Property 3), and ends at the quota allocation  $f$  that corresponds to free trade.  $\sigma^{**}(G_T)$  in Figure 6 starts from the origin  $o$  (Fact 2), goes upward through  $C$  (Property 3), reaches a quota allocation  $\alpha$  that is an element of  $P$ , and includes the graph of  $A_{i(\alpha)}$ , which is the line segment  $\alpha\alpha'$  in Figure 6 (Property 6).

Now we show that the standard-of-behavior  $\sigma^*$  associated with the graph of  $\sigma^*(G_T)$  is indeed stable. Take an arbitrary quota allocation  $x \in \sigma^*(G_T)$ , as in Figure 5. Country 1 can induce any quota allocation that lies on the dotted horizontal line segment passing through  $x$ , but the line segment has no point other than  $x$  in common with the graph of  $\sigma^*(G_T)$ . Similarly, country 2 can induce any quota allocation that lies on the dotted vertical line segment passing through  $x$ , but the line segment has no point other than  $x$  in common with the graph of  $\sigma^*(G_T)$ . Hence, due to equation (15), we have  $\sigma^*(G_z) = \emptyset$  for all  $G_z \in \gamma(\{k\}|G, x)$ ,  $k=1, 2$ , where  $z \neq x$ . Therefore, the standard-of-behavior  $\sigma^*$  is internally stable. Next, take an arbitrary quota allocation  $y \notin \sigma^*(G_T)$ , as in Figure 5. Country 1, in this case, can induce a quota allocation  $y' \in \sigma^*(G_T)$  from  $y$  and can improve its welfare according to  $\sigma^*$  (we have  $U_1(y') > U_1(y)$ ). That is, the standard-of-behavior  $\sigma^*$  is externally stable. (Country 2 can induce a quota allocation  $y'' \in \sigma^*(G_T)$  from  $y$ , but can not improve its welfare according to  $\sigma^*$ .) Therefore the standard-of-behavior  $\sigma^*$  is stable. Similarly, we can show that the standard-of-behavior  $\sigma^{**}$  associated with the graph of  $\sigma^{**}(G_T)$  is stable. Besides the graphs of  $\sigma^*(G_T)$  and  $\sigma^{**}(G_T)$ , we can draw (infinitely) many other graphs of  $\sigma(G_T)$  that have similar shapes to  $\sigma^*(G_T)$  or  $\sigma^{**}(G_T)$ , and we can prove each standard-of-behavior  $\sigma$  associated with such a graph of  $\sigma(G_T)$  is stable. Now we can state the following theorem.

**Theorem 1** *There exist (infinitely many) stable standards-of-behavior for the quota retaliation as an individual contingent threats situation.*

Note that both stable standards-of-behavior  $\sigma^*$  and  $\sigma^{**}$  are *arcwise-connected*. There may exist some *non-connected* stable standards-of-behavior.

Next let us consider the welfare properties of the stable standard-of-behavior for the quota retaliation as an individual contingent threats situation. First, note that each of  $\sigma^*(G_T)$  and  $\sigma^{**}(G_T)$  has at least one element in common with  $P$ . We can show that this property is shared by all *arcwise-connected* stable standards-of-behavior.

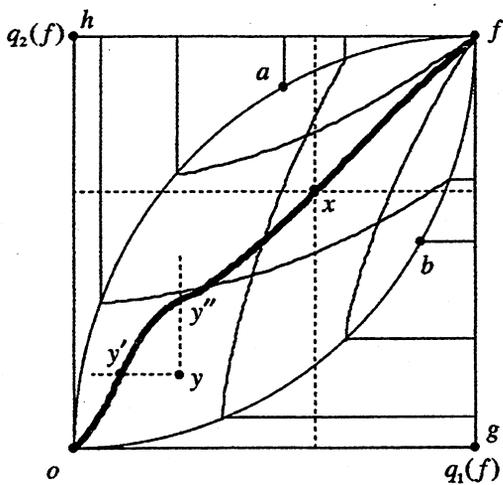


Figure 5: The graph of  $\sigma(G_T)^*$ .

