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Learning about Enforcement: A Model of Dumping

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Abstract

We study the effects of uncertainty about the intensity of enforcement of antidumping regulations. The desire to avoid penalties alters the foreign firm's behavior. In the first period of a two period model, domestic and foreign firms have common beliefs that the government is a strong enforcer of antidumping regulations. After observing whether a penalty has occurred, firms update their subjective probabilities and adjust their behavior. In the first period firms act strategically to manipulate the information received by the foreign firm. The effect of this information on the choice variables depends on second order properties of the second period value function.

I. Introduction

Domestic firms often invoke antidumping laws in order to avoid competition from foreign firms. The importance of this form of protection has increased recently, since, among other things, antidumping rulings contain an element of uncertainty.[1] Uncertainty about the application of the law

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1. There is uncertainty not only about the determination of whether dumping has occurred, but also as to the determination of material injury and the size of the penalty ⟨Boltuck, Francois and Kaplan [1992]⟩. In this paper, we concentrate on the first source of uncertainty, *i.e.*, the fact that the detection of dumping is an imperfect technology.

makes dumping accusations a useful tool for domestic firms because the possibility of an antidumping ruling can be used as a threat that can be withdrawn if a private agreement to reduce competition is reached.[2] According to US legislation, dumping occurs when imports are sold at less than fair trade value 〈Murray [1992]〉, where fair trade value can be defined in two different ways.[3] By one definition, fair trade value is the price of similar merchandise sold in foreign countries, while according to the alternative definition, fair trade value is the cost of production plus a fixed markup. Uncertainty arises because there are errors involved in measuring the relevant prices or in constructing artificial cost indexes for foreign firms. Hence, the detection of dumping is at best an inexact science. Nevertheless it is clear that, other things being equal, the higher the dumping margin (defined as the difference between the domestic price and fair trade value), the higher the probability of detecting dumping.

There is a further source of uncertainty in antidumping detection.[4] The intensity with which the government pursues dumping investigations depends on political considerations and in turn, the severity of government enforcement affects the probability of detection. Since dumping findings benefit domestic producers, domestic firms generally lobby for strong enforcement of antidumping legislation. On the other hand, consumers, downstream producers and foreign firms lobby for more lenient enforcement. Antidumping legislation is pursued more or less intensely depending on the strength of these various lobbies. Hence, it is difficult for foreign

2. Empirical evidence is found in the records of antidumping actions that are dropped before the investigation is completed. Presumably, the domestic firms have reached an agreement with the foreign competitor in order that the charges be dropped 〈Prusa [1992]〉.
3. This is the issue of detecting dumping. According to the GATT antidumping code, before antidumping duties can be imposed, material injury to a domestic firm must be determined. The assessment of material injury is a matter which is closely related to the detection of dumping, but one which we do not examine. Note that the larger the dumping margin, the more probable that dumping causes material injury. Thus a higher dumping margin makes it more likely that dumping and material injury are established.
4. In the NAFTA agreement, one of the objectives of Canada was to try to reduce the element of uncertainty stemming from US antidumping legislation.

firms to know if the government they face is a strong or a weak enforcer of antidumping legislation in their industry.

Because penalties reduce their profits, foreign firms design their actions to reduce the probability that dumping is detected. The actions of the foreign firms depends on their beliefs about the strength of governmental enforcement. The observation of previous penalties in the industry provides information about the intensity of enforcement. Indeed, this information affects the beliefs of the foreign firm about the commitment to antidumping legislation of the government. The observation of a penalty indicates a higher likelihood that the government is a strong enforcer. Likewise, if no penalty has been observed the likelihood of a weak government increases.

The purpose of this paper is to examine a model in which there is uncertainty, not only about the detection of dumping but also about the severity with which the government agency enforces antidumping regulation. We study how uncertainty about the strength of enforcement affects the strategic behavior of both domestic and foreign firms. Since the purpose of this paper is to study the effect of governmental policy on firms, we postulate the behavior of the government and do not study its optimal policy.

In this paper it is assumed that there are two firms, a domestic and a foreign firm, each producing a homogenous good. The home market of the foreign firm is assumed to be protected, while there is no protection in the home country. The foreign firm produces for its own home market, in which it is a monopolist, as well as for export to the domestic market. The domestic firm, on the other hand, produces only for the domestic market. The domestic market structure is assumed to be Cournot.[5] We assume that the demand function is the same in both markets. In the absence of antidumping legislation the foreign firm maximizes profits by selling at the monopoly price in the home market and at the Cournot price abroad, *i.e.*, it dumps in the domestic market. We assume dumping is not always detected, *i.e.*, dumping legislation is imperfectly enforced. But when it is determined that dumping has occurred, monetary penalties, which do not directly bene-

5. The main thrust of our results does not change if there is price competition and the goods are imperfect substitutes.

fit the domestic firm, are imposed on the foreign firm.[6] Finally, it is assumed that the probability that dumping is detected is an increasing function of the dumping margin, *i.e.*, the difference between the foreign and the domestic price. Hence, it is possible in our model that the foreign firm is penalized even if it is not dumping.

In order to study the effects of information on the strategies of the firms, we first consider a model in which there is only a single period. As the penalty does not affect the profits of the domestic firm, the possibility that a penalty may be imposed on the foreign firm does not alter the strategic behavior of the domestic firm, which continues to behave as a classical Cournot duopolist. The foreign firm, on the other hand, faced with the possibility of a penalty, changes its behavior in both markets in order to maximize expected profits. This involves reducing exports and expanding domestic sales to reduce the dumping margin. The domestic firm does benefit indirectly from the reduction in competition. If there is uncertainty about the enforcement of antidumping legislation, the domestic firm affects the probability that a penalty is imposed on the foreign firm and hence the behavior of the foreign firm.

Consider now the same model in a two period setting, so that informational effects play a role. Suppose there are two possible types of government: a strong or a weak enforcer of antidumping legislation. The second period assessment by the foreign firm of the type of government it faces depends on whether it suffered a penalty in the first period. In particular, the firm believes it is more likely that the government is a strong enforcer of antidumping legislation if dumping is detected than if dumping is not detected. In the second period the foreign firm can use the information of whether or not a penalty was imposed to update its a *priori* assessment of the type of government it faces. In this model the foreign firm experiments in order to affect the information flow. Moreover, the updating of the information of the

6. Lump sum penalties are a simplification of real penalties that allows us to convey our argument in a clearer way. Real penalties for dumping in the US involve surtaxes equivalent to the estimated margin of dumping. These real world penalties directly benefit the domestic competitor by raising the domestic price of the foreign rival. Our assumption that penalties do not benefit directly the domestic firm serves to illuminate the strategic role of information.

foreign firm provides a reason for experimentation by the domestic firm. Experimentation has a role because the domestic firm can affect the probability of a penalty in the first period and therefore has an informational effect through the update beliefs of the foreign firm.

