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TARIFFS WITH PRIVATE INFORMATION AND REPUTATION

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ABSTRACT

When governments choose trade policy, rarely do they have complete information. At the time decisions are made, policy makers have only estimates of market responses, as well as the responses of foreign governments. In many realistic situations, even the policy objectives of other governments may not be known. For example, the balance of constitutional powers in the United States is often cited as a source of confusion as to objectives of U.S. trade policy.

In this paper we examine the Bayesian Nash equilibria of several noncooperative tariff games with incomplete information. In the models examined, the home country has private information about whether its government is a low or high tariff type. If the foreign government is uncertain about this type in a one-shot game, its Nash equilibrium tariff will be lower (higher) than if it knew the home government were a low (high) tariff type. In two multistage games, misleading behavior by the home government is shown to be an equilibrium strategy for sufficiently high discount factors. Whether the uncertainty is persistent or can be resolved is shown to be important for welfare results in the multistage setting. In the models examined, tariff rules do not necessarily dominate discretionary policy.

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1. Introduction

When governments choose trade policy, rarely do they have complete information. At the time decisions are made, policy makers have only estimates of market responses, as well as the responses of foreign governments.[1] In many realistic situations, even the policy objectives of other governments may not be known. For example, the balance of constitutional powers in the United States is often cited as a source of confusion as to objectives of U.S. trade policy (Baldwin (1986), Dixit (1987a), and Richardson (1987)).[2]

In this paper we examine the Bayesian Nash equilibria of several noncooperative tariff games with incomplete information. Incomplete information is modelled as uncertainty about one country's optimum tariff schedule in a two country tariff game. At the time tariffs are chosen, this country's government has private information about either market or political conditions at home. Hence its true tariff schedule (reaction function) is unknown to the foreign country when tariffs are chosen. We shall focus on two issues: (i) how this type of uncertainty affects Nash equilibrium tariffs in a simple optimum tariff game, and (ii) whether it is worthwhile for the government with private information to misrepresent its true tariff schedule. To address the second of these, we examine subgame perfect equilibria of two multistage games. The question addressed is when it is an equilibrium strategy for the government to levy a tariff, not because it is the true optimum in an immediate sense, but to establish a reputation which will be useful in future periods. The question of how reputations of governments affect the time-path of trade policy has been asked in several recent policy studies (see, for example, Dixit (1987a) and Richardson (1987)), and this analysis provides some insight in the context of an optimum tariff model.

In Section 2 we describe the basic trade model and examine the Bayesian Nash equilibrium tariffs of a one-shot game. In Section 3 we examine two multistage games in which misleading

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[1] The uncertainty faced by policy makers because of inadequate information on producer and consumer behavior is more than an academic issue. For example, the range of estimates for foreign demand for U.S. agricultural products is so large that in 1987, the International Agricultural Trade Research Consortium (Carter and Gardiner, 1988) organized a conference designed to inform policy makers as to how consensus estimates might be achieved to aid in trade policy decisions.

[2] It is also easy to find realistic examples of private information when decision making is more centralized. See, for example, Japan's Rice Policy (USDA, 1981, p. 2) on the objectives of the Japanese Food Agency with regard to rice policy. An extremely interesting account of trade wars by Conybeare (1987) touches on these issues.

behavior by the government with private information can be an equilibrium strategy for high enough discount factors. The equilibria we examine are subgame perfect with the property that each government's beliefs are consistent with each other and the equilibrium strategies.

The two multistage games are distinguished by whether it is possible for the uncertainty to be resolved after the first stage or whether the uncertainty is persistent. To clarify what we mean by this, consider the following games with two stages. The first game begins with a random move which determines the true tariff schedule for both stages. The second game makes the alternative assumption that between the first and second stages there is an additional random move determining the true tariff schedule in the second stage. Although the latter assumption is not commonplace, it is not without precedent (see, for example, Rosenthal (1979)). The essential difference in the two games is that, in the second game, random shocks occur frequently enough that in stage one even the home government does not know the state of nature in stage two. One might think of the first game being applicable when a new government comes to power and is known to remain in power for two stages. If elections occur at each stage or if there are frequent production shocks, for example, then the game with persistent uncertainty would apply.

Both separating and pooling equilibria (the latter involving misleading behavior) are shown to exist in both multistage games. Pooling as an equilibrium of the game with persistent uncertainty is particularly interesting since incurring a stage one loss in order to establish a reputation cannot be beneficial to the misleading government if it is not in power in stage two. By analyzing both games, we show how ex ante welfare in the pooling equilibrium depends on the type of uncertainty underlying the model. In particular, we show conditions under which ex ante expected welfare of the misleading government is smaller in the game with persistent uncertainty. The intuition underlying the result is that it is harder for a government to successfully misrepresent itself with persistent uncertainty.

Private information in tariff games has also been analyzed by Feenstra (1987), Feenstra and Lewis (1988), and Riezman (1987). Feenstra examines incentive compatible trade policies with production uncertainty and Feenstra and Lewis address similar issues in a model with private information about political pressure. Riezman's model is an infinitely repeated game in which countries use trigger strategies and symmetric punishments. He shows that unobservable tariffs can prevent the attainment of free trade as an equilibrium. All of this work, as well as that of Dixit (1987b), Jensen and Thursby (1984), and Bagwell and Staiger (1988), focuses on when cooperation can be attained in a policy game. Our work is quite different since we are interested in the effect of private information on noncooperative equilibria, per se. Much of our analysis focuses on how the persistence (or nonpersistence) of uncertainty affects the incentives for governments to establish tariff reputations and how this affects noncooperative equilibria of the game.[3] Our results also show that whether rules are better than discretion depends on the nature of the rule.

2. A Static Bayesian Tariff Game

In this section we analyze a static tariff game between two countries when one of the countries has incomplete information about the other's reaction function. Governments choose their tariffs simultaneously. At the time tariffs are chosen the home government knows the foreign country's best response to any home tariff, but it has private information about its own best response to foreign tariffs. The foreign country is therefore uncertain about the home reaction function when it chooses its tariff. In order to solve the game, we assume the foreign government is Bayesian with a prior distribution on the possible home reaction functions. We assume this distribution is common knowledge, so that the home country knows the foreign country's prior distribution, the foreign country knows that the home country knows this prior, and so on.

To allow us to focus on the role of private information, we focus on a familiar underlying trade model. It is a standard two country, two good optimum tariff model with the exception that the home country's optimum tariff schedule (i.e. reaction function) is known only to the home country at the time tariffs are chosen. Producers and consumers in each country are atomistic, but the government of each country can affect the terms of trade by an import tariff, denoted by t for the

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[3] There is a large literature on other implications of uncertainty in trade models. For a few examples of studies which focus on trade policy, see Anderson and Young (1982), Cassing, Hillman, and Long (1985), Eaton and Grossman (1985), Newbery and Stiglitz (1984), Stockman and Dellas (1986), Young and Anderson (1980, 1982), and Young and Magee (1984).

home country and t^* for the foreign country. The foreign government's objective is to maximize aggregate utility, and both governments know the parameters of this function. In indirect form, foreign utility is given by $V^*(t, t^*)$. The home government chooses t to maximize an indirect utility function, but the foreign government is uncertain about its parameters. For simplicity, we consider two possible states (i.e. sets of parametric values).[4] With probability α, the function $V^{\ell}(t, t^*)$ describes the home country's objective function, and with probability $(1-\alpha)$, the function $V^h(t, t^*)$ represents the home country's objective function. For any t^*, the tariff implicitly defined by $\partial V^{\ell}/\partial t = 0$ is less than the tariff defined by $\partial V^h/\partial t = 0$. Hence we say the home country government is a low tariff type with probability α and a high tariff type with probability $(1-\alpha)$.

There are a variety of ways to motivate such uncertainty. Under production (consumer preference) uncertainty, $V^{\ell}(\cdot)$ and $V^h(\cdot)$ could be interpreted as home indirect utility under different assumptions on home production conditions (consumer preferences). The foreign government is less likely to know true home production conditions (preferences) than the "home" government. Alternatively, consider an example of political pressure to impose a tariff other than the standard optimum. Suppose a new home government is elected by an exogenous stochastic political process and that it is unclear whether the government will choose tariffs to maximize aggregate utility denoted by $V^{\ell}(\cdot)$ (redistributing incomes) or whether (because of costly income redistribution) it will bow to special interests with indirect utility given by $V^h(\cdot)$. This example is consistent with the stylized notion that special interests tend to lobby for larger tariffs than those which would maximize national welfare. In a related paper (Jensen and Thursby (1988)), we show that our assumptions on $V^{\ell}(\cdot)$ and $V^h(\cdot)$ are satisfied in a large country version of Mayer's (1984) majority voting model where the special interest group indexed by h represents the median voter who is well endowed (relative to the average citizen) with the factor used intensively in the import-competing sector.[5]

4 The model can be extended to more than two outcomes, but this complicates the analysis and exposition without substantively altering the results.

5 An alternative way to model this problem would be to have the home government choose a tariff to maximize a weighted average of the utilities of particular individuals. Uncertainty could be introduced by making these weights random variables. This approach is more cumbersome because the home objective function for each possible set of weights is a weighted average of the possible indirect utility functions. Moreover, if we assumed only two possible sets of weights, then the existence results would be qualitatively similar to those we state, although the exposition and analysis of welfare changes would be more complicated.

