# Dynamic Pricing in the Presence of Antidumping Policy: Theory and Evidence*

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**ABSTRACT**

Antidumping (AD) duties are often calculated as the difference between the foreign firm's product price in its own market and its product price in the export market. Additionally, AD laws allow for recalculation of the AD duties over time in what are known as the administrative review process. Despite the seemingly obvious incentive to raise its export price to replace (at least partially) the AD duty into part of its revenue, the exploitation of this opportunity is not a dominant choice for a typical foreign firm subject to the U.S. antidumping duty; only about 53% of reviewed cases (163 out of 306) out of 430 affirmative AD decision cases filed during 1980-1995 showed such reductions in AD duties.

Focusing on lags in adjusting AD duties in the review process that raise a dynamic pricing issue for a foreign firm, as well as on the nature of static profit maximization problem that generates an incentive to dump more in response to a raised AD duty, the dynamic programming analysis shows that the foreign firm will choose its prices in the review process such that the AD duty rises toward a stationary equilibrium value when enforcement of AD policy is certain. Thus, the structure of AD law itself (the lagged administrative review) can be a primary cause for higher degrees of dumping over time.

Introducing uncertainties into the AD enforcement, reflecting possibilities of both negative determinations and terminated cases based on collusive agreements, generates testable hypotheses: a higher ex ante probability of affirmative AD determination leads to less (likely) reduction in AD duties through the review process and a higher ex ante probability of a terminated case leads to more (likely) reduction in AD duties. The empirical study largely supports these hypotheses, finding some evidence for "doming dumping" phenomenon where the degree of dumping increases with a higher ex ante probability of a terminated case. By comparing the "initial" price choice of a foreign firm subject to various uncertainties of AD policy with the final price choice in the review process (the choice that the firm would have made under uncertain enforcement), the model provides a possible scheme for estimating the impact of regime shifts in AD policy (changes in probabilities for various contingencies of AD cases) on foreign firms' dumping behaviors.

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## 1. Introduction

Recent research on antidumping (AD) protection policies has revealed that the institutional structure surrounding the determination and administration of AD duties makes analysis of this form of trade policy quite interesting and complicated. On the surface, AD duties are simple *ad valorem* tariffs, intended to reflect the extent to which the foreign firm was dumping in the export destination market. The calculated degree of dumping (or dumping "margin") is the difference between a "normal" or "fair" value for the product and the price it is charging in the export market, and there is a positive dumping margin any time the export price is below the "normal" value. The U.S. Department of Commerce (USDOC) primarily uses the price charged by the foreign firm in its own market as the estimate of "normal" value in dumping calculations. Importantly, this means that the AD duty becomes a function of prices chosen by the firm across its export and own home market. In addition, after an AD duty comes into place there is the potential for continuous recalculation of the AD duty over time in what are called administrative reviews. These administrative reviews occur at the request of the foreign firm or other interested parties and, in fact, the vast majority of U.S. AD duties are reviewed at least once subsequent to a case. The method of AD duty calculation and administrative review process presents a foreign firm with a dynamic pricing problem that has not been explored before and will be the focus of this paper.

While previous research has not considered this dynamic pricing problem, there have been important examinations of how the structure of AD investigations affects economic outcomes, including price determination. Staiger and Wolak (1994) and Krupp and Pollard (1996) focus on how investigation "events" (i.e., the filing of the petition, public findings of the USDOC, terminations, etc.) affect import and pricing behavior by foreign firms. Staiger and Wolak focus mainly on import volume and price changes during U.S. AD investigations filed from 1980-1986. They find that changes in prices and import volumes during the investigation depend on whether the domestic industry has filed the case to merely harass the foreign firm (they call these domestic petitioners "process" filers) or to gain actual trade protection ("outcome" filers). To the extent that they examine changes in variables after the investigation, they do not consider the administrative review process. Krupp and Pollard use detailed data on chemical products subject to U.S. AD investigations to focus on changes in import volumes due to investigation events, as well as eventual AD duties. DeVault (1996) examines data on the changes in U.S. AD duties from the administrative review process. His empirical work uncovers factors that lead to lower AD duties over time, but he does not integrate these observations within a formal theoretical framework. Finally, Blonigen and Haynes (forthcoming) examine pass-through of exchange rates and antidumping duties to U.S. import prices for products involved in U.S. AD investigations. They present a one-period model of pricing for a firm subject to an AD duty to motivate their empirical work, which finds that exchange rate pass-through is substantially altered for their sample of Canadian steel products.

This paper's contribution is to more seriously consider the dynamic pricing problem firms face in the presence of AD investigations and duties. We first set up a formal theoretical model and then use data on AD duty changes from U.S. administrative reviews to test some of the model's implications. In the model, a foreign firm is solving a dynamic optimization problem, where the current period price (p) affects the anti-dumping duty in the next period ($T_{+1}$).[1] Specifically, the lower the current period price is relative to the fair value of the product ($p^f$), the higher the next period dumping duty ($T_{+1} = p^f/p$) will be. Given that the foreign firm has a static incentive to dump its product (the static profit maximizing price is less than the fair value), the firm needs to balance the loss in the current period from setting price higher than its static optimal against the gains in the future discounted payoff from having a lower dumping duty in the next period.

Under certain (without uncertainty) enforcement of anti-dumping policy, the dynamic programming analysis yields a surprising result with respect to the optimal pricing path. When a foreign firm dumps (setting its price lower than the fair value) in the initial period, then the firm will dump more over time (setting the price lower over time) until the price reaches a steady state value. Dumping duties will increase (or at least never decrease) through the review process! Knowing how an increase in the dumping duty affects the balance between the loss in the current profit and the gain in the future discounted profit associated with current pricing is the key to understanding this result. In particular, when the dumping duty increases, the rate of current-

[1] Note that this (one-period) lag in adjusting the anti-dumping duty is crucial in raising the "dynamic" pricing issue. This is because instantaneous adjustment in the anti-dumping duty will simply set the consumer price being fixed at the "fair value" regardless of foreign firms' pricing (below the fair value), eliminating the incentive to dump. As discussed in Section 2, it is reasonable to assume that there exist significant lags in adjusting AD duties given the practices of AD policy.

profit loss associated with pricing higher than the static optimal price increases, implying higher costs of reducing the dumping margin for a higher current dumping duty. Thus, once a firm dumps in the initial period free of any dumping duty, the firm will face a steeper trade-off between the current profit loss and the future gain with a dumping duty being imposed in the next period, inducing the firm to choose a price that is at least as low as the initial price. As the same process continues in the following periods, the foreign firm will lower its price over time toward a stationary equilibrium value, implying a rising AD duty through the review process. This result adds another reason to the growing list of theories for dumping activities.[2] However, it is a distinctively different one from the earlier studies largely focusing on strategic incentives, because it shows that the structure of AD law itself (the lagged administrative review) can be a primary cause for higher degrees of dumping over time.

It is well known that the enforcement of anti-dumping policy is far from certain, though. While the USDOC almost always makes positive dumping margin determinations, a large number of AD cases end with negative injury determinations.[3] AD investigations are also often withdrawn before they reach final determination. In fact, many of these cases are resolved in the form of voluntary export restraints (VERs) or other collusive agreements (e.g., see Prusa, 1992). To analyze how uncertain enforcement affects the dynamic pricing behavior, we modify the model to have a dumping firm face the possibilities of negative determinations and terminated cases based on collusive agreements, while assuming that the following review process will be enforced with certainty.

With this uncertain enforcement, the analysis shows that the foreign firm may try to reduce the dumping duty through the review process (setting higher price over time once the firm needs to pay the dumping duties) when the probability of getting the initial dumping duty is low enough. We can explain this result as follows. As the probability of getting the initial dumping

[2] The presence of AD law itself is not creating the incentive to dump initially when we exclude the possibility that AD investigation leads toward a VER, as analyzed in Anderson (1993). Once the foreign firm decides to dump, however, the lagged administrative review generates the incentive to dump more over time. As demonstrated in a numerical example in Section 3, this incentive may induce the firm to dump more (at the end of the review process) than it would do in the absence of AD policy.

[3] When an AD petition is filed, the USDOC determines whether the subject product is being sold at "less than fair value" in the United States, and the U.S. International Trade Commission (USITC) determines whether the relevant U.S. domestic industry has been materially injured, or is threatened with material injury, by reason of the imports subject to its investigation. Kaplan (1991) provides a detailed description of the USITC's injury determination, emphasizing significant uncertainties (caused by arbitrariness) involved in the injury determination.

duty becomes smaller, the foreign firm has an incentive to set its price closer to its static optimum. If it finds itself subject to paying a AD duty despite its low probability, the initial dumping price can be lower than the stationary equilibrium price under certain enforcement (note that certain enforcement is assumed in the review process). If this is the case, then the foreign firm will set its price higher over time until the price reaches the stationary value, implying reduction of AD duties through the review process.

Introducing these uncertainties into the AD enforcement, thus generates a set of testable hypotheses that links the *ex ante* probabilities of affirmative AD determinations (ADD) and of terminated cases (TER) with the reduction in AD duties through the review process: a higher ex ante probability of ADD leads to less (likely) reduction in AD duties and a higher ex ante probability of TER leads to more (likely) reduction in AD duties, where the latter hypothesis assumes that a more aggressive dumping will work as an advantage for the foreign firm under a collusive agreement.[4] The empirical study adopts a two-step estimation method: estimating parameters that determine the ex ante probabilities based on a probit model, then running various tests on the proposed hypotheses using the estimated ex ante probabilities. Using a sample of all firm-product combinations subject to U.S. affirmative AD decisions and AD duties for AD investigations filed between 1980 and 1995, the empirical results largely support the hypotheses. In particular, the positive relationship between the ex ante probability of TER and the reduction in AD duties can be viewed as an evidence for "doming dumping" phenomenon where the degree of dumping increases with a higher ex ante probability of TER.

The rest of the paper proceeds as follows. The next section provides some relevant details of U.S. AD trade protection and the administrative review process.  Section 3 provides formal dynamic pricing models and our main propositions. Section 4 then describes our empirical analysis and a final section concludes.

## 2. Salient Features of U.S. Antidumping Law and Administration

[4] If an agreement under a TER case takes a form of VER where more export licenses are given to a foreign firm with higher market share, like the one considered in Anderson (1993), then a more aggressive dumping will work as an advantage for the foreign firm under such an agreement. However, it may work as a disadvantage under different types of agreements, as discussed in Section 3.

This section provides a brief overview of the relevant details connected with U.S. AD investigations and administrative reviews. The U.S. AD laws are administered by the USDOC and U.S. International Trade Commission (USITC), each with distinct roles in the process. When an AD petition is filed, the USDOC determines whether the subject product is being sold at “less than fair value” in the United States. In contrast, the USITC determines whether the relevant U.S. domestic industry has been materially injured, or is threatened with material injury, by reason of the imports subject to its investigation.

The calculation of the dumping margin by the USDOC is usually not straightforward and revolves around how the USDOC measures what should be the “fair value” of the product sold in the United States. Selling a product in the United States at less than “fair value” is the definition of dumping and the difference between the U.S. price and “fair value” is the dumping margin. In theory, the USDOC defines “fair value” as the exporting firm’s price for the same product in its own home market. However, if the firm’s home market sales are deemed inadequate, then the USDOC may base “fair value” on the exporting firm’s prices in third country markets or on a constructed value for the product using manufacturing costs, selling, general and administrative costs, profits and packaging costs. These calculations obviously involve highly detailed and confidential data on the transactions of the investigated firm, which are requested by USDOC from the investigated firm. If the investigated firm does not comply sufficiently, the USDOC will turn to using the “best information available,” which is often information supplied by the U.S. firms that filed the petition.

If an affirmative preliminary determination is made by both the USDOC and the USITC, which may take up to 160days, then the importer must post a cash deposit, a bond or other security for each entry equal to the preliminary margin determined by the USDOC. This requirement stays in effect until either the USDOC or the USITC makes a negative final determination, which again may take another 120 days. If an affirmative final determination is made by both the USITC and USDOC, then USDOC issues an AD order to levy a duty equal to the estimated dumping margin on the subject product.

When a subject foreign product enters the United States, the importer must pay Customs a cash deposit equal to the margin times the value of the subject product. However, these cash deposits do not necessarily represent the final amount of duties to be assessed on the subject imports. Rather, the margin determined in USDOC's final investigation is only used as a basis for *estimating* the duty liability of the importer. The actual liability of the importer may be determined in subsequent years by the USDOC. Before 1984, this was accomplished by automatic yearly administrative reviews by the USDOC. However, since 1984, such reviews have become voluntary; that is, unless an interested party requests a review, the duties assessed are those found in USDOC's final determination (or most recent administrative review). An administrative review serves two purposes. First, it adjusts the margin on subject imports to reflect changes in the difference between the foreign firm's U.S. price and the fair value so that the importer pays an adjusted cash deposit based on the reviewed margin until the next administrative review. Second, it makes AD duties to be *retroactive*: if a review determines that the margin during the review period is different from the previous margin used as a basis for the importer's cash deposit, a bill (or refund) in the amount of the difference plus interest is assessed (or rebated). This administrative review process is important for the analysis in section 3 and 4.

## 3. The Theoretical Models

This section develops models of dynamic pricing of a foreign firm in the presence of AD policy described in the preceding section. We will first analyze the case where the policy is enforced without uncertainty and then analyze how allowing uncertain enforcement affects the optimal pricing path under the AD policy.

### 3.1. Basic Model

We assume that a foreign firm may sell its products both in foreign and domestic markets and these markets are separated from each other so that price discrimination is possible across the markets. However, when the foreign firm chooses its price in the domestic market, p, lower than its price in the foreign market, $p^f$, the foreign firm faces an AD duty, T ($\geq$1) such that $pT = p^f$ in the domestic market. When the foreign firm changes p or $p^f$, this dumping duty is subject to change through administrative review process, according to $pT = p^f$.

As the initial dumping determination and the following administrative review are far from instantaneous to changes in the prices, the foreign firm faces a dynamic price choice problem. To analyze this problem, we use an infinite horizon model in which the consumers' tastes are the same in each period. For simplicity, we assume that the change in the dumping duty lags one period to changes in the price, $T_i = p^f_{i-1} / p_{i-1}$ where the subscripts i and i-1 denote period i and period i-1, respectively, with $T_0 = 1$ (the initial period is free from dumping duties). In addition, we set $p^f_{i-1} = p^f_0$ (>0) for all $i \geq 1$ in determining $T_i$, because there are compelling reasons and empirical evidence that the overwhelming part of the price change affecting the dumping duties in the review process occurs with the domestic (U.S.) price, not the foreign price.[5] Let c be the foreign firm's constant marginal production cost and $q(p^c)$ be its per-period domestic demand function with $p^c$ (= pT) being the consumer price.[6] Then, the discounted profit from the domestic market for the foreign firm in period k is given by

$$(1) \qquad \sum_{i=0}^{\infty} \delta^i (p_{k+i} - c) \cdot q(p_{k+i} \cdot T_{k+i})$$

where $\delta \in (0,1)$ is the market discount rate, $T_{k+i} = p^f_0 / p_{k+i-1}$ if $0 < p_{k+i-1} \leq p^f_0$, $T_{k+i} = 1$ if $p_{k+i-1} > p^f_0$, and $T_{k+1} = \infty$ if $p_{k+i-1} = 0$, meaning that the imports will be prohibited from k+1 period on.[7]

[5] Gallaway et al. (1999) discuss this aspect of the review process in detail (pp. 219-220).