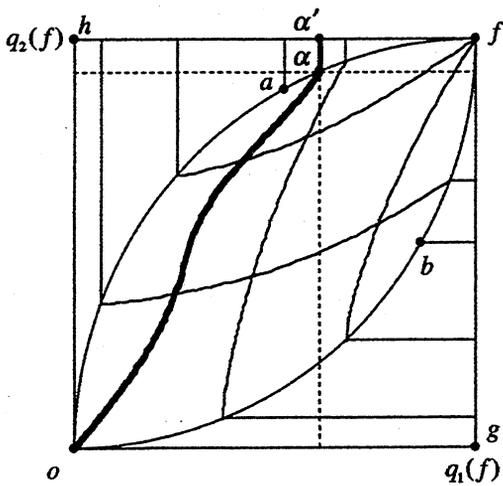


Figure 6: The graph of  $\sigma(G_T)^{**}$ .

**Theorem 2** *Let  $\sigma$  be an arcwise-connected stable standard-of-behavior for the quota retaliation as an individual contingent threats situation. Then  $\sigma(G_T)$  includes at least one element in common with the set  $P$  of Pareto-efficient quota allocations in terms of the strategic trade utility functions.<sup>19</sup>*

*Proof.* If the quota allocation  $f \in P$  is included in  $\sigma(G_T)$ , there is nothing to be proved. Suppose  $f \notin \sigma(G_T)$ . By the external stability of  $\sigma$ , either one of countries 1 and 2 must be able to induce a quota allocation  $x \in \sigma(G_T)$  from  $f$  and improve its welfare according to  $\sigma$ , that is,  $U_k(x) > U_k(f)$  ( $k=1$  or  $2$ ). Without loss of generality, we can assume

$$U_1(x) > U_1(f). \quad (16)$$

Note that  $L_1(f) \setminus \{f\} \subset A$ , and therefore  $x$  must be included in  $A$ .<sup>20</sup> If  $i(x) \leq i(a)$ , we have  $x \in P$  and the proof ends. If  $i(x) > i(a)$ , then we have  $A_{i(x)} \subset \sigma(G_T)$  by Property 7 (which depends on the connectedness of  $\sigma$ ). Then, by Property 8, we have

$$I_1(x) \subset \sigma(G_T). \quad (17)$$

Finally, equations (7), (16), and (17) together imply that

$$\sigma(G_T) \cap P \neq \emptyset. \quad (18)$$

Q.E.D.

Conversely, we can prove the following theorem.

**Theorem 3** *For any quota allocation  $x$  in  $P$ , there exists at least one arcwise-connected stable standard-of-behavior  $\sigma$  that supports  $x$  (that is,  $x \in \sigma(G_T)$ ).*

*Proof.* It suffices to show an appropriate graph of  $\sigma(G_T)$  for each  $x$  in  $P$ . If  $x = f$ , then  $\sigma^*$  is an example of the arcwise-connected stable standards-of-behavior that support  $x$ . Next, suppose that  $x \neq f$  and that, without loss of generality,  $x \in A_i$ ,  $i \leq i(a)$ . By Property 6, we have  $A_i \subset \sigma(G_T)$ . Take a quota allocation  $\alpha_i \in \text{cl}A_i \cap \text{cl}C$ , just like a quota allocation  $\alpha$  in Figure

<sup>19</sup>Using a 2 by 2 prisoners' dilemma game, Greenberg (1990, Chapter 7) shows a similar result. Theorem 2 can be considered, in a sense, a generalization of Greenberg's result.

<sup>20</sup>Remember that we identify  $\gamma(\{1\}|G, f)$  with  $L_1(f)$ .

6, where  $\text{cl}A_i$  and  $\text{cl}C$  denote the closures of  $A_i$  and  $C$ , respectively.<sup>21</sup> Draw a straight line from the origin  $o$  to  $\alpha_i$ .<sup>22</sup> The graph of this straight line and the graph of  $A_i$  together form the appropriate graph of  $\sigma(G_T)$ . The stability of  $\sigma$  with such a graph of  $\sigma(G_T)$  can be verified easily.

