Exploiting Future Settlements:
A Signaling Model of Most-Favored-Nation Clauses in Settlement Bargaining

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ABSTRACT

"Most-favored-nation" (hereafter, MFN) clauses have been used in analyses of international trade, durable-goods monopoly pricing, and franchise contracting to address a repeat player's time-inconsistency problem. Recent work by Spier (2002, 2003) has extended this perspective to the settlement of litigation by (for example) one defendant facing a collection of plaintiffs.

We examine a different motivation for the use of MFNs in settlement bargaining. We argue that a non-repeat player can use an MFN to extend her reach into subsequent bargaining games. That is, an early-bargaining plaintiff can use an MFN to modify the subsequent bargaining game between the defendant and a later-bargaining plaintiff in a manner that improves the early plaintiff's payoff. Moreover, we will identify two routes through which this improvement is achieved. The obvious route is that, if the MFN is triggered by the later settlement, the early plaintiff receives an additional payment. The less obvious route is that the early plaintiff's incentives for information-revelation can be enhanced by the potential for a future payment, so that the defendant can resort to trial on a less-frequent basis. Using a signaling model, we find that the repeat player (the defendant) is indifferent about the MFN, while the later plaintiff is always worse off when an MFN constrains her settlement bargaining with the defendant. Although MFNs can never provide a Pareto improvement in this model, we demonstrate that plausible circumstances exist under which total surplus is increased by an MFN.

1. Introduction

"Most-favored-nation" (hereafter, MFN) clauses have been used in a variety of contexts. In the context of international trade, a country might grant MFN status to another country, thereby promising to trade with that country on terms no worse than those enjoyed by any of the granting country's other trading partners. In the industrial organization context, a durable-goods monopolist might promise its buyers (or a franchisor might promise its franchisees) that, subsequent to concluding the instant deal, no other buyer (or franchisee) will obtain more favorable terms, unless those terms are retroactively extended to the previous buyers (or franchisees). In the context of settlement of litigation, which will be our primary interest, MFNs promise early-settling plaintiffs that later-settling plaintiffs will not obtain more favorable terms, unless those terms are retroactively extended to the early settlers. Such clauses have been employed in settlements associated with (among others) copyright infringement, bankruptcy proceedings, allegations of price-fixing and of racial discrimination, and claims by the states for restitution.[1]

An interesting proposed explanation for the use of MFN clauses in the industrial organization context is based on the recognition that these situations involve a repeat player who interacts with a collection of one-shot players over time. In this case, the repeat player can suffer from a problem of time inconsistency. The durable-goods monopolist, having sold some units at a relatively high

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[1] In the context of bankruptcy, the creditors are the plaintiffs; see Sage and Bennett (2001). Antitrust actions involving the airlines (see *In re Domestic Air Transportation Antitrust Litigation*, 148 F.R.D. 297) and manufacturers (see, for example, *In re Corrugated Container Antitrust Litigation*, 753 F.2d 137 and *Cintech Industrial Coatings*, 85 F.3d 1198) have involved settlements with MFN clauses. Recently a U.S. District Court gave preliminary approval to a proposed settlement in a Title VII racial discrimination suit against Coca-Cola (see Civil Action No. 1:98-CV-3679-RWS in 133 F. Supp. 2d 1364). Spier (2002, 2003) discusses examples drawn from antitrust (see *In re Chicken Antitrust*, 560 F. Supp. 943 and *In re Vitamins Antitrust*, 342 U.S. App. D.C. 26), copyright infringement (the recent settlements in the MP3.com case) and the settlements by Mississippi, Florida and Texas in the tobacco cases (see http://www.library.ucsf.edu/tobacco/litigation/).

price to those buyers with relatively high willingness-to-pay, is tempted to cut the price in the next period in order to sell to buyers with a somewhat lower willingness-to-pay (Coase, 1972, and Bulow, 1982). A franchisor, having concluded a contract with one franchisee, is tempted to offer more favorable terms to another franchisor whose market will overlap somewhat with that of the first franchisee. This encroachment explains the need to offer more favorable terms (see, for example, McAfee and Schwartz, 1994). A defendant, having concluded a settlement with relatively low-damaged plaintiffs, is tempted to offer a higher settlement to the remaining plaintiffs who (having rejected the first offer) can be inferred to have relatively high damages (Spier, 2003). In all of these cases, rational anticipation of more-favorable terms in the future interferes with the repeat player's ability to conclude the early deals at his preferred terms.

In several recent papers, scholars have demonstrated how the use of MFN clauses can solve the repeat player's time inconsistency problem. Butz (1990) shows that incorporating an MFN clause into the sale of a durable good allows a durable-goods monopolist to commit to the (one-shot) monopoly output; that is, to the output it would optimally choose if it could commit to a one-time choice of output. While this is clearly good from the perspective of the durable-goods monopolist, it reduces both consumers' surplus and total surplus. Marx and Shaffer (2001) examine non-discrimination clauses in intermediate-goods markets, with a special emphasis on franchisor-franchisee relationships. They find that an MFN enables the franchisor to offer a sequence of contracts which yields the same outcome as if the franchisor were able to commit to a single (observable) contract. The resulting prevailing contract terms maximize the joint surplus of the franchisor and its franchisees, thus internalizing the encroachment externalities that would result in lower final goods prices absent a commitment mechanism.

In a pair of companion papers, Spier (2002, 2003) demonstrates that a defendant being sued simultaneously by multiple plaintiffs can use an MFN clause to commit to a single take-it-or-leave it offer, much like in the context of a durable-goods monopolist. However, she finds that the implications for welfare are quite different in the settlement context. Like the durable-goods monopolist, the defendant always gains through the use of an MFN, but Spier also identifies conditions under which: the MFN results in a Pareto improvement (that is, plaintiffs may also gain) when an MFN is implemented; plaintiffs lose, but total surplus is still increased by an MFN; and total surplus is reduced (and hence plaintiffs lose more than the defendant gains) by an MFN.

We examine a different motivation for the use of MFNs in settlement bargaining, which we refer to as "leverage." We argue that a non-repeat player can use an MFN to extend her reach into subsequent bargaining games. That is, an early-bargaining plaintiff can use an MFN to modify the subsequent bargaining game between the defendant and a later-bargaining plaintiff in a manner that improves the early plaintiff's payoff. Moreover, we identify two routes through which this improvement is achieved. The obvious route is that, if the MFN is triggered by the later settlement, the early plaintiff receives an additional payment. The less obvious route is that the early plaintiff's incentives for information-revelation are enhanced by the potential future payment, so the defendant can resort to trial on a less-frequent basis. Using a signaling model, we find that the repeat player (the defendant) is indifferent about the MFN, while the later plaintiff is always worse off when an MFN constrains her settlement bargaining with the defendant. Although MFNs can never provide a Pareto improvement in this model, we demonstrate that plausible circumstances exist under which total surplus is increased by an MFN.[2]