[6] We do not analyze strategic interactions between firms in setting prices, focusing on how the structure of AD policy influences a foreign firm's dynamic pricing (dumping) behavior in the domestic market. This simple demand function, therefore, can be considered as an individual firm's demand in a monopolistically competitive industry. For the model with uncertain enforcement of AD policy in Section 3.2, however, we will allow industry characteristics to affect foreign firms' (dynamic pricing) behaviors by varying *ex ante* expectations about various contingencies of AD investigation. One may pursue an alternative path of modeling oligopoly firms and analyzing their dynamic pricing interactions in the presence of AD policy, but we do not pursue this venue in this paper.

[7] It is clear from this discounted payoff that the administrative review is not retroactive in this basic model. We can analyze the effect of introducing "retro-activeness" in the administrative review process by analyzing the following problem:

$$\sup_{\{p_i\}_{i=0}^{\infty}} \sum_{i=0}^{\infty} \delta^i [(p_i - c) + r_i] \cdot q(p_i \cdot T_i) \text{ subject to}$$

$$p_i \in [0, \infty), i = 0, 1, 2, ...,$$

$$T_i = (p^f_0 / p_{i-1}) \text{ if } 0 < p_{i-1} \leq p^f_0, T_i = 1 \text{ if } p_{i-1} > p^f_0, T_i = \infty \text{ if } p_{i-1} = 0,$$

$$r_i = (p_i \cdot T_i - p^f_0) \text{ if } p_i \leq p^f_0, \text{ and } r_i = (p^f_0 \cdot T_i - p^f_0) \text{ if } p_i > p^f_0.$$

However, it can be shown that analyzing the above problem will generate qualitatively the same result as the basic model (without retro-activeness) regarding the dynamic pricing behavior of the foreign firm. From now on, thus, we

The dynamic price choice problem of the foreign firm would involve choosing the sequence of its foreign prices, as well as the sequence of its domestic prices. To characterize the optimal sequence for the domestic prices, however, we can focus on the problem of maximizing the discounted profit from the domestic market by choosing the optimal domestic price sequence for a given $p_0^f$ (optimally chosen in the initial period). This is because only the initial foreign price will matter in determining all subsequent antidumping duties for the domestic market.

Therefore, we analyze the following optimization problem taking $p_0^f$ and $p_{-1} \in [0,\infty)$ as given:

$$\sup_{\{p_i\}_{i=0}^{\infty}} \sum_{i=0}^{\infty} \delta^i (p_i - c) \cdot q(p_i \cdot T_i) \text{ subject to}$$

(2) $$p_i \in [0,\infty), i = 0, 1, 2, ...,$$
$$T_i = p_0^f / p_{i-1} \text{ if } 0 < p_{i-1} \leq p_0^f, T_i = 1 \text{ if } p_{i-1} > p_0^f, \text{and } T_i = \infty \text{ if } p_{i-1} = 0,$$

or the corresponding dynamic programming problem:

(3) $$V(p_{-1}) = \sup_{p \in [0,\infty)} \left[(p - c) \cdot q(p \cdot T) + \delta V(p)\right]$$
$$T = p_0^f / p_{-1} \text{ if } 0 < p_{-1} < p_0^f, T = 1 \text{ if } p_{-1} > p_0^f, \text{and } T = \infty \text{ if } p_{-1} = 0.$$

under proper conditions that guarantee the equivalence between the above two problems. Denote the supremum function resulting from (2) by $V^*(p_{-1})$ and the value function satisfying (3) by $V(p_{-1})$. Given the existence, uniqueness, and equivalence of $V^*(p_{-1})$ and $V(p_{-1})$, we can describe the optimal pricing path of the foreign firm facing the anti-dumping policy by analyzing the optimal policy correspondence G: $(0, \infty) \to (0, \infty)$, defined by

(4) $$G(p_{-1}) = \{p \in [0,\infty) : V(p_{-1}) = (p - c) \cdot q(p \cdot T) + \delta V(p)\}.$$

Lemma 1 specifies the conditions for such analysis.

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will restrict our attention to the basic model. This basic model also confirms the structure of the EU's antidumping law, which lacks retro-activeness in its administrative review process.

**Lemma 1.** If $q(p^c) \geq 0$ is a bounded, continuous, and non-increasing function in $p^c \equiv p \cdot T \in [0,\infty)$ and there exists a constant $\bar{p} > 0$ s.t $q(p^c) = 0$ for all $p^c \geq \bar{p}$, then there exist unique solutions for (2) and (3), with $V^*(p_{-1})$ and $V(p_{-1})$ being bounded, continuous, and identical functions to each other. $G(p_{-1})$ is non-empty, compact-valued and upper-hemi continuous correspondence.

The lemma shows that we can use the dynamic programming problem (3) for almost any reasonable demand functions to analyze the problem (2). For further characterization of $G(p)$ and $V(p)$, however, we need to introduce more restraints on $q(p^c)$:

(A1) $\operatorname{Arg}\max\limits_{p}\left[(p-c)q(p)\right] < p_0^f$: the foreign firm has an incentive to dump ($p < p_0^f$) in the absence of anti-dumping policy.

(A2) $q(p^c)$ is twice differentiable.

(A3) $\partial^2\pi(p;T)/\partial p\partial T = (\partial q(p^c)/\partial p^c)\cdot p + (p - c)\cdot[(\partial q(p^c)/\partial p^c) + (\partial^2 q(p^c)/\partial p^{c2})\cdot p^c] < 0$, where $\pi(p;T) = (p - c)\cdot q(p\cdot T)$.

(A1) simply requires the demand to be relevant one for our analysis of the foreign firm's dynamic pricing under AD policy. (A2) is not a crucial one but facilitates the analysis by enabling us to use differentiation. (A3): $\partial^2\pi(p;T)/\partial p\partial T < 0$ implies that the cost of setting a higher price (higher than $p^*$ satisfying $\partial\pi(p=p^*;T)/\partial p = 0$) is increasing as the AD duty increases. Note that (A3) will be satisfied as long as the demand function is not too convex ($\partial^2 q(p^c)/\partial p^{c2} >> 0$) and it plays a crucial role in the following characterization of the optimal pricing path.[8]

[8] (A3) is also a sufficient condition for the second order condition for maximizing $\pi(p;T)$ with respective to p: $\partial^2\pi(p;T)/\partial p^2 = T\cdot[\ 2\cdot(\partial q(p^c)/\partial p^c) + (p - c)\cdot T\cdot(\partial^2 q(p^c)/\partial p^{c2})] < 0$. Because this assumption is important in the following analysis, it is worthwhile to explore the conditions under which (A3) is satisfied. One may try to make the connection between (A3) and the price elasticity of demand, $\varepsilon_p(p) = -(\partial q(p)/\partial p)\cdot(p/q(p))$. Because $\partial\varepsilon_p(p)/\partial p$ has the sign same as that of $-[(\partial q(p)/\partial p)(1+\varepsilon_p) + p\cdot(\partial^2 q(p)/\partial p^2)]$, it is easy to show that (A3) will be satisfied as far as $\partial\varepsilon_p(p)/\partial p \geq 0$ and $\varepsilon_p$ (>1) is close enough to 1. This result is not too surprising because $\partial\varepsilon_p(p)/\partial p > 0$ can be linked to an increasing cost for setting higher price as the price gets higher. However, increasing price elasticity w.r.t. p , is neither a sufficient nor a necessary condition for (A3). Even though (A3) holds for any linear or concave demand curve (as far as it is not too convex), the above analysis illustrates that (A3) may fail to be true. In fact, $\partial^2\pi(p;T)/\partial p\partial T > 0$ will imply a distinctively different and interesting pricing dynamics under AD policy, as discussed in Footnote 9. However, the following analysis will focus on the case with (A3), because the empirical findings on the price dynamics largely support the hypotheses generated by the model with (A3) rather than the ones generated from assuming $\partial^2\pi(p;T)/\partial p\partial T > 0$.

With (A1)-(A3), the following lemma provides sharper descriptions of $V(p)$, as well as narrowing down the economically relevant domain and the image of G(p) on which we will focus our analysis.

**Lemma 2.** V(p) is a non-decreasing function. If the foreign firm chooses its initial price $p_0$ in the absence of dumping duties ($T_0$ = 1), then we can focus on the optimal pricing path where $p_i \in (c, p_0^f]$ for i = 0, 1, 2, …, without loss of generality.

It is easy to understand why $V(p)$ is a non-decreasing function because the anti-dumping duty will be lower (or at least equal when $p \geq p_0^f$) with higher values for p, implying more (or at least equally) favorable environment for the dynamic profit maximization. p > c in Lemma 2 is also easy to understand. In comparison to any p > c with a positive current period profit, $(p-c)\cdot q(p\cdot T) > 0$, setting p < c will cause the current period payoff to be negative and will also lower (or at best not affect) the next period's discounted payoff by inducing a higher dumping duty. (A3) guarantees the second order condition for the current period profit maximization problem if p > c. When the current dumping duty is zero, then (A1) and (A3) together imply that setting $p = p_0^f$ will raise the current period profit compared with the case of setting $p > p_0^f$, and the next period's discounted payoff will be identical in both cases. This superiority of setting $p = p_0^f$ over $p > p_0^f$ will continue to be true as long as an increase in the current dumping duty would not make the foreign firm's static optimal price (maximizing the current period profit) to be higher than $p_0^f$. (A3) implies that the static optimal price will decrease as the current dumping duty increases, eliminating the possibility for $p > p_0^f$.

Based on Lemma 2, we will focus on the characterization of $G(p)$ on $p \in (c, p_0^f]$. Denote max{G(p)} by h(p) and min{G(p)} by l(p). Then, we can derive the following lemma.

**Lemma 3.** The optimal correspondence G(p) is non-decreasing in p in the sense that $h(p'') \leq l(p')$ for all $p' > p'' \in (c, p_0^f]$.

According to Lemma 3, the foreign firm's optimal price in the current period does not increase when the current anti-dumping duty increases. Figure 1 is helpful in understanding this result. Figure 1a depicts profit functions ($\pi$(p; T'), $\pi$(p; T")) with different dumping duties of the current period (T' < T"), and Figure 1b depicts the non-decreasing value function as a function of the current period price (V(p)). By definition, setting $p = l(p_0^f/T' = p')$ maximizes the current discounted payoff when the current dumping duty is T'; $\pi(l(p'); T') + \delta V(l(p')) \geq \pi(p; T') + \delta V(p)$ for all $p \in (c, p_0^f]$. If the current period dumping duty increases to T", the profit function shifts down in such a way that $\partial\pi(p; T')/\partial p > \partial\pi(p; T'')/\partial p$ for all p due to (A3). This shift in profit function in response to an increase in the dumping duty makes setting the current period higher than l(p') even less attractive than before. Note that the foreign firm tries to balance between the current period profit loss against the future discounted profit gain in setting the current price higher than its static optimum. Because a higher current duty will raises the current period profit loss associated with higher prices, it induces the foreign firm to choose a lower current price than before, if not a equal price.

Based on Lemma 1-3, we can now characterize the dynamic pricing behavior of the foreign firm in the presence of antidumping policy as follows:

**Proposition 1.** When $q(p^c)$ satisfies (A1)-(A3), there exist $\delta^c \in (0,1]$ such that

i) for $\delta > \delta^c$, the foreign firm will set $p_i = p_0^f$, thus $T_i = 1$ for i = 0, 1, 2, … .

ii) for $\delta < \delta^c$, the foreign firm will set $p_0 < p_0^f$, thus $T_0 > 1$ with $p_0 \geq p_1 \geq p_2$ …, thus $T_0 \leq T_1 \leq T_2 \leq \dots$ .

As mentioned earlier, the optimal price is set to balance the current period profit loss against the discounted profit gain in the next period. Therefore, we will observe the foreign firm to dump its products, only when the foreign firm values the current period profit high enough relative to its future discounted profit ($\delta < \delta^c$). If the foreign firm dumps in the initial period, then rather surprisingly the foreign firm will never try to reduce its dumping margin through the administrative review process, according to Proposition 1. For example, when $G(p;\delta < \delta^c)$ is as in Figure 2a, the dumping margin will increase through the review process, $1 < T_1$ $(= p_0^f/p_0) < T_2$

$(=p_0^f/p_1) < T_3$ …, until it reaches its stead state ($T^S = p_0^f/p^S$). The optimal policy correspondence may not behave smoothly as illustrated in Figure 2b, but we can easily check that the foreign firm will never reduce its dumping margin through the review process.[9]

We can explain this result in the following way. If a foreign firm dumps in the initial period, this behavior reveals that the firm values its current period profit gain associated with pricing closer to its static optimum relatively more than the loss in the future discounted profit associated with incurring a positive dumping duty in the next period. Then, in the next period with a positive dumping duty, (A3) assures that the current profit loss associate with higher pricing gets bigger than before, inducing the firm to reduce its price even further or to set the same price. Thus, the fact that a foreign firm dumps in the initial period despite the dynamic costs from future dumping duties, reveals the firm's dynamic preference toward dumping.

Proposition 1 generates a specific empirical prediction: foreign firms will never try to reduce its dumping duties through the administrative review process. Even a brief look at the U.S. anti-dumping review data can tell us that this prediction is largely wrong; about 38% of the initial dumping duties have been reduced through the review process during 1980-1995 period. We will introduce uncertainty in the enforcement of anti-dumping policy into the model, which may induce the foreign firms to reduce their dumping duties through the review.

### 3.2. The Model under Uncertain Enforcement of Anti-dumping Policy

A large portion of U.S. anti-dumping cases has been terminated, without reaching the final determination, in the forms of negative injury determinations, withdrawn cases based on agreements between domestic and foreign firms (often VERs), and etc.[10] Thus, it is obvious that

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[9] For the case where $\partial^2\pi(p;T)/\partial p\partial T > 0$ instead of having (A3), it can be shown that G(p) is decreasing in p, rather than increasing in p, using a similar argument as in Lemma 3. As illustrated in Figure 2c where G(p) is decreasing in p and the discount factor is low enough to induce the foreign firm to set $p_0 < p_0^f$, then it is possible to have a case where the dynamic pricing sequence through the administrative review process fluctuates yet moves toward a stationary price $p^S > p_0$, implying that AD duties under the review will move up and down, but eventually decrease to a lower value than the initial AD duty. This is theoretically an interesting phenomenon, generating a prediction on the movements of dumping duties under the review that contrasts to the one generated by the case with (A3), as discussed in Footnote 20. However, the empirical study in Section 4 generally supports the prediction from the model with (A3). Thus, the phenomenon described in Figure3c is not a dominant one, at least not for the U.S. dumping data during 1980-1995. As mentioned earlier, thus, we will focus our analysis on the model with (A3) being satisfied.

