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PERFECT EQUILIBRIA IN A TRADE LIBERALIZATION GAME

by

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Abstract

This paper investigates dynamic consistency of optimal temporary protection. To do so, a simple infinite horizon, perfect information game between the domestic government and the domestic firm is constructed. The government prefers liberalizing the domestic market, given the domestic firm's investment position. However, it is also willing to wait for another period if this could induce the firm to invest. The firm, if it believes that future liberalization is inevitable, prefers investing right before the liberalization in order to prepare for competition with its foreign rival. However, it may choose not to invest, hoping that this could induce the government to postpone the liberalization.

Dominant strategy, Nash, subgame perfect, Markov subgame perfect equilibria are studied. Generically, subgame perfection helps to eliminate all but a finite number of Nash equilibria, but, rather surprisingly, the optimal temporary protection can be supported by a subgame perfect equilibrium. There exists a unique Markov subgame perfect equilibrium in mixed strategies. The probability with which the optimal temporary protection succeeds and the expected length of protection period are calculated. It is shown that the success rate is higher as the government is more impatient and the firm is more patient. The expected length of the protection period is greater as both players are more patient.

1. Introduction

In trade policy debates, it is often argued that domestic industries should receive temporary protection from import competition. Immediate trade liberalization and ensuing inflows of foreign products and capital would jeopardize domestic firms, while protection would allow the domestic industries to introduce new technologies and products, thereby effectively competing with their foreign rivals. Any such protectionist measure should be temporary, because, under permanent protection, the lack of competitive pressure reduces incentives for domestic firms to rationalize their operations and to hold down costs. For example, this is the idea underlying the escape clauses in Article XIX of the General Agreement on Tariffs and Trade (GATT) and sections 201 through 203 of the U.S. Trade Act of 1974.

Despite its pervasiveness and (or perhaps, because of its) persuasiveness, very few studies have attempted to examine the logical consistency of this line of argument.[1] In a recent paper (Matsuyama and Itoh (1986)), we showed that it can be theoretically justified, using Spence's (1979) model of dynamic oligopoly market. In this model, temporary protection works for two reasons. First, it provides the domestic firm with opportunity to accumulate its capital stock. Second, the anticipation of future removal of the barrier gives an incentive for the domestic firm to do so. We also showed that such a temporary protection policy can be optimal from the national welfare viewpoint.

However, we did not advocate adopting temporary protection. For the optimality of temporary protection crucially rests on the presumption that the government can make a credible commitment on the future removal of protectionist measures, which we doubt is necessarily the case.[2] After all, there have been many protection policies, which were said to be temporary and turned out to be permanent. Indeed, this danger of prolonged protection is widely recognized. For example, McCulloch (1985, p.154) warns that:

> In principle, (temporary protection) policies provide breathing room for the affected industry, time in which to improve its competitive position or, in some cases, to phase out domestic production of goods where comparative advantage has shifted unambiguously abroad. In practice, however, neither adjustment to a status of full competitiveness nor phasing out of domestic production will necessarily occur during the limited period of import relief, so that the same industries return again and again for additional "temporary" relief.

In this paper, I will address dynamic consistency of optimal temporary protection.[3] To do so, I will consider a simple infinite horizon, perfect information game between the domestic government and the domestic firm. The government prefers liberalizing the domestic market, given the firm's investment position. However, it is also willing to wait for another period if this could induce the firm to invest. The firm, if it believes that future liberalization is inevitable, prefers investing right before the liberalization in order to prepare for competition with its foreign rival. However, it may choose not to invest, hoping that this could induce the government to postpone the liberalization.

In section 2, I will present this liberalization game formally. In section 3, I will discuss dominant strategy and iterative dominant strategy equilibria of this game, which could exist when either player has a very high discount rate. The only (iterative) dominant strategy outcome is immediate liberalization. In section 4, I will analyze Nash and subgame perfect equilibria, which are shown to exist as long as both players are sufficiently patient. Generically, subgame perfection helps to eliminate all but a finite number of Nash equilibria, but, surprisingly, optimal temporary protection can be supported by a subgame perfect equilibrium, which suggests the inadequacy of subgame perfect restriction in this game. In section 5, I will turn to the Markov subgame perfect equilibrium, which exists uniquely in mixed strategies. I will calculate the probability with which the optimal temporary protection succeeds and the expected length of the protection period. It is shown that the success rate is higher as the government is more impatient and as the firm is more patient and that, as both players are more patient, protection would last longer. The section ends by discussing an alternative interpretation of mixed strategies.

The liberalization game developed in this paper can be thought of as a "game of timing." In section 6, I will compare this game with other games of timing discussed in the existing literature. Section 7 concludes the paper.

2. The Liberalization Game

Consider the following scenario. Initially, the domestic monopoly firm (player 2) earns its maximum profit in the protected domestic market. Then, a new government (player 1) takes office and the game starts. At the beginning of period 1, the government decides whether it liberalizes the market (L) or not (NL). If it chooses L, the foreign firm enters the market and both firms play the post-entry game from period 1 on. The liberalization game ends. If the government chooses NL, the domestic firm decides whether it invests (I) or not (NI). If it chooses I, the domestic

Figure 1

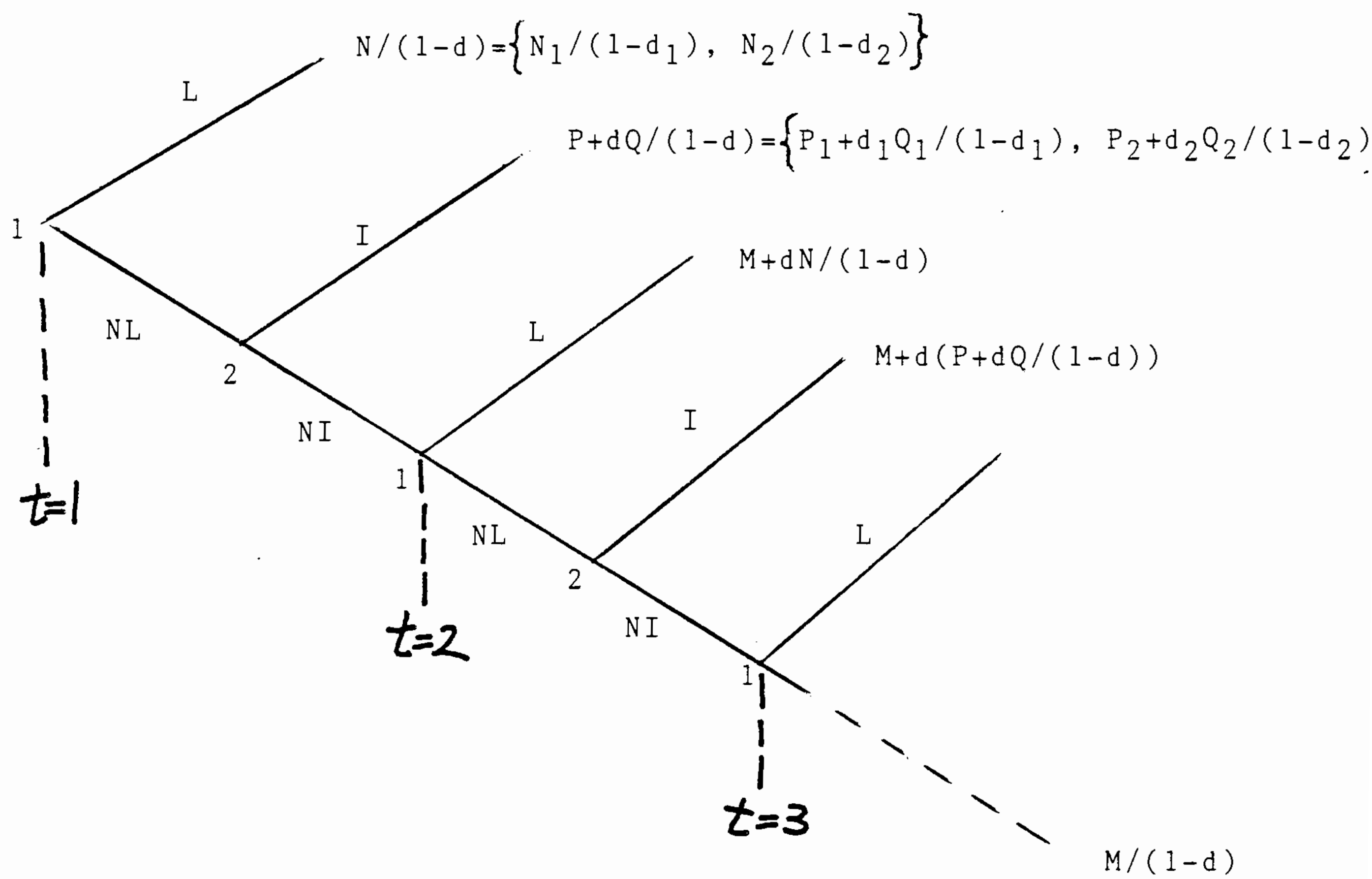
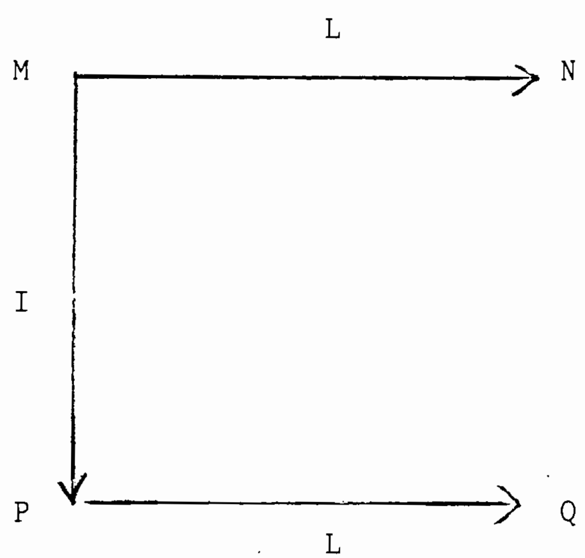