Rather than focusing on either of these examples, we shall keep our analysis and discussion general. The analysis applies to any situation in which the foreign government is uncertain about the home tariff reaction function. Randomness in the home reaction function can come either from randomness in the tariff selection process or from randomness in the underlying economic incentives even if the selection process is deterministic.

2.1 Nash Equilibrium Tariffs

Formally, the foreign country's strategy is a choice of a tariff t^* from T^*, a closed interval of the real line. The home country's strategy, however, is a mapping from the set of possible types into T, also a closed interval, or $t:\{\ell,h\}\rightarrow T$, where ℓ denotes low tariff and h denotes high tariff. That is, the home strategy is type contingent, depending on whether V^ℓ or V^h is the indirect utility being maximized by the home government. Given any feasible triple of tariffs (t^ℓ, t^h, t^*), the expected payoff to the foreign country from the game is

$$U^*(t^\ell, t^h, t^*) = \alpha V^*(t^\ell,t^*) + (1-\alpha)V^*(t^h, t^*) \tag{1}$$

where $V^*(t^i, t^*)$, $i = \ell, h$ is the foreign indirect utility function. The payoff associated with the high tariff government at home is denoted by $V^h(t^h, t^*)$, and the payoff associated with the home low tariff government is denoted by $V^\ell(t^\ell,t^*)$. In addition to the assumption that each indirect utility function is strictly concave in its own tariff, we assume each has a negative second cross partial derivative (i.e., the marginal utility of the own tariff is decreasing in the opposing country's tariff). Our analysis requires only that $V^h(\cdot)$ and $V^\ell(\cdot)$ satisfy these assumptions and occur with probabilities $(1-\alpha)$ and α respectively.

The Nash equilibrium for this Bayesian game is then a triple of tariffs $(t^\ell(\alpha), t^h(\alpha), t^*(\alpha))$, written as a function of α to denote the dependence of the equilibrium on the underlying uncertainty, such that

$$V^\ell(t^\ell(\alpha), t^*(\alpha)) \geq V^\ell(t, t^*(\alpha)) \quad \text{for all } t\in T \tag{2}$$

$$V^h(t^h(\alpha), t^*(\alpha)) \geq V^h(t, t^*(\alpha)) \quad \text{for all } t\in T \tag{3}$$

$$U^*(t^\ell(\alpha), t^h(\alpha), t^*(\alpha)) \geq U^*(t^\ell(\alpha), t^h(\alpha), t^*) \quad \text{for all } t^*\in T^*. \tag{4}$$

Notice that the equilibrium must specify the strategies for both possible home utility functions as well as the foreign tariff, since otherwise the foreign country would not be able to solve its problem in equilibrium.

It is helpful to first analyze the outcomes of the two possible certainty games. Suppose it is common knowledge that the home government is a high tariff type with certainty, or $\alpha=0$. Then we have the Nash equilibrium (t_h, t_h^*) given by the intersection of the reaction functions $r_h(t^*)$ and $r^*(t)$, which are defined implicitly by the equations $\partial V^h/\partial t = 0$ and $\partial V^*/\partial t^* = 0$. Under our assumptions on V^h and V^*, both reaction functions are negatively sloped, the slope of the composite best response function $r_h(r^*(t))$ is less than one, and the equilibrium is unique and locally stable. Conversely, suppose that it is common knowledge that the home government is a low tariff type with certainty, or $\alpha=1$. Then the Nash equilibrium is (t_ℓ, t_ℓ^*), given by the intersection of the reaction functions $r_\ell(t^*)$ and $r^*(t)$, where $\partial V^\ell/\partial t = 0$ implicitly defines $r_\ell(t^*)$. Under our assumptions on V^ℓ, the home government's reaction function is negatively sloped, the slope of the composite reaction function $r_\ell(r^*(t))$ is less than one, and the equilibrium is unique and locally stable. These equilibria are depicted in Figure 1. The assumptions made for these two certainty games are sufficient to prove the existence of a unique and locally stable equilibrium for the Bayesian game.

<u>Theorem 1</u>. There exists a unique and locally stable Bayesian equilibrium $(t^\ell(\alpha), t^h(\alpha), t^*(\alpha))$ such that for any given $\alpha \in (0, 1)$: $t_\ell < t^\ell(\alpha) < t^h(\alpha) < t_h$, $t_h^* < t^*(\alpha) < t_\ell^*$, $t^\ell(\alpha)$ and $t^h(\alpha)$ are decreasing in α, and $t^*(\alpha)$ is increasing in α.

Proof. A Bayesian equilibrium exists if there exists a $t^*(\alpha)$ such that $f(t^*(\alpha)) = 0$, where

$$f(t^*) = \alpha[\partial V^*(r_\ell(t^*), t^*)/\partial t^*] + (1-\alpha)[\partial V^*(r_h(t^*))/\partial t^*]. \quad (5)$$

Since $\partial^2 V^*/\partial t \partial t^* < 0$ and $r_\ell(t_h^*) < r_h(t_h^*) = t_h$, it follows that $f(t_h^*) = \alpha[\partial V^*(r_\ell(t_h^*), t_h^*)/\partial t^*] > 0$. Similarly, since $r_h(t_\ell^*) > r_\ell(t_\ell^*) = t_\ell$, $f(t_\ell^*) = (1-\alpha)[\partial V^*(r_h(t_\ell^*), t_\ell^*)/\partial t^*] < 0$. Now observe that $f'(t^*) = \alpha[(\partial^2 V^*/\partial t \partial t^*)r_\ell'(t^*) + (\partial^2 V^*/\partial t^{*2})] + (1-\alpha)[(\partial^2 V^*/\partial t \partial t^*)r_h'(t^*) + (\partial^2 V^*/\partial t^{*2})]$.

Notice that the condition for uniqueness and local stability of the Nash equilibrium of a certainty game between the foreign government and the low tariff home government, namely

$r_\ell'(r^*(t))r^{*\prime}(t)<1$, implies that the expression in the square brackets of the first term of $f'(t^*)$ is negative. The condition for uniqueness and local stability in the certainty game between the foreign government and the high tariff home government similarly implies that the expression in square brackets in the second term of $f'(t^*)$ is negative. Together these imply that $f'(t^*) < 0$, which completes the proof of existence (in pure strategies), uniqueness, and local stability. It also follows that $t_h^* < t^*(\alpha) < t_\ell^*$, and therefore that $t_\ell < t^\ell(\alpha) < t^h(\alpha) < t_h$ since $\partial^2V^*/\partial t\partial t^* < 0$, $r_\ell'(t^*) < 0$, and $r_h'(t^*) < 0$. That $t^*(\alpha)$ is increasing in α follows from $f'(t^*) < 0$ and the fact that $\partial^2V^*/\partial t\partial t^* < 0$ and $r_\ell(t^*) < r_h(t^*)$ imply $\partial f/\partial\alpha > 0$. This plus the negatively sloped reaction function of each home type proves that $t^\ell(\alpha)$ and $t^h(\alpha)$ are decreasing in α. Q.E.D.

Figure 1 shows the result of Theorem 1 in the standard reaction function framework. Given $t^*(\alpha)$, $t^\ell(\alpha)$ and $t^h(\alpha)$ are determined by the intersection of the horizontal line at $t^*(\alpha)$ with $r_\ell(t^*)$ and $r_h(t^*)$. Since $t^*(\alpha)\in(t_h^*, t_\ell^*)$, we must have $t_\ell < t^\ell(\alpha) < t^h(\alpha) < t_h$. Uncertainty in the foreign government about the home government's tariff type leads it to use a tariff lower than that it would use if it knew the home government were a low tariff type, but higher than that it would use if it knew the home government were a high tariff type. Because the home government knows that the foreign government is uncertain, it also uses a different tariff whatever its true reaction function. If $r_\ell(t^*)$ is its true reaction function, the equilibrium home tariff will be higher than if the foreign government knew the outcome, and if $r_h(t^*)$ is the true function, the home tariff will be lower than in the certainty outcome.[6]

Now consider an increase in the probability that the home government a low tariff type. Since $r_\ell(t^*) < r_h(t^*)$ and $\partial^2V^*/\partial t\partial t^* < 0$, this increases the expected marginal payoff to the foreign country and leads it to increase its tariff. This shifts up the horizontal line at $t^*(\alpha)$ and so leads to lower tariffs in equilibrium for both home country outcomes.

[6] We have assumed the foreign government's objective is known with certainty for simplicity, but similar results hold if this assumption is relaxed. In particular, in Jensen and Thursby (1988) we show that for high enough values of the probabilities that each governments is a low tariff type, both foreign and home tariffs are less than the Nash equilibrium tariffs of a certainty game with high tariff functions.

2.2 Welfare Effects

Since the home government has private information at the time tariffs are chosen, it is natural to ask whether the home country can gain from the existence of this private information. As one might expect, it is possible for either country to gain or lose, depending on the home government's true type. We summarize the results without proof since they follow immediately from Theorem 1 and our assumptions on utilities.

Proposition 1. (i) Suppose $r_{\ell}(t^*)$ is the true home reaction function. Then compared to the equilibrium if there were no private information, the possibility that $r_h(t^*)$ might have been the true function increases the equilibrium payoff to the home country and decreases the equilibrium payoff to the foreign country.

(ii) If $r_h(t^*)$ is the true function, the possibility that $r_{\ell}(t^*)$ is the true function decreases the equilibrium payoff to the home country and the effect on the foreign country's equilibrium payoff is ambiguous.