Q.E.D.

With Theorem 5, we can say that free trade, which corresponds to the quota allocation  $f \in P$ , can be "rationalized" by a stable standard-of-behavior. An example of such stable standards-of-behavior is  $\sigma^*$ .

The final theorem is concerned with the characterization of Pareto-efficient quota allocations that are supported by an arcwise-connected stable standard-of-behavior.

**Theorem 4** *For the quota retaliation as an individual contingent threats situation, all Pareto-efficient quota allocations that are supported by an arcwise-connected stable standard-of-behavior  $\sigma$  are Pareto-indifferent to each other.*

*Proof.* Suppose contrary, that is, there exist two distinct quota allocations  $x$  and  $y$  such that  $x, y \in \sigma(G_T) \cap P$ ,  $U_k(x) \neq U_k(y)$  for at least one  $k$  ( $k=1, 2$ ). Then, essentially, we have three cases: case 1 where  $x \in \{f\}$  and  $y \in A_i$ ,  $i \leq i(a)$  (by Property 6,  $A_i \subset \sigma(G_T)$ ); case 2 where  $x \in A_i$ ,  $y \in A_j$ ,  $i \neq j$ , and  $i, j \leq i(a)$  (by Property 6,  $A_i \subset \sigma(G_T)$  and  $A_j \subset \sigma(G_T)$ ); case 3 where  $x \in A_i$ ,  $i \leq i(a)$ ,  $y \in B_j$ ,  $j \leq i(b)$  (by Property 6,  $A_i \subset \sigma(G_T)$  and  $B_j \subset \sigma(G_T)$ ). First, let us consider case 1. By Property 6, there exists a quota allocation  $z$  such that  $z \in A_i \cap L_1(f) \subset \sigma(G_T)$ . But, since  $U_1(z) < U_1(f)$ , it contradicts to Property 1. Case 1 is not possible. In case 2, by Property 6 again, there exist quota allocations  $w$  and  $z$  such that  $w \in A_i \cap L_1(f) \subset \sigma(G_T)$  and  $z \in A_j \cap L_1(f) \subset \sigma(G_T)$ . But, because  $i \neq j$ , we have  $U_1(w) \neq U_1(z)$ . This contradicts to Property 1. Case 2 is not possible. Lastly, in case 3, there exists a quota allocation  $z$  such that  $z \in L_1(y) \cap L_2(x)$ . If either  $z \in A_i$  or  $z \in B_j$  holds (each of them implies  $z \in \sigma(G_T)$ ), then we have either  $U_1(y) \neq U_1(z)$  or  $U_2(x) \neq U_2(z)$ , respectively. This contradicts to Property 1. If both  $z \notin A_i$  and  $z \notin B_j$  hold, we must have  $z \in C$ . Take quota allocations  $\alpha_i \in \text{cl}A_i \cap \text{cl}C$  and  $\beta_j \in \text{cl}B_j \cap \text{cl}C$ , where  $\text{cl}A_i$  and  $\text{cl}B_j$  denote the closures of  $A_i$  and  $B_j$ , respectively.<sup>23</sup> In this case, we have both

<sup>21</sup>In almost all cases, we have  $\alpha_i \in A_i$ . The only one exception is the case where  $A_i$  is equal to the interval  $(o, h] \subset X$  in Figure 3. Since this interval has no point in common with  $P$ , we have  $\alpha_i \in A_i$  in this case.

<sup>22</sup>The readers may draw the graph for this proof.

<sup>23</sup>See footnote 21.

$\alpha_i \in A_i \subset \sigma(G_T)$  and  $\beta_j \in B_j \subset \sigma(G_T)$ . As is obvious from the figure,<sup>24</sup>  $\alpha_i$  is located "above"  $z$  and  $\beta_j$  is located to the "right" of  $z$ . This contradicts to Property 3. Case 3 is not possible. Therefore Theorem 4 must hold.

Q.E.D.