[10] Prusa (1992) provides a detailed analysis of the exemption (from AD duties) through agreements and its implication for the effects of antidumping law. Anderson (1993) provides a model showing how the possibility of

there exist uncertainties in the enforcement of AD policy, especially in its initial anti-dumping investigation. From the foreign firm's point of view, this implies that setting $p_0 < p_0^f$, does not necessarily incur $T_1 = p_0^f/p_0 > 1$.

To model the dynamic pricing problem in the presence of uncertain enforcement, we classify different contingencies of AD investigation into the following three categories: cases with final affirmative dumping determinations (*ADD*), cases being ended with negative injury or dumping determinations (*NEG*), and cases being terminated without any negative injury or dumping determinations (*TER*). In contrast to *NEG* cases terminated by "formal" negative determinations, *TER* cases represent the cases being terminated through case-withdrawals by petitioners, which often involve VERs or other collusive agreements between involved parties (foreign/domestic firms and the USDOC). Note that NEG cases include cases for which no investigation has been initiated. From a foreign exporting firm's point of view, thus, NEG cases will require no adjustment in its pricing behavior but TER cases will require some adjustments (which can either be favorable or unfavorable ones depending on the nature of collusive agreements it can reach).[11]

In the presence of uncertainties in the enforcement of AD policy mentioned above, a foreign firm's expectation on probabilities of different contingencies will play an important role in its decision on the initial pricing (dumping) decision and the following pricing decisions once it is subject to an AD duty. Given that a foreign firm dumps ($p_i < p_0^f$) in the absence of any current dumping duty ($T_i = 1$) at period i, let Pr(ADD), Pr(NEG), and Pr(TER)$\in$ [0, 1] respectively denote the ex ante probabilities of getting an AD duty, of getting a NEG case, and of getting a TER case in the next (i+1) period. By definitions, Pr(ADD) + Pr(NEG) + Pr(TER) = 1. Note that these are ex ante probabilities so that, for example, a firm having a very low value for Pr(ADD) may find itself to be subject to an AD duty in the next period, despite its low expectation of such a duty. As discussed later, this kind of potential "shocks" to expectation will

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having VERs instead of getting AD duties may promote the dumping behaviors of foreign firm. However, these studies do not analyze the dynamic pricing problem associated with AD policy, largely ignoring the effect of the administrative review policy.

[11] As discussed after Proposition 2, a certain form of VER may entail favorable changes for the dumping foreign firm, but other forms of agreements may hurt the profitability of the foreign firm.

generate an interesting pattern in dynamic pricing behaviors of firms subject to AD duties, on which the empirical analysis will focus.

For analytical simplicity, we introduce the following assumptions on the nature of uncertainties surrounding the AD investigation. First, once an AD duty is imposed, the initial dumping duty and the following administrative reviews will be perfectly enforced, applying $T_{i+1} = p_0^f / p_i$.[12] Second, once a TER case arises due to an agreement among interested parties, then such an agreement will be perfectly enforced, eliminating possibilities for any future anti-dumping investigation. Finally, we assume that these ex ante probabilities, $\Pr(\cdot)$s are not functions of the price chosen in the absence an dumping duty or an agreement, even though $\Pr(\cdot)$s may differ across different foreign firms belong to different industries.[13] Given the uncertain enforcement of AD policy described above, the discounted expected payoff in the initial period, $EV(p_0^f)$ will be given by:

$$
\begin{aligned}
EV(p_0^f) = &\left\{ \begin{array}{l} (p_0^e - c)\cdot q(p_0^e) + \Pr(TER)\times\left[\delta\cdot(p_0^{t0} - c)\cdot q\left(p_0^{t0}\right) + \delta^2\cdot(p_1^{t0} - c)\cdot q\left(p_1^{t0}\right) + \cdots\right] \\ + \Pr(ADD)\times\left[\delta\cdot(p_0^{d0} - c)\cdot q\left(p_0^{d0}\cdot(p_0^f / p_0^e)\right) + \delta^2\cdot(p_1^{d0} - c)\cdot q\left(p_1^{d0}\cdot(p_0^f / p_0^{d0})\right) + \cdots\right] \end{array} \right\} \\
+ \Pr(NEG)\times &\left\{ \begin{array}{l} \delta\cdot(p_1^e - c)\cdot q(p_1^e) + \Pr(TER)\times\left[\delta^2(p_0^{t1} - c)\cdot q\left(p_0^{t1}\right) + \delta^3\cdot(p_1^{t1} - c)\cdot q\left(p_1^{t1}\right) + \cdots\right] \\ + \Pr(ADD)\times\left[\delta^2\cdot(p_0^{d1} - c)\cdot q\left(p_0^{d1}\cdot(p_0^f / p_1^e)\right) + \delta^3\cdot(p_1^{d1} - c)\cdot q\left(p_1^{d1}(p_0^f / p_0^{d1})\right) + \cdots\right] \end{array} \right\} \\
+ \Pr(NEG)^2\times &\left\{ \begin{array}{l} \delta^2\cdot(p_2^e - c)\cdot q(p_2^e) + \Pr(TER)\times\left[\delta^3\cdot(p_0^{t2} - c)\cdot q\left(p_0^{t2}\right) + \delta^4\cdot(p_1^{t2} - c)\cdot q\left(p_1^{t2}\right) + \cdots\right] \\ + \Pr(ADD)\times\left[\delta^3\cdot(p_0^{d2} - c)\cdot q\left(p_0^{d2}\cdot(p_0^f / p_2^e)\right) + \delta^4\cdot(p_1^{d2} - c)\cdot q\left(p_1^{d2}\cdot(p_0^f / p_0^{d2})\right) + \cdots\right] \end{array} \right\} \\
+ \cdots,&
\end{aligned}
$$

where $p_i^e$ represents the price to be set in period $i$ when neither a ADD case nor a TER case has ever been occurred until period $i$, $\{p_0^{di},\ p_1^{di},\ p_2^{di},\ ...\}$ denotes the price sequence from period i+1

[12] In practice, it is often argues that there exist a significant amount of uncertainty in determining the fair value, $p_0^f$. The presence of uncertainty in $p_0^f$, however, will not affect the qualitative results on dynamic price behavior as far as $p_0^f$ remains stable throughout the review process, which applies to the majority of AD as discussed earlier.

[13] It is conceivable that a more aggressive dumping may increase Pr(ADD) or Pr(TER). However, given that each individual firm is a small player in a monopolistically competitive industry (the implicit assumption behind the modeling in this paper), Pr(ADD) and Pr(TER) can be considered as exogenous variables from an individual firm's point of view and mainly depend on the industry characteristics. If one analyzes this dynamic pricing issue based on an oligopoly model, then it would be appropriate to consider the effect of dumping levels on Pr(ADD) or Pr(TER).

in which an initial dumping duty is imposed based on $p_i^e$, and $\{p_0^{ti},\ p_1^{ti},\ p_2^{ti},\ ...\}$ denotes the price sequence from period i+1 in which a TER occurs with a specific value for $p_i^e$. Because the anti-dumping duty is determined by applying $T_{i+1} = p_0^f/p_i$, no previous periods' pricing but only $p_i^e$ will matter in determining $\{p_0^{di},\ p_1^{di},\ p_2^{di},\ ...\}$. Given that a TER case occurs in the presence of a possible ADD case, once again only $p_i^e$ (among all pervious periods' pricing) will play a role in determining $\{p_0^{ti},\ p_1^{ti},\ p_2^{ti},\ ...\}$.[14]

If neither a ADD nor a TER case has ever occurred, then the foreign firm will face the same problem as its initial problem regarding its choice of $p_i^e$ for i = 1, 2, 3, … . Thus, the optimal price will be identical to the initial optimal price as long as the foreign firm has continued to have negative cases. Denote this "initial" optimal choice to be $p_0^E$. If a dumping duty ($T_0^D = p_0^f/p_0^E$) is ever-imposed for the first time, then the foreign firm faces the same certainty problem described in Section 3.1 from that period on. Thus, we can use the same value function as in Section 3.1 to represent the discounted profit from that period on, $V(p_0^E)$: the solution to the problem in (3). If a TER case occurs in period i+1, then $p_0^E$ will determine the following periods' pricing path, $\{p_0^{ti},\ p_1^{ti},\ p_2^{ti},\ ...\}$, yielding the discounted profit from that period on, $(p_0^{ti}-c)\cdot q(p_0^{ti})+\delta(p_1^{ti}-c)q(p_1^{ti})\ +\delta^2(p_1^{ti}-c)q(p_1^{ti})+\cdots$. Denote this discounted profit for a TER case by $V^T(p_0^E)$, using the fact that $p_0^E$ is a major variable that determines the pricing path for a TER case. Then, we can rewrite the discounted expected payoff in the initial period as:

$$
\begin{aligned}
(5)\qquad EV(p_0^f) &= (p_0^E - c)q(p_0^E)\times\left[1+\delta\cdot\Pr(NEG)+\delta^2\cdot\Pr(NEG)^2+\delta^3\cdot\Pr(NEG)^3+\cdots\right] \\
&\quad +\delta\cdot\Pr(ADD)\cdot V(p_0^E)\times\left[1+\delta\cdot\Pr(NEG)+\delta^2\cdot\Pr(NEG)^2+\delta^3\cdot\Pr(NEG)^3+\cdots\right] \\
&\quad +\delta\cdot\Pr(TER)\cdot V^T(p_0^E)\times\left[1+\delta\cdot\Pr(NEG)+\delta^2\cdot\Pr(NEG)^2+\delta^3\cdot\Pr(NEG)^3+\cdots\right] \\
&= \left\{(p_0^E-c)\cdot q(p_0^E)+\delta\cdot\left[\Pr(ADD)\cdot V(p_0^E)+\Pr(TER)\cdot V^T(p_0^E)\right]\right\}/\left[1-\delta\cdot\Pr(NEG)\right].
\end{aligned}
$$

[14] In determining the outcome of an agreement for a TER case, it is obvious that the level of $p_0^E$ relative to $p_0^f$ will play a crucial role, because a VER often assigns export licenses based on the pervious period market share of relevant firms and the possible bargaining for an agreement will take place with an AD duty being considered as a possible alternative to an agreement.

Because the ex ante probabilities, $\Pr(\cdot)$s are not functions of $p_0^E$, the dynamic pricing problem under uncertain enforcement is reduced to find out $p_0^E$ satisfying:

$$(6) \qquad \operatorname*{Sup}_{p_0^E \in (c, p_0^f]} \left\{ (p_0^E - c) \cdot q(p_0^E) + \delta \cdot \left[ \Pr(ADD) \cdot V(p_0^E) + \Pr(TER) \cdot V^T(p_0^E) \right] \right\},$$

and then the optimal pricing path under the administrative review process will follow $G(p_0^E)$ defined in (4) of Section 3.1.[15] Therefore, to analyze the effect of introducing uncertain enforcement on the foreign firm's dynamic pricing path under the administrative review process, we should first focus on how changes in Pr(ADD) and Pr(TER) affect $p_0^E$. Proposition 2 provides results on this issue.

**Proposition 2.**

i) $p_0^E$ is increasing in Pr(ADD) if V(p) is strictly increasing in $p \in (c,\ p_0^f]$, for which the sufficient condition is $q(p_0^f(p_0^f/c)) > 0$.

ii) $p_0^E$ is decreasing in Pr(TER) if $V^T(p)$ is strictly decreasing in $p \in (c,\ p_0^f]$, and $p_0^E$ is increasing in Pr(TER) if $V^T(p)$ is strictly increasing in $p \in (c,\ p_0^f]$.

It is easy to understand why an increase in Pr(ADD) will induce the foreign firm to choose a higher (at least not lower) value for its initial price $(p_0^E)$.[16] Due to the same reason as

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[15] In the presence of a large value for Pr(TER) together with $V^T(p)$ being strictly decreasing in p, we cannot eliminate the possibility of having $p_0^E < c$. Because G(p) and V(p) are defined on $p \in (c,\ p_0^f]$, allowing $p_0^E < c$ will require defining these variables for p < c. For analytical simplicity, thus we will assume away the possibility of having $p_0^E < c$.

[16] If V(p) is differentiable at $p_0^E = p_0^{E^*}$, and $p_0^{E^*}$ is an interior solution that satisfies the first and the second order conditions for (6), then $p_0^E$ is strictly increasing in Pr(ADD) at $p_0^E = p_0^{E^*}$ in the sense that $\partial p_0^E / \partial \Pr(ADD) > 0$. This can be easily shown by applying the envelope theorem to the f.o.c. for (6). However, V(p) is only shown to be differentiable almost everywhere, implying that there may exist a set (with measure zero) where V(p) fails to be differentiable. Even in that case, however, $p_0^E$ is non-decreasing in Pr(ADD).

under certain enforcement, the optimal price (in the absence of dumping duty) $p_0^E$ is set to balance the current period profit loss from setting the price higher than its static optimum against the future expected discounted profit gain from reducing the dumping duty that the firm would incur once it becomes subject to a AD duty. A higher value for Pr(ADD) raises the cost for choosing a lower value for $p_0^E$, because it implies a higher probability of getting a costly (note that V(p) is strictly increasing in p) anti-dumping duty, reducing the incentive to set $p_0^E$ to be closer to its static optimum price, $p^*$.

The effect of an increased value for Pr(TER) on $p_0^E$ depends on whether $V^T(p)$ is strictly decreasing or increasing in p. If $V^T(p)$ is strictly increasing in p, a higher value for Pr(TER) inflicts a higher cost for choosing a lower value for $p_0^E$ because a lower value for $p_0^E$ will work as a disadvantage under a TER case. If a lower value for $p_0^E$ works as an advantage under a TER case ($V^T(p)$ is strictly decreasing in p), then a higher value for Pr(TER) will provide an extra incentive to choose a lower value for $p_0^E$. When an agreement under a TER case takes a form of VER where more export licenses are given to a firm with higher market share, like the one considered in Anderson (1993), then a lower $p_0^E$ will work as an advantage under such an agreement.[17] If a TER agreement is reached through a bargaining process between foreign and domestic firms with the ADD case as a threat point, however, it is possible to have a case where a lower $p_0^E$ works as a disadvantage for the foreign firm under a TER case. Therefore, which type of an agreement prevails under a TER case is an empirical question and will be analyzed in the following empirical section.