This paper is closely related to the work on dumping of Fischer [1992].[7] In Fischer there are no informational effects. The model has two periods but the domestic firm benefits directly from the penalty imposed on the foreign firm. This establishes the connection between the two periods. Indeed, a penalty in the first period in Fisher might require the foreign firm to pay a surtax in the second period. This increases the second period profits of the domestic firm. Hence the actions of the domestic firm are directed at increasing the likelihood of a penalty, which affects the future behavior of the foreign firm. In the present paper, the penalty does not directly benefit the domestic firm. If this was the case in Fischer's model, the behavior of the domestic firm would not be affected. However, in the present paper, these penalties change the foreign firm's assessment of the probability that the government is a strong enforcer. Hence, the domestic firm benefits indirectly through this informational effect, taking account of its effect on the probability of a penalty, which affects the behavior of the foreign firm. This subtle effect is exploited by the domestic firm in the first period in order to increase its profits.

There is a literature on the economics of information that is related to the work of this paper. In fact in this paper all decisions, *i.e.*, the outputs of both the domestic and the foreign firm, affect the amount of information contained in the observation that the government has imposed a penalty. This is true because it is assumed that increasing the margin of dumping increases the probability of a penalty more for the stronger government than for

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7. Other references to uncertainty as to domestic response and dumping are Bhagwati and Srinivasan [1976] who analyze the case of an exporting country facing a possible quota whose probability depends on the amount of exports. There is no strategic behavior in this case, since the importing country plays a passive role. Another reference is Das [1990], who analyzes a case in which domestic firms and foreign firms play a game of lobbying for protection by foreign and domestic firms. Protection in this case is not endogenous to the actions of the firms, but rather it is endogenous to their actions on the political market.

the weaker government. Thus there is more information contained in penalties that occur when the margin of dumping is high. Hence there is an incentive for both firms to experiment, *i.e.*, to deviate from their optimal decision when there is no informational effect, in order to affect the informational content of government decisions.

Basically the literature has confined itself to the case of a single decision maker ⟨Grossman, Kihlstrom and Mirman [1977], Mirman, Samuelson and Urbano [1992]⟩. Recently, however, there have been several papers dealing with the duopoly case ⟨Mirman, Samuelson and Schlee [1992], Aghion, Espinoza and Jullien [1990] and Harringtion [1991]⟩. In the case of a single decision maker, information is always valuable. The decision variable always moves in the direction yielding more information. The only issue that arises in this case is whether experimentation occurs and if the decision variable increases or decreases as compared to the myopic decision (the case where there is no informational effect). The situation is very different in the case of a duopoly. The reason for this difference is that information is not always valuable to a duopolist. In fact, it may well be that firms change their myopic decisions in the direction that provides less information. This can be the case because in equilibrium the rival can obtain an advantage from more information. Moreover, it is possible that both firms can be made worse off with more information, since the information could give both firms an incentive to change output so that profits are reduced ⟨Mirman, Samuelson and Schlee [1991]⟩.

Another paper that studies the relationship between dumping and information is Eaton and Mirman [1991].[8] There is no experimentation in Eaton-Mirman but rather, dumping is done in order to signal-jam, that is, in order to obscure information. The difference in the way information affects decisions in Eaton-Mirman and the present paper is that in Eaton-Mirman some decisions are not observable while in this paper all decisions are observable. If decisions are observable, there would be no informational effect in Eation-Mirman.

In our model (as well as in more general models of information), the

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8. See also Hartigan [1993], who discusses how dumping can be used to convey cost signals.

choice of an output decision corresponds to an experiment in the sense of Blackwell [1951]. If information is valuable, a more informative experiment raises expected profits in the next period while a less informative experiment decreases expected profits in the next period. In the second period (when there is no effect from information) the profits of both firms depend on the beliefs of the foreign firm. The effect of information on the behavior of both firms depends on the convexity or concavity of the profit function as a function of the beliefs of the foreign firm. In this model, increases in output in the domestic market is always a more informative experiment. This is so since after a penalty is observed the posterior that the government is a strong enforcer increases in the amount of output. The probability that the government is a weak enforcer decreases as output increases. Note also that the expected posterior is always equal to the prior. In this case, if the profit function is convex, information is valuable. Hence, looking from the perspective of the first period, increasing output yields higher expected profits for the domestic firm since when the value function is convex, the probability of a strong enforcer gets more weight than the probability of a weak enforcer in the assessment of the foreign firm. Thus the domestic firm is better off with more information. Less information is better when the value function is concave. Hence the effect of information is to increase output when information is valuable and to decrease output when information is detrimental.

The next section sets up the model. The following section examines the strategic role of information and proves the main results. The final section presents an example in which firms always desire more information.

II. The Model

There are two time periods, two firms and two countries. Each country represents a market. At the beginning of each period firm i sells quantities q_{ij}, $i, j = 1, 2$ of a homogeneous good in market H (Home market) in period j. The foreign firm also sells q_j^* at a price p^* in its own domestic market F in period j. At the end of each period a monitoring agency in the home market determines if dumping has occurred and if so, a penalty is imposed on the foreign firm.

The inverse demand function is the same in both market:

$$p = p(q),\ p' < 0\ p'' < 0, \tag{1}$$

where q is the total amount sold in the market. The price in market H is p and the price in market F is p^*. There are no transport costs and marginal costs are zero. In the absence of protection, the foreign firm would sell at different prices in the two markets because it is a monopolist in its own domestic market and a duopolist in the home market. It is natural to expect in this situation that dumping occurs. The problem is that the detection of dumping by the monitoring agency is uncertain. Since it is easier to observe dumping as the dumping margin increases, it is assumed that the probability of detection is an increasing function of the dumping margin $(p^* - p)$. Furthermore, we assume that there are two types of governments. The first type is a strong enforcer of antidumping legislation, while the second type takes a more relaxed attitude to dumping. This implies that there are two possible probabilities of protection. These probabilities are: $\overline{m}$, corresponding to a government that is a strong enforcer of antidumping legislation, and $\underline{m}$, which corresponds to a government that is a lax enforcer of antidumping legislation. Formally, we can write the probabilities of detection as

$\overline{m}(p^* - p)$, if government is a strong enforcer,

and (2)

$\underline{m}(p^* - p)$, if government is a weak enforcer,

with $\overline{m}', \underline{m}' > 0$. $\overline{m}(p^* - p) > \underline{m}(p^* - p)$, $\forall (p^* - p) \in \mathbb{R}$. We assume that the functions $\overline{m}$, $\underline{m}$ are twice differentiable and that $\overline{m}' > \underline{m}'$, *i.e.* the probability of protection increases faster for the strong enforcer than for the weak enforcer as the dumping margin increases. Neither firm knows whether the government is a strong or a weak enforcer of antidumping legislation. The firms have common prior beliefs about the type of government they face. The decisions of the foreign firm depend directly on the strength of the antidumping response by the domestic government. We assume that the firms have a prior probability ρ_0 that the government is a strong enforcer, *i.e.*, $\rho_0 = \text{Prob}\{m = \overline{m}\}$. All actions are observed by both firms. Hence the posterior beliefs of both firms about the type of government are the same. If dumping is detected, a fine $M > 0$ is imposed on the foreign firm. The penalty does not benefit the domestic firm and it is independent of the dumping margin.[9]

The sequence of events and the flow of information is this model are described as follows. In the first period both firms decide on their outputs. These outputs determine the price in each market. All prices and outputs are observed by both firms. After observing the price in both markets, the government either does of does not impose a fine on the foreign firm.[10] The probabilities of the penalties are given by (2). After the firms observe the reaction of government, both firms update their beliefs on which type of governmental enforcement the foreign firm faces. With these updated (posterior) beliefs, the markets open in the second period. The only connection between the periods is the learning by the foreign firm, which takes place after the government's action is observed. This learning is summarized in the posterior beliefs. In order to study this two period problem, it is necessary to study the second period profits as a function of the updated beliefs. These updated beliefs depend on the decisions of the firms as well as the decision of the government.