These results are easily seen from Figure 2. The reaction functions are shown as loci of the maximum points on tariff indifference curves (TIC) for the respective home and foreign utility functions. A TIC is concave in its own tariff, and by our assumptions on utility functions a higher subscript on a TIC denotes higher utility. A comparison of TICs at points a and b illustrates Proposition 1 (i) since a is the equilibrium of a game in which the home government is known with certainty to be the low tariff type and b is the equilibrium outcome of the Bayesian game when the home government actually is the low tariff type. Home indirect utility is higher at b than a since the uncertainty induces the foreign government to levy a lower tariff than if it had known the home government was the low tariff type. If we were to draw TICs with the usual properties through points c and d, we could illustrate part (ii) of the Proposition. It is clear that the TIC^h passing through c (the Bayesian equilibrium outcome when the home government actually is the high tariff type) will indicate lower utility than the one passing through d (the certainty equilibrium with a high tariff home government). It is also clear that the welfare implication of this outcome for the foreign country will vary depending on the slopes of the TIC^* through c and d.

Proposition 1 has important implications for a game with more than one stage. To see this consider a two stage game. Since a high tariff government loses in the one-stage game from the existence of private information, it has no incentive to imitate a low tariff government in stage one. If the home government is the low type, and if it levies a tariff in the first stage which reveals this fact to the foreign government, then its utility in the second stage will be lower than if the foreign government were still uncertain about its true type. However, if it levies the high tariff in the first stage, and if this succeeds in keeping the foreign government uncertain as to its true type, its second stage utility is higher than if it revealed its true type. It is therefore natural to ask when the gain from misleading the foreign government exceeds the cost of trying to establish a reputation as the high tariff type. We consider this in the next section.

3. Reputation and Tariff Equilibria

In this section we examine two closely related tariff games of incomplete information. For simplicity and ease of exposition we assume each game has only two stages. In the first game we make the orthodox assumption that the game begins with a random move that determines which tariff type the home government is in both stages. That is, it is either the high type in both stages or the low type in both stages. In the second game we make the less common assumption that there is an additional random move between stages one and two that determines which tariff type the home government is in stage two. We analyze both of these games to provide a comparison between two basic types of uncertainty that can affect tariff policy. In the first game random shocks to the home economy occur infrequently enough that the uncertainty about the home government's true type can be resolved (if the low type's stage one tariff reveals its true type, for example). In the second random shocks to the home economy occur frequently enough that the uncertainty about the home government's true type cannot be resolved (even if the low type's stage one tariff reveals its true type then, this does not guarantee the home government is also the low type in stage two).

Kreps and Wilson (1982) developed the concept of sequential equilibrium for finite games of incomplete information. Sequential equilibrium is not well defined for the games studied in this section because they are not finite (governments choose one of an infinite number of possible tariffs). Nevertheless, because the equilibria we analyze have the same intuitive properties, sequential rationality and consistency of beliefs, we shall call them sequential. Technically, we determine the subgame perfect equilibia of the games when the government's beliefs are consistent with each other and the equilibrium strategies.

3.1 Sequential Equilibria When Uncertainty Can Be Resolved

The game begins with a random move determining if the home government is a high or low tariff type for the entire game. As above, only the home government knows its own type at the time each government chooses a stage one tariff. The foreign government's prior belief (estimate) that the home government is a low type is α, which is common knowledge. The stage one outcome is a tariff for each country, say (t_1, t_1^*). Given this outcome, the foreign government forms a new belief that home is a low type in stage two, say $\mu^*(t_1, t_1^*)$. Sequential rationality requires the stage two tariffs be a Nash equilibrium of the static, stage two Bayesian tariff game. Consistency of beliefs requires that $\mu^*(t_1, t_1^*)$ be common knowledge. Then from Theorem 1, the stage two outcome must be $(t^{\ell}(\mu^*(t_1, t_1^*), t^*(\mu^*(t_1, t_1^*)))$ if the home government is a low type and $(t^h(\mu^*(t_1, t_1^*)), t^*(\mu^*(t_1, t_1^*)))$ if the home government is a high type.

Let ρ^* be the foreign country's social discount rate and assume it is common knowledge. Let ρ be the home country's social discount rate (the same for either type) and assume it is known by only the home government. Instead, the foreign government assumes ρ is distributed according to the distribution F, which is common knowledge. Also assume F is differentiable and $F'>0$. We assume the foreign government does not know ρ because this allows us to analyze equilibria in which the foreign government is never certain whether or not it will be misled. The foreign government well understands that a low tariff government may try to mislead it in stage one by levying the same tariff a high tariff government would. It therefore should form a probabilistic belief this will occur, say δ. Because a strategy of misleading involves a tradeoff between a stage one loss and a stage two gain, it is natural to conjecture that a low tariff type will mislead if and only if ρ is sufficiently large ($\rho>\bar{\rho}$ for $\bar{\rho}\in(0,1)$). If this is true, consistency of beliefs requires the foreign government's belief that a low type misleads be equal to the probability that a low type misleads implied by F and the low type's equilibrium strategy (i.e. $\delta = 1-F(\bar{\rho})$ if a low type's equilibrium strategy is to mislead if and only if $\rho > \bar{\rho}$). It is worth noting that this approach is essentially the same as the one employed by Milgrom and Roberts (1982) in their study of predation.

Given α and δ, the foreign government's stage one belief that the home government is a low type and misleads is $\alpha\delta$; the belief it is a low type but does not mislead is $(1-\alpha)\delta$, and that it is a high type is $1-\alpha$. Recall a high tariff home government has no incentive to mislead because its stage two welfare is highest when it is known to be a high type. Thus, it is natural to consider the following foreign stage two beliefs. If a high type's equilibrium tariff is observed in stage one, the foreign government infers home is either a high type or a low type that misled. Its stage one belief this will occur is $\alpha\delta+1-\alpha$. If any other home tariff is observed, it infers the home government is a low type that did not mislead. Its stage one belief this will occur is $\alpha(1-\delta)$. For notational convenience, let $\beta=\alpha(1-\delta)$. Because β is the foreign belief a low type will not mislead, it plays the same role in stage one of this game that α does in the static game of Section 2 (i.e., stage one expected foreign utility is $\beta V^*(t^\ell, t^*)+(1-\beta)V^*(t^h, t^*)$). Hence, if $t^h(\beta)$ is a high type's stage one equilibrium tariff, then from Bayes theorem the foreign government's stage two belief home is a low type is

$$\mu^*(t_1, t_1^*) = \alpha\delta/(\alpha\delta+1-\alpha) = \tau \qquad \text{if } t_1=t^h(\beta), \qquad (6a)$$

$$= 1 \qquad \text{if } t_1 \neq t^h(\beta). \qquad (6b)$$

Under these beliefs, the total utility (expected at the beginning of stage one) of a high type, a low type, and the foreign county are

$$R^h(t^h,t^*) = V^h(t^h,t^*) + \rho V^h(t^h(\tau), t^*(\tau)) \qquad \text{if } t^h = t^h(\beta), \qquad (7a)$$

$$= V^h(t^h,t^*) + \rho V^h(t^h(1), t^*(1)) \qquad \text{if } t^h \neq t^h(\beta), \qquad (7b)$$

$$R^\ell(t^\ell,t^*) = V^\ell(t^\ell,t^*) + \rho V^\ell(t^\ell(\tau), t^*(\tau)) \qquad \text{if } t^\ell = t^h(\beta), \qquad (8a)$$

$$= V^\ell(t^\ell,t^*) + \rho V^\ell(t^\ell(1), t^*(1)) \qquad \text{if } t^\ell \neq t^h(\beta), \qquad (8b)$$

$$R^*(t^\ell,t^h, t^*) = \alpha\delta\,[V^*(t^h, t^*) + \rho^* V^*(t^\ell(\tau), t^*(\tau))]$$
$$+ \alpha\,(1-\delta)\,[V^*(t^\ell, t^*) + \rho^* V^*(t^\ell(1),t^*(1))]$$
$$+ (1-\alpha)\,[V^*(t^h, t^*) + \rho^* V^*(t^h(\tau),t^*(\tau))]. \qquad (9)$$

Hence, given the foreign beliefs noted above, we posit the existence of two types of sequential equilibria. One is a separating equilibrium in which a low tariff home government does not mislead and stage one tariffs are $(t^{\ell}(\beta), t^{h}(\beta), t^{*}(\beta))$. The other is a pooling equilibrium in which a low tariff government misleads and stage one tariffs are $(t^{h}(\beta), t^{h}(\beta), t^{*}(\beta))$. We show in the appendix that both types of sequential equilibria exist if we assume,[7] as we shall,

$$V^{\ell}(t^{\ell}(0), t^{*}(0)) - V^{\ell}(t^{\ell}(1), t^{*}(1)) > V^{\ell}(t^{\ell}(\alpha), t^{*}(\alpha)) - V^{\ell}(t^{h}(\alpha), t^{*}(\alpha)). \quad (10)$$

If the foreign government believes a low type will not mislead, then $\delta=0$, $\beta=\alpha$, and $\tau=0$. In this case the foreign government can be "completely fooled" in the sense that observing $t^{h}(\alpha)$ in stage one convinces it the home government is a high type in stage two. If a low type misleads by levying $t^{h}(\alpha)$, the left hand side of (10) is the (undiscounted) equilibrium stage two gain and the right hand side is the equilibrium stage one loss. Hence, (10) merely says misleading can give a low type higher total utility if the foreign government can be completely fooled.