Given the analysis of effects of Pr(ADD) and Pr(TER) on $p_0^E$, we can now discuss the effect of uncertainties in the enforcement of AD policy on the dynamic pricing (AD duty) path

[17] In this case, the maximization in (6) can be used to demonstrate a result (Proposition 1) of Anderson (1993) that an increased enforcement ($\beta$) may intensify dumping behaviors for a sufficiently large probability of an anti-dumping VER ($\gamma$). Using that Pr(ADD) = $\beta\cdot(1-\gamma)$ and Pr(TER) = $\beta\cdot\gamma$, (6) can be rewritten as

$$\text{(6')}\quad \operatorname*{Sup}_{p_0^E\in(c,p_0^f]} \left\{(p_0^E - c)\cdot q(p_0^E) + \delta\cdot\left[\beta\cdot(1-\gamma)\cdot V(p_0^E) + \beta\cdot\gamma\cdot V^T(p_0^E)\right]\right\}.$$

When $\gamma$ is close to 1, then an increase in $\beta$ will raise Pr(TER) without really affecting Pr(ADD), thus strengthening the incentive to dump (setting a lower $p_0^E$) as $V^T(p_0^E)$ is strictly decreasing in $p_0^E$.

under an administrative review process. In contrast to the certain enforcement case where the AD duty can only increase (or stay the same) through the review process, the presence of uncertainty in enforcement generates the possibility for diminishing anti-dumping duties through the review process. The following Corollary 1 demonstrates this possibility by introducing uncertainty related to Pr(ADD).[18]

**Corollary 1.** Assume that there exists a unique stationary equilibrium under certain enforcement, denoted by $p^S$.[19]

i) If $p^S = p_0^f$, there exists $\Pr^c(ADD) \in (0,1]$ such that the foreign firm sets $p_0^E < p_0^f$ for $\Pr(ADD) < \Pr^c(ADD)$. If a dumping duty is imposed on setting $p_0^E < p_0^f$ by $T_0^d = p_0^f / p_0^E$, then the foreign firm will choose it pricing path so that the AD duty decreases toward zero through the review process.

ii) If $\underset{P}{\mathrm{Arg\,max}}\left[(p-c)q(p)\right] < p^S < p_0^f$, there exist $\Pr^c(ADD) \in (0,1]$ such that the foreign firm sets $p_0^E < p^S$ for $\Pr(ADD) < \Pr^c(ADD)$. If a dumping duty is imposed on setting $p_0^E < p^S$ by $T_0^d = p_0^f / p_0^E$, then the foreign firm will choose it pricing path so that the AD duty decreases toward $T^S = p_0^f / p^S$ through the review process.

[18] $\Pr(ADD) = 1$ for any $p_0^E < p_0^f$ implies certain enforcement. Thus, $\Pr(ADD) < 1$ needs to be introduced to generate the possibility of diminishing anti-dumping duties under the review process. One can generate a similar result with $\Pr(TER) > 0$.

[19] Even for the case with multiple stationary equilibria under certain enforcement, the possibility of diminishing AD duties through the review process will emerge with the introduction of uncertainty into the enforcement of AD policy. However, the monotonic relationship between Pr(ADD) and the possibility of diminishing AD duties presented in Corollary 1 may fail to hold with the existence of multiple stationary equilibria. The existence of multiple stationary equilibria itself generates an interesting issue as it can create an unstable equilibrium where a small shock initiates a motion to a new equilibrium.

This paper, however, will focus on the case of a unique stationary equilibrium. As discussed in the empirical section, the monotonic relationship between Pr(ADD) and the possibility of diminishing AD duties presented in Corollary 1 and in Corollary 2 is widely supported for the U.S. dumping data during 1980-1995 period, indicating that the phenomenon of multiple stationary equilibria may not be a dominant one for our data set.

Theoretically, differentiability of $V(p)$ will eliminate the possibility of multiple equilibria as the Euler equation defines a unique stationary equilibrium. However, $V(p)$ is only shown to be differentiable almost everywhere, implying a possibility of having multiple equilibria where $V(p)$ fails to be differentiable (even though the measure of a set of such non-differentiable points is zero). Finally, note that multiple equilibria may arise only if $G(p)$ has some section(s) where its slope is greater than one, implying that the foreign firm may reduce its price sharply in response to an increase in a AD duty so that it ends up selling more output than before. If this type of micro sales information is available, one may try to link such abnormality(?) in sales behaviors subject to AD duties to potential instability of equilibria.

In explaining the above results, Figure 3a and 3b containing the policy correspondences, G(p) derived from computationally solving the dynamic programming (pricing) problem based on a linear demand, are helpful. Figure 3a illustrates the case where the discount factor is high enough so that the foreign firm would set $p_0 = p_0^f = p^S = 8$ under certain enforcement. Because $p_0^E$ decreases as Pr(ADD) decreases, $p_0^E$ will become smaller than $p^S = 8$ for a low enough value of Pr(ADD) as illustrated in Figure 3a. If the firm find itself to be subject to a AD duty at period i, then it will adjust its pricing through the review as indicated by $\{p_0^{di},\ p_1^{di},\ p_2^{di},\ ...\}$ in Figure 3a, until its price reaches to the stationary equilibrium $p^S = 8$. This implies that the corresponding sequence of AD duties will approaches to zero as claimed in Corollary 1 (i).

Figure 3b depicts G(p) for the case where the discount factor is low enough to induce the foreign firm to dump even under certain enforcement, $p_0 < p_0^f = 8$. In fact, the discount factor is low enough to make $p^S$ (= 4) below $\underset{P}{\mathrm{Arg\,max}}\left[(p-c)q(p)\right] = 6$, potentially disabling the possibility of having $p_0^E$ < $p^S$, because the lowest optimal value for $p_0^E$ will be $\underset{P}{\mathrm{Arg\,max}}\left[(p-c)q(p)\right] = 6$ (when Pr(ADD) = 0) if there is no other incentive to reduce the price below the static optimal price. However, a large value for Pr(TER) together with $V^T(p)$ being strictly decreasing in p may generate an enough incentive for the foreign firm to cut its price below $p^S$ (= 4) in order to obtain more licenses to export under a possible VER. If $p_0^E$ is set below $p^S$ due to such a reason as in Figure 3b, then the pricing path through the review will follow $\{p_0^{di},\ p_1^{di},\ p_2^{di},\ ...\}$ indicated in Figure 3b, thus having the AD duties under the review decrease toward T = $p_0^f / p^S$, as predicted in Corollary 1 (ii).

Therefore, Corollary 1 implies that there exists a monotonic relationship between Pr(ADD) and the possibility of diminishing AD duties, generating a testable hypothesis: *the lower the value we have for Pr(ADD), the more likely we observe diminishing AD duties through the administrative review process, or equivalently, the higher the value we have for Pr(ADD), the more likely we observe non-diminishing AD duties through the administrative review process*. This hypothesis will be tested in the following empirical section.

We can also generate a related but different hypotheses that relate Pr(ADD) and Pr(TER) with the degree of increases in the dumping duties through the review process. Denote the initial AD duty when a ADD case occurs by $T_0$ with $T_0 = p_0^f / p_0^E$ and the stationary AD duty that will be reached at the end of the administrative review process by $T_S$ with $T_S = p_0^f / p^S$. Then, the degree of increases in the AD duties through the entire review process can be given by $(T_S - T_0)/T_0$, which equals to $(p_0^E - p^S)/p^S$. Because $p^S$ is fixed against changes in Pr(ADD) and Pr(TER), we only need to know how Pr(ADD) and Pr(TER) affect $p_0^E$ in order to analyze their effects on $(T_S - T_0)/T_0 = (p_0^E - p^S)/p^S$. Using the results in Proposition 2 on how Pr(ADD) and Pr(TER) affect $p_0^E$, we can easily derive the following Corollary 2 about the relationship between the degree of increase in the AD duties through the entire review process and the values for Pr(ADD) and Pr(TER).

**Corollary 2.** Given that there exists a unique stationary equilibrium under certain enforcement

i) the increase in the dumping duty through the administrative review process, $(T_S - T_0)/T_0 = (p_0^E - p^S)/p^S$ is increasing in Pr(ADD),

ii) if $V^T(p)$ is strictly decreasing in $p \in (c, p_0^f]$, the increase in the dumping duty through the administrative review process $(T_S - T_0)/T_0 = (p_0^E - p^S)/p^S$ is decreasing in Pr(TER), and

if $V^T(p)$ is strictly increasing in $p \in (c, p_0^f]$, the increase in the dumping duty through the administrative review process, $(T_S - T_0)/T_0 = (p_0^E - p^S)/p^S$ is increasing in Pr(TER).

Because the above results in Corollary 2 are direct results from applying Proposition 2, I will omit explanations for them. Note that $(T_S - T_0)/T_0 = (p_0^E - p^S)/p^S$ may take a negative value, implying a decrease in the AD duties through the review instead of an increase. Even in that case, note that the positive relationship between $(T_S - T_0)/T_0 = (p_0^E - p^S)/p^S$ and Pr(ADD) is still valid (the decrease in the AD duties through the review is decreasing in Pr(ADD)) for Corollary 2 (i). A similar statement can be made for Corollary 2 (ii).[20]

## 4. Empirical Analysis

The previous theoretical section develops a dynamic pricing model for firms facing U.S. AD duties. In this section, we use detailed data from U.S. AD investigations filed during the 1980-1995 period to test the implications presented in Corollary 2; namely, that the increase in the dumping duty is increasing in the *ex ante* probability of an ADD, and could be either decreasing or increasing in the *ex ante* probability of termination/VER, as well as that of Corollary 1; the higher the value we have for Pr(ADD), the more likely we observe non-diminishing AD duties through the administrative review process.

### 4.1. Empirical Methodology

A direct test of these implications would use price data. However, data on prices set by the foreign firm are unobservable. Instead, data on AD duties and changes in these duties from administrative reviews allow us to track pricing decisions by the foreign firms over time in the following way. As described in section 2, the assessed AD duty is the difference between the price of the product exported to the U.S. and some measure of "fair" or "normal" value for the product. Thus, the initial AD duty can serve as a benchmark for the level of the U.S. price relative to this normal value. Then, over time, administrative reviews of the dumping margin are conducted and AD duties are recalculated. The new dumping margin (and, hence, new AD duty) reflects changes in difference between the U.S. price of the product and the measure of normal value. To the extent that these changes in AD duties over time reflect changes in the U.S. price only, they give a good measure of dynamic changes in U.S. prices from which we can test

[20] As mentioned in Footnote 9, G(p) can be increasing in p if $\partial^2\pi(p;T)/\partial p\partial T > 0$. If $p_0^E$ is still increasing in Pr(ADD), then it is easy to check with Figure 2c that a higher Pr(ADD) will induce a larger decrease in the dumping duties through the review process, implying a negative relationship between $(p_0^E - p^S)/p^S$ and Pr(ADD), as opposed to a positive one described in Corollary 2 (i). The following empirical analysis supports the hypothesis of Corollary 2 (i), confirming the validity of using the model with (A3) rather than the one with $\partial^2\pi(p;T)/\partial p\partial T > 0$ in describing typical (average) dynamic pricing behaviors subject to AD duties for the U.S. dumping cases.

implications of the previous theoretical section. Gallaway et al. (1999) and Blonigen and Haynes (forthcoming) provide evidence that the majority of dumping margin changes stem from changes in the U.S. price, not measures of fair value.[21]

To examine our hypotheses, we need to relate these foreign firm price changes (reflected in dumping margin changes) to foreign firms' *ex ante* expectations of an AD case outcome. To accomplish this we employ a two-step estimation procedure. In the first step, we estimate *ex ante* probabilities of case outcomes using a multinomial logit regression framework on a sample of cases prior to the firm's own case. In the second step, we test whether these estimated *ex ante* probabilities affect the change in the AD duty (i.e., change in the firm's U.S. price relative to normal value) that we observe after the case, controlling for other factors. The next subsections provide more detail on each of these estimation steps.

### *4.1.1. First-stage Multinomial Logit Estimation*

In the first stage, we employ a multinomial logit specification to estimate the *ex ante* probabilities of various AD case probabilities. In particular, our dependent variable indicates three possible outcomes for an AD case: 1) affirmative decision with AD duties imposed, 2) a negative decision with no duties imposed, and 3) a termination, withdrawal, or suspension of the case due to a negotiated agreement between the domestic and foreign firms.[22] Each option is associated with a level of profitability denoted $\Pi_{kij} = \pi_k(X_{ij}) + \varepsilon_{kij}$, where k indexes actions, i indexes firms, j indexes products, $\pi_k$ represents observable profit from action k, $X_{ij}$ represents a vector of observable firm and product characteristics, and $\varepsilon_{kij}$ is a random variable representing unobservable profitability for firm i with product j choosing action k. Given this framework, the firm chooses the action that leads to the highest profitability. Assuming that $\pi_k(.)$ can be approximated as a linear function in $X_{ij}$ and the disturbances are independently and identically distributed with extreme value distribution, we can express the action probabilities as:

[21] An important reason why foreign firms would want to alter dumping margins through the U.S. price rather than normal value, is because the USDOC may use a different method of determining normal value in the administrative review from that used in the original case. For example, the USDOC may use the foreign firm's own home price as the measure of normal value at the time of the case, but then switch to "best information available" for the administrative review. These possibilities represent "rule changes" by USDOC that we will have to consider below when we estimate the determinants of dumping margin changes.

[22] Below we discuss sensitivity of results to alternative categorizations of AD case outcomes.

$$\text{Prob}\,[K_{ij} = \text{Action } k] = \frac{\exp(\boldsymbol{b}_{k'} X_{ij})}{\sum_k \exp(\boldsymbol{b}_{k'} X_{ij}),}$$

where $\beta_k$ are the parameters to be estimated, which by construction, vary by action, not by individual firm. We estimate this model using standard maximum likelihood techniques.

A number of empirical papers have examined the factors that determine the injury determination by the USITC which, in turn, largely determines whether a U.S. AD case will be ruled affirmative or negative. These studies include Finger, Hall and Nelson (1982), Baldwin (1985), Anderson (1992), Moore (1992), DeVault (1993), and Hansen and Prusa (1996,1997). Determinants of withdrawn/suspended cases are estimated by Zanardi (2000). We draw on these studies for specifying our matrix of explanatory variables, $X_{ij}$.

First, the economic factors that determine the USITC injury decision play a large role whether the USITC rules affirmative in the case, with imports and domestic profit loss in the period preceding the investigation found to be the main factors in this decision. Thus, we include the volume of investigated imports and the previous 3-year change in domestic shipments in the product's associated 4-digit SIC (as a proxy for profit loss) as explanatory regressors.[23] We expect that larger imports and smaller domestic shipment growth makes an affirmative decision more likely relative to a negative determination. However, as Zanardi (2000) points out, AD cases are more likely to lead to settlements when they involve products with substantial interest to the U.S. government. This suggests that cases may more likely lead to settlements once the trade volume becomes quite substantial. Thus, we include the import volume squared, since there may be a threshold where settlements begin to prevail over affirmative decisions.