The Second Period: In the second period firms choose quantities to maximize the expected value of profits without regard to future learning because this is the last period, so information has no further value (the second period problem can also be thought of as the myopic solution since no experimentation is entailed for both firms). We assume that the second period (or myopic) problem has a unique solution. Let ρ_1 be the updated (at the beginning of period 2) probability that the government is a strong enforcer.

Let

$$\hat{m}_i = \rho_i \bar{m} + (1 - \rho_i)\underline{m},\ i = 0, 1, \tag{3}$$

9. This assumption has no effect on the qualitative results and simplifies their interpretation.

10. There are two possible explanations for the fact that m is a probability that depends continuously on the dumping margin, rather than a function taking the values 0 (if the margin is zero) or 1 (if the margin is positive). The first is that the political pressures for antidumping enforcement increase in the dumping margin. The second explanation is that the government observes a noisy signal of the dumping margin, because it does not observe all prices correctly. Nevertheless, the higher the dumping margin, the easier it is to detect that dumping is actually occurring.

be the expected probability of a penalty in period i, given that the firms have beliefs ρ_i that the type of government is strong. The problem for the foreign firm, given the output q_{12} of the domestic firm, is

$$\Pi^*(q_{12}) = \text{Max}_{\{q_{22},\, q_2^*\}}\, p(q_{12}+q_{22})q_{22}+p^*(q_2^*)q_2^*-\hat{m}_1(p_2^*-p_2)M \tag{4}$$

The first order conditions (or the reaction functions) for the foreign are:

$$\partial\Pi^*/\partial q_{22} = p'q_{22}+p+\hat{m}_1'p'M=0 \tag{5}$$

$$\partial\Pi^*/\partial q_2^* = p^{*\prime}q^*+p_2^*-\hat{m}_1'p^{*\prime}M=0 \tag{6}$$

The linkage between the domestic and foreign markets occurs through the probability of protection, which is a function of the dumping margin $p_2^*-p_2$. The dumping margin, in turn, depends on all outputs q_{12}, q_{22} and q_2^* through the demand function. The effect of a threat of a penalty is that for each q_{12} the foreign firm changes its sales in both markets in order to reduce the dumping margin. In comparison to the case in which there is no antidumping legislation, the foreign firm reduces its exports and increases its domestic sales (in its own market) to lower the probability of a fine. In doing so it raise prices in H and reduces prices in F, lowering the dumping margin and thus, the probability of a penalty.

The second period profit for the domestic firm is given by:

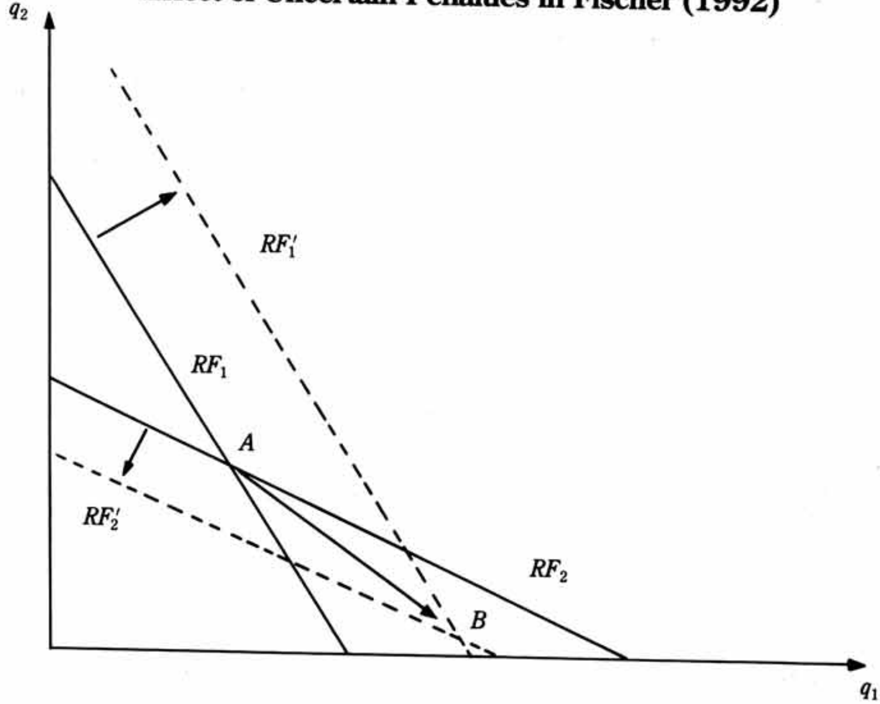
$$\underset{\{q_{12}\}}{\text{Max}}\; p(q_{12}+q_{22})q_{12} \tag{7}$$

The first order condition (or the reaction function) for the domestic firm is:

$$p'q_{12}+p(q_{12}+q_{22})=0 \tag{8}$$

Expression (8) shows that the possibility of a penalty has no effect on the output choice of the domestic firm (See Figure 1). Nevertheless, the probability of a penalty creates an incentive for the foreign firm to decrease its exports in orders to reduce the probability of the penalty, thus increasing the profits of the domestic firm. This is the conclusion of Fischer [1991] for the case in which the probability of protection is endogenous, the type of government is known and the domestic firm obtains no benefits from the penalty on the foreign firm.

Figure 1
Effect of Uncertain Penalties in Fischer (1992)



Note that the simultaneous solution of the reaction functions (5), (6) and (8), assumed to be unique, determines the equilibrium outputs q^e_{22}, q^e_{12}, q^{e*}_2. In particular, the dumping margin depends on p^*_2 and p_2 and thus on the variables q^e_{22}, q^e_{12}, q^{e*}_2. It is important to note that these equilibrium values all depend on the posterior ρ_1. Moreover, the equilibrium profits for both firms depend on ρ_1. Hence let

$$V^*(\rho_1) = \Pi^*(q^e_{12}(\rho_1)) \tag{9}$$

and

$$V(\rho_1) = \Pi\left(q^e_{22}(\rho_1), q^{*e}_2(\rho_1)\right) \tag{10}$$

be the value functions for the domestic and the foreign firm, respectively. The value functions (9) and (10) represent the profits in a Cournot-Nash equilibrium as a function of the posterior beliefs. The value function of the domestic firm depends on ρ_1, because ρ_1 determines the extent to which the probability of a penalty shifts the foreign firm's reaction function and therefore reduces its exports. Since in the second period there are no informational considerations, these are the only effects of protection. However, in the first period, informational considerations play a crucial role.