Theorem 2. Under the structure assumed, there exists a unique $\bar{\rho} \in (0,1)$ such that:

(i) If $\rho > \bar{\rho}$, equilibrium tariffs in stages one and two are

$(t^{h}(\bar{\beta}), t^{*}(\bar{\beta}))$ and $(t^{\ell}(\bar{\tau}), t^{*}(\bar{\tau}))$ for a low tariff home government and

$(t^{h}(\bar{\beta}), t^{*}(\bar{\beta}))$ and $(t^{h}(\bar{\tau}), t^{*}(\bar{\tau}))$ for a high tariff government.

(ii) If $\rho < \bar{\rho}$, equilibrium tariffs in stages one and two are

$(t^{\ell}(\bar{\beta}), t^{*}(\bar{\beta}))$ and $(t^{\ell}(1), t^{*}(1))$ for a low tariff home government and

$(t^{h}(\bar{\beta}), t^{*}(\bar{\beta}))$ and $(t^{h}(\bar{\tau}), t^{*}(\bar{\tau}))$ for a high tariff government.

(iii) For all ρ, $\bar{\delta} = 1-F(\bar{\rho})$, $\bar{\beta} = \alpha F(\bar{\rho})$ and $\bar{\tau} = \alpha[1-F(\bar{\rho})] / [1-\alpha F(\bar{\rho})]$.

This confirms our conjecture that misleading by a low type is a sequential equilibrium if and only if the home discount factor is large enough. Condition (iii) is important because it verifies that all governments' beliefs are consistent with each other and their equilibrium strategies. In particular, the foreign belief that the home government is a low type and misleads in stage one and that it is a low type in stage two are consistent with the equilibrium strategies of both home government types, given the prior α and the distribution F of home discount rates.

[7] We also must assume a standard monotonicity condition which is given in the appendix.

Theorem 2 may not describe all possible sequential equilibria for this game. In particular, different types of equilibria may obtain for foreign country beliefs which differ from those given in (6). We focus on these results because the beliefs in (6) seem the most plausible ones for this economic problem. The same comment applies to Theorem 3 below.

Because $\alpha>\bar{\beta}$, it follows from Theorem 1 that $t^{\ell}(\bar{\beta})>t^{\ell}(\alpha)$, $t^{h}(\bar{\beta})>t^{h}(\alpha)$, and $t^{*}(\bar{\beta})<t^{*}(\alpha)$. Compared to the static game (in which there is no possibility of misleading), stage one equilibrium tariffs are higher for a high type and a nonmisleading low type, but lower for the foreign country. This implies stage one home utility for both types is higher and stage one foreign expected utility is lower. The following result is immediate.

Proposition 2. Suppose a home low tariff government can be prevented from misleading in a credible fashion. Then compared to this case, the possibility a home low tariff government will mislead increases the home country's total utility when it is a low tariff government whether it misleads or not. Moreover, this possibility may, but need not, decrease the home country's total utility when it is a high tariff government or the foreign country's expected total utility.

Proof. Recall from the proof of Theorem 1 that $(t^{\ell}(\alpha), t^{h}(\alpha), t^{*}(\alpha))$ are defined by $\partial V^{\ell}(t^{\ell}(\alpha), t^{*}(\alpha))/\partial t = 0$, $\partial V^{h}(t^{h}(\alpha), t^{*}(\alpha))/\partial t = 0$, and $\partial U^{*}(t^{\ell}(\alpha), t^{h}(\alpha), t^{*}(\alpha))/\partial t^{*} = 0$. Hence, $\partial^2 V^{\ell}(t^{\ell}(\alpha),t^{*}(\alpha))/\partial t\partial\alpha< 0$, $\partial^2 V^{h}(t^{h}(\alpha),t^{*}(\alpha))/\partial t\partial\alpha< 0$, and $\partial^2 U^{*}(t^{\ell}(\alpha),t^{h}(\alpha),t^{*}(\alpha))/\partial t^{*}\partial\alpha> 0$. If misleading can be prevented, total utility of a low type, a high type, and the foreign country are $H^{\ell}(t^{\ell}(\alpha),t^{*}(\alpha)) = V^{\ell}(t^{\ell}(\alpha),t^{*}(\alpha)) + \rho V^{\ell}(t^{\ell}(1),t^{*}(1))$, $H^{h}(t^{h}(\alpha),t^{*}(\alpha)) = V^{h}(t^{h}(\alpha),t^{*}(\alpha)) + \rho V^{h}(t^{h}(0), t^{*}(0))$, and $H^{*}(t^{\ell}(\alpha),t^{h}(\alpha),t^{*}(\alpha)) = U^{*}(t^{\ell}(\alpha),t^{h}(\alpha),t^{*}(\alpha)) + \rho^{*}[\alpha V^{*}(t^{\ell}(1),t^{*}(1)) + (1-\alpha)V^{*}(t^{\ell}(0),t^{*}(0))]$. If $\rho<\bar{\rho}$, then $R^{\ell}(t^{\ell}(\bar{\beta}),t^{*}(\bar{\beta})) = V^{\ell}(t^{\ell}(\bar{\beta}),t^{*}(\bar{\beta})) + \rho V^{\ell}(t^{\ell}(1), t^{*}(1)) > H^{\ell}(t^{\ell}(\alpha), t^{*}(\alpha))$ since $\alpha>\bar{\beta}$ and the result above imply $V^{\ell}(t^{\ell}(\bar{\beta}),t^{*}(\bar{\beta})) > V^{\ell}(t^{\ell}(\alpha),t^{*}(\alpha))$. If $\rho>\bar{\rho}$, then $R^{\ell}(t^{h}(\bar{\beta}),t^{*}(\bar{\beta})) > R^{\ell}(t^{\ell}(\bar{\beta}),t^{*}(\bar{\beta})) > H^{\ell}(t^{\ell}(\alpha),t^{*}(\alpha))$. Similar comparisons show positive and negative terms in both $R^{h}(t^{h}(\bar{\beta}),t^{*}(\bar{\beta})) - H^{h}(t^{h}(\alpha),t^{*}(\alpha))$ and $R^{*}(t^{\ell}(\bar{\beta}),t^{h}(\bar{\beta}),t^{*}(\bar{\beta})) - H^{*}(t^{\ell}(\alpha),t^{h}(\alpha),t^{*}(\alpha))$. Q.E.D.

This result can be seen from Figure 1. If in equilibrium a low tariff government does not mislead, its stage 2 utility is the same as if it were prevented from misleading (by some home country law for example). However, the possibility of misleading implies the foreign belief that a low equilibrium tariff will be used in stage one is smaller, or $\bar{\beta}<\alpha$. This means the horizontal line for $t^*(\bar{\beta})$ lies below the one for $t^*(\alpha)$. Hence, if the home government is a low type that does not mislead, stage one home country utility must be higher because it is further down its reaction function $r_\ell(t^*)$ and thus on a higher TIC. Therefore the home government's total utility is higher. Home country total utility also must be higher if its government is a low type that misleads because this is an equilibrium only if its total utility is greater than that if it is a low type that does not mislead.

If misleading is possible, the high tariff government gains in stage one but loses in stage two compared to the case where misleading is not possible. The stage one gain occurs for the same reason as when the home government is a low tariff type. Because $\bar{\beta}<\alpha$ the home country must be further down its reaction function, $r_h(t^*)$, and thus on a higher TIC. Stage two utility for a high type is lower with the possibility of misleading because the horizontal line for $t^*(\tau)$ lies above the one for $t^*(0)$. Therefore the home country's total utility under the high tariff government may or may not be greater when misleading is possible.

Finally, consider ex ante expected total home welfare (where the term welfare is used when the expectation is taken before the stage one home government is determined). The preceding results imply that expected total home welfare may or may not be greater when misleading is credibly prevented. Hence, a rule preventing misleading need not make the home country better off because the low tariff government would clearly be worse off and a high tariff government might be worse off.

3.2 Sequential Equilibria When Uncertainty Persists

Now consider a slightly modified two stage game. This game begins with a random move that determines whether the home government is a high or low tariff type for the first stage only. Again, it is common knowledge that the home government is the low type with probability α, and only the home government knows its own type when each government chooses its stage one tariff. However, after stage one tariffs are chosen and observed, another random move determines whether the home government is a high or low tariff type for the second stage. In this game the home government's type need not be the same in the second stage as in the first. We assume that the home government is the low type in stage two with probability $u(\alpha)$ if it was the low type in stage one and with probability $d(\alpha)$ if it was the high type in stage one, where $d(\alpha)<\alpha<u(\alpha)$. That is, the home government is more (less) likely to be the low type in stage two if it was the low (high) type in stage one. Compared to the preceding game, this is the case in which random shocks occur more frequently, just as production shocks can occur more frequently than policy changes due to elections, for example.

Formally, let α^* be the true probability the home government is a low type in either stage. Assume neither government knows the true probability, so both estimate it by α in stage one. The observation of which type was chosen in stage one is then used by the home government types to update this estimate to $u(\alpha)$ or $d(\alpha)$ in the ordinary fashion using Bayes theorem. However, the foreign government does not update in this fashion because again a low type may mislead by choosing the high type's equilibrium tariff in stage one. As before, let δ be the foreign belief that the home government misleads if it is a low type. If a high type's equilibrium tariff is observed in stage one, again assume the foreign government infers the home government was either a high type or a low type that misled. Its belief that the home government was a low type in stage one is then τ, as defined in (6a). Also assume the foreign belief that the home government was a low type in stage one is 1 if any other home country tariff is observed. Again, β is the foreign belief that a low type does not mislead in stage one, and it plays the same role in stage one of this game that α does in the static game. However, because the type chosen in stage one need not be chosen in stage two, the foreign belief that the home government is a low tariff type in stage two is now

$$\tilde{\mu}^*(t_1, t_1^*) = \tau u(\alpha)+(1-\tau)d(\alpha) \equiv \eta \qquad \text{if } t_1=t^h(\beta), \qquad (10a)$$

$$= u(\alpha) \qquad \text{if } t_1\neq t^h(\beta). \qquad (10b)$$

Sequential rationality and consistency of beliefs requires that stage two equilibrium tariffs be $(t^\ell(\tilde{\mu}^*(t_1,t_1^*)),t^*(\tilde{\mu}^*(t_1,t_1^*))$ if home is the low type in stage two and $(t^h(\tilde{\mu}^*(t_1,t_1^*)),t^*(\tilde{\mu}^*(t_1,t_1^*))$ if home is the high type.