Figure 2



firm earns less profit in period 1. The government will liberalize the market at the beginning of period 2 and the foreign firm will enter and both firms will play the post-entry game from period 2 on, with the domestic firm having the first-mover advantage. The liberalization game ends. If the domestic firm chooses NI, then it earns its maximum profit in period 1. In this case, the government must decide between L and NL at the beginning of period 2 in the same situation as in period 1. This process continues until either the government chooses L or the domestic firm chooses I.

Figure 1 gives an extensive form representation of this game. Some explanations of notations are in order.

M: The government does not liberalize (NL) and the firm does not invest (NI). This is the status quo situation. Denote M_1 and M_2, national welfare and the domestic firm's profit in M, respectively.

N: The government liberalizes (L) before the firm invests. The firm plays the post-entry game with its foreign rival without the first-mover advantage. Denote N_1 and N_2, national welfare and the domestic firm's profit in N, respectively.

P: The government does not liberalize (NL) and the firm invests (I). Denote P_1 and P_2, national welfare and the domestic firm's profit in P, respectively.

Q: The government liberalizes (L) after the firm invests. The firm plays the post-entry game with its foreign rival, with its first-mover advantage. Denote Q_1 and Q_2, national welfare and the domestic firm's profit in Q, respectively. (See Figure 2)

Both players are impatient. Let $0<d_1<1$ and $0<d_2<1$ be the discount factors of the government and the firm. In Figure 1, payoffs of both players are given at each terminal node. For example, if the government chooses NL in period 1, the firm responds by NI and the government chooses L in period 2, then the state of the market is M in period 1 and N from period 2 on. Therefore, the payoff of the government is $M_1+d_1N_1+d_1{}^2N_1+d_1{}^3N_1+\ldots=$ $M_1+d_1N_1/(1-d_1)$ and the payoff of the firm $M_2+d_2N_2/(1-d_2)$. If the government never liberalizes and the firm never invests, then the market remains in M forever and the payoffs of both players are given by $M/(1-d)=$ $\{M_1/(1-d_1), M_2/(1-d_2)\}$.

I will make the following assumptions on the national welfare and the profit functions. First, given the investment position of the domestic firm, the government always prefers liberalization and the firm always prefers protection.

(A1) $M_1 < N_1$,

(A2) $P_1 < Q_1$,

(A3) $M_2 > N_2$,

(A4) $P_2 > Q_2$,

Note that (A2) is consistent with the assumption implicit above that, once the firm invests, the government liberalizes the market in the next period. Second, the firm has no incentive to invest without threat of future liberalization:

(A5) $M_2 > P_2$.

But, investment before liberalization gives the firm advantage in the post-entry game with the foreign firm: .

(A6) $Q_2 > N_2$.

Note that assumptions (A4-6) implies (A3). Finally, the government prefers the domestic firm having advantage over the foreign firm:

(A7) $Q_1 > N_1$.

Assumptions (A1-7) can be summarized by:

$$M_2 > P_2 > Q_2 > N_2,$$

$$Q_1 > N_1 > M_1;\ Q_1 > P_1.$$

Matsuyama and Itoh (1986) provides an example which satisfies assumptions (A1-7).[4] Moreover, these assumptions seem to be consistent with the view of the world held by those who advocate trade policies like escape clauses.

To analyze this game formally, it is necessary to define each player's strategy set and payoff function. A strategy for a player is a complete plan which specifies the move to be chosen for each of its decision node. Denoting the set of all positive integers by **N**, the government (player 1)'s strategy set is given by:[5]

$$S_1 := \{g \mid g : \mathbf{N} \rightarrow \{L, NL\}\},$$

where $g=\{g(1),g(2),g(3),g(4),,,,\}$ with $g(t)$ being the government's move in period t if the game has not ended. Likewise, the firm (player 2)'s strategy set is:

$$S_2 := \{f \mid f : \mathbf{N} \rightarrow \{I, NI\}\}.$$

For each pair of strategies, $(g,f) \in S = S_1 x S_2$, it is convenient to define $s(g,f)$, a sequence of moves:

$$s(g,f) := \{g(1),f(1),g(2),f(2),g(3),,,,,\}.$$

For each $(g,f) \in S$, or $s(g,f)$, there is a unique outcome of the game, i.e., the terminal node to be reached. For example, when $s(g,f)=\{L,,,,,\}$, the outcome of the game is <u>immediate liberalization</u>. When $s(g,f)=$

{NL,I,,,,}, the outcome is <u>successful one period protection</u>. A relevant case is s(g,f)={NL,I,L,,,,,,,,,}. This is the case where the government waits for one period and liberalizes in period 2, <u>no matter what</u> the firm's investment decision in period 1 is, and the firm responds by investing in period 1. Note that g(2) does not change the outcome of the game as long as f(1)=I. However, it is still important to know g(2), because the firm's incentive to invest in period 1 might depend on its expectation on g(2).

To simplify the notation further, I will introduce two functions, $m: S_1 \rightarrow N^U\{+\infty\}$ and $n: S_2 \rightarrow N^U\{+\infty\}$, as follows:

$$m(g) := \begin{cases} \text{the smallest integer } t \text{ satisfying } g(t)=L, \text{ if any.} \\ +\infty, \text{ if } g(t)=NL \text{ for all } t \in N. \end{cases}$$

$$n(f) := \begin{cases} \text{the smallest integer } t \text{ satisfying } f(t)=I, \text{ if any.} \\ +\infty, \text{ if } f(t)=NI \text{ for all } t \in N. \end{cases}$$

Then, payoff functions of the two players, $U_1: S \rightarrow R$ and $U_2: S \rightarrow R$, are given by:

$$(1) \quad U_h(g,f) := \begin{cases} [1-d_h{}^{m(g)-1}]M_h/(1-d_h) + d_h{}^{m(g)-1}N_h/(1-d_h), & \text{if } m(g) \leq n(f), \\ [1-d_h{}^{n(f)-1}]M_h/(1-d_h) + d_h{}^{n(f)-1}[P_h+d_hQ_h/(1-d_h)], & \text{if } n(f) < m(g), \end{cases}$$

for h=1, or 2. Note that, if $m(g)=n(f)=+\infty$, this implies that $U_h(g,f) = M_h/(1-d_h)$.