## 6 Remarks

We showed that free trade is "rationalized" by a stable standard-of-behavior, for example, by  $\sigma^*$  in Section 5. At the same time, consistently with the presence of utility maximizing countries, a stable standard-of-behavior can explain the persistence of strictly binding quotas with non-zero trade. Consider a quota allocation  $x \in \sigma^*(G_T)$  in Figure 5. Once the non-trade equilibrium under  $x$  has been established, both countries can not induce better positions according to  $\sigma^*$ , and therefore they do not change their quotas. The threat of retaliation forces the utility maximizing countries who can understand the standard-of-behavior to stick to the status quo.

Although we showed that a stable standard-of-behavior supports at least one Pareto-efficient quota allocation in terms of the strategic trade utility functions and vice versa, this does not imply the superiority (either from a viewpoint of an individual country or from a viewpoint of the countries involved as a whole) of quotas over other trade policy instruments, such as tariffs. A stable standard-of-behavior  $\sigma$  can support a *true Pareto-efficient trade equilibrium in terms of the usual trade utility functions* only when  $\sigma(G_T)$  includes the quota allocation  $f$  that corresponds to the free trade equilibrium. Even if a quota allocation, other than  $f$ , that is Pareto-efficient in terms of the strategic trade utility functions is supported by  $\sigma$  for the quota retaliation as an individual contingent threats situation, there remain possibilities to improve welfare of all countries simultaneously either by introducing other policy instruments into the model or by constructing a model of the quota retaliation as other "social situations."

<sup>24</sup>See Figure 3; the readers may draw the figure for this proof.

## A Formal statements and proofs of Properties 1 through 8

In this appendix we give formal statements and proofs of Properties 1 through 8. We denote a stable standard-of-behavior as  $\sigma$ . The proofs heavily depend on the whole structure of the strategic trade indifference maps (Figure 3). Although we do not show the graphs for the proofs, the reader may draw them. Some additional notations used in the proofs are defined and listed in Appendix B together with others in the text.

**Property 1** *Suppose  $x \in \sigma(G_T)$ . If  $y \in \sigma(G_T) \cap L_k(x)$ ,  $y \neq x$ , then  $U_k(x) = U_k(y)$ ,  $k=1, 2$ .*

*Proof.* Suppose contrary, then, without loss of generality, we can assume  $U_k(x) < U_k(y)$ . Since country  $k$  can induce  $y$  from  $x$  and can improve its welfare according to  $\sigma$ , this contradicts to the internal stability of  $\sigma$ .

Q.E.D.

**Property 2**  $\text{int}\sigma(G_T) = \emptyset$ .

*Proof.* Suppose contrary, that is,  $\text{int}\sigma(G_T) \neq \emptyset$ . Then there exist  $x \in \text{int}X := (0, e_1^1) \times (0, e_2^2)$  and a sufficiently small  $\varepsilon > 0$  such that  $O_\varepsilon(x) \subset \sigma(G_T)$ . Then we can find either  $y \in O_\varepsilon(x) \cap L_1(x)$  such that  $U_1(x) \neq U_1(y)$  or  $z \in O_\varepsilon(x) \cap L_2(x)$  such that  $U_2(x) \neq U_2(z)$ . This contradicts to Property 1.

Q.E.D.

**Property 3** *If  $x, y \in \sigma(G_T) \cap \text{cl}C$  and  $x \neq y$ , then either  $x \ll y$  or  $y \ll x$  holds.*

*Proof.* Suppose contrary, for example,  $q_1(x) \leq q_1(y)$  and  $q_2(y) \leq q_2(x)$ . Then we can have a quota allocation  $z := (q_1(x), q_2(y)) \in L_1(y) \cap L_2(x)$ . It can be easily seen from the figure that  $z \in C$ . If  $z \in \sigma(G_T)$ , since  $U_1(y) \neq U_1(z)$ , it contradicts to Property 1. Then we must have  $z \notin \sigma(G_T)$ . But, since we have both  $U_1(z) > U_1(y)$  and  $U_2(z) > U_2(x)$ , no country can improve its welfare according to  $\sigma$  by inducing  $x$  or  $y$  from  $z$ . It also contradicts to the external stability of  $\sigma$ .

Q.E.D.