Relationship to Previous Work on MFNs in Settlement Bargaining

Since the Spier (2002, 2003) papers are closest to the current paper, it is worth spending some time comparing and contrasting them. In Spier (2003), there is a continuum of injured plaintiffs facing a single defendant. Each plaintiff's level of damages is drawn independently from a common distribution, and a plaintiff's damages are her private information. Settlement bargaining takes place over (at most) two periods, under the following extensive form. In the first period, the uninformed defendant makes a single offer to all plaintiffs (thus, this is a screening model). Each plaintiff decides whether to accept or reject the offer; a plaintiff who accepts receives the offered amount and is out of the game. Any plaintiff who rejects the first-period offer pays a "delay cost" (as does the defendant), and proceeds to the second period. In the second period, the defendant makes another offer to all remaining plaintiffs. Each remaining plaintiff decides whether to accept or reject the offer; a plaintiff who accepts receives the offered amount and is out of the game, while any plaintiff who rejects the second-period offer goes to trial. Note that each plaintiff can choose to settle in either period. This model is analyzed both with, and without, an MFN, where an MFN specifies that if the defendant settles in period 2 for a higher amount than the settlement in period 1, he must rebate the difference to those plaintiffs with whom he settled in period 1. Spier shows that an MFN implements the full-commitment solution (a single, take-it-or-leave-it offer).

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[2] The motivation for the use of MFNs that we focus on in this paper is similar to that addressed in our recent work on the use of confidential settlements in sequential suits wherein two plaintiffs sue the same defendant (see Daughety and Reinganum, 1999, 2002). There we found that an early-bargaining plaintiff could use a confidential settlement to extract surplus from a later-bargaining plaintiff, using the defendant as a conduit. Again, although confidential settlements did not provide a Pareto improvement, we identified circumstances under which total expected surplus was nevertheless increased (because expected trial costs were decreased) by confidentiality.

There are two margins of interest in this model: one involves the overall extent of settlement, while the other involves the timing of settlement. The full-commitment (and MFN) offer is accepted in the first period by all plaintiffs with damages below a critical level, denoted $\hat{x}$. By contrast, without an MFN the defendant makes an increasing sequence of offers; some plaintiffs settle in each of the periods, and all plaintiffs with damages below a critical level (denoted $\tilde{x}$) settle.

When all litigants can settle in either period, the use of the MFN eliminates delay costs that arise in equilibrium without an MFN. Spier shows that the MFN increases (leaves unchanged, decreases) overall settlement if the density function is increasing (constant, decreasing) at $\tilde{x}$. An MFN increases expected total litigation costs only if the overall extent of settlement falls enough that increased trial costs offset saved delay costs. Plaintiff welfare also pivots on this feature of the density function: plaintiffs are better off (the same, worse off) under an MFN if the density function is increasing (constant, decreasing) at $\tilde{x}$. The defendant is better off with an MFN (since it implements his full-commitment outcome), so an MFN provides a Pareto improvement if the density function is non-decreasing at $\tilde{x}$.

This model and motivation seem to represent well situations wherein all plaintiffs are present at the same time and negotiations proceed on a multilateral basis, and when strategic delay can be expected to contribute substantially to private, and social, costs. This can (but need not) occur when there is some precipitating event that launches a collection of suits; for instance, a successful government antitrust suit will be followed by a number of private suits for damages, and a bankruptcy will trigger action by all the creditors. In the vitamins case, the Department of Justice obtained guilty pleas from several manufacturers, which then led to the filing of approximately 49 private suits for damages within three months (see Schlosser, 2001, and *In re Vitamins Antitrust*, 342

U.S. App. D.C. 26). In the MP3.com copyright infringement case, MP3.com was sued (essentially simultaneously) by five major record labels for unauthorized distribution of music (see Spier, 2002, 2003, for details). The proposed class-action settlement of a Title VII racial discrimination suit involving Coca-Cola cited earlier also seems to fit this model; an MFN is used to encourage plaintiffs to opt-in to the class settlement rather than opt-out and settle/litigate on their own.

However, an alternative extensive form, in which plaintiffs bargain bilaterally with the defendant, would seem to be a better representation of some cases. For example, the lawsuits by the states in the tobacco cases were filed over a four-year period as legislatures and political decision-makers wrangled over whether and how to proceed. Mississippi was the first state to pursue a theory of restitution, claiming that the tobacco companies should pay past health-care expenditures made by the state on behalf of smokers. They filed their case in May, 1994, and included an MFN provision in their settlement with the tobacco companies, which was concluded in July, 1997. Florida filed in February, 1995 and settled (with an MFN) in August, 1997; Texas filed in March, 1996 and settled (with an MFN) in January, 1998. All these MFNs were triggered by the Minnesota settlement in May, 1998 (they had filed in August, 1994). This was against a backdrop of industry-proposed federal legislation which died in the Senate in June, 1998 (see Viscusi, 2002). After the federal approach failed, the remaining forty-six states were included in the Master Settlement Agreement (proposed in November, 1998) which is generally viewed as providing less favorable conditions than Mississippi, Florida, Texas and Minnesota already enjoyed (LaFrance, 2000).

In the case *In re: Domestic Air Transportation Antitrust Litigation* (148 F.R.D. 297), the class of consumer-plaintiffs is the repeat player, and the airline-defendants are non-repeat players. In June, 1990, a (would-be) class of consumer-plaintiffs filed suit against seven major airlines

(Northwest, TWA, American, Delta, United, USAir and Continental) and the Airline Tariff Publishing Company (ATPCO), alleging that these companies conspired, through the use of ATPCO's computerized fare-publishing system, to fix the prices of passenger air tickets. Class certification was sought by the plaintiffs and opposed by the defendants. In May, 1991, prior to class certification, Northwest settled with the pending class. Included in its settlement was an MFN clause, and an agreement to withdraw its objection to class certification.[3] In June, 1992, American, Delta, United, USAir and ATPCO reached a proposed settlement with the plaintiff class, and Continental followed a week later. The pattern of settlement suggests that, early in the litigation process, the plaintiff class and some defendants were engaged in bilateral negotiations. Another example of (largely sequential) bilateral negotiations in an antitrust setting occurred in the Cintech case cited earlier. In both the airline and Cintech cases, the record indicates that it was the non-repeat player who demanded an MFN, not the repeat player.

In this paper, we examine sequential bilateral bargaining and we also assume that the informed plaintiffs make the demands; thus, our game involves a sequence of signaling subgames. Furthermore, while Spier employs a continuum of plaintiffs (and thereby guarantees that some fraction will accept the first offer), we focus on the case of two plaintiffs, so none, one or both may end up at trial. This modeling difference is driven by the desire to analyze different strategic influences. With a continuum of plaintiffs, delay is the strategic focus and inter-plaintiff interaction is suppressed, while in our analysis, inter-plaintiff strategic considerations are highlighted and consideration of strategic delay is suppressed. In our first period, the early plaintiff makes a

[3] TWA settled in June, 1991, on "substantially the same terms (148 F.R.D. 297 at 310)," and the Court preliminarily approved these settlements in September, 1991.

settlement demand, possibly incorporating an MFN. If the defendant rejects the demand, the case goes to trial and the early plaintiff is out of the game; the second period commences without an MFN to (potentially) constrain the bargaining. On the other hand, if the defendant accepts the first plaintiff's demand and an MFN was included, then second-period bargaining will be (potentially) constrained by the MFN. In the second period the later plaintiff makes a settlement demand, which the defendant either rejects or accepts. If this demand is rejected, the later plaintiff and the defendant go to trial and the game is over. If this demand is accepted, then the later plaintiff receives the amount she demanded. Moreover, if this accepted demand exceeds that at which the early plaintiff settled (and that settlement included an MFN), then the early plaintiff receives a supplementary payment equal to the difference in the settlement amounts.