As shown in (1), the outcome of the game, and therefore the payoffs depend solely on m(g) if $m(g) \leq n(f)$ and solely on n(f) if $m(g) > n(f)$. However, this does not mean that one can redefine the strategy sets as $S_1' := N^U\{+\infty\}$ and $S_2' := N^U\{+\infty\}$, so that a player's strategy is simply when it chooses to end the liberalization game. This is because the credibility of both the government and the firm's actions cannot be discussed without referring to the belief on what would occur in case one of the players fails to carry out its prescribed action.

3. Dominant Strategy Equilibria

Equation (1) shows that $U_h(g,f)$ is a weighted average of $M_h/(1-d_h)$, $N_h/(1-d_h)$ and $P_h+d_hQ_h/(1-d_h)$. Therefore, from (A1):

(2) $\qquad U_1(g,f) \leq \text{Max}\ \{N_1/(1-d_1),\ P_1+d_1Q_1/(1-d_1)\}.$

Note that $N_1/(1-d_1)$ is the government's payoff when $m(g)=1$, or $s(g,f)=\{L,,,,,,\}$, i.e., when the outcome is immediate liberalization. On the other hand, $U_1(g,f) = P_1+d_1Q_1/(1-d_1)$ when $m(g)\geq 2$ and $n(f)=1$, or $s(g,f)=\{NL,I,,,,\}$, i.e., when the outcome is successful one period protection. The central question of this paper is whether "optimal" (from the national welfare viewpoint) temporary protection can be supported in an equilibrium. This suggests the following assumption.

(A8) $\qquad N_1/(1-d_1) < P_1+d_1Q_1/(1-d_1),$

which implies $U_1(g,f) \leq P_1+d_1Q_1/(1-d_1)$ from (2): that is, successful one period protection is the optimal outcome. From (A2) and (A7), (A8) is equivalent to:

(A8′) $\qquad (N_1-P_1)/(Q_1-P_1) < d_1 < 1.$

(Note that N_1 may be smaller P_1, in which case, (A8′) imposes no restriction.) (A8′) implies that, for the government to be interested in temporary protection, it may need to be patient. Otherwise, the government can always reach its first best outcome by liberalizing immediately. More formally:

Proposition 1: Suppose that (A8) does not hold. Then, any strategy g $\in$

S_2 such that $m(g)\geq 2$ is dominated by a strategy g^* with $m(g^*)=1$.[6]

Proof: See Appendix.

Therefore, the government always chooses to liberalize the domestic market. Immediate liberalization is the dominant strategy outcome. In what follows, I will assume that (A8) holds.

When (A8) holds, the government may want to postpone the liberalization, hoping that it would induce the firm to invest. The firm may invest in case the government liberalizes in the next period. This suggests that a necessary condition for temporary protection to work is:

(A9) $\quad P_2+d_2Q_2/(1-d_2) > M_2+d_2N_2/(1-d_2)$.

The left hand side of (A9) is the firm's payoff if it invests in period 1. The right hand side is the firm's payoff if it does not invest in period 1 and the government liberalizes in period 2. From (A5-6), (A9) is equivalent to:

(A9') $\quad (M_2-P_2)/[(M_2-P_2)+(Q_2-N_2)] < d_2 < 1$.

Therefore, the firm needs to be patient. If the firm is myopic, there is no way of inducing the firm to invest. To state this formally, let f* the strategy such that $f^*(t)=NI$ for all $t \in \mathbf{N}$. Then,

Proposition 2: Suppose that (A9) does not hold. Then, the strategy f* dominates any strategy $f\neq f^*$.

Proof: See Appendix.

Proposition 2 states that, if the firm is myopic enough, it always prefers earning its maximum profit (M_2), instead of preparing for possible future entry of the foreign firm. Knowing this, the government chooses to liberalize the market in period 1. This is because, for any $g \in S_1$, $n(f^*)=+\infty$ implies that:

$$U_1(g,f^*) = M_1/(1-d_1) - d_1^{m(g)-1}(M_1-N_1)/(1-d_1),$$

which is maximized only by setting $m(g)=1$, from (A1). In summary,

Proposition 3: Suppose that (A9) does not hold. Then, immediate liberalization is the iterative dominant strategy outcome.[7]

In what follows, I assume that (A9) holds.

4. Subgame Perfect Equilibria

When (A8) holds, the optimal outcome is successful one period protection. As shown in the previous section, temporary protection policy never succeeds if (A9) does not hold. What if (A9) holds? The answer depends on the equilibrium concept employed.

Let me first look at Nash equilibria. A pair of strategies $(g,f) \in S$ is a Nash equilibrium if and only if:

$$U_1(g,f) \geq U_1(g',f) \qquad \text{for any } g' \in S_1,$$

and

$$U_2(g,f) \geq U_2(g,f') \qquad \text{for any } f' \in S_2.$$

That is, at a Nash equilibrium, each player chooses its strategy to maximize its payoff, given the opponent's strategy. A Nash outcome is a terminal node to be reached at a Nash equilibrium. Proposition 4 states that optimal temporary protection can be implemented by a Nash equilibrium.

Proposition 4: Suppose that (A8) and (A9) hold. Then, any $(g,f) \in S$ such that $m(g)=2$ and $n(f)=1$ is a Nash equilibrium. Therefore, successful one period protection, $s(g,f)= \{NL, I, L, ...\}$ is a Nash outcome.

Proof: See Appendix.

At this equilibrium, the government is willing to wait in period 1 if the firm invests in period 1 ((A8)). The firm will invest in period 1 if it believes that the government will liberalize in period 2, no matter what its investment position is ((A9)); The threat of liberalization works, if believed. Moreover, since the firm invests in period 1, the government pays no cost by committing to the liberalization in period 2.

It is often argued, however, that the Nash equilibrium concept requires very weak rationality on the part of players, and therefore, allows too many outcomes, some of which are unreasonable on intuitive grounds. In the context of the liberalization game, is it reasonable for the firm to believe that the liberalization in period 2 is inevitable? Is the government's commitment credible? If the government had to choose between L and NL in period 2 after the firm chose NI in period 1 --which would never happen when the prescribed strategies $m(g)=2$, $n(f)=1$, are followed--, does the government still have an incentive to stick to the prescribed move $g(2)=L$?

To examine whether Nash equilibria possess this sort of credibility, I will look at subgame perfect equilibria, following Selten (1975). Subgame perfection requires that, at every point during any play of the game, each player must believe that its prescribed strategy will maximize its payoff in the remainder of the game. In other words, in a subgame perfect equilibrium, no player can influence the outcome of the game by trying to make a threat which it would not carry out if called upon to do so. It turns out that, generically, subgame perfection helps to eliminate all but a finite number of Nash equilibria, but, surprisingly, it is not powerful enough to eliminate "unreasonable" successful temporary protection outcomes.

In order to define subgame perfect equilibria formally, I will first introduce two functions. For any $T \in \mathbf{N}$, and any $g \in S_1$, define $g_T \in S_1$ as follows:

$$g_T(t) = \begin{cases} NL & \text{if } t < T, \\ g(t) & \text{if } t \geq T. \end{cases}$$

Likewise, define $f_T \in S_2$ by:

$$f_T(t) = \begin{cases} NI & \text{if } t < T, \\ f(t) & \text{if } t \geq T. \end{cases}$$

Note that g_T and f_T satisfy $m(g_T) \geq T$ and $n(f_T) \geq T$. Then, $(g,f) \in S$ is a <u>subgame perfect equilibrium</u> if and only if:

$$U_1(g_T, f_T) \geq U_1(g'_T, f_T) \qquad \text{for any } g' \in S_1,$$

and

$$U_2(g_{T+1}, f_T) \geq U_2(g_{T+1}, f'_T) \qquad \text{for any } f' \in S_2,$$

for all $T \in \mathbf{N}$. An outcome is <u>subgame perfect</u> if and only if there exists a subgame perfect equilibrium, which leads to this outcome. By setting T=1, one can check that a subgame perfect equilibrium is a Nash equilibrium: that is, subgame perfection is a refinement of Nash equilibria.