**Property 4** Suppose  $x \in \sigma(G_T) \cap \text{int}A$ . If  $y \in \sigma(G_T) \cap \text{int}A \cap O_\varepsilon(x)$  for sufficiently small  $\varepsilon > 0$ , then  $y \in A_{i(x)}$ . The same property holds for  $B$ .

*Proof.* Suppose contrary, that is,  $y \notin A_{i(x)}$ . Then we must have either  $U_1(x) > U_1(y)$  or  $U_1(x) < U_1(y)$ . Let us take the former case (the latter case can be proved similarly). Define  $z := (q_1(x), q_2(y)) \in L_1(y) \cap L_2(x) \subset \{A_{i(x)} \cap O_\varepsilon(x)\}$ . The latter inclusion can be proved easily, and it implies both  $U_1(x) = U_1(z)$  and  $U_2(x) = U_2(z)$ . If  $z \in \sigma(G_T)$ , it contradicts to Property 1. Therefore we must have  $z \notin \sigma(G_T)$ . But, since country 2 can not improve its welfare by inducing  $x$  from  $z$  according to  $\sigma$ , by the external stability of  $\sigma$ , country 1 must be able to improve its welfare by inducing  $y$  from  $z$  according to  $\sigma$ . But it is not possible.

Q.E.D.

**Property 5** If  $A_{i(a)} \cap \sigma(G_T) \neq \emptyset$ , then  $A_{i(a)} \subset \sigma(G_T)$ . The same property holds for  $B_{i(b)}$ .

*Proof.* Suppose  $x, y \in A_{i(a)}$ ,  $x \in \sigma(G_T)$ , and  $y \notin \sigma(G_T)$ . From  $y$ , country 2 can induce  $x$ , but can not improve its welfare according to  $\sigma$ . Therefore, by the external stability of  $\sigma$ , country 1 must be able to induce a quota allocation  $z \in L_1(y)$  from  $y$  and able to improve its welfare according to  $\sigma$ . But since  $U_1$  attains its maximum at  $y$ , it is not possible.

Q.E.D.

**Property 6** If  $A_i \cap \sigma(G_T) \neq \emptyset$  for  $i < i(a)$ , then  $A_i \subset \sigma(G_T)$ . The same property holds for  $B_i$ ,  $i < i(b)$ .

*Proof.* Suppose  $x, y \in A_i$ ,  $x \in \sigma(G_T)$ , and  $y \notin \sigma(G_T)$ . Similar to the proof of Property 5, there must exist a quota allocation  $z \in \sigma(G_T) \cap L_1(y)$  such that  $U_1(z) > U_1(y) = U_1(x)$ . Define  $w := (q_1(z), q_2(x)) \in L_1(x) \cap L_2(z)$ . Such a quota allocation  $w$  always exists and satisfies  $U_1(w) = U_1(z)$ . If  $w \in \sigma(G_T)$ , it contradicts to Property 1. Therefore we have  $w \notin \sigma(G_T)$ . From  $w$ , country 2 can induce  $z$ , but can not improve its welfare according to  $\sigma$ . Therefore, by the external stability of  $\sigma$ , country 1 must be able to induce a quota allocation  $v \in L_1(w) = L_1(x)$  such that  $U_1(v) > U_1(w)$  from  $w$  and able to improve its welfare according to  $\sigma$ . But this contradicts to Property 1.

Q.E.D.

**Property 7** Suppose a stable standard-of-behavior  $\sigma$  is arcwise-connected. If  $x \in A_i \cap \sigma(G_T)$  for  $i > i(a)$ , then  $A_i \cap L_1^-(x) \subset \sigma(G_T)$ . Similarly, if  $x \in B_i \cap \sigma(G_T)$  for  $i > i(b)$ , then  $B_i \cap L_2^-(x) \subset \sigma(G_T)$ .