Non-economic factors have been found to affect AD case outcomes in these studies as well. Many studies have found that certain regions are more likely to receive certain outcomes than others. Studies on USITC decisions find that cases against EU countries are more likely to receive a negative outcome, while cases against Japan and non-market economies are more likely to receive affirmative outcomes. Zanardi (2000) finds that EU and non-market countries are

[23] The USITC considers economic conditions up to three years prior to the case in making their injury determination. Specifications with one-year lagged domestic shipment growth yielded qualitatively similar coefficient estimates as the three-year lagged variable, but with less precision.

more likely to have settled cases. We include region dummies for the EU, non-market countries, Japan, Asian NICs, and less-developed countries.

Another common focus is whether steel and steel-related industries receive different outcomes, everything else, because so many U.S. AD cases cover these products and they were often high profile trade disputes. The USITC studies often find these industries are more likely to receive affirmative decisions. Also, a disproportionate number appear to end with settlements/VERs as well, though Zanardi (2000) does not find a statistically significant steel effect. We include variables to capture industry effects for steel (SIC 3312, 3313, and 3315) and steel pipes and tubes (SIC 3317).

Finally, we include year dummies to capture a number of additional important factors. First, it may capture changes in the composition of the USITC commissioners, which has been found to influence outcomes. Second, it may capture macroeconomic changes, such as exchange rate or GDP changes, that may make certain outcomes more likely (see Knetter and Prusa, 2000). Finally, year dummies will capture rule or administrative changes, such as cumulation in the injury determination, that may make certain outcomes more likely (see Hanson and Prusa, 1996).

This empirical framework allows us to estimate measures of expected probabilities of AD outcomes, which will then be used as explanatory variables for changes in dumping duties after affirmative AD cases. The important question is which sample we use to estimate these probabilities. One possibility is to estimate these probabilities using the full sample. But this assumes that firms earlier in the sample have the same information as the firms later in the sample for forming their expectations on AD outcomes. Instead, to estimate current year expected probabilities, we use only the previous years in the sample. For example, to estimate probabilities for 1986 cases, we use sample years from 1980 to 1985. This assumes that firms do not use information prior to our sample, 1980, to form expectations. However, this seems reasonable in that a substantial U.S. AD law change occurred in 1979 that led to a drastic increase in U.S. AD petitions and success rates.

#### *4.1.2. Second-stage Estimation of Dumping Margin Changes*

In the second stage, we sample all firm and product combinations that were subject to an affirmative U.S. AD decision during our sample and examine whether changes in the dumping duties subsequent to the case are related to the *ex ante* AD case outcome probabilities estimated in the first stage. As discussed, dumping margins change through administrative reviews, which can be initiated every year at the anniversary date of the initial AD orders. Since these reviews can take a number of years to be completed in practice, we specify our dependent variable as the percentage change (in decimal form) in the dumping duty four years subsequent to the case. This time period is long enough so that firms that initiated administrative reviews had experienced at least one change in the dumping duty since the time of the case. A significant number of margins (160 or 25%) were reduced to zero during this time period, which means a lower bound of –1. For this reason, we use a tobit specification truncated at –1, though, as a sensitivity check, we also report results for a probit specification where the dependent variable indicates whether the dumping margin stays the same (or increases) after the case or not.

**4.2. Data**

Our sample for the first stage estimates consists of all U.S. AD cases filed between 1980 and 1995. Data on the cases and antidumping decisions were collected from *Federal Register* notices. We define terminated/VER cases as only those where a VER or other formal settlement is publicly announced, and classify other withdrawn or terminated cases as negative outcomes. Below, we present results when we categorize these cases in an alternative manner. Thus, of the 715 case determinations for which we have observable data, 296 (41%) are categorized as affirmative, 338 (48%) are categorized as negative, and the remaining 81 (11%) are categorized as terminated/VER. Subject import volumes for the cases were taken from USITC reports and estimated when not available by collecting trade volumes of the subject tariff line codes from the NBER Trade Database. Real shipment growth is for the associated 4-digit SIC code and is taken from the NBER Productivity Database. Table 1 gives the descriptive statistics for the variables we use in our first-stage estimation for the entire sample from 1980 through 1994.

Our sample for the second stage estimates consists of all firm-product combinations subject to U.S. affirmative AD decisions and AD duties for U.S. AD investigations filed between 1980 and 1995. Much of the data were initially collected by James DeVault from *Federal Register* notices and USITC reports connected with each case (See DeVault (1996 for more details on data collection). Information available from these data sources includes firm-specific AD duties both at the time of the initial case, and in subsequent administrative reviews. As discussed, these AD duties are estimated dumping margins and reflect differences in the firm's

U.S. price and a definition of “normal” value, which is often the foreign firm’s price in its home market.

The evidence from our sample is that there is substantial variation in AD duty changes from administrative review. Out of 658 firm-specific initial AD duties assessed during this period, 418 (64.0%) were subsequently reviewed at least once. The average change in the AD duty after the first administrative review is from 37.4% to 26.9%, a sizeable decrease. However, there were 45 cases (6.9%) where the AD duty increased after the first administrative review.

## 4.3. Empirical Results

### *4.3.1. First-stage Multinomial Logit Estimates*

As described above, we estimate separate multinomial logit estimates for each year from 1981 through 1995 using the data from previous years back to 1980. These estimates are then used to construct *ex ante* probabilities of AD case outcomes for our second stage. For the sake of space, table 2 presents coefficient estimates from three of the fifteen subsamples: Estimates used to construct *ex ante* probabilities for AD cases in years 1985, 1990 and 1995, using subsamples, 1980-1984, 1980-1989, and 1980-1994, respectively. We normalize the coefficient estimates for a negative AD outcome, in order to identify and, hence, estimate the parameters of the model. Thus, table 2 gives coefficient estimates for affirmative and terminated/VER outcomes, which are interpreted as effects relative to the negative outcome.

For all three regression estimates presented in table 2, the chi-squared statistic easily rejects the null hypothesis of jointly zero slopes at the 1 percent significance level. Interestingly, all three regressions yield pseudo $R^2$ measures between 0.22 and 0.26. However, the number of statistically significant coefficients increases for the later-year estimates, as the number of observations increases. Lower real shipment growth generally displays a negative coefficient for both the probability of affirmative and terminated/VER, as one would expect, though these effects are generally not precisely estimated. Also, as expected, larger volume of imports increases the probability of affirmative and terminated/VER AD outcomes (relative to negative outcomes) as one would expect, and these effects are generally statistically significant. Other statistically significant estimates are positive coefficients on the steel, steel pipes, and non-market economies variables in the terminated/VER equation and a positive coefficient on AD cases involving Japan for the affirmative equation. Also, many of the year dummies (not reported for the sake of space) are statistically significant as well.

One important result to note is that there is often not very large variation in coefficient estimates for the same regressor across the three data subsamples. This suggests that there do not seem to be any large structural breaks in the determinants of AD outcomes that cannot be captured by the year dummies.[24] Another issue, standard with multinomial logit estimation, is its assumption of the independence of irrelevant alternatives. Hausman tests comparing coefficients of model specifying only two alternatives to the full model with three alternatives always rejects the hypothesis that the independence of irrelevant alternatives is violated.

#### *4.3.2. Second-stage Estimates – Testing Implications of Corollary 1 and 2*

Using the coefficient estimates from the first stage, we now construct predicted *ex ante* probabilities of affirmative and terminated/VER AD outcomes to be used as regressors to test the implications of Corollary 1 and 2. Obviously, the constructed probabilities are for only the 647 firm-product combinations that became subject to affirmative AD decisions and, hence, AD duties.[25]

Table 3 reports estimates from the tobit estimates where the dependent variable is the 4-year percentage change in the dumping margin after the case and the regressors are a constant and the predicted probabilities of affirmative and terminated/VER outcomes. The chi-squared statistic easily rejects the null hypothesis of jointly zero slopes at the 1 percent level.

The coefficients on both *ex ante* probabilities are statistically significant at the 1 percent level. The positive coefficient on the *ex ante* affirmative probability variable indicates that a higher *ex ante* probability of an affirmative AD outcome increases (or, equivalently, decreases the fall in) the percentage change in the dumping duty after the case. This confirms the first part

[24] One alternative is to only use the most recent previous five years of data for each regression; for example, using estimates from 1990-1994 to construct predicted probabilities for 1995. This would be important if the U.S. AD decision process was changing so much that firms felt that any information on outcomes earlier than the previous five years was uninformative or even misleading. However, using these alternative 5-year samples to construct predicted probabilities leads to qualitatively identical second-stage results to those reported below.

[25] This is after eliminating outliers where the percentage change in the duty is greater than 500%. Inclusion of these outliers in the estimation still yields identical signs on our regressors of interest, as well as strong statistical significance, but give unreasonably large coefficient estimates that are not representative of the sample. These were primarily cases that began with relatively small AD duties, so that moderate increases in the level of the AD duty that translated into drastically large percentage changes.

of Corollary 2. In fact, with an average fall of 33.5% in the dumping duty for the sample, the point estimates suggest that at the means, a 10 percentage point increase in the *ex ante* affirmative probability means only a 27.9% fall in the dumping duty, rather than the average 33.5% fall. Thus, this effect predicted by Corollary 2 is of substantial magnitude in our sample.

The coefficient on the *ex ante* probability of termination/VER is negative and statistically significant which confirms Corollary 2 in the case where $V^T(p)$ is strictly decreasing in p. The coefficient magnitude in this case is likewise substantial. At the means, a 10 percentage point increase in the *ex ante* termination/VER probability means an additional 4.9 percentage point decrease in the dumping duty.

One potential concern with these estimates is that the USDOC often changes the way it measures normal value from the time of the case to subsequent administrative reviews. This could have a substantial effect on the dumping margin over time, even if the foreign firm did not alter its pricing policies. The most substantial of these rule changes is when the USDOC uses "best information available" (BIA), because then the USDOC uses information supplied by the petitioners rather than the foreign firms.[26] A second concern is that from 1980-1984 administrative reviews occurred automatically each year at the anniversary of the case, whereas after 1984 these reviews occurred only if an interested party (a foreign or domestic firm involved in the case) requested a review. This structural change in the law may also alter the dumping margin changes that we observe. We add a number of control variables to account for these administrative changes connected with USDOC dumping margin calculations. Specifically, we include a dummy variable when the original margin calculation was calculated using BIA at the time of the case, but not during the subsequent administrative review. We also include a dummy variable for the reverse case, where BIA was not used at the time of the case, but then used for the administrative review. Finally, we include a dummy variable for any cases that occurred when administrative reviews were automatic, rather than only initiated upon the request of an interested party.

Column 2 of table 3 present results of our second stage estimates when we include these additional controls. All three additional control variables are statistically significant and the pseudo $R^2$ increases substantially. The positive coefficient on the second control variable

[26] Another practice often used by USDOC is constructed cost measures to rule out foreign home prices (used to determine fair value) as below cost.

("Change from no BIA to BIA") is as expected, since the USDOC switching to information from the domestic petitioners to calculate dumping margins should lead to more adverse dumping duties. By the same rationale, though, the coefficient on the first additional control ("Change from BIA to no BIA") is expected to be negative, but is positive. We note, however, that the coefficient on this variable is much smaller and more imprecisely estimated than for the second control variable. Finally, the coefficient on the third control for automatic administrative reviews is negative. One possible explanation for this is that many firms that decrease their dumping behavior after a case if they can receive automatic reviews, may not be willing to incur costs of having to request administrative reviews and, thus, settle for no change in their dumping duties. Importantly, controlling for these additional variables reduces the coefficients on the *ex ante* probabilities in half, but they remain statistically significant at standard confidence levels.

We also tried a number of alternative specifications to check the sensitivity of our results. First, in the initial specifications, we took a strict definition of terminated/VER cases, in the sense that we included only those cases where VERs or settlements were publicly announced. Any other withdrawn or terminated cases were treated as negative outcomes for our estimation of the *ex ante* probabilities. However, as indicated by Prusa (1991), many withdrawn cases may be due to private settlements that yield similar outcomes for the involved firms. Thus, as an alternative we included all cases withdrawn after at least a preliminary decision by the USITC or USDOC in our categorization of terminated/VER cases. Tobit estimates using *ex ante* probabilities generated from this alternative categorization are shown in column 3 of table 3. Results are qualitatively identical to those in column 2 of table 3, though the coefficient on the terminated/VER probability falls by one-half is more imprecisely estimated. This suggests that it may be improper to include these withdrawn cases with no publicly announced settlements as ones where a settlement was reached.

To test the implication of Corollary 1 (and also as another sensitivity check), we substituted a dummy variable that takes the value of "1" if the dumping duty does not decline (either increases or stay the same) after the AD case for our dependent variable and estimated the coefficients using a standard probit model. These estimates are reported in column 4 of table 3. Again, we get qualitatively similar results that provide statistically significant evidence for Corollary 1.

## 5. Concluding Remarks

Our theoretical model under certain enforcement of AD trade policy can explain what are seemingly unreasonable behaviors of foreign firms subject to AD duties: not all the foreign firms try to take advantage of the administrative review process by raising their export prices, thus replacing the AD duties with their increased prices. For the firms that choose to dump in the initial period despite AD duties to follow in the next period, the presence of AD duties will make the inter-temporal tradeoff between the current and the future discounted profits more favorable to dumping behaviors in the next period, yielding constant or higher AD duties through the review process. Introducing uncertain enforcement of AD trade policy generates incentives for the foreign firms to reduce their AD duties through the review process. Once a foreign firm is subject to AD duties despite a high *ex ante* probability for avoiding such duties, the firm may adjust its prices so that AD duties fall over time in subsequent reviews.

The empirical results support the theoretical model by showing that a lower ex ante probability for getting AD duties is positively correlated with a higher (probability for) reduction in AD duties in the administrative review. The empirical study also finds that the expectation about avoiding a AD duty through reaching an agreement with domestic firms, like a VER agreement, plays an important role in determining the aggressiveness of the initial dumping behavior. In particular, it indicates an increased expectation of such an agreement encourages more aggressive dumping by a foreign firm, suggesting the existence of "domino dumping phenomenon" studied by Anderson (1993). It is also worthwhile to mention that the model provides a possible scheme for estimating the impact of regime shifts in AD policy (changes in probabilities for various contingencies of AD cases) on foreign firms' dumping behaviors, by comparing the "initial" price choice of a foreign firm subject to various uncertainties of AD policy with the final price choice in the review process (the choice that the firm would have made under uncertain enforcement).

There are various ways to extend the current theoretical model. We can study how different types of uncertainties, like fluctuations in exchange rates or in product demands, affect firms' dynamic pricing under AD trade policy. We can also analyze how the vertical relationship between a foreign exporter and a domestic importer may affect the foreign firm's dynamic pricing path. These theoretical extensions may generate a new set of testable predictions on dynamic pricing of firms subject to AD duties.