In the first period of the model analyzed in Fischer, the domestic firm acts strategically because it receives future benefits from a penalty imposed on the foreign firm. By acting strategically, the domestic firm changes the probability that dumping is detected and thus the probability of receiving the benefits derived from the penalty. The reasoning in this paper is more subtle, since a penalty does not benefit the domestic firm directly. In our model, a penalty during the first period changes the common assessment of the type of government and therefor changes the second period behavior of the foreign firm. The domestic firm takes advantage of this behavior by choosing outputs appropriately. In order to capture this informational effect, the second order properties of the value function must be studied.[11]

First we consider the effects of an increase in ρ_1 on the value function of the domestic firm,

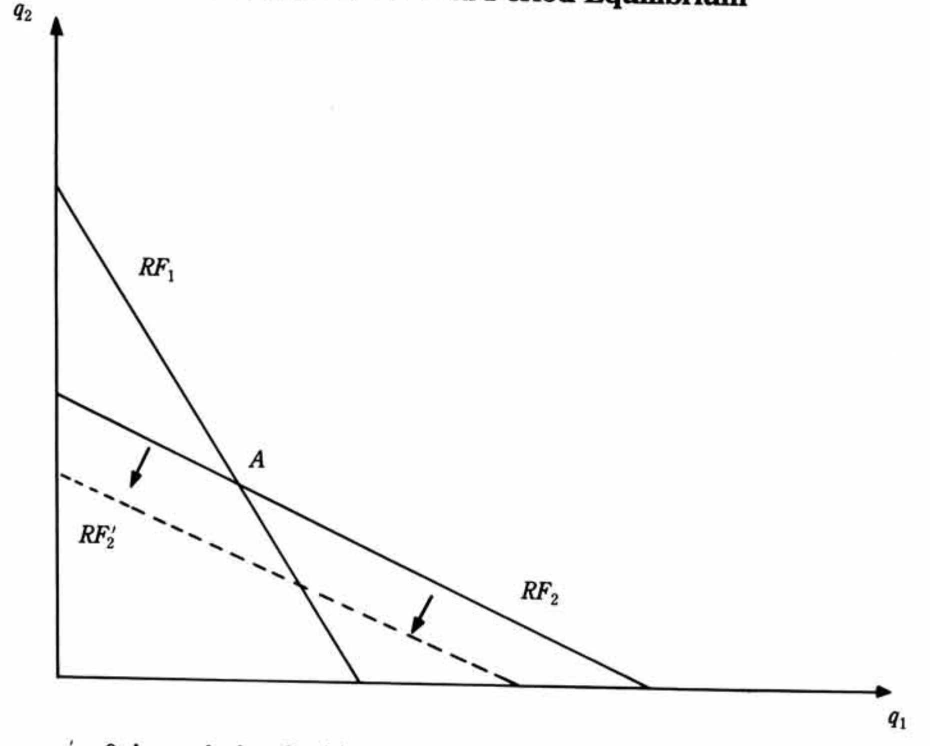
$$\frac{dV}{d\rho_1} = p' q_{22}' q_{12} > 0 \tag{11}$$

This follows from the envelope theorem when the sign of $q_{22}' = q_{22}'(\rho_1)$ is negative. However, under the assumption $\overline{m}' > \underline{m}'$, q_{22}' is negative since this assumption ensures that the reaction curve moves outward as ρ_1 increases. The intuition for (11) is that the foreign firm cuts back exports if its posterior probability of a strong government increases. This raises domestic prices, increasing the profits of the domestic firm. (See Figure 2). Clearly, the domestic firm would prefer that the foreign firm believe that the probability that the government is a strong enforcer is high. Another application on the envelope theorem leads to an expression for the changes in the value function of the foreign firm:

$$\frac{dV^*}{d\rho_1} = p' q_{12}' q_{22} + \left(\overline{m}' p' q_{12}' \rho_1 + (1-\rho_1)\, \underline{m}'\, p' q_{12}'\right) M + (\underline{m} - \overline{m}) M < 0, \tag{12}$$

11. In general the value function may not be differentiable. We will assume that it is differentiable in our analysis. The example at the end of the paper studies a problem where the value function is differentiable.

Figure 2
Shifts in the Second Period Equilibrium



here $q_{12}^{'}>0$, is again implied by the assumption $\bar{m}' > \underline{m}'$. Notice that there are three channels in the second period through which an increase in the assessment of ρ_1 affects foreign firm profits: (i) the negative effect induced by the domestic firm increasing output in response to the foreign firm's cutback; (ii) the effect of the increase in the domestic firm's output on the probability of a penalty under the two types of government and (iii) the direct effect of the increased probability of a strong enforcer on the profits of the firm. These points appear in Fischer [1991]. However, as shown below, the first order approach used in Fischer [1992] is not enough to sign the effect of information on first period outputs. We need the second order approach to determine the effect of information.

The First Period: The problem facing the domestic firm is (we assume that future profits are not discounted to simplify the notation)

$$\begin{aligned}\underset{\{q_{11}\}}{\text{Max}}\ & p(q_{11}+q_{21})q_{11}+\hat{m}_0 V(\rho_1^h(q_{11},q_{21},q_1^*)) \\ & +(1-\hat{m}_0)V(\rho_1^1(q_{11},q_{21},q_1^*))\end{aligned} \tag{13}$$

The last two terms on the RHS of (13) represent the expected value of second period profits to the domestic firm. The second term is the value to the firm if dumping is detected in the first period, weighted by the expected probability of enforcement. This expected probability depends on the a priori beliefs that the government is a strong enforcer as well as on the observed market variables. The third expression corresponds to the case where dumping is not detected.

In the first period each firms' decisions depend on the effect of their output choices on second period profits through the change in the posterior probability. Suppose that a penalty is observed at the end of the first period. Then the undated probability that the type of the government is strong is:

$$\rho_1^h = \frac{\rho_0 \overline{m}}{\rho_0 \overline{m} + (1-\rho_0)\underline{m}} \tag{14}$$

whereas if the penalty is not observed, the updated probability that the government is strong is:

$$\rho_1^1 = \frac{\rho_0(1-\overline{m})}{\rho_0(1-\overline{m}) + (1-\rho_0)(1-\underline{m})} \tag{15}$$

Here the superindex stands for high and low government responsiveness, respectively. In this situation there are two possibilities, or two "signals": penalty or no penalty. Denoting no penalty by s_0 and penalty by s_1, the assumption $\overline{m} > \underline{m}$ implies that $\rho_1^h > \rho_1^1$. Thus in a very simple way, the posterior probability is monotonic in the signal. This property is just a manifestation of what is generally called the Monotone Likelihood Ratio Property (MLRP). Note that through (2), it is possible to write these updated probabilities as functions of first period outputs: $\rho_1^h = \rho_1^h(q_{11}, q_{21}, q_1^*)$. Moreover, we have the important relation,

$$\rho_0 = \hat{m}_0 \rho_1^h + (1-\hat{m}_0)\rho_1^1 = E\rho_1 \tag{16}$$

When a firm observes a penalty, it does not know whether the type of the government is strong. Firms can only deduce that it is more probable that the type of government is strong. Therefore, the updated value for ρ is independent of the actual (but unobserved) type of the government.