*Proof.* Take  $x \in A_i \cap \sigma(G_T)$  for  $i > i(a)$ . If  $x = \alpha_i$ , then  $A_i \cap L_1^-(x) = \emptyset \subset \sigma(G_T)$ . Suppose  $x \neq \alpha_i$  (this implies  $x \in \text{int}A$ ), and consider a half-open interval  $(x, \alpha_i] \subset X$ . It is obvious from the figure that  $A_i \cap L_1^-(x) \subset (x, \alpha_i]$ . From arcwise-connectedness of  $\sigma$  and Fact 2, there exists a continuous path  $\text{Arc}(ox) \subset \sigma(G_T)$  that connects the origin  $o$  and  $x$ . By Property 4,  $\text{Arc}(ox)$  must include the closed interval  $[x, \alpha_i]$ . Therefore we have  $A_i \cap L_1^-(x) \subset \sigma(G_T)$ . Similarly, we can prove the case for  $x \in B_i \cap \sigma(G_T)$ .

Q.E.D.

**Property 8** If  $A_i \subset \sigma(G_T)$  for  $i > i(a)$ , then  $I_1(x) \subset \sigma(G_T)$  where  $x \in A_i$ . Similarly, if  $B_i \subset \sigma(G_T)$  for  $i > i(b)$ , then  $I_2(x) \subset \sigma(G_T)$  where  $x \in B_i$ .

*Proof.* Suppose  $A_i \subset \sigma(G_T)$  for  $i > i(a)$ , and take a quota allocation  $x \in A_i$ . Take another quota allocation  $y \in L_1(f)$  such that  $U_1(y) > U_1(x)$ . It is obvious from the figure that  $y$  lies on the region to the "right" of  $A_i$ . By Property 1, and since  $A_i \cap L_1(f) \neq \emptyset$ , we have  $y \notin \sigma(G_T)$ . Country 1 can induce a quota allocation in  $A_i \subset \sigma(G_T)$  from  $y$ , but can not improve its welfare according to  $\sigma$ . Therefore, by the external stability of  $\sigma$ , country 2 must be able to induce a quota allocation  $z \in \sigma(G_T) \cap L_2(y)$  from  $y$  and able to improve its welfare according to  $\sigma$ . There are three possibilities: case 1 where  $z \in L_1^+(\alpha_i)$ ; case 2 where  $z \in C \cap L_1^-(\alpha_i)$ ; case 3 where  $z \in B \cap L_1^-(\alpha_i)$  such that  $U_2(z) > U_2(y)$ . In case 1, by Property 1 and the internal stability of  $\sigma$ , we have  $z \in I_1(x)$ . In case 2,  $z$  lies on the "Southeast" region of  $\alpha_i \in \sigma(G_T)$ . Therefore, by Property 3, case 2 is not possible. In case 3, by Property 7, we have  $[\beta_{i(z)}, z] \subset \sigma(G_T)$ . If  $[\beta_{i(z)}, z] \cap L_2(x) = \emptyset$ , and this implies that  $\beta_{i(z)}$  lies on the "Southeast" region of  $\alpha_i$ . Similar to case 2, it is not possible. Among three possibilities, only case 1 holds as far as  $U_1(y) > U_1(x)$ . If  $y \in L_1(f)$  satisfies that  $U_1(y) = U_1(x)$  and  $y \notin A_i$ , then  $y \in \sigma(G_T)$  (if not, it contradicts to the external stability of  $\sigma$ ). As  $y$  such that  $U_1(y) \geq U_1(x)$  moves along  $L_1(f)$ ,  $z$  defined above moves over  $I_1(x) \setminus A_i$ . Similarly, we can prove the case for  $B_i$ ,  $i > i(b)$ .

Q.E.D.

## B List of notations

### • Trade equilibrium

$V_k$  : the usual trade utility function for country  $k$ .

$e_k$  : the quantity of exports of country  $k$ .

$m_k$  : the quantity of imports of country  $k$ .

$F_k$  : the offer curve of country  $k$ .

$e_k^f$  : the free trade export level of country  $k$ .

### • Quota allocations

$X_k := \{q_k | 0 \leq q_k \leq e_k^f\}$ : the range of quota of country  $k$ .

$X := X_1 \times X_2$ : the set of all quota allocations.

$(q_1, q_2)$  : a quota allocation.