Under these beliefs, the total utility (expected at the beginning of stage one) of a high type, a low type, and the foreign country are

$$P^h(t^h,t^*) = V^h(t^h,t^*) + \rho d(\alpha)V^h(t^\ell(\eta),t^*(\eta)) + \rho(1-d(\alpha))V^h(t^h(\eta),t^*(\eta)) \quad \text{if } t^h=t^h(\beta), \qquad (11a)$$

$$=V^h(t^h,t^*) + \rho d(\alpha)V^h(t^\ell(u(\alpha)),t^*(u(\alpha))) + \rho(1-d(\alpha))V^h(t^h(u(\alpha)),t^*(u(\alpha))) \quad \text{if } t^h\neq t^h(\beta), \qquad (11b)$$

$$P^\ell(t^\ell,t^*) =V^\ell(t^\ell,t^*) + \rho u(\alpha)V^\ell(t^\ell(\eta),t^*(\eta)) + \rho(1-u(\alpha))V^\ell(t^h(\eta),t^*(\eta)) \quad \text{if } t^\ell=t^h(\beta), \qquad (12a)$$

$$=V^\ell(t^\ell,t^*) + \rho u(\alpha)V^\ell(t^\ell(u(\alpha)),t^*(u(\alpha))) + \rho(1-u(\alpha))V^\ell(t^h(u(\alpha)),t^*(u(\alpha))) \quad \text{if } t^\ell\neq t^h(\beta), \qquad (12b)$$

$$P^*(t^\ell,t^h,t^*)=\beta V^*(t^\ell,t^*) + \beta\rho^*u(\alpha)V^*(t^\ell(u(\alpha)),t^*(u(\alpha))) + \beta\rho^*(1-u(\alpha))V^*(t^h(u(\alpha)),t^*(u(\alpha))) + (1-\beta)V^*(t^h,t^*) + (1-\beta)\rho^*\eta V^*(t^\ell(\eta),t^*(\eta)) + (1-\beta)\rho^*(1-\eta)V^*(t^h(\eta),t^*(\eta)). \qquad (13)$$

Hence, given the foreign beliefs noted above, we posit the existence of two types of sequential equilibria. One is a separating equilibrium in which a low tariff home government in stage one does not mislead and tariffs are $(t^\ell(\beta), t^h(\beta), t^*(\beta))$, and the other is a pooling equilibrium in which it does mislead and stage one tariffs are $(t^h(\beta), t^h(\beta), t^*(\beta))$. Of course, if such equilibria exist, in general the values taken on by δ, β, and τ will not be the same as those in the preceding game because the stage two utilities differ. Existence can be proved assuming, as we shall, that misleading gives a stage one low type higher total utility if the foreign government can be completely fooled, or

$$u(\alpha)\,[V^\ell(t^\ell(d(\alpha)),t^*(d(\alpha)))-V^\ell(t^\ell(u(\alpha)), t^*(u(\alpha)))] + (1-u(\alpha))[V^\ell(t^h(d(\alpha)),t^*(d(\alpha)))-V^\ell(t^h(u(\alpha)),t^*(u(\alpha)))] > V^\ell(t^\ell(\alpha), t^*(\alpha))-V^\ell(t^h(\alpha),t^*(\alpha)). \qquad (14)$$

The left hand side of (14) is the (undiscounted) expected stage two gain and the right hand side is the stage one loss if a low tariff home government misleads and the foreign country is completely fooled (into believing the home government is a high type when it is actually a low type).

Theorem 3. Under the structure assumed, there exists a unique $\tilde{\rho} \in (0,1)$ such that:

(i) If $\rho > \tilde{\rho}$, equilibrium stage one tariffs are $(t^h(\tilde{\beta}), t^*(\tilde{\beta}))$ for either type of home government; equilibrium stage two tariffs are $(t^{\ell}(\tilde{\eta}), t^*(\tilde{\eta}))$ for a low tariff type and $(t^h(\tilde{\eta}), t^*(\tilde{\eta}))$ for a high tariff type.

(ii) If $\rho < \tilde{\rho}$ and the home government is the low tariff type in stage one: stage one equilibrium tariffs are $(t^{\ell}(\tilde{\beta}), t^*(\tilde{\beta}))$; and stage two equilibrium tariffs are $(t^{\ell}(u(\alpha)), t^*(u(\alpha)))$ for a low tariff type and $(t^h(u(\alpha)), t^*(u(\alpha)))$ for a high tariff type.

(iii) If $\rho < \tilde{\rho}$ and the home government is the high tariff type in stage one: stage one equilibrium tariffs are $(t^h(\tilde{\beta}), t^*(\tilde{\beta}))$; and stage two equilibrium tariffs are $(t^{\ell}(\tilde{\eta}), t^*(\tilde{\eta}))$ for a low tariff type and $(t^h(\tilde{\eta}), t^*(\tilde{\eta}))$ for a high tariff type.

(iv) For all ρ, $\tilde{\delta} = 1-F(\tilde{\rho})$, $\tilde{\beta} = \alpha F(\tilde{\rho})$, $\tilde{\tau} = \alpha[1-F(\tilde{\rho})] / [1-\alpha F(\tilde{\rho})]$, and $\tilde{\eta} = \tilde{\tau}u(\alpha) + (1-\tilde{\tau})d(\alpha)$.

Misleading is an equilibrium strategy for a low type home government if and only if the home discount factor is sufficiently large, or $\rho > \tilde{\rho}$. As before, all governments' beliefs are consistent with each other and their equilibrium strategies. Because $\tilde{\beta} > \alpha$, the result of Proposition 2 holds for this game also, regardless of which home government is chosen in stage two.

3.3 Ex Ante Welfare Comparison Between Resolved and Persistent Uncertainty

Our comparison of the effects of these two types of uncertainty focuses on ex ante expected total welfare. Let $W(\alpha,\rho)$ be expected total welfare for the home country if uncertainty can be resolved (as in Section 3.1) and $\tilde{W}(\alpha,\rho)$ be that if uncertainty persists (as in 3.2). In general, the relative magnitudes of $W(\alpha,\rho)$ and $\tilde{W}(\alpha,\rho)$ cannot be determined. However, if we place additional restrictions on the low tariff government's incentive to mislead, expected home welfare will be higher in the game where it is possible for uncertainty to be resolved (see Proposition 3 below). It is not surprising that additional assumptions about the low type's incentives will allow us to rank the low type's utility in the two types of games. What is interesting is that these assumptions also allow us to derive the same ranking for the high type's utility.

To see the difficulty in ranking expected home welfare, one need only examine the expressions for $W(\alpha,\rho)$ and $\tilde{W}(\alpha,\rho)$. $W(\alpha,\rho)$ is given by

$$W(\alpha,\rho) = \alpha R^{\ell}(t^h(\bar{\beta}),t^*(\bar{\beta})) + (1-\alpha)R^h(t^h(\bar{\beta}),t^*(\bar{\beta})) \qquad \text{for } \rho>\bar{\rho}, \qquad (15)$$

$$W(\alpha,\rho) = \alpha R^{\ell}(t^{\ell}(\bar{\beta}),t^*(\bar{\beta})) + (1-\alpha)R^h(t^h(\bar{\beta}),t^*(\bar{\beta})) \qquad \text{for } \rho<\bar{\rho}, \qquad (16)$$

where $R^{\ell}(\cdot)$ and $R^h(\cdot)$ are defined by (7) and (8). $\tilde{W}(\alpha,\rho)$ is given by

$$\tilde{W}(\alpha,\rho) = \alpha P^{\ell}(t^h(\tilde{\beta}),t^*(\tilde{\beta})) + (1-\alpha)P^h(t^h(\tilde{\beta}),t^*(\tilde{\beta})) \qquad \text{for } \rho>\tilde{\rho}, \qquad (17)$$

$$\tilde{W}(\alpha,\rho) = \alpha P^{\ell}(t^{\ell}(\tilde{\beta}),t^*(\tilde{\beta})) + (1-\alpha)P^h(t^h(\tilde{\beta}),t^*(\tilde{\beta})) \qquad \text{for } \rho<\tilde{\rho}, \qquad (18)$$

where $P^{\ell}(\cdot)$ and $P^h(\cdot)$ are defined by (11) and (12). If misleading is the equilibrium in both games, the relevant comparison is between (15) and (17). Because the expression is lengthy it is given in the Appendix (see equation (A3)). It is important to notice, however, that to sign this expression we need to rank $V^i(t^h(\bar{\beta}),t^*(\bar{\beta}))$ and $V^i(t^h(\tilde{\beta}),t^*(\tilde{\beta}))$ for $i=\ell,h$. From Theorem 1, the ranking of these depends on relative sizes of $\bar{\beta}$ and $\tilde{\beta}$, the foreign country's estimates that a low tariff government would not mislead in the two games. But $\bar{\beta} = (1-\alpha)F(\bar{\rho})$ and $\tilde{\beta} = (1-\alpha)F(\tilde{\rho})$, so that $\bar{\beta} \gtreqless \tilde{\beta}$ if and only if $\bar{\rho} \gtreqless \tilde{\rho}$. Similarly we also need to rank $V^i(t^i(\bar{\tau}),t^*(\bar{\tau}))$ and $V^i(t^i(\tilde{\eta}),t^*(\tilde{\eta}))$ for $i=\ell,h$. There is nothing in the model that guarantees the relative magnitudes of $\bar{\tau}$ and $\tilde{\eta}$. These problems also prevent determining whether $\bar{\rho}$ is larger or smaller than $\tilde{\rho}$. Similar problems arise in comparing (16) and (17) (see equation (A4) in the Appendix).