Although Spier (2002) mostly considers a two-type version of the model developed in Spier (2003), with a greater emphasis on the legal issues and related scholarship, she briefly considers therein a complete-information version of the sequential bargaining model in which plaintiffs make the demands.[4] Despite the simplicity of this model, it does yield some of the features of the asymmetric information version we consider below. For instance, it identifies the way in which the early plaintiff's settlement amount constrains (under an MFN) the feasible demands of the later plaintiff, and it shows that some later cases that would otherwise have settled must go to trial under an MFN. However, because settlement in a complete information analysis occurs either with probability one or with probability zero, the use of an MFN can only raise expected total trial costs (all cases settle for sure without an MFN, but some can fail to settle with an MFN).

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[4] Other papers using complete information models to examine sequential bargaining include Cooper and Fries (1991) and Nielson and Winter (1994), who argue that a seller can use MFNs to extract surplus from buyers.

Under asymmetric information, we obtain a much more nuanced picture of how an MFN affects the likelihood of settlement in each case. In particular, some later plaintiff types are more likely to settle, while others are less likely to do so, under an MFN. We identify plausible circumstances under which the overall likelihood that the later case settles is <u>increased</u> by an MFN. Similarly, we find that (under these same circumstances) every early plaintiff type is more likely to settle under an MFN. In these circumstances, the prospect of a future payoff weakens a plaintiff's incentives to mimic a higher-damaged type, and thus the defendant need not be as skeptical (i.e., he can reject a given demand with lower probability). We also find that the defendant's welfare is unaffected by an MFN (and thus, the MFN does not enhance or reduce the defendant's incentives to take care in any previous stage), while the later plaintiff's welfare is lower for those types who are constrained by an MFN. Thus in the sequential signaling model, an MFN will never provide a Pareto improvement but will, under plausible circumstances, reduce expected total trial costs.

<u>Plan of the Paper</u>

In Section 2, we briefly describe the two-stage game and provide the basic notation. Section 3 considers the benchmark game when there is no MFN while Section 4 reconsiders this game when an MFN has been incorporated into the first-stage settlement. Section 5 assesses the impact of an MFN on the extent of litigation and on the private and social incentives to employ an MFN. Section 6 contrasts our results with those of Spier and uses this comparison to discuss issues relevant to judicial review of settlement agreements with MFN clauses. An Appendix provides proofs of the more central propositions and relevant properties of our model; some derivations are included in the main text so as to facilitate exposition. A Technical Appendix, available on the web at (XXXX), provides the remaining proofs.

2. Model Structure

A defendant, D, faces a sequence of plaintiffs, P_1 and P_2. As in Spier (2002, 2003), P_i's expected damages that would arise from a trial are denoted x_i, and they follow a density f(•) which is everywhere positive on its support; we write the support as $[\underline{x}, \overline{x}]$, though we will also consider an example with support $[\underline{x}, \infty)$. There are no costs of negotiation, but D incurs a court cost, k^D, if there is a trial (for each trial), and each P_i incurs a court cost, k^P, if she goes to trial against D; for convenience, let $K \equiv k^P + k^D$. Moreover we assume $\underline{x} - k^P > 0$, so that it is credible for P_i to threaten to take D to trial. Each P_i's level of expected damages is private information for that plaintiff, and we assume that (from the perspective of the other plaintiff and D) x_1 and x_2 are independent and identically distributed random variables. We will indicate as we proceed how correlation between x_1 and x_2 would affect the results.

The game is comprised of two stages and the sequence of actions is as follows. In stage one, P_1 makes a demand S_1, which D then accepts or rejects. If D accepts the demand, he pays P_1 the amount S_1, while if he rejects the demand D and P_1 go to trial, P_1 is awarded x_1 (i.e., this is revealed at trial), D pays this amount and each litigant then pays their respective court costs.[5] Stage 2 repeats the preceding scenario, but now with plaintiff P_2 making demand S_2 of D. Should S_2 exceed S_1, and should D accept S_2, then D pays S_2 to P_2 and pays $S_2 - S_1$ to P_1 (if and only if there is an MFN clause in any settlement between D and P_1); if D rejects P_2's demand and goes to trial, then x_2 is revealed at trial, D pays x_2 to P_2 and nothing more to P_1, and then P_2 and D pay their respective court costs.

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[5] An alternative game form might allow counter-proposals. In our signaling model, the counteroffer subgame would involve screening (since the equilibrium initial demand would no longer be revealing) and, similarly, if counter-proposals were added to Spier's screening model, the counteroffer subgame would involve signaling. Since our primary concern is to explore an alternative motivation for MFN use (leverage), we abstract from such considerations.

If $S_2 \leq S_1$, and D accepts S_2, then D pays S_2 to P_2 and nothing more to P_1 (even if there was an MFN clause in a previous agreement between P_1 and D). Finally, the plaintiffs are "time inflexible" in that they cannot adjust the timing of their negotiation with D by either delaying or moving early.[6]

Although the bargaining subgames examined in the next two sections differ in some respects, their equilibria have similar attributes. Equilibrium behavior for a plaintiff will involve a settlement demand function that maps the interval of types, $[\underline{x}, \overline{x}]$, into an interval of settlement demands, $[\underline{S}, \overline{S}]$, with higher types making higher demands. Equilibrium behavior for the defendant will involve a probability of rejection function which is continuous on $[\underline{S}, \overline{S}]$, begins at zero and is strictly increasing up to (at most) one, whereafter it remains constant at one.[7] We will rely on these properties to motivate the derivation of the equilibrium strategies.

3. Equilibrium Analysis of the Two-Stage Signaling Game When There is No MFN Clause

Since the levels of expected damages for the plaintiffs, x_1 and x_2, are independent and identically distributed random variables from the perspective of D and the other plaintiff, the two-

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[6] In many cases, the order of play will be dictated by exogenous considerations. For instance, harms may arise sequentially, leading to sequential suits and settlements. This is particularly likely to be true when an action on the part of the defendant leads to exposure of several plaintiffs to a dangerous substance or condition (e.g., a defective product). Harms may not be immediate, but may rather arise stochastically over time. Endogenous timing is briefly discussed at the end of Section 5.