$x, y, z$  : typical elements of  $X$ .

$q_k(x)$  : components of  $x$ , i.e.,  $x = (q_1(x), q_2(x))$ .

$a$  : the quota allocation associated with the country 1's optimal quota.

$b$  : the quota allocation associated with the country 2's optimal quota.

$o$  : a quota allocation such that  $q_k(o) = 0$ ,  $k=1, 2$ .

$f$  : a quota allocation such that  $q_k(f) = e_k^f$ ,  $k=1, 2$ , which corresponds to the free trade equilibrium.

$A := \{(q_1, q_2) \in X \setminus \{o, f\} | q_2 \geq F_2(q_1)\}$ .

$B := \{(q_1, q_2) \in X \setminus \{o, f\} | q_1 \geq F_1(q_2)\}$ .

$C := \{(q_1, q_2) \in X | q_2 < F_2(q_1) \text{ and } q_1 < F_1(q_2)\}$ .

$\text{int}A$  : interior of  $A$  relative to  $X$ .

$\text{int}B$  : interior of  $B$  relative to  $X$ .

$\{A_i\}$  : the partition of  $A$ .

$\{B_i\}$  : the partition of  $B$ .

$\text{cl}A_i$  : the closure of  $A_i$ .

$\text{cl}B_i$  : the closure of  $B_i$ .

$\text{cl}C$  : the closure of  $C$ .

$\alpha_i$  : an element of a singleton  $\text{cl}A_i \cap \text{cl}C$ .

$\beta_i$  : an element of a singleton  $\text{cl}B_i \cap \text{cl}C$ .

• **The strategic trade utility function and related sets**

$U_k : X \rightarrow \mathfrak{R}$  : the strategic trade utility function for country  $k$ .

$I_k(x) := \{y \in X \mid U_k(y) = U_k(x)\}$ : the set of all quota allocations that are indifferent to  $x$  for country  $k$ .

$P := \{x \in X \mid \text{there is no } y \in X \text{ s.t. } U_k(y) > U_k(x), k=1,2\}$ : the set of Pareto-efficient quota allocations in terms of the strategic trade utility functions.

• **Quota game in normal form and the quota retaliation**

$N := \{1,2\}$  : the set of countries.

$\gamma$  : the inducement correspondence.

$\sigma$  : a standard-of-behavior.

$\sigma^*$  : an example of the stable standard-of-behavior.

$\sigma^{**}$  : an example of the stable standard-of-behavior.

$T := (N, \{X_k\}_{k=1,2}, \{U_k\}_{k=1,2})$ : the quota game in normal form.

$G_T := (N, X, \{U_k\}_{k=1,2})$ : the position associated with  $T$ .

$G_x := (N, \{x\}, \{U_k\}_{k=1,2})$ : a position with outcome  $x$ .

$\Gamma := \{G_T\} \cup \{G_x \mid x \in X\}$ : the set of positions for the quota retaliation as an individual contingent threats situation.

• **Others**

$\text{proj}_k(\cdot)$  : projection onto  $X_k$ ,  $k=1, 2$ .

$i(x)$  : the index number of an element of the partition (either of  $A$  or of  $B$ ) that includes the quota allocation  $x$ .

$L_k(x) := \{(q_1, q_2) \in X \mid q_k \in X_k, q_l = q_l(x) \text{ for all } l \neq k\}$ ,  $k=1, 2$ .

$L_k^+(x) := \{(q_1, q_2) \in X \mid q_k \in X_k, q_l > q_l(x) \text{ for all } l \neq k\}$ ,  $k=1, 2$ .

$L_k^-(x) := \{(q_1, q_2) \in X \mid q_k \in X_k, q_l < q_l(x) \text{ for all } l \neq k\}, k=1, 2.$

$Arc(xy)$  : a continuous path (arc) of points in  $\sigma(G_T)$  that connects quota allocations  $x$  and  $y$ .

$O_\varepsilon(x)$  :  $\varepsilon$ -neighborhood around  $x$ .

$\text{int}\sigma(G_T)$  : the interior of  $\sigma(G_T)$  relative to  $X$ .

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