Despite these problems, assuming $\bar{\rho}<\tilde{\rho}$ allows us to rank welfare in the two games. This assumption means a low tariff type has less incentive to mislead in the game with persistent uncertainty. Since a low tariff type chosen in stage one of the game with persistent uncertainty may not be chosen in stage two, $\bar{\rho}<\tilde{\rho}$ is an intuitively appealing assumption.

Proposition 3. Suppose $\bar{\rho}<\tilde{\rho}$. Then the home country's ex ante expected total welfare is larger in the game where it is possible for uncertainty to be resolved, if $\rho>\tilde{\rho}>\bar{\rho}$. If, in addition, $V^{\ell}(t^h(\bar{\beta}),t^*(\bar{\beta})) \geq V^{\ell}(t^{\ell}(\tilde{\beta}),t^*(\tilde{\beta}))$, this result holds for all ρ.

Because the proof is tedious, but straightforward, it is given in the Appendix. The result follows from the fact that $\bar{\rho}<\tilde{\rho}$ implies both $\bar{\beta}<\tilde{\beta}$ and $\bar{\tau}<\tilde{\eta}$. The former implies stage one home utility with both high and low tariff governments is higher in the game of Section 3.1 (recall the discussion of

Proposition 2). The latter implies that, if the high home tariff is levied in stage one, then stage two home utility with both types of governments is also higher in the game of Section 3.1. Therefore home utility is higher in this game for all ρ with a high tariff government and for all $\rho>\tilde{\rho}$ with a low tariff government.

Recall $\bar{\beta}<\tilde{\beta}$ says the foreign government's estimate that the home high tariff is levied in stage one is higher in the game of Section 3.1. Similarly, $\bar{\tau}<\tilde{\eta}$ says that if a home high tariff is levied in stage one, then the foreign government's estimate that it was misled is lower in this game. Therefore <u>ex ante</u> home expected welfare when misleading is an equilibrium is greater in this game because the home low tariff government is better able to develop a reputation as a high tariff government. Stated alternatively, <u>ex ante</u> home welfare is lower in the game with persistent uncertainty because it is harder for the home low tariff government to misrepresent itself.

Finally, only when ρ is low enough that misleading is not an equilibrium in both games ($\rho<\tilde{\rho}$) is an additional assumption required to generate this result. The condition $V^{\ell}(t^{h}(\bar{\beta}),t^{*}(\bar{\beta})) \geq V^{\ell}(t^{\ell}(\tilde{\beta}),t^{*}(\tilde{\beta}))$ is sufficient to guarantee that the total utility with a low tariff government from misleading in the game of Section 3.1 is greater than the total home utility with the low tariff government in equilibrium in the game of Section 3.2. This condition may seem strong, but it can hold because $\bar{\beta}<\tilde{\beta}$. Moreover, as we show in the proof, this additional assumption is not required for the result when ρ is low enough.

4. Concluding Remarks

We have examined several stochastic optimum tariff games in which the home government has private information about its reaction function. Depending on the position of its reaction function, the home government is identified as a low or high tariff type. If the foreign government is uncertain about this type in a one-shot game, it will levy a tariff which is lower (higher) than that it would levy if it knew the home government were a low (high) tariff type. An increase in the probability the home government is a high type decreases the equilibrium foreign tariff in this game. This result led us to consider when a low type would want to establish a reputation as a high type if there were more than one stage to the game. We found similar results in both multistage games examined. For example, stage one foreign tariffs in these games are lower than the foreign tariff in the one-shot game. This occurs because the possibility that a low type will misrepresent itself gives a higher probability that the home government will levy a high tariff in stage one (compared to the static game).

These tariff comparisons are similar in spirit to Thursby and Jensen's (1983) result that conjectured retaliation in a static optimum tariff game would lower at least one country's equilibrium tariff. The problem with the conjectural variation result is the well known fact that there is no scope for action and reaction in a static game. What is interesting about the tariff comparisons in the present paper is that a similar result comes out of a well specified game theoretic structure. In this paper, beliefs about the home type are really foreign conjectures about the home reaction function and discount factor. In the multistage games, these beliefs are revised according to the tariffs observed in the first stage. The equilibria we examine are subgame perfect and have the desirable property that governments' conjectures (beliefs) are consistent with each other and the equilibrium strategies.

Our welfare results are interesting for several reasons. First, they allow us to characterize expected welfare in terms of how uncertainty enters the tariff game. Recall that the two multistage games differ by how frequently random shocks to the home economy occur. If they occur frequently enough that uncertainty cannot be resolved (even if a low tariff government levies a revealing tariff in the first stage), then ex ante expected home welfare is lower than in the game with less frequent shocks (i.e., where a random shock occurs only at the beginning of the game). The result occurs because of the effect of persistent uncertainty on the incentives for misleading. Second, Prepositions 1 and 2 have normative implications for the question of rules versus discretion in trade policy. Our results suggest that, in the context of this model, rules may or may not benefit the home country. For example, a rule specifying that the home government's true type be revealed before tariffs are chosen is beneficial if and only if the home country has a high tariff government. However, a rule which credibly prevents the home government from misleading may hurt the home country because the low tariff government would clearly be worse off and the high tariff government might also be worse off. In a different set of models, Staiger and Tabellini (1988) find several examples where rules are superior to discretionary policy. A crucial difference in their analysis and ours is that trade policy is a second best policy in their models, so that time-consistency issues can arise. We examine the classic competitive large country model (with no lags between production and trade [8]) where tariffs have a first best role from a single country's perspective. By looking at subgame perfect equilibria we avoid time consistency issues.

Finally, the limitations of our analysis propose several interesting extensions. For example, the extension to an infinite horizon model would allow analysis of how uncertainty about the home objective function affects the ability to attain cooperative outcomes as noncooperative equilibria. Another extension of interest is to endogenize the probability that the home government is a low tariff type by developing a political economy model. This would allow one to examine how concern about election and/or re-election affects misleading behavior.

[8] See Lapan (1988) on time consistency and the optimum tariff with such lags.

Appendix

Proofs of Theorems 2 and 3

We prove only Theorem 2 because the proof of Theorem 3 is entirely analogous. Given α, δ, and the foreign beliefs in (6), sequential rationality requires that the stage two equilibria be the Bayesian equilibria of the static game when the foreign belief that home is the low type in (6) is common knowledge. That is, given α, δ, and (6), equations (7) - (9) give the payoffs to a high type, a low type, and the foreign country from the two stage game. Notice that (9) can be rewritten as

$$R^*(t^\ell, t^h, t^*) = \beta V^*(t^\ell, t^*) + (1-\beta)V^*(t^h, t^*) + \alpha\delta\rho^* V^*(t^\ell(\tau), t^*(\tau))$$
$$+\alpha(1-\delta)\rho^* V^*(t^\ell(1), t^*(1)) + (1-\alpha)\rho^* V^*(t^h(\tau), t^*(\tau)). \qquad \text{(A1)}$$

Consider the stage two candidate equilibrium tariffs $(t^\ell(\beta), t^h(\beta), t^*(\beta))$. It follows from the proof of Theorem 1 that $\partial V^\ell(t^\ell(\beta),t^*(\beta))/\partial t = 0$, $\partial V^h(t^h(\beta),t^*(\beta))/\partial t=0$, and $\partial R^*(t^\ell(\beta),t^h(\beta),t^*(\beta))/\partial t^*=0$. Hence, given $t^*(\beta)$ and these beliefs, strict concavity of V^h in t implies that $R^h(t^h, t^*(\beta))$ is maximized at $t^h=t^h(\beta)=r_h(t^*(\beta))$ because $V^h(t^h(\tau), t^*(\tau)) > V^h(t^h(1),t^*(1))$ for all $\tau<1$ (and $\tau<1$ for $\alpha<1$). Given $t^*(\beta)$ and these beliefs, strict concavity of V^ℓ in t implies $R^\ell(t^\ell,t^*(\beta))$ is maximized either at $t^\ell=t^\ell(\beta)=r_\ell(t^*(\beta))$ if $V^\ell(t^\ell(\beta),t^*(\beta))+\rho V^\ell(t^\ell(1),t^*(1))>V^\ell(t^h(\beta),t^*(\beta))+\rho V^\ell(t^\ell(\tau),t^*(\tau))$, or at $t^\ell=t^h(\beta)$ if the reverse inequality holds (which is possible because $V^\ell(t^\ell(\tau),t^*(\tau))>V^\ell(t^\ell(1),t^*(1))$ for all $\tau<1$). Since the foreign government is aware of these facts, its beliefs must be that the stage one home tariff is $t^\ell(\beta)$ with probability β or $t^h(\beta)$ with probability $1-\beta=\alpha\delta+1-\alpha$. It then follows from (A1) and Theorem 1 that $t^*(\beta)$ maximizes R^*. Hence, given these beliefs, $(t^\ell(\beta),t^h(\beta),t^*(\beta))$ and $(t^\ell(\beta),t^h(\beta),t^*(\beta))$ are both possible stage one tariff equilibria.