The following lemmas show that subgame perfection imposes strong restrictions on the firm's strategy along off-equilibrium paths. See Appendix for proofs.

Lemma 1: Let $(g,f) \in S$ be a subgame perfect equilibrium. Then, $g(T+1)=NL$ implies that $f(T)=NI$.

Lemma 2: Suppose that (A9) holds. Let $(g,f) \in S$ be a subgame perfect equilibrium. Then, $g(T+1)=L$ implies that $f(T)=I$.

Lemma 3: Suppose that (A9) holds. Let $(g,f) \in S$ be a subgame perfect equilibrium. Then, $f_T \neq f^*$ for all $T \in \mathbf{N}$.

Lemma 1 states that the firm has no incentive to invest until right before the liberalization. Lemma 2 states that the firm invests if the government liberalizes in the next period. Lemma 3 shows that for any $T \in \mathbf{N}$, there exists $t>T$ such that $f(t)=I$.

The next lemma is concerned with the subgame perfect restriction on the government's strategy. It shows how long the government would be willing to postpone the liberalization in order to induce the firm to invest, instead of liberalizing immediately. First, define a sequence $X_h:\mathbf{N} \rightarrow \mathbf{R}$ (h = 1 or 2) by:

$$X_h(q):=d_h^{q-1}[P_h+d_hQ_h/(1-d_h)-M_h/(1-d_h)] + M_h/(1-d_h).$$

Clearly, $X_h(q)$ is the payoff for player h when $m(g)>n(f)=q$, or when the outcome is successful q-period protection. When (A8) holds, (A1) implies that $P_1+d_1Q_1/(1-d_1) > N_1/(1-d_1) > M_1/(1-d_1)$ and therefore,

$$P_1+d_1Q_1/(1-d_1) = X_1(1) > X_1(2) >,,,> X_1(+\infty) = M_1/(1-d_1),$$

and there exists a positive integer q^* such that:

$$(3) \qquad X(q^*) \geq N_1/(1-d_1) > X(q^*+1),$$

which implies that the government can wait for at most q^* periods, but not for q^*+1 periods. On the other hand, from (A4-6):

$$N_2/(1-d_2) < P_2+d_2Q_2/(1-d_2) = X_2(1) < X_2(2) <,,,< X_2(+\infty) = M_2/(1-d_2).$$

It is useful to derive an alternative representation of (3). To do so, define a sequence $d: \mathbf{N} \rightarrow R$ by:

$d(q) :=$ the greatest real root of $F(x;q) = (Q_1-P_1)x^q + (P_1-M_1)x^{q-1} + M_1 - N_1 = 0$.

Note that $d(1) = (N_1-P_1)/(Q_1-P_1)$, which is the lower bound of (A8'). Furthermore, one can show that, from (A1-2) and (A7), $\mathrm{Max}\{0, d(1)\} < d(2) < d(3) <,,,< d(+\infty) = 1$, and:

(4) $\quad d(q^*) \leq d_1 < d(q^*+1)$,

is equivalent to (3). This shows that a more patient government is willing to wait longer. It also implies that, for any large positive integer q, there exists a number $d \in (d(q), 1)$, such that the government whose discount factor is equal to d is willing to wait for more than q periods.

Now, Lemma 4 can be put forward.

Lemma 4: Suppose that (A8) holds. Let $(g,f) \in S$ be a subgame perfect equilibrium such that, for some positive integers, T and q, $m(g_{T+1}) \geq T+q$ and $n(f_T) = T+q-1$. Then,

$$g(T) = \begin{cases} L & \text{if } N_1/(1-d_1) > X(q) \quad (\text{if } d_1 < d(q)) \\ NL & \text{if } N_1/(1-d_1) < X(q) \quad (\text{if } d_1 > d(q)) \\ L \text{ or } NL & \text{if } N_1/(1-d_1) = X(q) \quad (\text{if } d_1 = d(q)). \end{cases}$$

Proof: See Appendix.

Using Lemmas 1-4, the next proposition provides a complete characterization of (pure strategy) subgame perfect equilibria and outcomes of this game.

<u>Proposition 5:</u> Suppose that (A8) and (A9) hold. Let q^* be the positive integer satisfying (3), or (4).

(5.1) If $N_1/(1-d_1) < X(q^*)$ $(d_1 > d(q^*))$, there are q^*+1 pure strategy subgame perfect equilibria. They have the following periodic form:

$$s(g,f)=\{,,,,,,I;L,\underbrace{NI,NL}_{1},\underbrace{NI,NL}_{2},,,,,,,\underbrace{NI,NL}_{q^*-1},\underbrace{NI,NL}_{q^*},I;L,,,,,,,\}.$$

(5.2) If $N_1/(1-d_1) = X(q^*)$ $(d_1 = d(q^*))$, there are an infinite number of pure strategy subgame perfect equilibria, which have the following form:

$$s(g,f)=\{,,,,I;L,,,,I;L,,,,I;L,,,,I;L,,,,I;L,,,,,,,\},$$

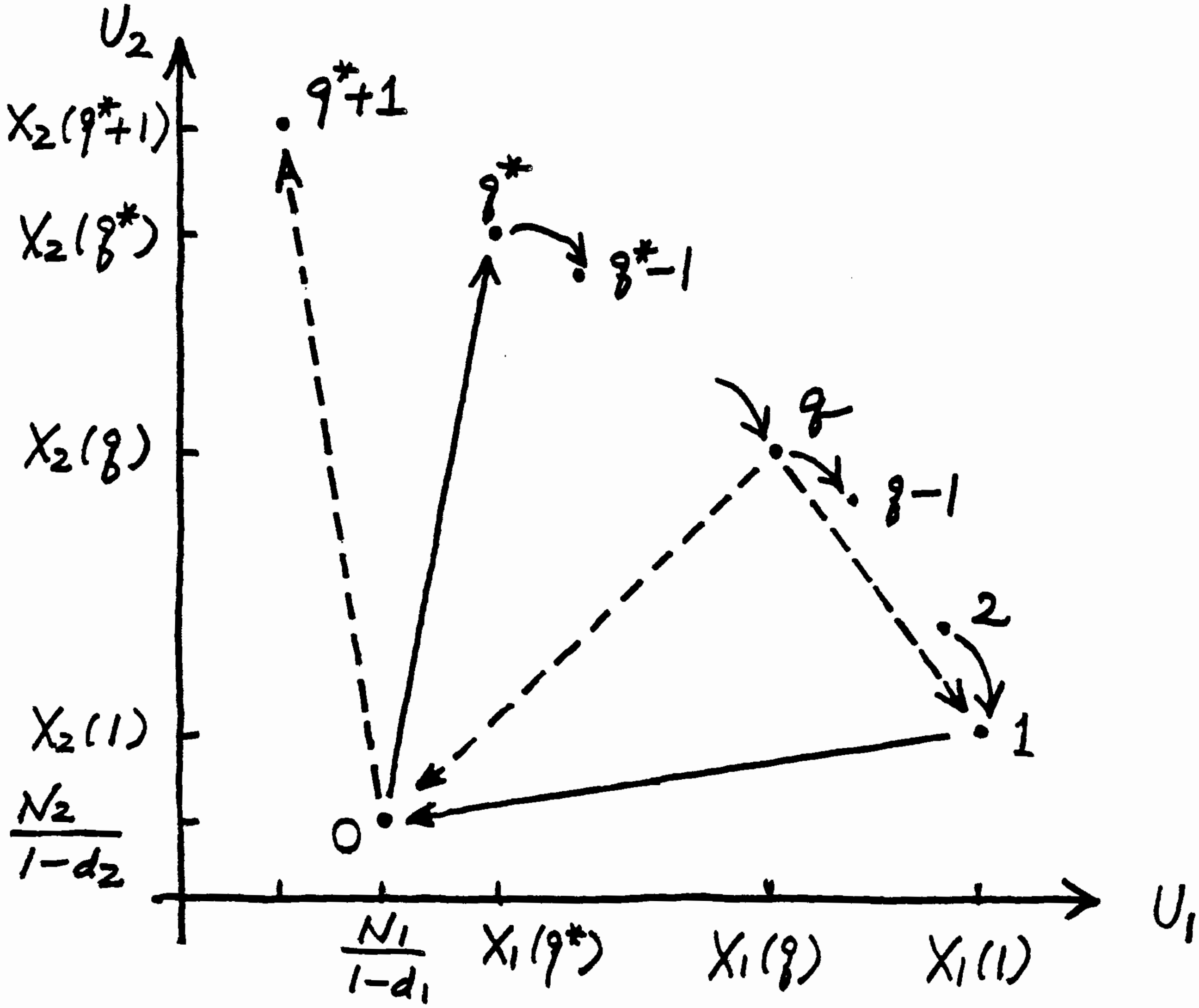
with either q^*-1 or q^* rounds of (NI,NL) between L and I.