## Appendix

### Proof for Lemma 1.

We can directly apply Theorem 4.6 in Stokey et al. (1989) to prove Lemma 1. Denote the domain of the prices that the foreign firm can choose from by P, and let $\Gamma: P \rightarrow P$ be the correspondence describing the feasibility constraints, following Stokey et al. Thus, for each p $\in$ P, $\Gamma(p)$ is the set of feasible values for the state variable in the next period if the current state is p. To apply Theorems 4.6, we need to show that

i) P is a convex subset of R, and the correspondence $\Gamma: P \rightarrow P$ is nonempty, compact-valued, and continuous.

ii) The function $(p_t - c) \cdot q(p_t \cdot (p_0^f / p_{t-1}))$: $A \rightarrow R$ is bounded and continuous, where A = $\{(p_{t-1}, p_t) \in P \times P : p_t \in \Gamma(p_{t-1})\}$.

(i) Without loss of generality, we can define P to be $[0, \overline{p}]$. This is because the effect of setting p > $\overline{p}$ is identical to that of setting p = $\overline{p}$: both actions will eliminate current period sales without affecting future AD duty (when there is no imports, the AD duty stays the same). Then, $\Gamma(p)$ is [0, $\overline{p}$] for all p $\in$ [0, $\overline{p}$], satisfying (i).

(ii) Because $q(p^c) = 0$ when $p^c \rightarrow \infty$ and $q(p^c)$ is bounded, $(p_t - c) \cdot q(p_t \cdot (p_0^f / p_{t-1}))$ is also a bounded function in A. Because multiplication of continuous functions generates a continuous function, $(p_t - c) \cdot q(p_t \cdot (p_0^f / p_{t-1}))$ is also a continuous function.

### Proof for Lemma 2.

We can use a similar argument as in Theorem 4.7 of Stokey et al. to show that $V(p_{-1})$ is a non-decreasing function. To directly apply the theorem to lemma 2, (i) $\Gamma(p) \subseteq \Gamma(p')$ if p ≤ p' and (ii) $(p_t - c) \cdot q(p_t \cdot (p_0^f / p_{t-1}))$ is non-decreasing function in $p_{t-1}$ for every $p_t \in [0, \overline{p}]$ need to be satisfied. (i) is satisfied because $\Gamma(p) \equiv \Gamma(p') \equiv [0, \overline{p}]$, but $(p_t - c) \cdot q(p_t \cdot (p_0^f / p_{t-1}))$ is not non-decreasing in $p_{t-1}$ when $p_t < c$. However, we can still show that $V(p_{-1})$ is a non-decreasing function as follows.

Define the operator T on C(P), a space of bounded continuous functions f: P $\rightarrow$ R with the sup norm, by (Tf)($p_{-1}$) = $\underset{p\in\Gamma(p_{-1})}{\mathrm{Max}}\left[(p-c)q(p\cdot(p_0^f/p_{-1}))+\delta f(p)\right]$. From lemma 1, we know that the operator T maps C(P) into itself, T: C(P) $\rightarrow$ C(P) and T has a unique fixed point V($p_{-1}$) $\in$ C(P). Define C'(P) to be a space of bounded, continuous, and non-decreasing functions g:P $\rightarrow$ R with the sup norm. C'(P) is a closed subset of C(P), thus if T(C') $\subseteq$ C', then V($p_{-1}$) $\in$ C' according to Corollary 1 to Theorem 3.2 (Contraction Mapping Theorem) in Stockey et al (1989). Thus, it remains to show that T(C') $\subseteq$ C'. Because T(C') is already been shown to be bounded and continuous, we only need to show that (Tg)($p_{-1}$) = $\underset{p\in\Gamma(p_{-1})}{\mathrm{Max}}\left[(p-c)q(p\cdot(p_0^f/p_{-1}))+\delta g(p)\right]$ is non-decreasing in $p_{-1}$. For any given $p_{-1}$, p will be chosen to maximize $(p-c)q(p\cdot(p_0^f/p_{-1}))+\delta g(p)$ with $-(p-c)\cdot(\partial q(p\cdot(p_0^f/p_{-1}))/\partial p^c)\cdot(p_0^f/p_{-1})-q(p\cdot(p_0^f/p_{-1})) \in \delta\cdot\partial g(p)$ from the f.o.c. This implies that $-(p-c)\cdot(\partial q(p\cdot(p_0^f/p_{-1}))/\partial p^c)\cdot(p_0^f/p_{-1})\geq 0$ because q $\geq$ 0 and all sub-gradients of g(p) will be non-negative (g(p) is a non-decreasing in p). Because $\partial[(p-c)q(p\cdot(p_0^f/p_{-1}))+\delta g(p)]/\partial p_{-1} = -(p-c)\cdot(\partial q(p\cdot(p_0^f/p_{-1}))(p\cdot p_0^f/p_{-1}^2)\geq 0$ for p satisfying the f.o.c., (Tg)($p_{-1}$) is non-decreasing in $p_{-1}$.

Now we can narrow down the economically relevant domain and image of G(p) as follows. Let's assume that the firm chooses $p_0 \leq c$ in the initial period. However, this cannot be a part of optimal pricing path because there exists an option of setting $p_0^{/}$ = c + $\varepsilon$ > $p_0$, with $\varepsilon$ >0, which can strictly increase the discounted payoff in the initial period; ($p_0^{/}$ - c)q($p_0^{/}$) + V($p_0^{/}$) > ($p_0$ - c)q($p_0$) + V($p_0$) because there exist $\varepsilon$ >0 such that ($p_0$ - c)q($p_0$) $\leq$ 0 < ($p_0^{/}$ - c)q($p_0^{/}$) and V($p_0^{/}$) $\geq$ V($p_0$) with $p_0^{/}$ > $p_0$. Now assume that the firm chooses $p_0$ > $p_0^f$ in the initial period. This cannot be a part of optimal pricing path because setting $p_0^{/}$ = $p_0^f$ will strictly raise the discounted payoff, ($p_0^{/}$ - c)q($p_0^{/}$) + V($p_0^{/}$) > ($p_0$ - c)q($p_0$) + V($p_0$); (A3) is a sufficient condition for $2\times\partial q(p^c)/\partial p^c + (p^c-c)(\partial^2 q(p^c)/\partial p^{c2}) < 0$ (the second order condition for static profit maximization with T=1) as long as $p^c > c$. Thus, (A1) and (A3) together imply that $q(p^c) + (p^c-c)\cdot(\partial q(p^c)/\partial p^c) < 0$ for $p^c \geq p_0^f$, which in turn implies ($p_0$ - c)q($p_0$) < ($p_0^{/}$ - c)q($p_0^{/}$). V($p_0^{/}$) = V($p_0$) because $T_1$ =1 for both $p_0^{/}$ and $p_0$.

Given that $p_0 \in (c, p_0^f]$, now consider $p_1 \leq c$ in the next period. Without loss of generality, we can focus on an optimal pricing path of setting the price of period 1 to be greater than c because the firm can strictly increase or achieve at least the same level of the discounted payoff by properly setting $p'_1 = c + \varepsilon > p_1$ with $\varepsilon > 0$; there exists $p_1'$ such that $(p_1' - c)q(p_1'T_1) + V(p_1') \geq (p_1 - c)q(p_1T_1) + V(p_1)$ because there exists $\varepsilon > 0$ such that $(p_1 - c)q(p_1T_1) \leq 0 \leq (p_1' - c)q(p_1'T_1)$ and $V(p_1') \geq V(p_1)$ with $p_1' > p_1$. If $q(p_0^f) > 0$, note that the firm can strictly increase its payoff, because $1 \leq T_1 \leq (p_0^f/c)$, thus there exists $\varepsilon > 0$ such that $(p_1 - c)q(p_1T_1) \leq 0 < (p_1' - c)q(p_1'T_1)$. Now, assume that the firm chooses $p_1 > p_0^f$. This cannot be a part of optimal pricing path since setting $p'_1 = p_0^f$ will strictly raise the discounted payoff, $(p_1' - c)q(p_1'T_1) + V(p_1') > (p_1 - c)q(p_1T_1) + V(p_1)$; (A3) implies that $q(p^cT_1) + (p^c-c)\cdot T_1\cdot(\partial q(p^cT_1)/\partial p^c)$ is a decreasing function in $T_1$. Thus, $q(p^cT_1) + (p^c-c)\cdot T_1\cdot(\partial q(p^cT_1)/\partial p^c) < 0$ for $p^c \geq p_0^f$, implying that $(p_1 - c)q(p_1T_1) < (p_1' - c)q(p_1'T_1)$. $V(p_1') = V(p_1)$ because $T_2 = 1$ for both $p'_1$ and $p_1$. For the next period on, we can apply the same logic that we use for period 1.

**<u>Proof for Lemma 3</u>**

First, note that p' in G(p') defines the current period dumping duty by $T' = p_0^f/p'$, since we can focus on $p \in (c, p_0^f]$ due to Lemma 2 . By definition of l(p'),

(a1) $$(l(p') - c)\cdot q(l(p')\cdot T') + \delta V(l(p')) \geq (p - c)\cdot q(p\cdot T') + \delta V(p) \text{ for all } p \in (c, p_0^f].$$

Consider p'' < p', thus T'' > T'. Then, there exists $\alpha \geq 0$ such that $(l(p') - c)\cdot q(l(p')\cdot T'') + \delta V(l(p'))$ $+ \alpha = (l(p') - c)\cdot q(l(p')\cdot T') + \delta V(l(p'))$ because $\partial q(p^c)/\partial p^c \leq 0$. We can show that

(a2) $$(p - c)q(pT') + \delta V(p) > (p - c)q(pT'') + \delta V(p) + \alpha \text{ for all } p \in (l(p'), p_0^f]$$

Define $A(p) = [(p - c)q(pT') + \delta V(p)] - [(p - c)q(pT'') + \delta V(p) + \alpha]$. By definition of $\alpha$, $A(l(p)) = 0$ and $\partial A(p)/\partial p = [q(pT') - q(pT'')] + (p - c)[T'(\partial q(pT')/\partial p^c) - T''(\partial q(pT'')/\partial p^c)] > 0$ for $p \in [l(p'), p_0^f]$. $\partial A(p)/\partial p > 0$ because $q(pT) + (p - c)\cdot T\cdot(\partial q(pT)/\partial p^c)$ is decreasing in T by (A3):

$(\partial q(pT)/\partial p^c) + (\partial^2 q(pT)/\partial p^{c2})\cdot pT < 0$. From (a1), (a2), and $(l(p') - c)\cdot q(l(p')\cdot T'') + \delta V(l(p')) + \alpha = (l(p') - c)\cdot q(l(p')\cdot T') + \delta V(l(p'))$, we have $(l(p') - c)\cdot q(l(p')\cdot T'') + \delta V(l(p')) > (p - c)q(pT'') + \delta V(p)$ for all $p \in (l(p'), p_0^f]$. Thus, $G(p'') \not\subset (l(p'), p_0^f]$, implying $h(p'') \le l(p')$ for $p'' < p'$.

**Proof for Proposition 1**

First, we can easily show that there exists a critical level of $\delta$, denoted by $\delta^c$, such that the foreign firm will necessarily dump in the initial period, $p_0 < p_0^f$ iff $\delta < \delta^c$. The foreign firm will not dump in the initial period iff $\pi(p_0^f;T_0 = 1) + \delta V(p_0^f) > \pi(p;T_0 = 1) + \delta V(p)$, or equivalently $\pi(p;T_0 = 1) - \pi(p_0^f;T_0 = 1) < \delta[V(p_0^f) - V(p)]$ for all $p \in (c, p_0^f)$. Define a set $\Delta \equiv \{\delta \in (0,1) \mid \underset{p \in (c, p_0^f]}{\mathrm{Max}} [\pi(p;T_0) - \pi(p_0^f;T_0)] > \delta[V(p_0^f) - V(p)]\}$. Then, $\Delta \notin \emptyset$ because there exists $p' \in (c, p_0^f)$ such that $\pi(p';T_0 = 1) - \pi(p_0^f;T_0 = 1) > 0$ from (A1) and (A3). Now, define $\delta^c \equiv \sup(\Delta)$, then the foreign firm will necessarily set $p_0 < p_0^f$ in the initial period iff $\delta < \delta^c$. If $\delta^c = 1$, then the foreign firm will necessarily dump for all $\delta \in (0,1)$. If $\delta^c < 1$, the foreign will not dump in the initial period if $\delta > \delta^c$.

To prove (ii), we can use the same argument as in Lemma 3. With $\delta < \delta^c$, the foreign firm will set its initial optimal price, $p_0 < p_0^f$, having

(a3) $$(p_0 - c)\cdot q(p_0 \cdot T_0) + \delta V(p_0) \ge (p - c)\cdot q(p \cdot T_0) + \delta V(p) \text{ for all } p \in (c, p_0^f],$$

where $T_0 = 1$. In the next period, the firm will try to choose $p_1$ to maximize its discounted profit given that $T_1 = p_0^f / p_0 > 1$. Let's consider $p_1 = p_0$ as such a choice, then there exists $\alpha \ge 0$ such that $(p_0 - c)\cdot q(p_0 \cdot T_1) + \delta V(p_0) + \alpha = (p_0 - c)\cdot q(p_0 \cdot T_0) + \delta V(p_0)$ because $\partial q(p^c)/\partial p^c \le 0$ and $T_1 > T_0$. We can show that

(a4) $$(p - c)q(pT_0) + \delta V(p) > (p - c)q(pT_1) + \delta V(p) + \alpha \text{ for all } p \in (p_0, p_0^f]$$

Define $A(p) = [(p - c)q(pT_0) + \delta V(p)] - [(p - c)q(pT_1) + \delta V(p) + \alpha]$. By definition of $\alpha$, $A(p_0) = 0$ and $\partial A(p)/\partial p = [q(pT_0) - q(pT_1)] + (p - c)[\, T_0(\partial q(pT_0)/\partial p^c) + T_1(\partial q(pT_1)/\partial p^c)] > 0$ for $p \in [p_0, p_0^f]$ by the same reason as in Lemma 3. From (a3), (a4), and $(p_0 - c)\cdot q(p_0 \cdot T_1) + \delta V(p_0) + \alpha = (p_0 - c)\cdot q(p_0 \cdot T_0) + \delta V(p_0)$, we have $(p_0 - c)\cdot q(p_0 \cdot T_1) + \delta V(p_0) > (p - c)q(pT_1) + \delta V(p)$ for all $p \in (p_0, p_0^f]$. This implies $p_1 \notin (p_0, p_0^f]$, thus $p_1 \le p_0$. If $p_1 < p_0$, then we can repeat the same argument as above to show that $p_2 \le p_1$ by replacing $T_0$ and $T_1$ ($>T_0$) with $T_1$ and $T_2$ ($>T_1$). If $p_1 = p_0$, then we can use the exactly same argument as above to show that $p_2 \le p_1 = p_0$.