The first order conditions for the domestic firm can be written as:

$$\frac{\partial \Pi}{\partial \rho_{11}} = p'q_{11} + p + \hat{m}\frac{\partial \rho_1^h}{\partial q_{11}} V'(\rho_1^h) + (1-\hat{m})\frac{\partial \rho_1^1}{\partial q_{11}} V'(\rho_1^1)$$
$$+ [V(\rho_1^h) - V(\rho_1^1)]\frac{\partial \hat{m}}{\partial q_{11}} = 0 \tag{17}$$

where

$$\frac{\partial \hat{m}}{\partial q_{11}} = -(\rho_0 \overline{m}' + (1-\rho_0)\underline{m}')p_1' > 0 \tag{18}$$

Notice that in (17), the first two terms correspond to the first order conditions in a single period duopoly without regard to information, *i.e.* it corresponds to the myopic solution when there are no informational considerations. The last three terms in (17) represent the effect of information. In particular, the last term is analogous to the term that drives the strategic effects in Fischer. It can be interpreted as the expected change in profits due to the change in the expected probability of protection. The two middle terms are new to this formulation. The third term corresponds to the change in the second period assessment of the probability of a strong government and its effect on the value if dumping is detected, weighed by the probability of detection. Finally, the fourth term corresponds to the change in the second period assessment of the probability of a strong government and its effect on the value if dumping is not detected, weighed by the probability of no detection. If these middle terms have the same sign as the last term, then the effects discussed in Fischer are amplified in this new setting. On the other hand, if these terms have the opposite sign of the last term, the strategic changes to domestic firm output can be smaller than those described in Fischer. The effects may even be reversed.

III. The Strategic Role of Information

In the following we distinguish between two types of myopic responses. A myopic response of type 1 occurs if firms do not take account of the possibility of a penalty, as in the myopic firms described by Fisher. A myopic response of type 2 occurs if the firms are aware of the possibility of a penalty and react accordingly, but do not realize that their actions can affect their future assessments of the type of government.

Lemma: *Suppose* $\overline{m}\,\underline{m}' - \underline{m}\overline{m}' < 0$. *Then* $\partial\rho_1^h/\partial q_{11} > 0$ *and* $\partial\rho_1^1/\partial q_{11} < 0$. *On the other hand, if* $\overline{m}'(1-\underline{m}) - \underline{m}'(1-\overline{m}) < 0$ *then* $\partial\rho_1^h/\partial q_{11} < 0$ *and* $\partial\rho_1^1/\partial q_{11} > 0$.

Proof: To show that $d\rho_1^h/dq_{11}$ and $d\rho_1^1/dq_{11}$ move in opposite directions, first consider the expressions

$$\frac{\partial\rho_1^h}{\partial q_{11}} = \frac{p'\rho_0(1-\rho_0)(\overline{m}\,\underline{m}' - \overline{m}'\underline{m})}{A^2}$$

and (19)

$$\frac{\partial\rho_1^1}{\partial q_{11}} = \frac{\rho_0(1-\rho_0)p'[\overline{m}'(1-\underline{m}) - (1-\overline{m})\underline{m}']}{(1-A)^2}$$

where $A = \rho_0\overline{m} + (1-\rho_0)(1-\underline{m}) > 0$.

Note that a condition for the two expressions (19) to be positive is that

$$\begin{aligned} &\overline{m}\,\underline{m}' - \underline{m}\overline{m}' < 0 \\ &\overline{m}'(1-\underline{m}) - \underline{m}'(1-\overline{m}) < 0 \end{aligned} \tag{20}$$

However, these two conditions cannot hold: the first condition in (20) is equivalent to

$$1 < \overline{m}\,/\,\underline{m} < \overline{m}'/\underline{m}'$$

while the second condition imply that

$$\overline{m}'/\underline{m}' < (1-\overline{m})\,/\,(1-\underline{m}) < 1$$

Hence, the assumption $\overline{m}\,\underline{m}' - \underline{m}\overline{m}' < 0$ implies that $\dfrac{\partial\rho_1^h}{\partial q_{11}} > 0$ and $\dfrac{\partial\rho_1^1}{\partial q_{11}} < 0$.

Conversely if $\overline{m}'(1-\underline{m}) - \underline{m}'(1-\overline{m}) < 0$, then $\dfrac{\partial\rho_1^h}{\partial q_{11}} < 0$ and $\dfrac{\partial\rho_1^1}{\partial q_{11}} > 0$.

Q.E.D.

Similar results can be shown for q_1^* since

$$\frac{\partial \rho_1^h}{\partial q_1^*} = \frac{p_1^{*\prime} \rho_0 (1-\rho_0)(\overline{m}' \underline{m} - \overline{m}\, \underline{m}')}{A^2}$$

and (21)

$$\frac{\partial \rho_1^1}{\partial q_1^*} = \frac{p_1^{*\prime} \rho_0 (1-\rho_0)[(1-\overline{m})\underline{m}' - (1-\underline{m})\overline{m}']}{(1-A)^2}.$$

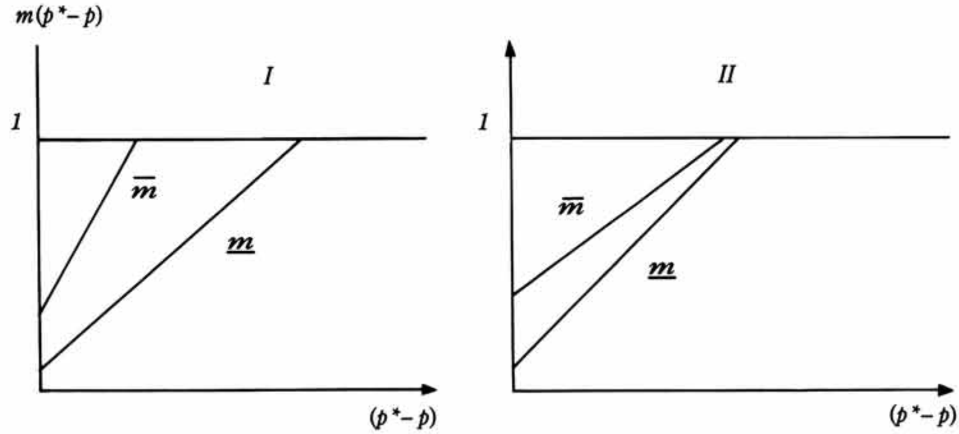
Note that, from (16), the mean of the posterior always equals the prior. Hence changes in the decision variables imply an experiment in the sense of Blackwell. In fact, a more informative experiment implies that ρ_1^h increases and ρ_1^1 decreases as output changes. If the value function is convex, the domestic firm wants to make the difference between these two values as large as possible. The reason is that when V is convex, the domestic firm gains more by increasing ρ_1^h than it loses by decreasing ρ_1^1 *i.e.*, information is valuable. A less informative experiment implies that ρ_1^h and ρ_1^1 move closer together.