(5.3) Only immediate liberalization and successful q-period protection, where $1 \leq q \leq q^*$, are pure strategy subgame perfect outcomes.

<u>Proof:</u> See Appendix.

Figure 3 helps to illustrate the nature of the subgame perfect equilibria shown in Proposition 5 for the case of $d(q^*) < d_1 < d(q^*+1)$. The point indexed by q (≥ 1) represents the payoff vector associated with successful q-period protection. Point 0 shows the payoffs of the immediate liberalization outcome. To demonstrate that successful q-period protection ($2 \leq q \leq q^*$) is subgame perfect, it is sufficient to show that (i) the government has no incentive to deviate from $g(1)$=NL, (ii) the firm has no incentive to deviate from $f(1)$=NI, and (iii) the restriction of the equilibrium to the subgame beginning at t=2 is also a subgame perfect equilibrium. Deviation from $g(1)$=NL to L implies the shift from point q to point 0 in Figure 3, reducing the government's payoff. This proves

Figure 3



U_2
$X_2(q^*+1)$
q^*+1
$X_2(q^*)$
q^*
q^*-1
$X_2(q)$
q
$q-1$
2
$X_2(1)$
1
$\frac{N_2}{1-d_2}$
0
U_1
$\frac{N_1}{1-d_1}$
$X_1(q^*)$
$X_1(q)$
$X_1(1)$

(i). Deviation from $f(1)=NI$ to I implies the shift from point q to point 1, reducing the firm's payoff. This proves (ii). It remains to prove (iii), but given the recursive structure of the game, this can be done by showing that successful (q-1)-period protection is subgame perfect. Repeating this process from $q=q^*$ to $q=2$, it is sufficient to show that successful one period protection is subgame perfect. This in turn can be proved by showing that immediate liberalization is subgame perfect: that is, if the next period liberalization is credible, the firm will invest in this period and the government will wait (see Proposition 4). To prove that immediate liberalization is subgame perfect, it is sufficient to prove that (i) the government has no incentive to deviate from $g(1)=L$, (ii) the firm has no incentive to deviate from $f(1)=NI$, and (iii) the restriction of the equilibrium to the subgame beginning at $t=2$ also forms a subgame perfect equilibrium. The periodic strategies shown in Proposition 5 are constructed so as to guarantee that (i) deviation from $g(1)=L$ to NL implies the shift from point 0 to point q^*+1, reducing the government's payoff, (ii) deviation from $f(1)=NI$ to I implies the shift from point q^*+1 to point 1, reducing the firm's payoff and (iii) the subgame beginning at $t=2$ has the outcome of successful q^*-period protection. Therefore, immediate liberalization is subgame perfect if successful q^*-period protection is subgame perfect. Obviously, one can repeat this whole process without leading to a contradiction.

The next proposition is a direct corollary of Proposition 5.

<u>Proposition 6:</u> Suppose that (A8) and (A9) hold. Then, optimal temporary protection $s(g,f)=\{NL,I,,,\}$ can be supported by a subgame perfect equili-

brium $(g,f) \in S$, which is defined by:

i) $g(t)=g(t+q^*+1)$, $f(t)=f(t+q^*+1)$ for all $t \in \mathbf{N}$,

ii) $g(1)=NL$, $f(1)=I$, and $g(2)=L$,

iii) $f(2)=f(3)=,,,,,=f(q^*+1)=NI$,

and

iv) if $q^* \geq 2$, $g(3)=g(4),,,,,=g(q^*+1)=NL$,

where q^* satisfies $d(q^*) \leq d_1 < d(q^*+1)$. Furthermore, if $d_1 \neq d(q^*)$, this is the only subgame perfect equilibrium, which supports optimal temporary protection.

Proposition 6 states that optimal temporary protection {NL,I,,,,,} can be supported by a subgame perfect equilibrium by making g(2)=L credible through constructing a periodic form of strategies after period 2. It demonstrates that one of the Nash equilibria shown in Proposition 4 (and, in most cases, only one of them) is a subgame perfect equilibrium. For example, {NL,I,L,NI; NL,I,L,NI; ,,,} is a subgame perfect equilibrium if $\text{Max}\ \{0,d(1)\} < d_1 \leq d(2)$, and {NL,I,L,NI,NL,NI; NL,I,L,NI,NL,NI; ,,,,} if $d(2) < d_1 \leq d(3)$.

The question is then: are these equilibria "reasonable"? My answer is "probably not." First, these equilibria have a "bootstrap" nature. The government conditions its behavior on the past history of the game up to q^*+1 periods only because the firm does so, and the firm does so only because the government does so. Second, successful one period protection can be made credible only if immediate liberalization is credible. But, in the subgame perfect equilibrium shown above, immediate liberalization can be made credible only because, if it would fail to liberalize, the government would punish itself by making a commitment not to liberalize for some time to come. This "self-punishing" property makes this equilibrium hardly convincing.

Third, a non-cooperative solution like a subgame perfect equilibrium is sometimes interpreted as a "self-enforcing agreement." Imagine the situation where players can freely discuss their strategies, but cannot make binding commitments. Then any viable agreement must be self-enforcing: that is, once players agree to play equilibrium strategies, no player has an incentive to renege. In games with many equilibria as the liberalization game, this interpretation is appealing as a way of explaining how players know which equilibrium is to be played. Moreover, in the liberalization game, if the government and the firm were barred from communicating with each other, they could hardly coordinate their strategy choices so that one of the bootstrap equilibria described above would emerge. However, this ability to communicate itself would make these equilibria untenable. To see why, consider a subgame perfect equilibrium supporting immediate liberalization. As shown in Figure 3, this outcome is Pareto-dominated by other subgame perfect outcomes. Therefore, it is hard to imagine that the government and the firm agree upon this outcome. But, once they recognize this, other subgame perfect equilibria would become also untenable. More specifically, consider optimal temporary protection in Proposition 6. If the firm reneges and does not invest in period 1, the government is supposed to liberalize in period 2. But, at the beginning of period 2, the firm could make a proposal of moving to an alternative subgame perfect outcome which is more attractive to both the government and the firm than immediate liberalization. If the firm realized that it could renegotiate with the government in this way, it might find not to invest advantageous. Therefore, optimal temporary protection equilibria would collapse. Likewise, all equilibria in Proposition 5 have the same problem. In a nutshell, they are not renegotiation-proof.

Finally, the periodic nature of the strategies seems at odds with the following intuitive, although somewhat ad-hoc, argument. If the firm does not invest in period 1, the situation the government faces in period 2 is exactly the same as in period 1, given the recursive structure of the game. If the government did not liberalize in period 1, how can one believe that it does not do the same in period 2?

This last consideration leads to a stronger restriction on equilibria: that is, each player must choose the same move when he faces the same situation. In the next section, I will turn to a Markov subgame perfect equilibrium, which satisfies this requirement.[8]

5. Markov Subgame Perfect Equilibrium

The Markov equilibrium requires that strategies depend only on "payoff-relevant" history.[9] This helps to eliminate the bootstrap equilibria. In the context of this liberalization game, the Markov property simply implies that each player chooses the same action at each node.