To complete the proof we must show these beliefs are consistent with a low type's decision to use $t^\ell(\beta)$ or $t^h(\beta)$ in stage one. Let $\delta(x) = 1-F(x)$, $\beta(x) = \alpha(1-\delta(x)) = \alpha F(x)$, $\tau(x) = \alpha\delta(x)/[\alpha\delta(x)+1-\alpha] = \alpha[1-F(x)]/[1-\alpha F(x)]$, and

$$g(\rho,x) = V^\ell(t^h(\beta(x)),t^*(\beta(x)))-V^\ell(t^\ell(\beta(x)),t^*(\beta(x)))$$
$$+\rho[V^\ell(t^\ell(\tau(x)),t^*(\tau(x)))-V^\ell(t^\ell(1),t^*(1))]. \qquad \text{(A2)}$$

The function $g(\rho,x)$ is the gain (or loss) to a low type from using $t^h(\beta(x))$ instead of $t^\ell(\beta(x))$ in stage one if the foreign country assumes $t^h(\beta(x))$ is used if and only if $\rho>x$ and estimates this occurs with probability $\delta(x)$. Notice that $g(0,x) = V^\ell(t^h(\beta(x)), t^*(\beta(x))) - V^\ell(t^\ell(\beta(x)), t^*(\beta(x))) < 0$ and $\partial g(\rho,x)/\partial\rho>0$ for all $x\in[0,1]$. Hence, for all x such that $g(1,x)>0$, there exists a unique $\phi(x)\in(0,1)$ such that $g(\rho,x)<0$ for all $\rho<\phi(x)$, $g(\phi(x),x)=0$, and $g(\rho,x)>0$ for all $\rho>\phi(x)$. That is, if the foreign country assumes $t^h(\beta(x))$ is used if and only if $\rho>x$ and estimates this occurs with probability $\delta(x)$, then a low type should use $t^h(\beta(x))$ if and only if its discount factor ρ exceeds a critical value $\phi(x)$. Consistency of beliefs then requires that this critical value be equal to the foreign country's estimate of it, or $\phi(x)=x$. Use (A2) to define the function $\theta(x)=g(x,x)$. Then we need only show there exists a unique $\bar{\rho}\in(0,1)$ such that $\theta(x)<0$ for $x<\bar{\rho}$, $\theta(\bar{\rho})=0$, and $\theta(x)>0$ for all $x>\bar{\rho}$. If $\theta(0)<0<\theta(1)$, then continuity of $\theta(x)$ guarantees the existence of at least one such $\bar{\rho}$. Since $\beta(0)=0$, $\theta(0) = V^\ell(t^h(0), t^*(0))-V^\ell(t^\ell(0),t^*(0))<0$. Since $\beta(1)=\alpha$ and $\tau(1)=0$, $\theta(1)>0$ if the inequality (10) holds. Uniqueness of $\bar{\rho}$ follows if $\theta'(\bar{\rho})>0$, which is the monotonicity condition we refer to in footnote 6.

Proof of Proposition 3

If $\rho>\tilde{\rho}>\bar{\rho}$ then $W(\alpha,\rho)-\tilde{W}(\alpha,\rho)$ is given by

$$\begin{aligned} W(\alpha,\rho)-\tilde{W}(\alpha,\rho)=&\alpha[V^\ell(t^h(\bar{\beta}),t^*(\bar{\beta}))-V^\ell(t^h(\tilde{\beta}),t^*(\tilde{\beta}))] \\ &+\alpha\rho[V^\ell(t^\ell(\bar{\tau}),t^*(\bar{\tau}))-u(\alpha)V^\ell(t^\ell(\tilde{\eta}),t^*(\tilde{\eta}))-(1-u(\alpha))V^\ell(t^h(\tilde{\eta}),t^*(\tilde{\eta}))] \\ &+(1-\alpha)[V^h(t^h(\bar{\beta}),t^*(\bar{\beta}))-V^h(t^h(\tilde{\beta}),t^*(\tilde{\beta}))] \\ &+(1-\alpha)\rho[V^h(t^h(\bar{\tau}),t^*(\bar{\tau}))-d(\alpha)V^h(t^\ell(\tilde{\eta}),t^*(\tilde{\eta}))-(1-d(\alpha))V^h(t^h(\tilde{\eta}),t^*(\tilde{\eta}))]. \end{aligned} \quad \text{(A3)}$$

Since $V^\ell(t^\ell(\tilde{\eta}),t^*(\tilde{\eta}))>V^\ell(t^h(\tilde{\eta}),t^*(\tilde{\eta}))$ and $V^h(t^h(\tilde{\eta}),t^*(\tilde{\eta}))>V^h(t^\ell(\tilde{\eta}),t^*(\tilde{\eta}))$, manipulation gives $W(\alpha,\rho)-\tilde{W}(\alpha,\rho) > \alpha\{V^\ell(t^h(\bar{\beta}),t^*(\bar{\beta}))-V^\ell(t^h(\tilde{\beta}),t^*(\tilde{\beta}))+\rho[V^\ell(t^\ell(\bar{\tau}),t^*(\bar{\tau}))-V^\ell(t^\ell(\tilde{\eta}),t^*(\tilde{\eta}))]\}+ (1-\alpha)\{V^h(t^h(\bar{\beta}),t^*(\bar{\beta}))-V^h(t^h(\tilde{\beta}),t^*(\tilde{\beta}))+\rho[V^h(t^h(\bar{\tau}),t^*(\bar{\tau}))-V^h(t^h(\tilde{\eta}),t^*(\tilde{\eta}))]\}$.

Hence, $W(\alpha,\rho)-\tilde{W}(\alpha,\rho)$ if $\bar{\beta}<\tilde{\beta}$ and $\bar{\tau}<\tilde{\eta}$ (recall the proof of Proposition 2). The assumption that $\tilde{\rho}>\bar{\rho}$ implies $\bar{\beta} = (1-\alpha)F(\bar{\rho}) < \tilde{\beta} = (1-\alpha)F(\tilde{\rho})$ since $F'>0$. One can show that $\bar{\tau}<\tilde{\eta}$ if $\alpha(1-u(\alpha))F(\bar{\rho})$ $F(\tilde{\rho})$ - $(1-\alpha)F(\bar{\rho})$ - $(\alpha-u(\alpha))F(\tilde{\rho}) < 0$, which also follows from assuming $\tilde{\rho}>\bar{\rho}$ and $F'>0$. This proves the first statement of the proposition.

To prove the second statement, consider $\tilde{\rho}>\bar{\rho}>\rho$. Then $W(\alpha,\rho)$ is given by (16), $\tilde{W}(\alpha,\rho)$ is given by (18), and $W(\alpha,\rho)-\tilde{W}(\alpha,\rho) = \alpha[V^{\ell}(t^{\ell}(\bar{\beta}),t^*(\bar{\beta}))-V^{\ell}(t^{\ell}(\tilde{\beta}),t^*(\tilde{\beta}))]$

$$+ \alpha\rho[V^{\ell}(t^{\ell}(1),t^*(1)) - u(\alpha)V^{\ell}(t^{\ell}(u(\alpha)),t^*(u(\alpha))) - (1-u(\alpha))V^{\ell}(t^h(u(\alpha)),t^*(u(\alpha)))]$$
$$+ (1-\alpha)[V^h(t^h(\bar{\beta}),t^*(\bar{\beta})) - V^h(t^h(\tilde{\beta}),t^*(\tilde{\beta}))]$$
$$+ (1-\alpha)\rho[V^h(t^h(\bar{\tau}),t^*(\bar{\tau}))-d(\alpha)V^h(t^{\ell}(\tilde{\eta}),t^*(\tilde{\eta})) - (1-d(\alpha))V^h(t^h(\tilde{\eta}),t^*(\tilde{\eta}))]. \quad (A4)$$

Since the last two terms in (A4) are identical to the last two terms of (A3), we need only show the sum of the first two terms in (A4) is positive. Since $\bar{\beta}>\tilde{\beta}$ this is trivial for sufficiently low ρ.