Since, by assumption, $\bar{m} > \underline{m}$, the condition $\bar{m}\underline{m}' - \underline{m}\bar{m}' < 0$ implies that the difference between $\bar{m}$ and $\underline{m}$ is increasing in the dumping margin *i.e.*, a strong government becomes increasingly better than a weak government at detecting dumping (see Figure 3). Conversely, when $\bar{m}'(1-\underline{m}) - \underline{m}'(1-\bar{m}) < 0$, the probability of a penalty under the two types of government moves closer as the dumping margin increases. If the value function is convex, the domestic firm wants to create more information on the type of government (*i.e.*, wants to separate ρ_1^1 from ρ_1^h). When $m\underline{m}' - \underline{m}\bar{m}' < 0$, this requires an increase in output so that the domestic price falls and the dumping margin increases. We show this in the following proposition.

In fact, the effect of information on the optimal decision can best be seen from the first period optimization problems (13) for the domestic firm and (18) for the foreign firm. The first period optimization problem is a two period problem and the information gleaned after observing the first period variables is used in the second period. The second period problem does not have an informational effect since there are no future periods. As mentioned above, the case in which information plays no role shall be referred to as the myopic solution. To study the role of information, it is necessary to

Figure 3

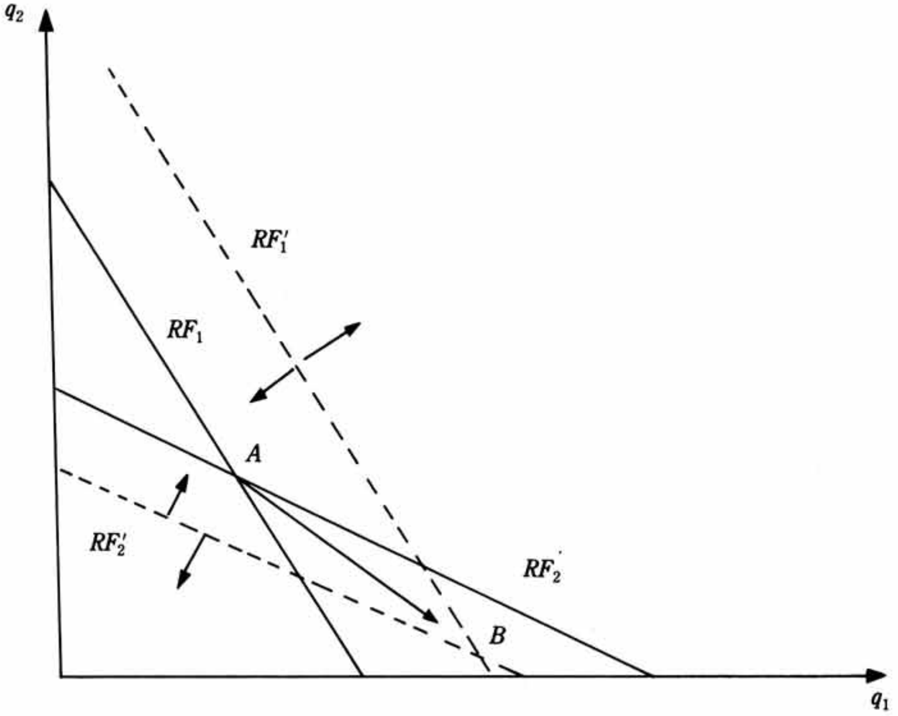
I) $\overline{m}\underline{m}' - \underline{m}\overline{m}' < 0$ and II) $\overline{m}'(1-\underline{m}) - \underline{m}'(1-\overline{m}) < 0$



study the second order derivatives of V and V^*, since the first order approach as used in Fischer is inconclusive. In particular, in equation (16) and (24)-(25) all the first order derivatives are signed but ρ_1^h and ρ_1^1 move in opposite direction, *i.e.*, either a more or less informative experiment is created. The second order properties of V and V^* allows us to compare these magnitudes and to sign the comparative statics (see Figure 4).

It is the second order properties of the value function that determine the effect of information on the optimal decision. The first period decision for either firm involves an experiment in the sense of Blackwell. If the value function is convex, information is valuable and the optimal decision of the firm is to adjust (as compared to a myopic case) output in the direction that yields more information. If the value function is concave, information is detrimental and the output decision is adjusted in the direction that yields less information. In either case the effect of the optimal decision is to increase second period expected utility. It is not possible to determine the convexity or concavity of V for general market demand functions. In the next section we shall study the problem in the context of an example that can be solved explicitly.

Figure 4
The Strategic Effect of Information



Proposition 1: *If V is convex (concave) and $\bar{m}\underline{m}' - \underline{m}\bar{m}' < 0$, then for every quantity of exports of the foreign firm, the best response of the domestic firm is to sell more (less) than in the myopic case.*

Proof: The proof depends on the sign of the term

$$\Phi = \hat{m}\frac{\partial \rho_1^h}{\partial q_{11}}V'(\rho_1^h) + (1-\hat{m})\frac{\partial \rho_1^1}{\partial q_{11}}V'(\rho_1^1) + [V(\rho_1^h) - V(\rho_1^1)]\frac{\partial \hat{m}}{\partial q_{11}} \quad (22)$$

If this term is positive (negative), the reaction curve shifts out (in), because $p'' + 2q_{11}p' < 0$. The domestic firm increases sales if Φ is positive. Differentiating (16) we have

$$\frac{1}{(\rho_1^1 - \rho_1^h)}\left(\hat{m}_0\frac{\partial \rho_1^h}{\partial q_{11}} + (1-\hat{m}_0)\frac{\partial \rho_1^1}{\partial q_{11}}\right) = \frac{\partial \hat{m}_0}{\partial q_{11}}.$$

This expression can be substituted in Φ to obtain

$$\Phi = (1-\hat{m}_0)\frac{\partial \rho_1^1}{\partial q_{11}}\left(V'(\rho_1^1) - \frac{V(\rho_1^h) - V(\rho_1^1)}{(\rho_1^h - \rho_1^1)} \right)$$
$$+ \hat{m}_0 \frac{\partial \rho_1^h}{\partial q_{11}}\left(V'(\rho_1^h) - \frac{V(\rho_1^h) - V(\rho_1^1)}{(\rho_1^h - \rho_1^1)} \right).$$