Once the Markov property is imposed, one cannot hope that a subgame perfect equilibrium exists in pure strategy space, if (A8) and (A9) hold. This is a direct consequence of Proposition 5, which states that every pure strategy subgame perfect equilibrium has a periodic form, with the period equal to q^*+1.[10] Intuition behind the non-existence in pure strategies should be clear. If the firm believes that the government will liberalize with probability one, it would invest. But, if the government believes that the firm will invest with probability one, it would wait. But, if the firm believes that the government will wait, it would not invest. But, if the firm will not invest, the government would not wait. But, if....

In this section, I allow randomized strategies. Both players are assumed to be risk-neutral. Figure 4 shows how to find a Markov subgame perfect equilibrium. The vector $V=(V_1, V_2)$ represents the value of (the remainder of) the game for both players. In each round, the government chooses L with probability u and the firm chooses I with probability v. Let (u^*, v^*) denote an equilibrium mixed strategies. Then, from the argument above, $0<u^*<1$, $0<v^*<1$. This implies that both players are indifferent between their alternatives: that is,

$$P_2+d_2Q_2/(1-d_2) = M_2+d_2V_2 \tag{5}$$

$$N_1/(1-d_1) = v^*\{P_1+d_1Q_1/(1-d_1)\} + (1-v^*)(M_1+d_1V_1). \tag{6}$$

Furthermore, $V=(V_1,V_2)$ satisfies;

$$V_1 = N_1/(1-d_1) \tag{7}$$

$$V_2 = u^*N_2/(1-d_2) + (1-u^*)\{P_2+d_2Q_2/(1-d_2)\}. \tag{8}$$

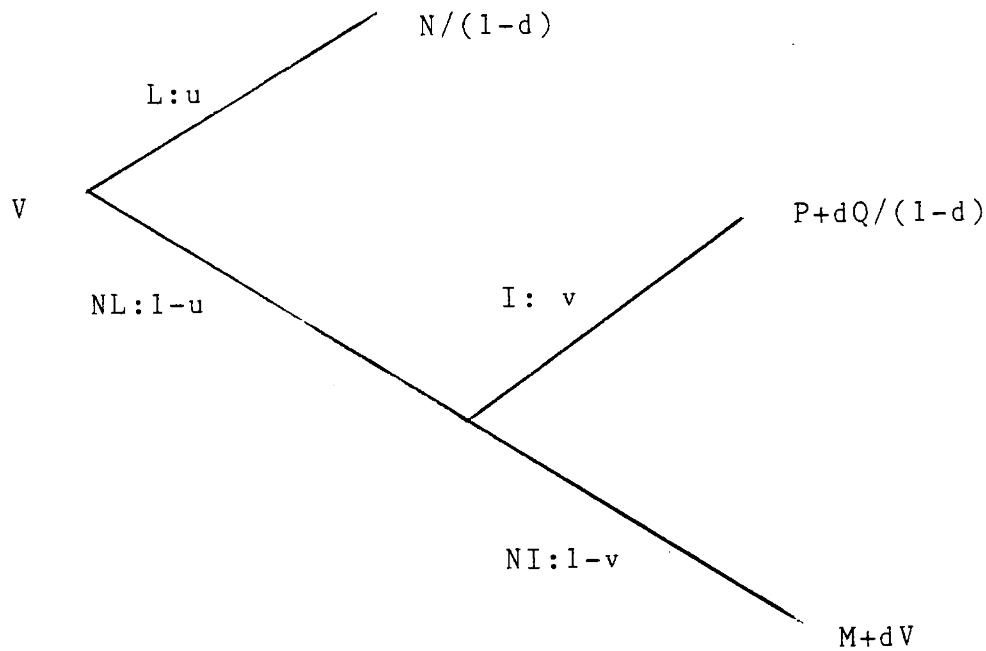
Eliminating V_1 and V_2 from (5-8) gives:

$$N_1/(1-d_1) = v^*\{P_1+d_1Q_1/(1-d_1)\} + (1-v^*)\{M_1+d_1N_1/(1-d_1)\} \tag{9}$$

$$P_2+d_2Q_2/(1-d_2) = M_2 + d_2[u^*N_2/(1-d_2) + (1-u^*)\{P_2+d_2Q_2/(1-d_2)\}]. \tag{10}$$

There is a unique $0<u^*<1$, which satisfies (10) and a unique $0<v^*<1$, which satisfies (9). Furthermore, u^* is a function of d_2, but not of d_1 and v^* is a function of d_1, but not of d_2, which allows us to denote $u^*=u(d_2)$ and

Figure 14



$v^*=v(d_1)$. One can also show that these functions have the following properties: $u(d_2)$ is decreasing in d_2, $u(d_2)\rightarrow 1$ as $d_2\rightarrow \underline{d}$, where $\underline{d}$ is the lower bound of (A9′), and $u(d_2)\rightarrow 0$ as $d_2\rightarrow 1$; $v(d_1)$ is decreasing in d_1, $v(d_1)\rightarrow 1$ as $d_1\rightarrow d(1)$, and $v(d_1)\rightarrow 0$ as $d_1\rightarrow 1$. In other words:

<u>Proposition 7:</u> Suppose that (A8) and (A9) hold. Then, there exists a unique mixed strategy Markov subgame perfect equilibrium, in which the government chooses L with probability $u(d_2)$ and the firm chooses I with probability $v(d_1)$, where both $u:(\underline{d},1)\rightarrow(0,1)$ and $v:(d(1),1)\rightarrow(0,1)$ are decreasing, one-to-one functions.[11]

It is easy to see why functions u and v have these properties. In order to make the choice between L and NL indifferent, a more impatient government (a lower d_1) needs to be convinced that it is likelier that the firm would invest before liberalization, if another chance is given (a higher v^*). Likewise, in order to be indifferent between I and NI, a more myopic firm (a lower d_2) needs to be convinced that future liberalization is likelier, even if it does not invest (a higher u^*).

From (7), the value of the game to the government is equal to $N_1/(1-d_1)$. It fails to achieve its maximum payoff due to its inability to make a credible commitment on the second period liberalization:

$$V_1 = N_1/(1-d_1) < P_1+d_1Q_1/(1-d_1).$$

The probability with which optimal temporary protection succeeds is given by $(1-u^*)v^*$, or:

$$[1-u(d_2)]v(d_1).$$

The success rate is higher as the government is more impatient and as the firm is more patient. An alternative measure of "success" would be the probability with which the firm will eventually invest and the market ends up in Q. This is given by:

$$(1-u^*)v^*/[1-(1-u^*)(1-v^*)],$$

which is also decreasing in d_1 and increasing in d_2. One can also calculate the expected length of protection. The market is liberalized in period 1 with probability u^*. The second period liberalization has probability equal to $(1-u^*)v^*+(1-u^*)(1-v^*)u^*=(1-u^*)\{1-(1-u^*)(1-v^*)\}$. In general, protection lasts for T periods with probability $(1-u^*)\{1-(1-u^*)(1-v^*)\}\{(1-u^*)(1-v^*)\}^{T-1}$. From this, the expected length of protection is:

$$(1-u^*)/\{1-(1-u^*)(1-v^*)\},$$

which increases with d_1 and d_2. Therefore, if both players are more patient, protection would last longer.

To some economists, mixed strategies seem odd and less appealing, but they would appear more reasonable upon closer inspection. Certainly, it is hard to imagine the chairperson of the International Trade Commission (ITC) or the president casting dice to decide whether or not to protect the domestic industries not ready to face import competition. However, this aspect of the equilibrium is attributable to the fact that there is no chance move in the model. To see this, note that randomizing matters, not because it would affect the distribution of the player's payoff directly, but because it would keep the opponent uncertain about the player's choice. (This also explains why the probability distribution of the player's choice depends on the opponent's discount rate, but not on the player's.) Therefore, a random disturbance to the player's payoff, which is unknown when the opponent moves but known when the player moves would do.[12] For example, suppose that, in each period, uncertainty about the domestic demand resolves after the government's move and before the firm's. The firm can make a choice deterministically contigent on the market condition, but the government knows only the probability distribution of the firm's choice. Likewise, the government's decision in the next period would reflect new developments on economic and political situations after the firm's investment decision in this period. Then, even if the government uses pure strategies, the firm is uncertain about the government's move.