[7] These properties are direct extensions of those proven in Reinganum and Wilde (1986). Notice that monotonicity of the probability of rejection implies its continuity since, if there were a jump (which would be upward), that type making the demand just above the jump could make an infinitesimal reduction in demand and enjoy a non-infinitesimal decrease in the probability of rejection. However, an upward jump can (and sometimes does) occur for $S > \overline{S}$, since there is no type which would thereby be induced to defect.

stage game (with no MFN) is simply the concatenation of two independent, one-stage signaling games as discussed in Reinganum and Wilde (1986). For completeness, we provide the necessary detail of such a one-stage game between P and D, where P is privately informed about her expected level of damages $x \in [\underline{x}, \overline{x}]$, D's prior on these damages is a density $f(\bullet)$, which is everywhere positive on $[\underline{x}, \overline{x}]$, and court costs are as described in Section 2. We use a subscript '0' to indicate the analysis and solution when there is no MFN, and subscripts '1' and '2' in later sections when the analysis involves an MFN, as this requires distinguishing the two bargaining games.

D observes P's demand S and forms beliefs, $b_0(S)$, about P's type. Since D wants to minimize his expected cost, he is willing to accept P's demand S if and only if $S \leq b_0(S) + k^D$, where the right-hand-side is what D anticipates he would pay if there were a trial against P.[8] Let $r_0(S)$ denote D's probability of rejecting a demand of S. Then P's expected payoff from making such a demand, denoted $\pi_0^P(S)$, is $\pi_0^P(S) = (1 - r_0(S))S + r_0(S)(x - k^P)$, and P chooses S so as to maximize her expected payoff. Let $S_0^*(x)$ denote the equilibrium revealing settlement demand made by a P of type x, and let $r_0^*(S)$ be the equilibrium rejection function for D. Then $S_0^*(x)$ and $r_0^*(S)$ should satisfy the following conditions:

a) $S_0^*(x) = x + k^D$;

b) $1 - r_0^*(S) - (S - x + k^P)\, r_0^{*\prime}(S) = 0$;

c) $r_0^*(S_0^*(\underline{x})) = 0$.

Condition (a) provides the revealing demand that a P should make, which makes D indifferent between trial and settlement. In a revealing equilibrium, D's beliefs should be correct: $b_0^*(S_0^*(x)) = x$, for all x; hence, from the demand made by P, D can infer which type of P would make that

[8] Thus, D's payoff consists of his expected costs, which are non-negative.

demand (that is, $b_0^*(S) = S - k^D$). Condition (b) says that S_0^* should maximize P's expected payoff, accounting for D's equilibrium rejection function $r_0^*(S)$, while condition (c) provides the boundary requirement that D should certainly accept the lowest rational demand any P would make (that is, $\underline{x} + k^D$, which is the minimum D would pay were he to go to trial against P).

Upon substitution of $x = S - k^D$ from condition (a) into condition (b), we obtain the following differential equation,

$$1 - r_0^*(S) - Kr_0^{*\prime}(S) = 0, \tag{1}$$

whose solution, employing condition (c), is straightforward. This leads to the following proposition which summarizes the equilibrium strategies for D and P, as well as D's equilibrium beliefs, in the one-stage game (see the Technical Appendix for the proof).[9]

Proposition 1. Let $\underline{S} = \underline{x} + k^D$ and $\overline{S} = \overline{x} + k^D$. For the single-stage signaling game between P and D, the following strategies ($r_0^*(S)$, $S_0^*(x)$) and beliefs $b_0^*(S)$ provide the unique revealing equilibrium.

$$\text{(i) } r_0^*(S) = \begin{cases} 1 & S > \overline{S}, \\ 1 - \exp\{-(S - \underline{S})/K\} & S \in [\underline{S}, \overline{S}], \\ 0 & S < \underline{S}. \end{cases}$$

$$\text{(ii) } S_0^*(x) = x + k^D, \qquad x \in [\underline{x}, \overline{x}].$$

$$\text{(iii) } b_0^*(S) = \begin{cases} \overline{x} & S > \overline{S}, \\ S - k^D & S \in [\underline{S}, \overline{S}], \\ \underline{x} & S < \underline{S}. \end{cases}$$

Thus, in the two-stage game without an MFN, P_1 and D play the single-stage game

[9] For the refinement afficionados, this equilibrium (and the others discussed in this paper) is the unique Perfect Bayesian equilibrium surviving the D1 refinement of Cho and Kreps (1987).

equilibrium strategies as specified above; this is followed by P_2 and D playing the single-stage game equilibrium strategies as specified above.

Note that the revealing equilibrium does not depend on the distribution of x_2, except through its support. Thus, if x_1 and x_2 were correlated and the first bargaining game revealed x_1, then D could update his distribution over x_2, but this would have no effect on equilibrium play or payoffs as long as the support remains $[\underline{x}, \overline{x}]$; thus, this equilibrium is robust with respect to correlation.

4. Equilibrium Analysis of the Two-Stage Signaling Game When There is an MFN Clause

Analyzing the Signaling Game's Second Stage

Now assume that bargaining proceeds as proposed in Section 2 above with the feature that any settlement between P_1 and D includes an MFN clause for future agreements between D and other plaintiffs; we return to consider whether P_1 and D would agree to include such a clause later in Section 5. Thus, P_2's equilibrium demand, S_2^*, may be influenced by the level of S_1 (assuming settlement in stage 1), as may the rejection probability that D uses when bargaining with P_2. Of course, if P_1 and D went to trial, then the bargaining game between P_2 and D is completely characterized by Proposition 1 above.

Hence, assume that P_1 and D settled at the amount S_1 and that P_2 demands S_2. Let $b_2(S_2; S_1)$ be D's belief about what type of P_2 would make such a demand. If $S_2 \leq S_1$, then D's (second-stage) cost from accepting the demand S_2 is simply S_2; if $S_2 > S_1$, then D's (second-stage) cost from accepting the demand S_2 is $S_2 + S_2 - S_1$. If D rejects the demand, then since it is a dominant strategy for P_2 to proceed to trial, D's anticipated (second-stage) cost is $b_2(S_2; S_1) + k^D$. Thus, if $S_2 \leq S_1$, then D is willing to accept S_2 if $S_2 \leq b_2(S_2; S_1) + k^D$ while if $S_2 > S_1$, then D is willing to accept S_2 if S_2

$\leq (b_2(S_2; S_1) + k^D + S_1)/2$.

As in Section 3 above, P_2 will choose a demand that makes D indifferent between his (second-stage) cost under settlement and his anticipated (second-stage) cost from trial, inducing D to randomize between accepting and rejecting the demand. When $x_2 + k^D \leq S_1$, a revealing equilibrium would involve P_2 making the demand $S_2 = x_2 + k^D$, while if $x_2 + k^D > S_1$, a revealing equilibrium would involve P_2 demanding $S_2 = (x_2 + k^D + S_1)/2$. In each setting, D is then forced to a point of indifference between accepting the demand or going to trial.