By the previous lemma we know that the condition $\overline{m}\,\underline{m}' - \underline{m}\,\overline{m}' < 0$ implies that $\partial \rho_1^h / \partial q_{11} > 0$ and $\partial \rho_1^1 / \partial q_{11} < 0$. The convexity (concavity) of V implies that the first term in brackets in Φ is negative (positive) and that the second term in brackets is positive (negative), ensuring the Φ is positive (negative). Since Φ is positive (negative), the domestic firm increases (decreases) output for each level of output of the other firm. Q.E.D

The problem facing the foreign firm is:

$$\underset{\{q_{11},\, q_1^*\}}{\text{Max}}\; p(q_{11}+q_{21})q_{21} + p_1^*(q_1^*)q_1^* + \hat{m}V^*(\rho_1^h(q_{11},q_{21},q_1^*)) \tag{23}$$
$$+ (1-\hat{m})V^*(\rho_1^1(q_{11},q_{21},q_1^*)) - \hat{m}_0 M$$

For the foreign firm, the first order conditions are:

$$\frac{\partial \Pi^*}{\partial q_{21}} = p_1{}' q_{21} + p_1 + \hat{m}_0 \frac{\partial \rho_1^h}{\partial q_{21}} V^{*\prime}(\rho_1^h) + (1-\hat{m}_0)\frac{\partial p_1^1}{\partial q_{21}} V^{*\prime}(\rho_1^1$$
$$+ \left[V^*(\rho_1^h) - V^*(\rho_1^1) - M \right] \frac{\partial \hat{m}_0}{\partial q_{21}} = 0 \tag{24}$$

and

$$\frac{\partial \Pi^*}{\partial q_1^*} = p_1^{*\prime} q_{21}^* + p_1^* + \hat{m}_0 \frac{\partial \rho_1^h}{\partial q_1^*} V^{*\prime}(\rho_1^h) + (1-\hat{m}_0)\frac{\partial \rho_1^1}{\partial q_1^*} V^{*\prime}(\rho_1^1)$$
$$+ \left[V^*(\rho_1^h) - V^*(\rho_1^1) - M \right] \frac{\partial \hat{m}_0}{\partial q_1^*} = 0$$

where $\frac{\partial \rho_1^h}{\partial q_{11}} = \frac{\partial \rho_1^h}{\partial q_{21}} = -\frac{p^{*\prime}}{p'}\frac{\partial \rho_1^h}{\partial q_1^*}$, $\frac{\partial \rho_1^1}{\partial q_{11}} = \frac{\partial \rho_1^1}{\partial q_{21}} = -\frac{p^{*\prime}}{p'}\frac{\partial \rho_1^1}{\partial q_1^*}$, $\frac{d\hat{m}_0}{dq_{11}} = \frac{d\hat{m}_0}{dq_{21}} > 0$ and $\frac{\partial \hat{m}_0}{\partial q_1^*} < 0$.

Proposition 2: *If V^* is concave and $\bar{m}\underline{m}' - \underline{m}\bar{m}' < 0$, then the best response of the foreign firm to any quantity sold by the domestic firm is the reduce exports as compared to the myopic case of type 2.*

Proof: Let

$$\Omega = \hat{m}_0 \frac{\partial \rho_1^h}{\partial q_{21}} V^{*\prime}(\rho_1^h) + (1-\hat{m}_0)\frac{\partial \rho_1^1}{\partial q_{21}} V^{*\prime}(\rho_1^1) + \left[V^*(\rho_1^h) - V^*(\rho_1^1) - M\right]\frac{\partial \hat{m}_0}{\partial q_{21}}$$

We need to show that Ω is negative. The proof is similar to the proof of proposition 1. Q.E.D

The general principle is simple: since its value function is concave, the foreign firm tries to reduce the amount of information available. It achieves this reduction by cutting down exports and increasing sales in its own domestic market.

Note that the difference between Φ and Ω lies in the term $-M\partial\hat{m}_0/\partial q_{12} < 0$. This term appears in Fischer [1992], and leads to the myopic response of type 2 (which captures the desire to avoid a penalty, but does not consider the strategic aspects of information). The existence of this term implies that even for V^* which are slightly convex, the foreign firm reduces exports as compared to a myopic firm of type 1. For larger degrees of convexity, the reaction function of the foreign firm does shift out, even compared to the myopic firm of type 1. Under the conditions of Proposition 2, the foreign firm increases sales in its own domestic market.

It is interesting to observe that there are two ways in which the shifts of the reaction curves could go in the opposite direction. One possibility is that the condition $\bar{m}'(1-\underline{m}) - \underline{m}'(1-\bar{m}) < 0$ holds. In this case more information is obtained by reducing total quantities sold in the domestic market. Thus the domestic firm reduces sales, while the foreign firm may (if the term $-M\partial\hat{m}_0/\partial q_{12}$ does not overpower the information part) increase the exports of the foreign firm. In this case we would have the strange result that facing dumping accusations, the foreign firm increases exports in order to reduce the price of the good it is being accused of dumping, while the domestic firm acts in order to raise the price and make dumping accusations more unlikely. The explanation lies in that by doing so, the domestic firm increases the amount of information (the separation between ρ_1^h and ρ_1^1), while the foreign firms reacts in the opposite way.[12]

The second way in which the shifts could go in the opposite direction is when the V is concave and V^* is convex. In this case, the shifts go in the opposite direction because the domestic firm prefers to reduce the amount of information available to its rival, while the foreign firm prefers to increase the amount of information.

Finally, we are interested in the effects of these shifts of the reaction functions on the equilibrium outcomes. Given that $p'' < 0$ implies downward sloping reaction curves, the next proposition follows immediately.

Proposition 3: *Suppose V is convex, V^* is concave and $\bar{m}\underline{m}' - \underline{m}\bar{m}' < 0$. Then first period exports of the foreign firm are smaller, while first period sales by the domestic firm are larger than in the myopic case of type 2.*

The other cases, when the reaction curves shifts in other directions, have equilibrium effects that are more difficult to determine.

Existence: The existence of a solution requires the uniqueness of the second stage equilibrium. Concavity of the second period profit function follows from $p'' < 0$ for the domestic firm. For the foreign firm, it is necessary to impose the additional condition that $\frac{\partial^2 \Pi^*}{\partial q_{22}^2} < 0$ and $\frac{\partial^2 \pi^*}{\partial q_2^*} < 0$. Since costs are zero, it is always profitable to produce a small amount q_{22}. Finally, we require that the q_{22} corresponding to $q_{21} = 0$ is larger than the monopoly quantity for the domestic firm. These conditions ensure existence and in this case they also ensure uniqueness of the second period solution.

IV. An Example

To be more concrete on the shifts in the equilibrium induced by the possibility of penalties and information, consider an example with linear demands and linear probability of protection. In order to provide more flexibility we will assume that the goods are imperfect substitutes.