In reality, it is highly uncertain whether a domestic industry would receive temporary protection. For example, Lawrence and Litan (1986, Table 3-2) reports the U.S. experience of escape clause relief. It shows that, between 1975 and 1985, the presidents have granted domestic industries import relief in only fourteen of the thirty three cases in which the ITC affirmed import injury. It is not difficult to imagine that the presidents made their decisions taking into account many factors which did not exist when these industries had brought the cases before the ITC.

6. Games of Timing

It would be instructive to compare the game developed in this paper with other games known in the existing literature.

The liberalization game belongs to a class of games called "games of timing." In a simple game of timing, each player's only choice is when and whether to take a single pre-specified action, and the game ends once one player has moved. Two kinds of timing games are extensively discussed in the literature. The first is the "war of attrition" developed in theoretical biology. Two animals fight over a territory. Fighting costs. Once one animal quits, its opponent gains the territory. This game has been applied to the problem of exit. See, for example, Ghemawat and Nalebuff (1985); Think of a declining industry where, if two firms remain active, each makes losses and, if one firm exits, the other can make a profit. In a war of attrition, each player prefers that the other moves first, but, if it has to move first, it prefers to do so sooner.

On the other hand, in the second type of game of timing, "preemption game", each player prefers to move first, but, it prefers to do so later. See Fudenberg and Tirole (1985) and Pitchik (1982); The two firms plan to introduce a new product to the market that can profitably support only one firm, and it would be cheaper to introduce the product later. Or see Holt and Sherman (1982); A ticket to the concert will be given at the ticket office on a first-come first-served basis, and nobody wants to wake up early.

One can think of the liberalization game as a hybrid of a war of attrition and a preemption game; The government's payoff has the same property as in a war of attrition, while the firm's payoff has the same as in a preemption game. That is, the government prefers that the firm moves first (invest before liberalization), but if it has to move first (liberalize before investment), it prefers to do so sooner. On the other hand, the firm prefers to move first (invest before liberalization), but it prefers to do so later.

7. Concluding Remarks

In this paper, I have investigated dynamic consistency of optimal temporary protection, by constructing a simple, infinite horizon, perfect information game between the domestic government and the domestic firm. I examined subgame perfect equilibria under the assumptions which guarantee that optimal temporary protection can be supported by a Nash equilibrium. Generically, subgame perfection helps to eliminate all but a finite number of equilibria, but, rather surprisingly, optimal temporary protection can be supported by a subgame perfect equilibrium. This is because the threat of period 2 liberalization can be made credible through constructing a particular periodic form of strategies after period 2. I do not find this equilibrium intuitively appealing. There exists a unique Markov subgame perfect equilibrium in mixed strategies. In this equilibrium, the government's payoff is smaller than in the first best outcome, due to its inability to make a credible commitment.

However, this does not necessarily imply that the government has no way of making a credible commitment to the future liberalization in reality. There are several possibilities which the liberalization game fails to take into account. First, the government might be aware of "the demonstration effect" of liberalization. If there are an infinite number of industries, which ask for import relief sequentially, the government can and has incentive to build a reputation to be tough through a similar mechanism as the Folk Theorem in the repeated Prisoner's Dilemma game. Second, the government might be able to sign a contract with a third party (perhaps, the GATT) to make the cost of renewal of temporary protection prohibitively high. Third, the domestic government might want to ask a foreign government to exert diplomatic pressure to liberalize the domestic market (as some observers suspect that Japanese Ministry of International Trade and Industry (MITI) has done with the United States). Of course, these mechanisms should be analyzed more formally by explicitly modifying the game between the government and the firm, which I will leave on the agenda for future research.

Throughout the paper, I have asked whether a particular equilibrium is reasonable by investigating its credibility. An alternative criterion of "reasonableness" would be its robustness. If a set of possible equilibria disappears when the game is slightly perturbed in a natural way, one cannot rely on such equilibria in prediction. For one can never be sure of the exact nature of the games governments and firms play in reality. Therefore, it is highly desirable to examine the robustness of equilibria by, say, introducing informational asymmetry into the game.

Perhaps, the most problematic feature of the model would be its treatment of the domestic government as a unified, coherent body of decision-makers. In reality, any economic policy is a product of complex interactions among different parts of the government, each of which has its own objectives. In fact, a number of recent studies deal with the political economy of protectionism, as exemplified in Baldwin (1985). The approach adopted here should be regarded as a complement of, not a substitute for this growing body of literature.

Finally, some mention should be made regarding two other possible solutions to avoid permanent protection. First, some observers suggest that temporary protection should be granted to domestic industries only when they commit to adjustment plans. This view is reflected in a number of recent congressional proposals to reform the U.S. escape clause. In the context of the liberalization game, this amounts to enforcing the domestic firm to invest during the protection period. This approach, however, requires the government to participate actively in retooling process of the industries. The danger of such government intervention in practice might be substantial and it is well documented.[13] Second, one might hope that the danger of prolonged protection can be reduced by designing appropriate institutional arrangements. In fact, it is often argued that the escape clause itself is "a useful safety valve for protectionist pressures (Dam (1970,p.106))." However, this approach is, at best, an imperfect solution to the problem. As long as temptations to provide further protection remain, there exists a tendency to circumvent the institutional arrangements, as suggested by the recent drift of U.S. practice away from the escape clauses in negotiating orderly market arrangements and voluntary export restraints.

Appendix

Proof of Proposition 1:

For any $f \in S_2$, $U_1(g^*,f)=N_1/(1-d_1)$ since $m(g^*)=1$. From (2) and the assumption that (A8) does not hold, this implies:

$$U_1(g^*,f)=N_1/(1-d_1) \geq U_1(g,f) \qquad \text{for all } f \in S_2.$$

Take f' such that $n(f') \geq 2$. Then, from (A1), $U_1(g,f')$ is strictly less than $N_1/(1-d_1)$, because $m(g)$, $n(f') \geq 2$ implies that a positive weight is attached to $M_1/(1-d_1)$. Therefore,

$$U_1(g^*,f')=N_1/(1-d_1)>U_1(g,f').$$

Thus, g^* dominates g. Q.E.D.

Proof of Proposition 2:

Note that $n(f^*)=+\infty$ and $n(f)<+\infty$ for any $f \neq f^*$. Take any $g \in S_1$. If $m(g) \leq n(f) < n(f^*)$, $U_2(g,f)=U_2(g,f^*)$. If $n(f)<m(g) \leq n(f^*)$, then,

$$\begin{aligned} U_2(g,f) &= [1-d_2^{n(f)-1}]M_2/(1-d_2) + d_2^{n(f)-1}[P_2+d_2Q_2/(1-d_2)] \\ &\leq [1-d_2^{n(f)-1}]M_2/(1-d_2) + d_2^{n(f)-1}[M_2+d_2N_2/(1-d_2)] \\ &= [1-d_2^{n(f)}]M_2/(1-d_2) + d_2^{n(f)}N_2/(1-d_2) \\ &\leq [1-d_2^{m(g)-1}]M_2/(1-d_2) + d_2^{m(g)-1}N_2/(1-d_2), \quad \text{as } m(g) \geq n(f)+1. \\ &= U_2(g,f^*). \end{aligned}$$

The first inequality is due to the assumption that (A9) does not hold. The second inequality holds strictly when $m(g)>n(f)+1$, since $M_2 > N_2$ ((A3)). This implies that:

$$U_2(g,f) \leq U_2(g,f^*) \text{ for all } g \in S_1,$$

and:

$$U_2(g,f) < U_2(g,f^*) \text{ for some } g \in S_1.$$

Q.E.D.

Proof of Proposition 4:

For any f such that $n(f)=1$,

$$U_1(g,f)=\begin{cases} N_1/(1-d_1) & \text{if } m(g)=1 \\ P_1+d_1Q_1/(1-d_1) & \text{if } m(g)\geq 2. \end{cases}$$

Therefore, (A8) implies that any g with $m(g)=2$ is the best response to f. For any g such that $m(g)=2$,

$$U_2(g,f)=\begin{cases} P_2+d_2Q_2/(1-d_2) & \text{if } n(f)=1 \\ M_2+d_2N_2/(1-d_2) & \text{if } n(f)\geq 2. \end{cases}$$

Therefore, (A9) implies that any f with $n(f)=1$ is the best response to g.