**Proof for Proposition 2**

(i) To prove $p_0^E$ is non-decreasing in Pr(ADD), we use a similar argument as in Lemma 3. Let's assume that the foreign firm sets its initial optimal price, $p_0^E$ for a given Pr(ADD), having

$$\text{(a5)}\qquad \begin{aligned} &(p_0^E - c)\cdot q(p_0^E) + \delta\cdot[\Pr(ADD)\cdot V(p_0^E) + \Pr(TER)\cdot V^T(p_0^E)] \ge \\ &(p - c)\cdot q(p) + \delta\cdot[\Pr(ADD)\cdot V(p) + \Pr(TER)\cdot V^T(p)] \text{ for all } p \in (c, p_0^f]. \end{aligned}$$

Now consider Pr'(ADD) > Pr(ADD), and the foreign firm tries to set its initial optimal price $p_0^{E}{'}$ for the given Pr'(ADD). There exists $\alpha > 0$ such that $(p_0^E - c)\cdot q(p_0^E) + \delta\cdot \Pr'(ADD)\cdot V(p_0^E) - \alpha = (p_0^E - c)\cdot q(p_0^E) + \delta\cdot \Pr\cdot V(p_0^E)$ because Pr'(ADD) > Pr(ADD). We can show that

$$\text{(a6)}\qquad \begin{aligned} &(p - c)\cdot q(p) + \delta\cdot[\Pr(ADD)\cdot V(p) + \Pr(TER)\cdot V^T(p)] > \\ &(p - c)\cdot q(p) + \delta\cdot[\Pr'(ADD)\cdot V(p) + \Pr(TER)\cdot V^T(p)] - \alpha, \text{ for all } p \in (c, p_0^E), \end{aligned}$$

as long as V(p) is strictly increasing in p. Define $A(p) = [(p - c)\cdot q(p) + \delta\cdot \Pr(ADD)\cdot V(p)] - [(p - c)\cdot q(p) + \delta\cdot \Pr'(ADD)\cdot V(p) - \alpha]$. By definition of $\alpha$, $A(p_0^E) = 0$ and $A(p) = [\Pr(ADD) - \Pr'(ADD)]\cdot V(p) + \alpha > 0$ for $p \in (c, p_0^E)$ when V(p) is strictly increasing in p. From (a5), (a6), and $(p_0^E - c)\cdot q(p_0^E) + \delta\cdot \Pr'(ADD)\cdot V(p_0^E) - \alpha = (p_0^E - c)\cdot q(p_0^E) + \delta\cdot \Pr(ADD)\cdot V(p_0^E)$, we have $(p_0^E - c)\cdot q(p_0^E) + \delta\cdot Pr'(ADD)\cdot V(p_0^E) > (p - c)\cdot q(p) + \delta\cdot Pr'(ADD)\cdot V(p)$ for all $p \in (c, p_0^E]$. This implies $p_0^{E}{}' \leq p_0^E$ for all Pr'(ADD) > Pr(ADD).

To prove that $q(p_0^f(p_0^f/c)) > 0$ is a sufficient condition for V(p) being strictly increasing in p, first note that $q(p_0^f(p_0^f/c)) > 0$ guarantees $q(p\cdot(p_0^f/p_{-1})) > 0$ for all p, $p_{-1} \in (c, p_0^f]$. This implies that $-(p-c)\cdot(\partial q(p\cdot(p_0^f/p_{-1}))/\partial p^c)\cdot(p_0^f/p_{-1}) > 0$ for p satisfying the f.o.c. for $\underset{p\in(c,p_0^f]}{\text{Max}}(p-c)q(p\cdot(p_0^f/p_{-1})) + \delta G(p)$ in Lemma 3. This in turn implies that $(Tg)(p_{-1})$ in Lemma 3 is strictly increasing in $p_{-1}$, which with we can establish that V(p) is a strictly increasing function in p by using Corollary 1 to Theorem 3.2. in Stocky et al. (1989).

(ii) We can use the same argument as in the proof for Proposition 2 (i), except using that there exists $\alpha > 0$ such that $(p_0^E - c)\cdot q(p_0^E) + \delta\cdot Pr'(TER)\cdot V(p_0^E) - \alpha = (p_0^E - c)\cdot q(p_0^E) + \delta\cdot Pr(TER)\cdot V(p_0^E)$ and

(a6') $$\begin{aligned}&(p-c)\cdot q(p) + \delta\cdot\left[Pr(ADD)\cdot V(p) + Pr(TER)\cdot V^T(p)\right] > \\ &(p-c)\cdot q(p) + \delta\cdot\left[Pr(ADD)\cdot V(p) + Pr'(TER)\cdot V^T(p)\right] - \alpha,\end{aligned}$$

for all $p \in (p_0^E, p_0^f)$ if $V^T(p)$ is strictly decreasing in p, or for all $p \in (c, p_0^E)$ if $V^T(p)$ is strictly increasing in p.

**Proof for Corollary 1.**

(i) $p^S = p_0^f$ implies that $\underset{p\in(c,p_0^f]}{\text{Max}}[\pi(p;T_0) - \pi(p_0^f;T_0)] \leq \delta[V(p_0^f) - V(p)]$. Because $\underset{p\in(c,p_0^f]}{\text{Max}}[\pi(p;T_0) - \pi(p_0^f;T_0)] > 0$ from (A1) and (A2), there exist $Pr^c(ADD) \in (0,1]$ such that $\underset{p\in(c,p_0^f]}{\text{Max}}[\pi(p;T_0) - \pi(p_0^f;T_0)] = Pr^c(ADD)\cdot\delta[V(p_0^f) - V(p)]$. For $Pr(ADD) < Pr^c(ADD)$, the foreign firm will sets $p_0^E$

$< p_0^f$ because $\underset{p \in (c, p_0^f]}{\text{Max}}\ [\pi(p;T_0) - \pi(p_0^f;T_0)] > \Pr(ADD)\cdot \delta\cdot[V(p_0^f) - V(p)]$ for $\Pr(ADD) < \Pr^c(ADD)$. If a ADD case occurs with $T_{i+1}^{di} = p_0^f / p_0^E > 1$ at period i, then the following pricing path $\{p_0^{di}, p_1^{di}, p_2^{di}, ...\}$ under the administrative review will be determined by $G(p_0^E)$; note that the administrative review is enforced with certainty. Because $p^S$ is the unique stationary equilibrium under certain enforcement and G(p) is a non-decreasing upper-hemi continuous correspondence, $p_j^{di}$ with $j \geq i+1$ will increase toward $p^S = p_0^f$. This in turn implies that $T_j^{di}$ with $j \geq i+1$ will decrease toward zero.

(ii) For the foreign firm with $p^S < p_0^f$, $\text{Arg}\max_p [(p-c)q(p)] \equiv p^* < p^S$ is a necessary condition for the existence of $\Pr^c(ADD) \in (0,1]$ such that the foreign firm sets $p_0^E < p^S$ for $\Pr(ADD) < \Pr^c(ADD)$. Note that $p_0^E \geq p^*$ because V(p) is non-decreasing in p and $\pi(p;T_0 = 1) < \pi(p = p^S;T_0 = 1)$ for all $p < p^*$. Given that $p^* < p^S$, there exists $\Pr^c(ADD)$ close enough to 0 such that $p_0^E - \varepsilon = p^* < p^S$ for any $\varepsilon \geq 0$. If a ADD case occurs with $T_{i+1}^{di} = p_0^f / p_0^E > p_0^f / p^S$ at period i, then the following pricing path $\{p_0^{di}, p_1^{di}, p_2^{di}, ...\}$ under the administrative review will be determined by $G(p_0^E)$. Because $p^S$ $(> p_0^E)$ is the unique stationary equilibrium under certain enforcement and G(p) is a non-decreasing upper-hemi continuous correspondence, $p_j^{di}$ with $j \geq i+1$ will increase toward $p^S$. This implies that $T_j^{di}$ with $j \geq i+1$ will decrease toward $p_0^f / p^S$.

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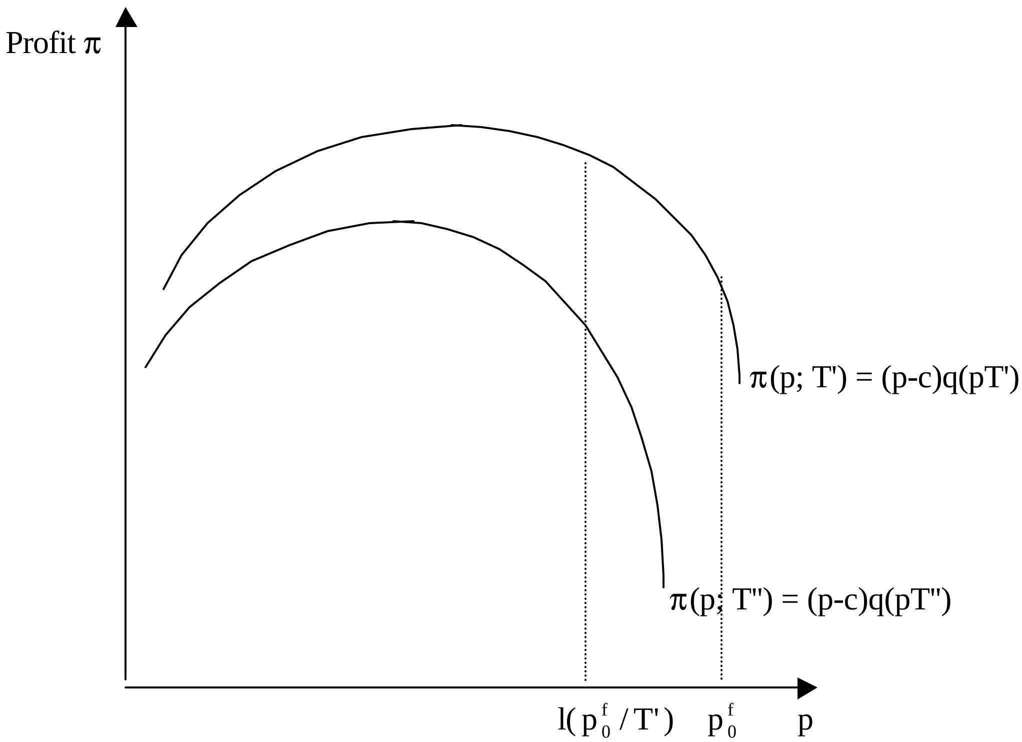