Because $\rho<\bar{\rho}$, $W(\alpha,\rho)$ as given by (16) is greater than $W(\alpha,\rho)$ as given by (15). Hence, for $\rho<\bar{\rho}$

$$W(\alpha,\rho)-\tilde{W}(\alpha,\rho) > \alpha[V^{\ell}(t^h(\bar{\beta}),t^*(\bar{\beta}))-V^{\ell}(t^{\ell}(\tilde{\beta}),t^*(\tilde{\beta}))]$$
$$+ \alpha\rho[V^{\ell}(t^{\ell}(\bar{\tau}),t^*(\bar{\tau})) - u(\alpha)V^{\ell}(t^{\ell}(u(\alpha)),t^*(u(\alpha))) - (1-u(\alpha))V^{\ell}(t^h(u(\alpha)),t^*(u(\alpha)))]$$
$$+ (1-\alpha)[R^h(t^h(\bar{\beta}),t^*(\bar{\beta})) - P^h(t^h(\tilde{\beta}),t^*(\tilde{\beta}))], \quad (A5)$$

where $R^h(t^h(\bar{\beta}),t^*(\bar{\beta})) > P^h(t^h(\tilde{\beta}),t^*(\tilde{\beta}))$ as noted above. It then follows from (A4) that

$$W(\alpha,\rho)-\tilde{W}(\alpha,\rho) > \alpha[V^{\ell}(t^h(\bar{\beta}),t^*(\bar{\beta}))-V^{\ell}(t^{\ell}(\tilde{\beta}),t^*(\tilde{\beta}))]$$
$$+ \alpha\rho[V^{\ell}(t^{\ell}(\bar{\tau}),t^*(\bar{\tau})) - V^{\ell}(t^{\ell}(u(\alpha)),t^*(u(\alpha)))]$$
$$+ (1-\alpha)[R^h(t^h(\bar{\beta}),t^*(\bar{\beta})) - P^h(t^h(\tilde{\beta}),t^*(\tilde{\beta}))] > 0$$

if $V^{\ell}(t^h(\bar{\beta}),t^*(\bar{\beta})) \geq V^{\ell}(t^{\ell}(\tilde{\beta}),t^*(\tilde{\beta}))$ and $\bar{\tau} \leq u(\alpha)$. One can show that the sign of $u(\alpha)-\bar{\tau}$ is given by $u(\alpha)-\alpha+(1-u(\alpha))\alpha F(\bar{\rho}) > 0$, so $W(\alpha,\rho) >\tilde{W}(\alpha,\rho)$ for $\rho<\bar{\rho}$ if $V^{\ell}(t^h(\bar{\beta}),t^*(\bar{\beta})) \geq V^{\ell}(t^{\ell}(\tilde{\beta}),t^*(\tilde{\beta}))$. This also completes the proof for all ρ because $W(\alpha,\rho)-\tilde{W}(\alpha,\rho)$ is given by the right hand side of (A5) when $\rho\in[\bar{\rho},\tilde{\rho}]$.

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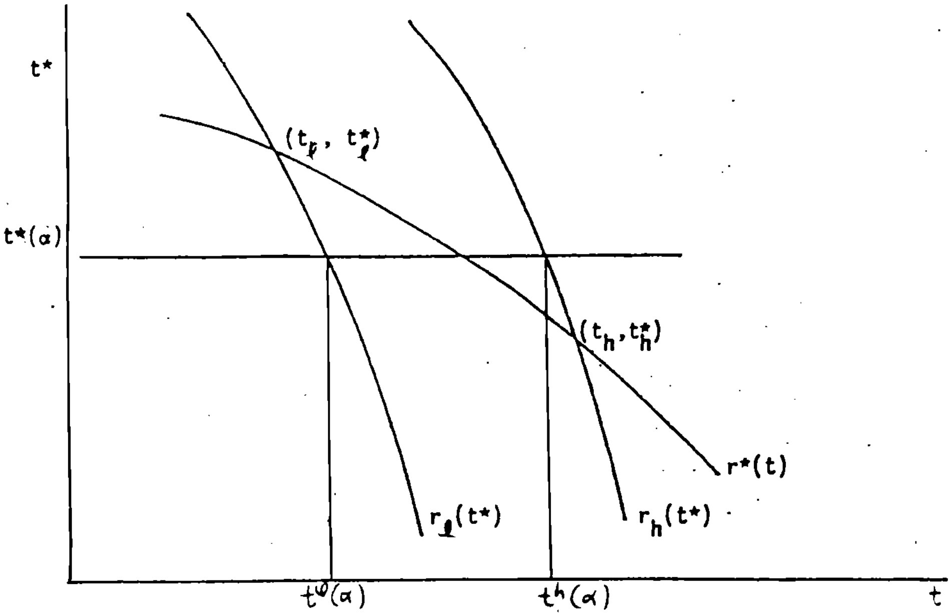

FIGURE 1

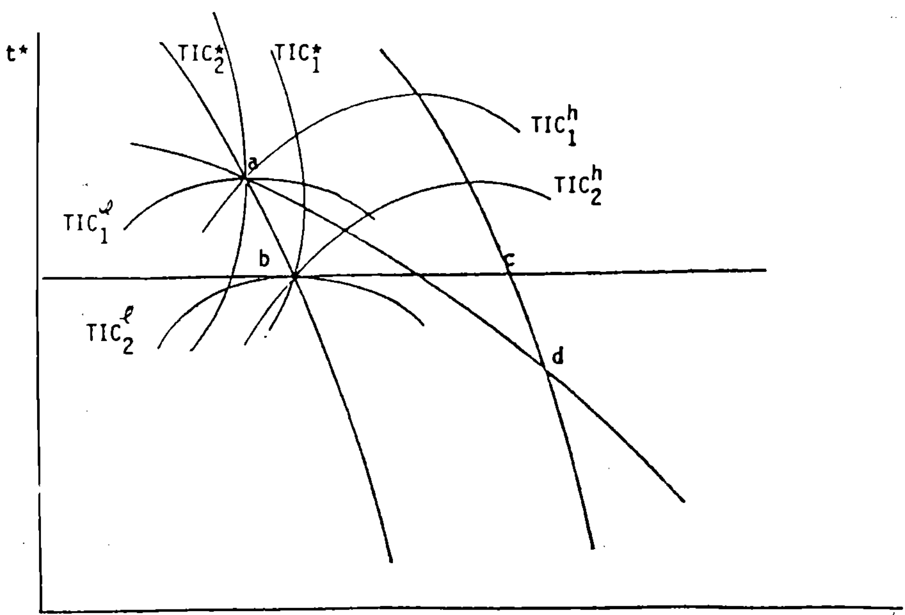

FIGURE 2

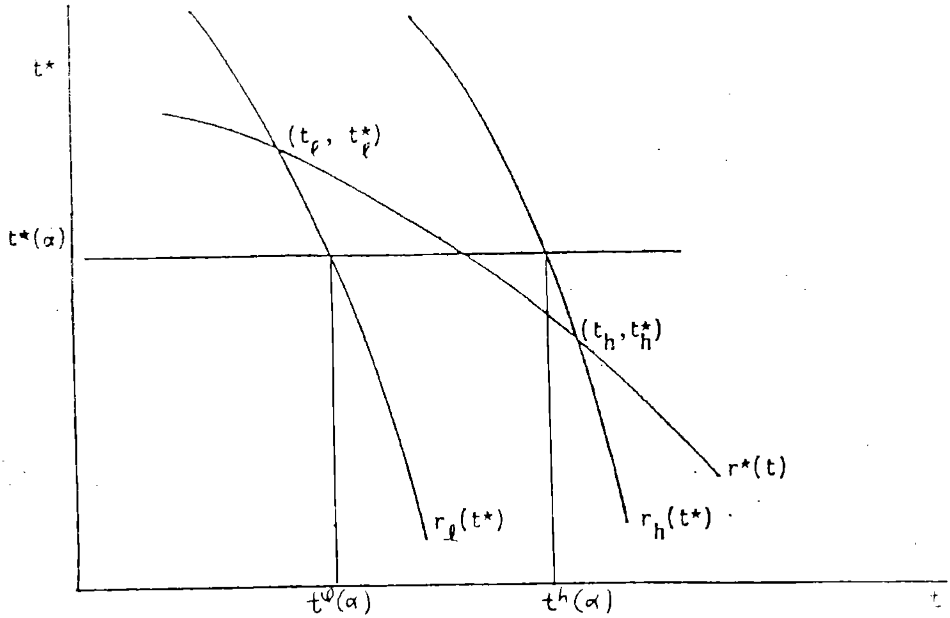

FIGURE 1

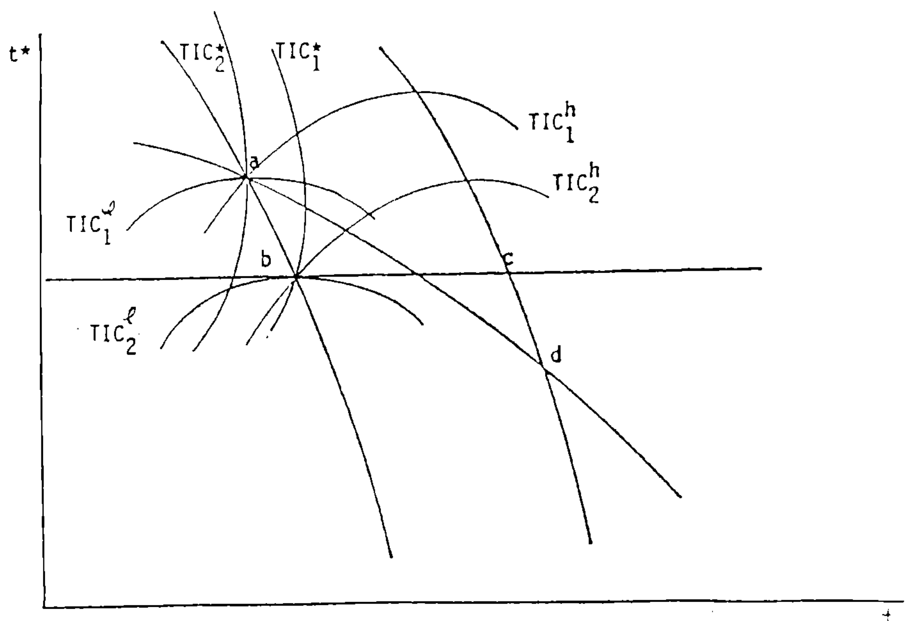

FIGURE 2