Q.E.D.

Proof of Lemma 1:

Note that $g(T+1)=NL$ implies $m(g_{T+1})\geq T+2$. If $n(f_T)=T$, then,

$$\begin{aligned} U_2(g_{T+1},f_T) &= (1-d_2{}^{T-1})M_2/(1-d_2) + d_2{}^{T-1}(P_2+d_2Q_2/(1-d_2)) \\ &< (1-d_2{}^{T})M_2/(1-d_2) + d_2{}^{T}(P_2+d_2Q_2/(1-d_2)) \quad \text{(from (A4-5))} \\ &= U_2(g_{T+1},f'_T) \end{aligned}$$

for any $f'\in S_2$ such that $n(f'_T)=T+1$, which contradicts the subgame perfection. Therefore, $n(f_T)\neq T$, or $f(T)=NI$. Q.E.D.

Proof of Lemma 2:

Note that $g(T+1)=L$ implies $m(g_{T+1})=T+1$. If $n(f_T)\geq T+1$,

$$\begin{aligned} U_2(g_{T+1},f_T) &= (1-d_2{}^{T})M_2 + d_2{}^{T}N_2/(1-d_2) \\ &= (1-d_2{}^{T-1})M_2/(1-d_2) + d_2{}^{T-1}(M_2+d_2N_2/(1-d_2)) \\ &< (1-d_2{}^{T-1})M_2/(1-d_2) + d_2{}^{T-1}(P_2+d_2Q_2/(1-d_2)) \quad \text{(from (A9))} \\ &= U_2(g_{T+1},f'_T) \end{aligned}$$

for any $f'\in S_2$ such that $n(f'_T)=T$, which contradicts the subgame perfection. Since $n(f_T)\geq T$, this implies $n(f_T)=T$, or $f(T)=I$. Q.E.D.

Proof of Lemma 3:

Suppose that $f_T=f^*$ for some $T\in\mathbf{N}$. Then, it also implies $f_{T+1}=f^*$. Since $n(f_{T+1})=n(f^*)=+\infty$,

$$U_1(g_{T+1},f_{T+1}) = M_1/(1-d_1) - d_1^{m(g_{T+1})-1}(M_1-N_1)/(1-d_1).$$

From (A1), this is maximized if and only if $m(g_{T+1})=T+1$, or $g(T+1)=L$ (Recall $m(g_{T+1}) \geq T+1$). Due to Lemma 1, this implies $f(T)=I$, which contradicts $f_T=f^*$. Q.E.D.

Proof of Lemma 4:

If $g(T)=L$, then $m(g_T)=T\leq n(f_T)$. Therefore,

(*) $$U_1(g_T,f_T) = (1-d_1^{T-1})M_1/(1-d_1) + d_1^{T-1}N_1/(1-d_1).$$

If $g(T)=NL$, then $m(g_T)\geq T+q>n(f_T)$. Therefore,

(**) $$U_1(g_T,f_T) = (1-d_1^{T+q-2})M_1/(1-d_1) + d_1^{T+q-2}(P_1+d_1Q_1/(1-d_1))$$

$$= (1-d_1^{T-1})M_1/(1-d_1) + d_1^{T-1}[M_1/(1-d_1) + d_1^{q-1}\{P_1+d_1Q_1/(1-d_1)-M_1/(1-d_1)\}].$$

$$= (1-d_1^{T-1})M_1/(1-d_1) + d_1^{T-1}X(q).$$

From comparison of (*) and (**) , the conclusion is immediate. Q.E.D.

Proof of Proposition 5:

(5.1) From Lemma 3, there exists T' such that $f(T'+q^*)=I$. The conditions in Lemma 4 are satisfied with $T=T'+q^*$ and $q=1$. Therefore, $g(T'+q^*)=NL$, since $X(1) = P_1+d_1Q_1/(1-d_1) > N_1/(1-d_1)$ ((A8)). From Lemma 1, $f(T'+q^*-1)=NI$. Using Lemma 4 and Lemma 1 repeatedly,

$$f(T'+q^*-1)= f(T'+q^*-2)= f(T'+q^*-3)=,,,,,,,= f(T'-1)= f(T')=NI,$$

$$g(T'+q^*)= g(T'+q^*-1)= g(T'+q^*-2)=,,,,,,,= g(T'+2)= g(T'+1)=NL,$$

and,

$$g(T')=L.$$

Therefore, from Lemma 2, $f(T'-1)=I$. Repeating this process proves (5.1). The proof of (5.2) can be done in a similar manner. (5.3) is immediate from (5.1) and (5.2). Q.E.D.

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Footnotes:

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1. In the standard literature of infant industry protection, the argument for temporary protection is based on the technological assumption that dynamic external economies, which could justify protection policies, disappear once the industry becomes mature. For example, Corden (1974, p.256) discusses why protection should be temporary.

> The temporary element can enter in three ways. (1) The learning may itself be temporary, being a characteristic of the firm's infancy period. (2) The imperfection of information or of the capital market, as these apply to the firm concerned, may be temporary: as the firm expands and its costs fall it may find it easier to finance further investments, whether in visible or invisible capital. (3) We may be constrained to the use of a tariff as a method of protection (the fiscal constraint ruling out direct or indirect export subsidization), so that the tariff could end once imports of the product have been completely replaced, and <u>should</u> end if the firm has monopoly power and above-normal profits are to be avoided.

On the other hand, the common argument in trade policy debates puts more emphasis on the incentive effect of temporary protection. For example, the OECD study (1985, p.22) argues that:

> Protection itself becomes less effective in promoting adjustment when --as a result of the repeated renewal of protectionist measures-- the firms being protected have no reason to expect that they will even be exposed to the full challenge of international competition.

2. This is not the only reason why we did not advocate temporary protection. See the concluding section of Matsuyama and Itoh (1986) for other reasons.

3. Seminal papers on the issues of dynamic consistency of optimal economic policies are Calvo (1978) and Kydland and Prescott (1977). Most of recent developments center on monetary policies: see Barro (1986) and Rogoff (1986) for surveys. Little works have addressed this issue in trade policies: see Maskin and Newberry (1986) and Staiger and Tabellini (1986) for exceptions.

4. This example in Matsuyama and Itoh (1986) also satisfies that $P_1 > M_1$: the domestic firm under-invests. However, I do not use this assumption below.

5. I consider only pure strategies until section 5.

6. Strategy x of a player is a dominated strategy if and only if there exists a strategy y of the player such that (i) it never pays more to play x than y, and (ii) it pays less for some strategy choices by the opponent. When elimination of dominated strategies is sufficient to predict the unique outcome, the game has a dominant strategy equilibrium and the outcome is called the dominant strategy outcome.

7. When successive elimination of dominated strategies leads to the unique outcome, the game has an iterative dominant equilibrium (or a dominance solvable equilibrium) and the outcome is called the iterative dominant outcome.

8. An alternative would be to impose a "renegotiation-proofness." However, it remains unsettled how to formalize the idea of renegotiation-proofness: see Farrel and Maskin (n.d.) and Pearce (1987).

9. See Maskin and Tirole (1986) for discussion on Markov equilibria.

10. More generally, one can conclude from Proposition 5 that, if strategy spaces are restricted so that a strategy has a finite memory up to q^*-1 periods, there exists no subgame perfect equilibrium in pure strategies. (In this game, a Markov strategy can be thought of as a strategy with no memory.)

11. It remains an open question whether a non-Markov mixed strategy subgame perfect equilibrium exists.

12. Harsanyi (1973) proves that, in a static game context, a mixed strategy equilibrium in a game with deterministic payoffs can be approximated as a pure strategy equilibrium in a game with randomly disturbed payoffs.

13. See U.S. Council of Economic Advisers (1984, pp.108-9) and Lawrence and Litan (1986,pp.84-96).