Let $r_2(S_2; S_1)$ be D's probability of rejecting P_2's demand, which means that P_2's expected payoff is $\pi_2^P(S_2; S_1) = (1 - r_2(S_2; S_1))S_2 + r_2(S_2; S_1)(x_2 - k^P)$. Let $S_2{*}(x_2; S_1)$ denote the equilibrium revealing settlement demand made by a P_2 of type x_2, when P_1 had previously settled with D at S_1, and let $r_2{*}(S_2; S_1)$ be the equilibrium rejection function for D, when P_2 demands S_2 and P_1 had previously settled with D at S_1. Then $S_2{*}(x_2; S_1)$ has the two-part form described above and $r_2{*}(S_2; S_1)$ should satisfy the following first order condition for all S_1:

$$\text{d)}\quad 1 - r_2{*}(S_2; S_1) - (S_2 - x_2 + k^P)\, r_2{*}'(S_2; S_1) = 0.$$

This condition is parallel to our earlier condition (b). When $x_2 + k^D \leq S_1$ we invert the revealing demand for P_2 and substitute $x_2 = S_2 - k^D$ into (d) to obtain the differential equation:

$$1 - r_2{*}(S_2; S_1) - Kr_2{*}'(S_2; S_1) = 0, \tag{2}$$

which has the same structure as equation (1). Since $S_2 \leq S_1$, the appropriate boundary condition is $r_2{*}(S_2{*}(\underline{x}; S_1); S_1) = 0$, which is parallel to our earlier condition (c). This means that when $S_2 \leq S_1$, $r_2{*}(S_2; S_1) = r_0{*}(S_2)$.

On the other hand, if $x_2 + k^D > S_1$, then we invert the revealing demand for P_2 and substitute $x_2 = 2S_2 - S_1 - k^D$ into (d), yielding the following differential equation, which must again hold for all possible S_1.

$$1 - r_2^*(S_2; S_1) + (S_2 - (S_1 + K))r_2^{*\prime}(S_2; S_1) = 0. \tag{3}$$

Since $r_2^*(S_2; S_1)$ is continuous at $S_2 = S_1$ (see the earlier footnote on continuity of the rejection function), the appropriate boundary condition for this equation is that $r_2^*(S_1; S_1) = r_0^*(S_1)$, which again must hold for all S_1. As indicated earlier, for revelation we will need $r_2^{*\prime}(S_2; S_1) \geq 0$. If $r_2^*(S_2; S_1)$ is less than 1 then from equation (3) we see that $S_2^*(x_2; S_1)$ must be less than $S_1 + K$. When P_2's demand is in this range, then all types settle with positive probability. On the other hand, if $S_2^*(x_2; S_1) \geq S_1 + K$, then (3) can only be solved for a rejection function such that $r_2^*(S_2; S_1) = 1$ and $r_2^{*\prime}(S_2; S_1) = 0$. In this case, demands are being rejected for sure, which means that each type goes to trial and gets their expected damages less k^P.

Thus, there are three parts to the probability of rejection function. When $S_2 \leq S_1$ the MFN constraint is not binding and $r_2^*(S_2; S_1) = r_0^*(S_2)$. When $S_1 \leq S_2 \leq S_1 + K$, then $r_2^*(S_2; S_1) = 1 - \{[S_1 + K - S_2]/K\}\exp\{- (S_1 - \underline{S})/K\}$. Note that this function is increasing and linear in S_2, has a slope equal to the slope of $r_0^*(S_2)$ at $S_2 = S_1$, and equals 1 if $S_2 = S_1 + K$. Finally, if $S_2 > S_1 + K$, then $r_2^*(S_2; S_1) = 1$.

Proposition 2 summarizes this discussion and also provides P_2's equilibrium demands as well as D's beliefs (the proof is in the Appendix).[10]

<u>Proposition 2</u>. Let $\underline{S} = \underline{x} + k^D$ and $\overline{S}_2(S_1) = (\overline{x} + k^D + S_1)/2$. The following strategies $(r_2^*(S_2; S_1), S_2^*(x_2; S_1))$ and beliefs $b_2^*(S_2; S_1)$ provide the unique revealing equilibrium for

[10] The Proposition claims uniqueness. As discussed in the Appendix, there is a trivial multiplicity of revealing equilibrium demands that are rejected with probability one; the ones we emphasize are the lowest such revealing demands, and are the natural extension of the demands that enjoy a positive probability of acceptance.

period 2.

$$\text{(i)}\quad r_2^*(S_2;S_1) = \begin{cases} 1 & S_2 > S_1 + K \\ 1 - \{[S_1 + K - S_2]/K\}\exp\{-(S_1 - \underline{S})/K\} & S_2 \in [S_1, S_1 + K] \\ 1 - \exp\{-(S_2 - \underline{S})/K\} & S_2 \in [\underline{S}, S_1] \\ 0 & S_2 < \underline{S}. \end{cases}$$

$$\text{(ii)}\quad S_2^*(x_2;S_1) = \begin{cases} (x_2 + k^D + S_1)/2 & x_2 \in [S_1 - k^D, \overline{x}] \\ x_2 + k^D & x_2 \in [\underline{x}, S_1 - k^D] \end{cases}$$

$$\text{(iii)}\quad b_2^*(S_2;S_1) = \begin{cases} \overline{x} & S_2 > \overline{S}_2(S_1) \\ 2S_2 - k^D - S_1 & S_2 \in [S_1, \overline{S}_2(S_1)] \\ S_2 - k^D & S_2 \in [\underline{S}, S_1] \\ \underline{x} & S_2 < \underline{S}. \end{cases}$$

Note that if $\overline{S}_2(S_1) \geq S_1 + K$, then types making demands $S_2 \geq S_1 + K$ reveal, but these demands are rejected with probability 1. As is discussed in the proof (see the Appendix), these types would have to cut their demands below what they could get at trial in order to settle with positive probability, which is irrational. If, on the other hand, $\overline{S}_2(S_1) < S_1 + K$, then even $\overline{x}$'s revealing demand is less than $S_1 + K$, so that all types have a positive probability of settling.

These two circumstances are illustrated in Figure 1 below, with the left-hand-panel illustrating $r_2^*(S_2; S_1)$ when $\overline{S}_2(S_1) < S_1 + K$ and the right-hand-panel illustrating $r_2^*(S_2; S_1)$ when $\overline{S}_2(S_1) > S_1 + K$. Note that both panels also illustrate the rejection function D would employ if there were no MFN in use (i.e., $r_0^*(S_2)$).