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12. Since the model takes the form of a game, it is well known that information can be beneficial or detrimental depending upon the circumstances. For the model presented in this paper, Mirman, Samuelson and Schlee [1993] provide a more detailed explanation of the result.

Let domestic demand be given by

$$p_1 = \theta - \phi q_1 - \chi p_2, \text{ for good 1} \tag{26}$$
$$p_2 = \theta - \phi q_2 - \chi p_1, \text{ for good 2, } |\chi| > 1$$

(where $\chi < 0$ for substitutes) and foreign demand by

$$p^* = \alpha - \beta q^*, \text{ in the market.}$$

For our purposes, it is easier to work with prices as a function of quantities. We obtain

$$p_1 = a - bq_1 - dq_2$$
$$p_2 = a - bq_2 - dq_1$$

where $a = \theta/(1+\chi)$, $b = \phi/(1-\chi^2)$ and $d = \chi\phi/(1-\chi^2)$.

The probability of detection is given by either

$$\bar{m} = \bar{A} + \bar{B}(p - p^*)$$

or

$$\underline{m} = \underline{A} + B(p - p^*), \text{ where } \bar{A} > \underline{A} \text{ and } \bar{B} > \underline{B}.$$

This specification of probabilities may lead to some difficulties in interpretation. When there is no dumping, there still may be sanctions. This is not unrealistic, since in real economies domestic firms often push for sanctions for anti-competitive reasons and antidumping penalties may be imposed when there is no dumping.[13]

The second period value function of the domestic firm is

$$V(\rho_1) = \underset{\{q_{12}\}}{\text{Max}}[a - bq_{12} + dq_{22}]q_{12} \tag{28}$$

with first order condition

$$a - 2bq_{12} - dq_{22} = 0 \qquad (p_1 = a - bq_{12} - dq_{22} = bq_{12}) \tag{29}$$

13. In American antidumping legislation, negative dumping margins are not considered, *i.e.*, if $(p^* - p) < 0$, it is registered as zero. Since several price observations are made and averaged, but only positive values are kept, it is possible that there is a penalty when on average there is no dumping ⟨Boltuck, Francois and Kaplan [1991], Murray [1991]⟩.

Let a hat (^) over a variable denote its expected value. The second period value function for the foreign firm is

$$V^*(\rho_1) = \underset{\{q_{22},q_2^*\}}{\text{Max}}[a - bq_{22} - dq_{12}]q_{22} + [\alpha - \beta q_2^*]q_2^* \\ -[\hat{A} + \hat{B}(p^* - p_2)]M. \tag{30}$$

The first order condition for the foreign firm are:

$$a - 2bq_{22} - dq_{12} - \hat{B}bM = 0 \qquad (a - bq_{22} - dq_{12} - b\hat{B}M = bq_{22}) \tag{31}$$

$$\alpha - 2\beta q_2^* - \beta\hat{B}M = 0 \qquad (\alpha - \beta q_2^* + \beta\hat{B}M = \beta\hat{B}q_2^*) \\ \Rightarrow (\alpha + \beta\hat{B}M)/2\beta = q_2^* \Rightarrow q_2^{*\prime}(p_1) = M(\overline{B} - \underline{B})/2 \text{ and } q_2^{*\prime\prime} = 0. \tag{32}$$

Using (29) and (31) to solve for the equilibrium values,

$$q_{12} = \frac{(2b-d)a + db\hat{B}M}{4b^2 - d^2}, \; q_{22} = \frac{(2b-d)a + 2b^2\hat{B}M}{4b^2 - d^2}$$

and

$$q_{12}' = [\overline{B} - \underline{B}]Mbd \;/\; (4b^2 - d^2) > 0,$$
$$q_{22}' = -2[\overline{B} - \underline{B}]Mb^2 / (4b^2 - d^2) < 0, \; q_{12}'' = q_{22}'' = 0.$$

Hence

$$V = bq_{12}^2 = \frac{b\left(a(2b-d) - \hat{B}Mbd\right)^2}{4b^2 - d^2}$$

Using the expressions in parenthesis in (31) and (32),

$$V^* = bq_{22}^2 + \beta q_2^{*2} - \hat{B}dq_{11}M - \hat{A}M - \hat{B}(\alpha - a)$$

Therefore

$$V' = 2bq_{12}q_{12}' > 0$$

and

$$V'' = 2bq_{12}'^2 + 2bq_{12}q_{12}'' = 2b^3d^2M^2(\overline{B} - \underline{B})^2 / (4b^2 - d^2) > 0$$

Notice that the value function of the domestic firm in this example is always convex. This implies that the domestic firm's objective in the first period is to manipulate output in the direction of a more informative experiment. This always leads the domestic firm to increase sales and thus adds to the effect of a penalty described in Fischer [1992]. As was mentioned above, when the value function is convex, the domestic firm gains when it can better discriminate between ρ_1^h and ρ_1^1 *i.e.*, from more information.

For the foreign firm, simplification leads to

$$V^{*\prime} = 2bq'_{22}\,q_{22} + 2\beta q_2^{*\prime}\,q_2^* - (\overline{B} - \underline{B})Mdq_{12} - \hat{B}dMq'_{12}$$
$$- (\overline{A} - \underline{A})M - (\overline{B} - \underline{B})\,(\alpha - a)M$$

and

$$V^{*\prime\prime} = 2b(q'_{22})^2 + 2\beta(q_2^{*\prime})^2 - 2d(\overline{B} - \underline{B})Mq_{12}$$

The first term in the expression for $V^{*\prime\prime}$ corresponds to the change in marginal profits in the domestic market induced by the changes in quantities sold in that market. It is negative because the foreign firm exports less and the increase in the domestic firm's sales reduces domestic prices. The second term corresponds to the effects of increases in foreign market sales, which lower prices (by $\beta q_2^{*\prime}$) but increase marginal revenues. The last term corresponds to the change in the marginal probability of a fine induced by the change in the quantities sold by the domestic firm.

Simplifying the expression for $V^{*\prime\prime}$ using the equilibrium values of q_{22} and q_2^*, we get

$$\text{sign}(V^{*\prime\prime}) = \frac{4b^5}{(4b^2 - d^2)^2} - \frac{bd^2}{(4b^2 - d^2)} + \frac{\beta}{4}$$
$$= 16b^5 + \beta(4b^2 - d^2)^2 - 4d^2b(4b^2 - d^2)$$

Note that the value function for the foreign firm can be convex or concave. In the case of the example, with linear demand and enforcement policies, the value function of the foreign firm is always convex. For more general specifications, however, this value function can be concave. An example in which the value functions is concave appears in Mirman, Samuelson and Schlee [1992]. When V^* is convex, the foreign firm wishes to increase the information on the probability of a penalty. This requires that the foreign firm increase exports for each level of home firm sales. In doing this, the foreign firm risks a higher probability of a penalty in the first period, but obtains better information as to the type of the government, which it may use in the second period. This means that the effects described in Fischer [1992] are reduced.

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