**Figure 1a**

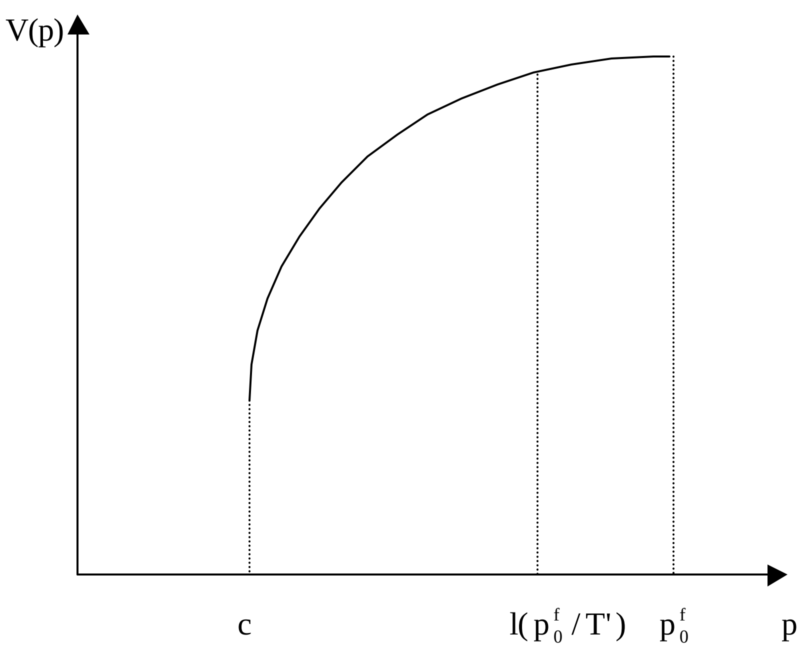


**Figure 1b**

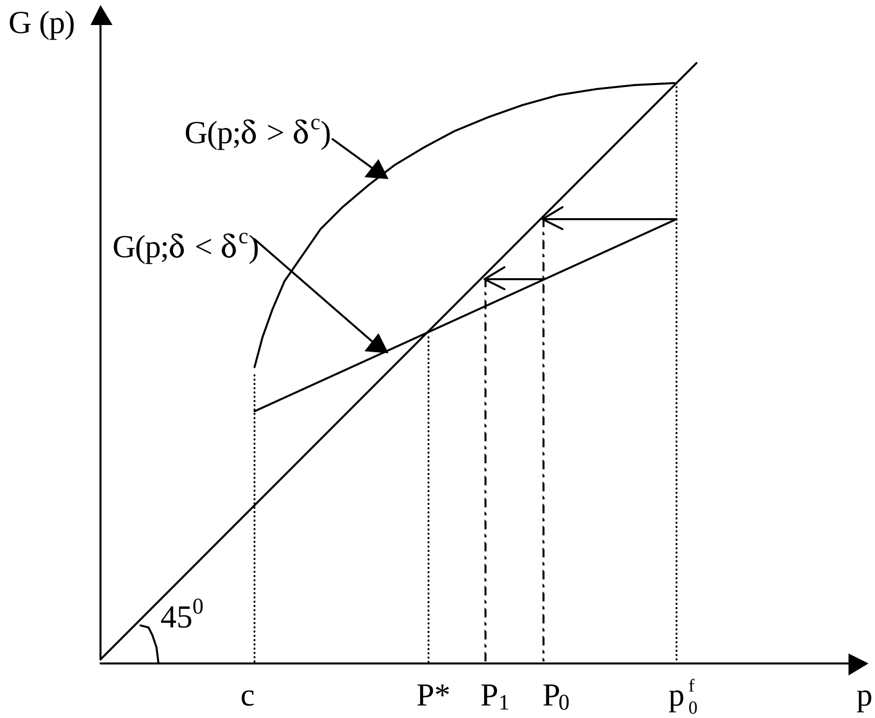


**Figure 2a**

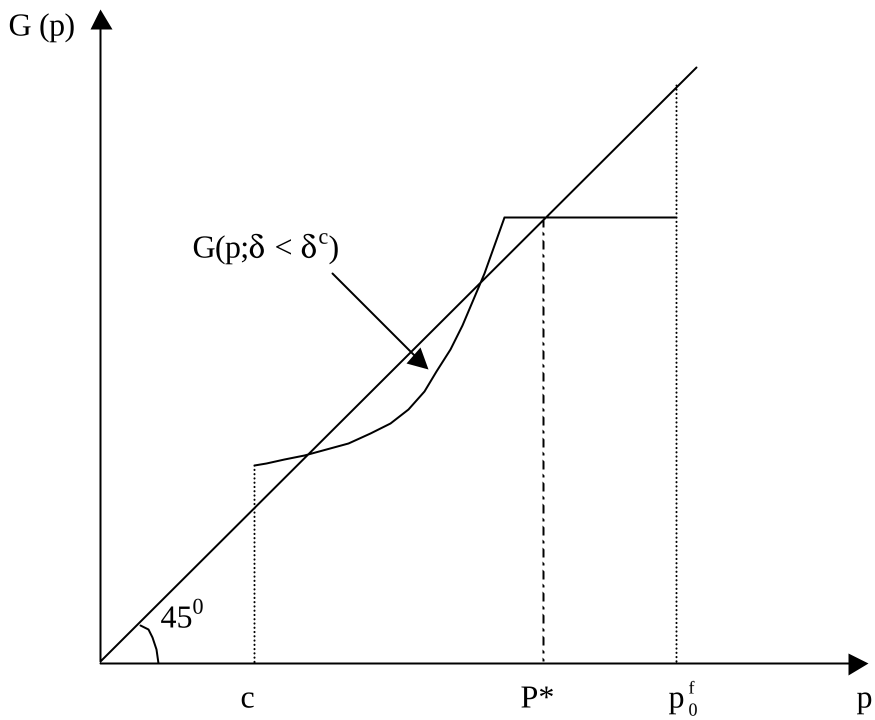


**Figure 2b**

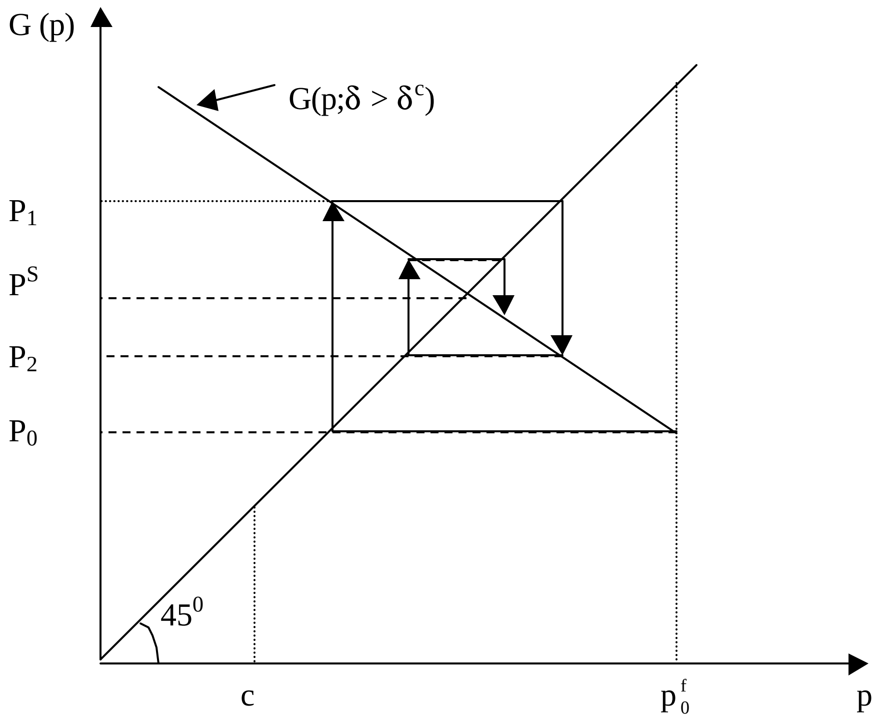


**Figure 2c**

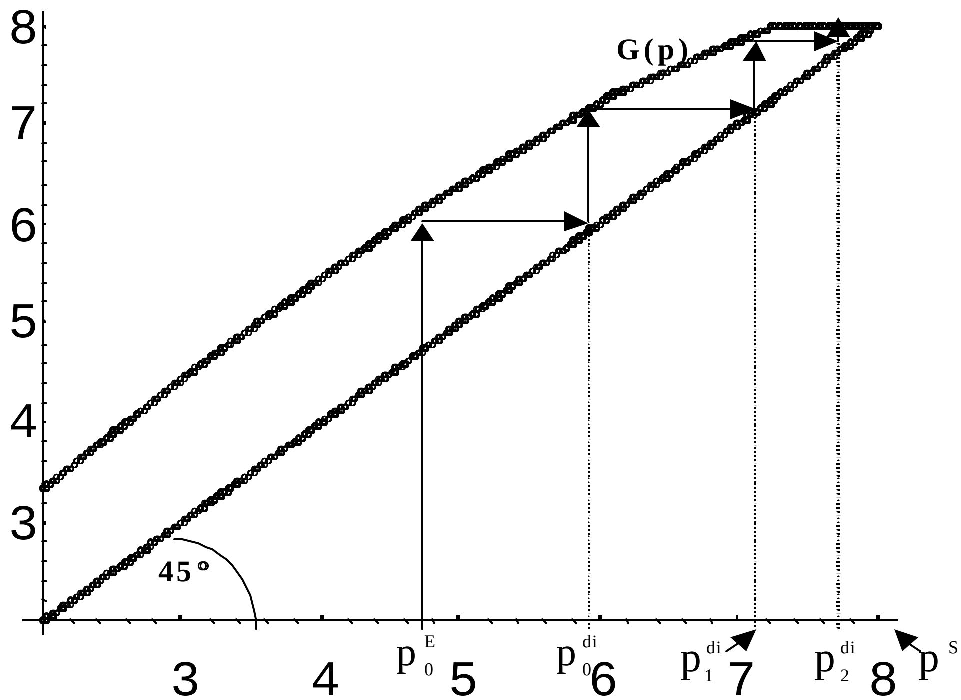


Figure 3a. (q(p)=10-p, c = 2, pf = 8, δ = 0.9)

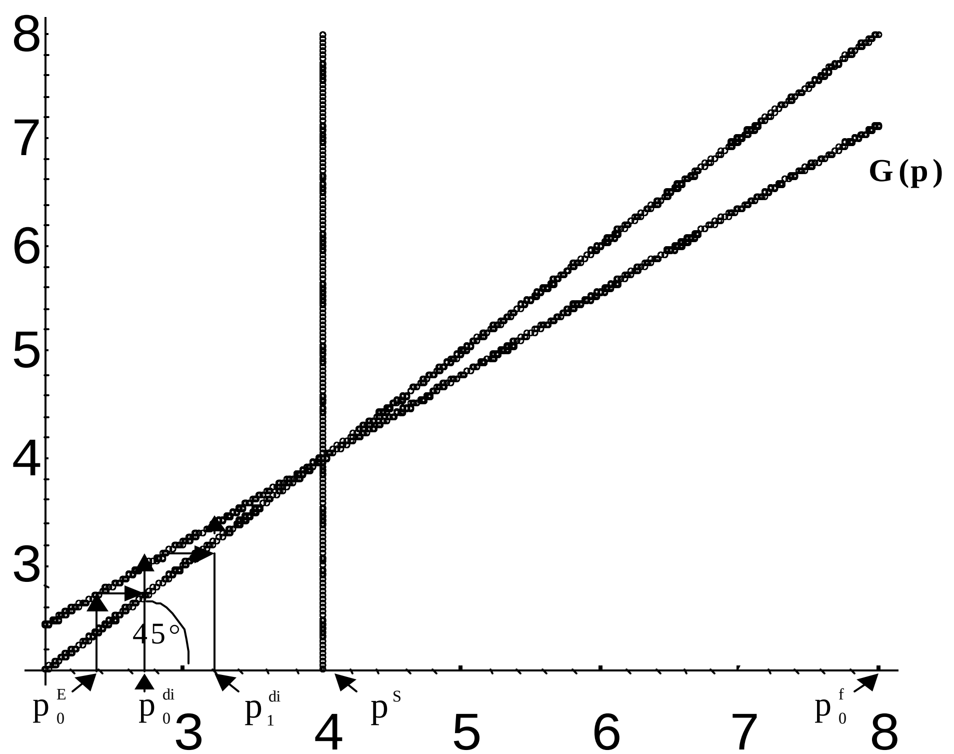


Figure 3b. (q(p)=10-p, c = 2, pf = 8, δ = 0.5)

**Table 1: Descriptive Statistics for Entire First-stage Sample of Variables, 1980-1994.**

| Variables | Mean | Standard Deviation | Minimum | Maximum |
|---|---|---|---|---|
| **Dependent variable:** “1”= affirmative, “2”=negative, “3”=terminated/VER | 1.699 | 0.661 | 1.000 | 3.000 |
| **Independent Variables:** | | | | |
| Real domestic shipment 3-year growth. | - 0.037 | 0.208 | - 0.479 | 0.831 |
| Value of investigated imports. | 33826 | 83351 | 0.000 | 859800 |
| Value of investigated imports squared. | 8.08E+09 | 4.82E+10 | 0.000 | 7.39E+11 |
| Iron and steel products. | 0.366 | 0.442 | 0.000 | 1.000 |
| Steel pipe products | 0.083 | 0.275 | 0.000 | 1.000 |
| Non-market economy | 0.108 | 0.310 | 0.000 | 1.000 |
| Less-developed country | 0.499 | 0.500 | 0.000 | 1.000 |
| European union | 0.288 | 0.453 | 0.000 | 1.000 |
| Japan | 0.122 | 0.327 | 0.000 | 1.000 |
| Asian NICs | 0.158 | 0.365 | 0.000 | 1.000 |

**Table 2**: **Multinomial logit estimation of first-stage determinants of U.S. AD case outcomes.**

| Explanatory Variables | Dependent Variable: “1” if affirmative; “2” if negative; “3” if terminated/VER. | | |
|---|---|---|---|
| | Estimates for **1985** (using 1980-1984 data) | Estimates for **1990** (using 1980-1989 data) | Estimates for **1995** (using 1980-1994 data) |
| Determinants of affirmative outcomes | | | |
| Real domestic shipment 3-year growth. | 0.334<br>(1.019) | - 1.809***<br>(0.670) | - 0.452<br>(0.538) |
| Value of investigated imports. | - 5.83e-06<br>(8.39e-06) | 1.48e-06<br>(3.74e-06) | 4.85e-06*<br>(2.76e-06) |
| Value of investigated imports squared. | 1.21e-11<br>(3.29e-11) | - 2.21e-12<br>(7.00e-12) | - 7.06e-12<br>(4.64e-12) |
| Iron and steel products. | - 0.016<br>(0.579) | - 1.025**<br>(0.415) | - 0.118<br>(0.268) |
| Steel pipe products | 1.221<br>(0.880) | 0.367<br>(0.447) | 1.197***<br>(0.352) |
| Non-market economy | 0.260<br>(0.780) | 0.911<br>(0.511) | 0.855***<br>(0.328) |
| Less-developed country | 1.027<br>(0.698) | 0.194<br>(0.400) | 0.419<br>(0.314) |
| European union | 0.301<br>(0.612) | - 0.140<br>(0.375) | 0.048<br>(0.304) |
| Japan | 1.821**<br>(0.713) | 1.049**<br>(0.449) | 1.072***<br>(0.371) |
| Asian NICs | - 0.333<br>(0.687) | - 0.031<br>(0.367) | - 0.084<br>(0.269) |
| Determinants of terminated outcomes | | | |
| Real domestic shipment 3-year growth. | - 0.224<br>(2.226) | - 0.239<br>(1.544) | - 0.404<br>(1.244) |
| Value of investigated imports. | 2.04e-05**<br>(8.78e-06) | 1.55e-05**<br>(6.99e-06) | 1.67e-05***<br>(4.38e-06) |

| | | | |
|---|---|---|---|
| Value of investigated imports squared. | - 2.55e-11<br>(2.34e-11) | - 1.47e-11<br>(2.06e-11) | - 1.60e-11**<br>(6.82e-12) |
| Iron and steel products. | 3.484***<br>(0.920) | 2.838***<br>(0.608) | 2.403***<br>(0.473) |
| Steel pipe products | 5.053***<br>(1.233) | 3.182***<br>(0.749) | 2.647***<br>(0.611) |
| Non-market economy | 2.674**<br>(1.198) | 2.268***<br>(0.706) | 1.830***<br>(0.586) |
| Less-developed country | - 0.922<br>(0.950) | - 0.285<br>(0.587) | 0.046<br>(0.535) |
| European union | 0.069<br>(0.765) | 0.433<br>(0.583) | 0.474<br>(0.525) |
| Japan | - 0.113<br>(1.337) | 0.397<br>(0.933) | 0.250<br>(0.809) |
| Asian NICs | -1.297<br>(1.404) | - 1.788<br>(1.138) | - 1.350<br>(0.844) |
| Chi-squared statistic | 113.34*** | 236.86*** | 307.52*** |
| Pseudo $R^2$ | 0.25 | 0.26 | 0.22 |
| Number of observations | 214 | 448 | 715 |

NOTES: Standard errors are in parentheses, with ***, ** and * denoting statistical significance (two-tailed test) at the 1, 5 and 10 percent levels, respectively. All specifications also include year dummies.

**Table 3**: **Estimation of second-stage determinants of AD margin reductions after affirmative AD outcome.**

| Explanatory Variables | Tobit estimation (1) | (2) | (3) | Probit estimation (4) |
|---|---|---|---|---|
| <u>Focus Variables</u> | | | | |
| *Ex ante* probability of AFFIRMATIVE outcome. | 0.560** | 0.194* | 0.307** | 0.524** |
| | (0.131) | (0.116) | (0.118) | (0.232) |
| *Ex ante* probability of TERMINATION/VER outcome. | - 0.487** | - 0.364** | - 0.183* | - 0.333 |
| | (0.118) | (0.104) | (0.103) | (0.208) |
| Controls for DOC methodology | | | | |
| Change from BIA to no BIA. | | 0.126** | 0.133** | 0.548 |
| | | (0.062) | (0.062) | (0.129) |
| Change from no BIA to BIA. | | 1.350** | 1.402** | 1.696** |
| | | (0.120) | (0.121) | (0.341) |
| Period of automatic administrative reviews. | | - 0.837** | - 0.833** | - 1.164** |
| | | (0.066) | (0.067) | (0.128) |
| Chi-squared statistic. | 59.08** | 330.55** | 315.41** | 202.10** |
| Pseudo $R^2$. | 0.04 | 0.22 | 0.21 | 0.22 |
| Number of observations. | 652 | 652 | 652 | 652 |

NOTES: Dependent variable for tobit estimation is the 4-year percentage change in the dumping duty, while the dependent variable for the probit estimation a dummy variable that takes the value of "1" if dumping duty does not decrease. Robust standard errors are in parentheses, with ** and * denoting statistical significance (two-tailed test) at the 5 and 10 percent levels, respectively.