Figure 2 below illustrates the revealing equilibrium demand function for P_2. There is a kink at S_1; higher demands are the simple average of the non-MFN-constrained demand ($x_2 + k^D$) and the demand made by P_1. This is how P_1's demand constrains P_2's demand if $x_2 + k^D > S_1$. As will be

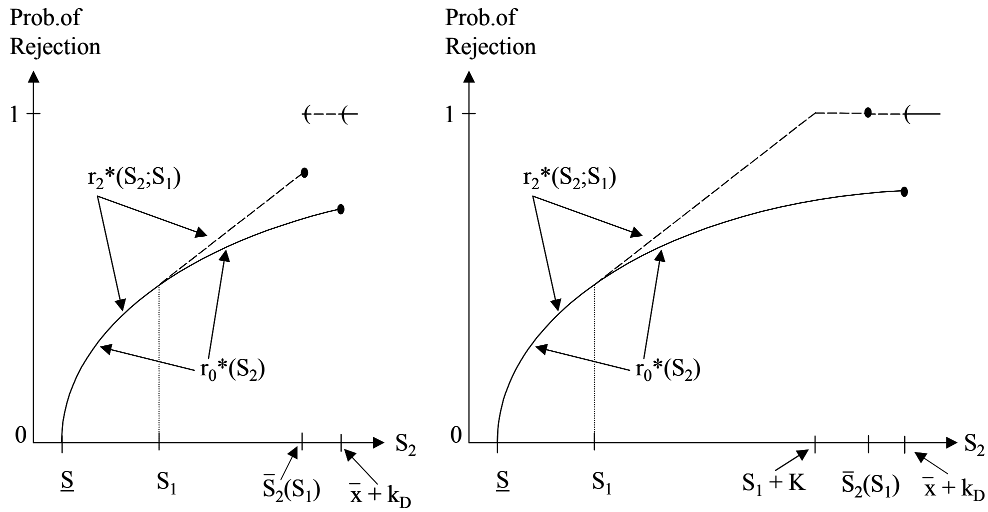

Figure 1: Equilibrium Probability of Rejection

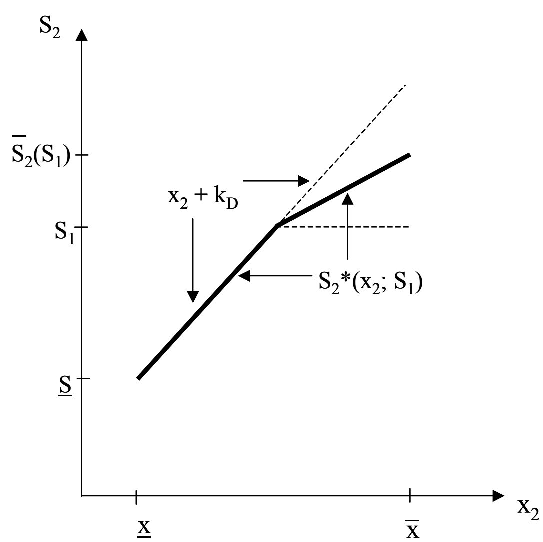

Figure 2: Equilibrium Settlement Demands

demonstrated below, when we discuss the equilibrium for the first stage, the MFN will bind henever $x_1 < x_2$. Note that, if there were no MFN, then there would be no kink at S_1 and demands would follow $x_2 + k^D$. Note further that correlation between x_1 and x_2 (that does not affect the support of x_2) would have no impact here, since the equilibrium strategies for period 2 depend on the distribution only through its support.

Analyzing the Signaling Game's First Stage

First, let us consider D's expected continuation value; that is, given any outcome in stage 1, what D expects his stage-two cost will be. Since, in equilibrium, D is always indifferent between settlement and trial, D's realized continuation value is $x_2 + k^D$ for every x_2. Therefore, D's expected continuation value, ECV^D, is $E(x_2) + k^D$. This is the same expected continuation value for D as if there were no MFN in use, since the second stage in Section 3 also results in D being indifferent between trial and settlement. In other words, D is "fully extracted" with or without an MFN in any agreement reached in the first stage (or, should D go to trial in the first stage). This means that D is willing to accept P_1's demand of S_1 if and only if $S_1 + ECV^D \leq b_1(S_1) + k^D + ECV^D$, that is, if and only if $S_1 \leq b_1(S_1) + k^D$, where $b_1(S_1)$ is D's belief about what type of P_1 would make such a demand.

Let $r_1(S_1)$ be D's probability of rejecting P_1's demand of S_1. Thus, P_1's expected payoff from such a demand, denoted $\pi_1^P(S_1)$, is $\pi_1^P(S_1) = r_1(S_1)(x_1 - k^P) + (1 - r_1(S_1))(S_1 + g(S_1))$, where $g(S_1)$ is the expected payment by D to P_1 under an MFN if D settles with P_2 at an amount $S_2 \geq S_1$. The first term above on the right reflects the possibility that D and P_1 go to trial while the second term on the right reflects the possibility that D and P_1 settle, and that the settlement uses an MFN.

In the revealing equilibrium for stage two described above, settlements by D which might trigger an MFN payment to P_1 are made by types x_2 in the set $T(S_1) \equiv [S_1 - k^D, \min\{\bar{x}, S_1 + K + k^P\}]$. Types below $S_1 - k^D$ demand $S_2 < S_1$, and types above $\min\{\bar{x}, S_1 + K + k^P\}$ go to trial with probability one; in both cases an MFN is not triggered.

This expected MFN payment is denoted above as $g(S_1)$:

$$g(S_1) \equiv \int_{T(S_1)}[(x_2 + k^D - S_1)/2][1 - r_2^*((x_2 + k^D + S_1)/2; S_1)]f(x_2)dx_2.$$

The term in the first pair of brackets is the excess of the equilibrium demand over S_1, $S_2^*(x_2; S_1) - S_1$, for type x_2, while the term in the second pair of square brackets is the equilibrium probability that D will accept the demand $S_2^*(x_2; S_1)$. As is shown in the Appendix: 1) $g(S_1) > 0$ for all $S_1 \in [\underline{S},\overline{S})$, and $g(\overline{S}) = 0$; 2) $1 + g'(S_1) > 0$ for all $S_1 \in [\underline{S},\overline{S}]$; and 3) $g'(S_1) \leq 0.5$ for all $S_1 \in [\underline{S},\overline{S}]$.

We use these properties below. In particular, $1 + g'(S_1) > 0$ means P_1's payoff from settling $(S_1 + g(S_1))$ is increasing in S_1, providing the usual incentives for (essentially) all types of P_1 to be tempted to inflate their demands, making it necessary for D's probability of rejection function to be increasing in S_1. The conditions for a revealing equilibrium are analogous to those in Section 3:

e) $S_1^*(x_1) = x_1 + k^D$;

f) $[1 - r_1^*(S_1) - (S_1 - x_1 + k^P)\, r_1^{*\prime}(S_1)] + [(1 - r_1^*(S_1))g'(S_1) - r_1^{*\prime}(S_1)\, g(S_1)] = 0$;

g) $r_1^*(\underline{S}) = 0$.

Condition (e) reflects that, in a revealing equilibrium, D is indifferent between trial and settlement (and thus randomizes with probability r_1^*), and therefore the revealing equilibrium demand, $S_1^*(x_1)$, is $x_1 + k^D$. Condition (g) provides the boundary requirement that D accepts the lowest possible revealing demand.

We can re-write condition (f) above by collecting terms and substituting $x_1 = S_1 - k^D$ (that is, by requiring that the solution be revealing):

$$(1 - r_1^*(S_1))(1 + g'(S_1)) - r_1^{*\prime}(S_1)(K + g(S_1)) = 0. \tag{4}$$

If $0 \leq r_1^*(S_1) < 1$ for all $S_1 \in [\underline{S},\overline{S}]$, then the previously asserted properties of $g(S_1)$ and $g'(S_1)$ imply that $r_1^{*\prime}(S_1) > 0$ for all $S_1 \in [\underline{S},\overline{S}]$. Solving (4) yields the following probability of rejection function for D (we delay considering specific forms of $g(S_1)$ and their effect on $r_1^*(S_1)$ until the next section):

$$r_1^*(S_1) = 1 - \exp\{-\int_{[\underline{S}, S_1]} (1 + g'(t))/(K + g(t))\,dt\}.$$

The boundedness of $g'(t)$ guarantees that $0 \leq r_1^*(S_1) < 1$, as assumed above; in the Appendix, we show that this probability of rejection function is a best response for D to P_1's revealing equilibrium demand. Our equilibrium is summarized in Proposition 3 below (recall that $\overline{S}$ and $\underline{S}$ were defined in Proposition 1).

Proposition 3. For the first-stage signaling game between P_1 and D, the following strategies $(r_1^*(S_1), S_1^*(x))$ and beliefs $b_1^*(S_1)$ provide the unique revealing equilibrium when an MFN is employed.

$$\text{(i) } r_1^*(S_1) = \begin{cases} 1 & S_1 > \overline{S}, \\ 1 - \exp\{-\int_{[\underline{S}, S_1]} (1 + g'(t))/(K + g(t))\,dt\} & S_1 \in [\underline{S}, \overline{S}], \\ 0 & S_1 < \underline{S}. \end{cases}$$

$$\text{(ii) } S_1^*(x_1) = x_1 + k^D, \qquad x_1 \in [\underline{x}, \overline{x}].$$

$$\text{(iii) } b_1^*(S_1) = \begin{cases} \overline{x} & S_1 > \overline{S}, \\ S - k^D & S_1 \in [\underline{S}, \overline{S}], \\ \underline{x} & S_1 < \underline{S}. \end{cases}$$

The Effect of Correlation on the Analysis

Recall that correlation of the plaintiffs' types has no effect on the continuation game between P_2 and D. Moreover, there will be no effect on P_1's demand in a revealing equilibrium. However, any such correlation can influence the likelihood of settlement, and the expected MFN payment, in the game between P_1 and D. To see this, let $f(x_2| x_1)$ be the density of x_2 conditional on P_1's value of x_1, with $f(x_2| x_1) > 0$ for all $(x_1, x_2) \in [\underline{x}, \overline{x}]^2$. Now the expected MFN payment is $g(S_1; x_1)$:

$$g(S_1; x_1) \equiv \int_{T(S_1)} [(x_2 + k^D - S_1)/2][1 - r_2^*((x_2 + k^D + S_1)/2; S_1)] f(x_2| x_1)\,dx_2.$$

It is straightforward to show that this function shares the properties of the former function $g(S_1)$, now for each $x_1 \in [\underline{x}, \overline{x}]$. Re-tracing the preceding analysis would lead to a modified form for $r_1^*(S_1)$:

$$r_1^*(S_1) = 1 - \exp\{-\int_{[\underline{S},\, S_1]} (1 + g'(t; t - k^D))/(K + g(t; t - k^D))\, dt\},$$

where $g'(t; t - k^D)$ is the derivative of $g(t; t - k^D)$ with respect to its first argument. We return to the effect of correlation on the probability of settlement in the next section.

5. Payoffs and Welfare Considerations

Let a "^" on a function be the reduced-form (i.e., equilibrium type-specific) version of the strategies and payoffs specified earlier. Thus, for example, $\hat{r}_0(x_1) \equiv r_0^*(S_0^*(x_1))$, $\hat{r}_1(x_1) \equiv r_1^*(S_1^*(x_1))$, and $\hat{g}(x_1) \equiv g(S_1^*(x_1))$. Further, let $\hat{\pi}_0^P(x_i) \equiv \pi_0^P(S_0^*(x_1))$ denote the equilibrium type-specific (reduced-form) payoff for plaintiff i when no MFN is employed and let $\hat{\pi}_1^P(x_1)$ be P_1's reduced-form expected payoff under an MFN:

$$\hat{\pi}_1^P(x_1) = (1 - \hat{r}_1(x_1))(S_1^*(x_1) + \hat{g}(x_1)) + \hat{r}_1(x_1)(x_1 - k^P),$$

while

$$\hat{\pi}_0^P(x_1) = (1 - \hat{r}_0(x_1))S_0^*(x_1) + \hat{r}_0(x_1)(x_1 - k^P).$$

Since $S_0^*(x_1) = S_1^*(x_1) = x_1 + k^D$, a P_1 of type x_1 prefers to include an MFN clause in the settlement (about which inclusion D is indifferent) if and only if:

$$\hat{g}(x_1) \geq K(\hat{r}_1(x_1) - \hat{r}_0(x_1))/(1 - \hat{r}_1(x_1)). \tag{5}$$

A sufficient condition that guarantees this is true for all types of P_1 is that:

$$\hat{r}_1(x_1) < \hat{r}_0(x_1) \text{ for all } x_1 \in (\underline{x},\overline{x}], \tag{6}$$

with equality necessary at $x_1 = \underline{x}$ (since under both rejection functions, a demand of $\underline{x} + k^D$ is accepted with certainty). Thus all distributions f(•) such that inequality (6) holds guarantee that inequality (5) holds and therefore guarantee that all types of P_1 will employ an MFN in the settlement demand, thereby inducing the equilibrium specified by Proposition 2 in Section 4 above.

Note that if inequality (6) holds, it is immediate that P_1's payoff is higher for two reasons. First, $g(S_1)$ is non-negative, so this adds to P_1's payoff. Second, P_1 makes the same demands with or without an MFN, and D is more likely to accept these demands with an MFN: the anticipated rebate means that lower types of P_1 are less tempted to mimic higher types and risk trial, so D does not need to reject them at as high a rate (as would be required in the non-MFN case) in order to maintain revelation.

While a complete characterization of when $\hat{r}_1(x_1) < \hat{r}_0(x_1)$ for all $x_1 \in (\underline{x},\overline{x}]$ is not possible, the following proposition provides several sufficient conditions on $F(\bullet)$ for this to hold (see the Technical Appendix for the proof).

<u>Proposition 4</u>. $\hat{r}_1(x_1) < \hat{r}_0(x_1)$ for all $x_1 \in (\underline{x},\overline{x}]$ when:

i) $F(\bullet)$ is the uniform distribution (i.e., $f(x) = 1/(\overline{x} - \underline{x})$);

ii) $F(\bullet)$ is the exponential distribution (i.e., $f(x) = \lambda\exp\{-\lambda(x - \underline{x})\}$, where $\overline{x}$ is now infinite);

iii) $F(\bullet)$ arbitrary, but with bounded support $[\underline{x}, \overline{x}]$, where $\overline{x} - \underline{x} \leq (1 + 5^{1/2})K/2$.

Thus, for example, for distributions sufficiently close to the uniform (but possibly with $f'(\bullet)$ positive, negative, or varying in sign), P_1 always prefers an MFN. Alternatively, for distributions sufficiently close to the exponential, again, P_1 always prefers an MFN. The third sufficient condition allows for arbitrary (bounded-support) distributions as long as the support is not too big; in particular, a sufficient condition is that the difference between the maximum and minimum possible expected damages is less than (approximately) 1.6K.

On the other hand, P_2 is never helped (and is sometimes harmed) by the presence of an MFN in the settlement between P_1 and D, independent of the distribution of damages. The impact of an

MFN on P_2's equilibrium payoff is summarized in the following proposition, which is proved in the Appendix.

Proposition 5. P_2's type-specific equilibrium payoff, $\hat{\pi}_2^P(x_2; x_1)$:

iv) $= \hat{\pi}_0^P(x_2)$ when $x_2 \in [\underline{x}, x_1]$;

v) $< \hat{\pi}_0^P(x_2)$ when $x_2 \in [x_1, \min\{\bar{x}, x_1 + 2K\}]$;

vi) $< \hat{\pi}_0^P(x_2)$ when $x_2 \in (\min\{\bar{x}, x_1 + 2K\}, \bar{x}]$ (if non-empty).

Therefore, there will be no general agreement among P_1, P_2 and D as to whether an MFN is preferred: the adoption of an MFN clause is not Pareto-superior for all types of litigants. Moreover, this also means that the expected payoff to P_2 under an MFN (that is, taking the expectation of $\hat{\pi}_2^P(x_2; x_1)$ with respect to x_2) is strictly lower than the expected payoff to P_2 without the MFN.

However, if we consider an alternative measure of welfare, expected trial costs, it is surprising that an MFN can actually reduce expected trial costs for the second period. Proposition 6, which is proved in the Technical Appendix, provides sufficient conditions on $F(\bullet)$ for the expected trial costs generated by P_2 and D to be strictly lower (whenever $x_1 < \bar{x}$; when $x_1 = \bar{x}$ the expected trial costs are the same) if there is an MFN in a settlement between P_1 and D than if there were no MFN.

Proposition 6. Given a first-stage settlement with type $x_1 < \bar{x}$, if $F(\bullet)$ satisfies any of the following conditions, then the second-stage expected trial costs under an MFN, $K\int \hat{r}_2(x_2;x_1)f(x_2)dx_2$, are strictly less than the second-stage expected trial costs without an MFN, $K\int \hat{r}_0(x_2)f(x_2)dx_2$, where both integrals are over $x_2 \in [\underline{x}, \bar{x}]$.

i) $F(\bullet)$ is the uniform distribution (i.e., $f(x) = 1/(\bar{x} - \underline{x})$);

ii) $F(\bullet)$ is the exponential distribution (i.e., $f(x) = \lambda\exp\{-\lambda(x - \underline{x})\}$, where $\bar{x}$ is now infinite);

iii) $F(\bullet)$ arbitrary, but with bounded support $[\underline{x}, \overline{x}]$, where $\overline{x} - \underline{x} \leq \alpha K$, where α solves the equation: $\exp(-\alpha) + \alpha/2 = 1$.

Thus, for an open set of distributions sufficiently close to the uniform, expected trial costs for P_2 and D are lowered when an MFN is employed. This is also true for an open set of distributions sufficiently close to the exponential. The third condition provides a slightly smaller bound on the support of arbitrary $F(\bullet)$ than specified in Proposition 4 (though it is still, approximately, 1.6K).

This is possible because an MFN creates both a direct and an indirect (equilibrium) effect on the likelihood that a later plaintiff type's demand is rejected. When an MFN results in a higher probability of rejection for a given demand made by a later plaintiff (the direct effect), it also moderates the demand that later plaintiff types make (the indirect, or equilibrium, effect). It is the composition of these two effects that determines whether a later plaintiff type's demand is more or less likely to be rejected under an MFN. For some later plaintiff types, these more moderate demands are rejected less often, but for sufficiently high types these more moderate demands are rejected more often. Under any of the conditions of Proposition 6 the expected probability of trial in the later suit declines. We also know that, under essentially the same conditions (see Proposition 4) P_1's expected trial costs are also strictly lower with an MFN; thus, total expected trial costs (for all litigants) are lower when an MFN is used.

What has happened here? Without an MFN incomplete information results in an inefficiency wherein trials sometimes occur. In both suits, D is fully extracted, so any gains for P_1 must come out of any reduction in expected trial costs and any reduction in P_2's take from bargaining. The presence of an MFN makes P_2 moderate her demand if $x_2 > x_1$; this moderation means that low types of P_2 (those such that $x_2 \leq x_1$) are unaffected but high types ($x_2 > x_1$) are worse off. P_1 further benefits "twice" from the MFN. First, there is the direct payment, $g(S_1{}^*(x_1))$, which occurs with positive probability. Second, the presence of this extra source of income for P_1 also improves her credibility, thereby further reducing the need for D to reject P_1's demand in order to deter mimicry by low types of P_1. Since P_2 is never better off with an MFN and, under conditions discussed above, her expected trial costs are reduced, the fact that D is fully extracted with or without an MFN means that there is a positive expected transfer from P_2 to P_1 when an MFN has been employed.[11] Thus, the inclusion of an MFN provision in the agreement between P_1 and D potentially allows P_1 to exploit future agreements that D will enter into with similarly situated (i.e., associated with the same distribution of damages) plaintiffs.

Endogenous Timing for P_1 and P_2

The preceding analysis raises a modeling issue: should we expect to see sequential play? As argued in Section 2, in many cases harms will naturally arise at different points in time, and these suits are likely to be filed, and settlement negotiated, sequentially. In other cases, the timing of actions by plaintiffs may be endogenous. Although a complete model of endogenous timing is beyond the scope of this paper, some observations are in order. First, the two plaintiffs might sequence themselves as a consequence of cooperation. They are, on average, better off by engaging

[11] Aghion and Bolton (1987) show that an incumbent seller can use stipulated damages in a contract with a buyer to extract rent from an entering seller, thereby deterring some efficient entry. Generally, their optimal contract requires stipulated damages to exceed actual harm due to a breach. In American courts, stipulated damages in excess of actual harm are called a "penalty" and are generally not enforced (Rea, 1998, and Cooter and Ulen, 2000). The Aghion and Bolton argument suggests one reason why courts should not enforce such penalties. MFNs, on the other hand, are now generally enforced (or their non-enforcement is because subsequent litigants are viewed by the Court as bargaining under substantially dissimilar circumstances).

in sequential settlement negotiations and employing an MFN. If they could commit, *ex ante* of learning their expected damages, to a mechanism that randomizes the order of bargaining, they would do so. One such mechanism might be provided by their lawyers, who are repeat players and can expect to achieve (a share of) the long-run average payoff.

Second, the two plaintiffs might sequence themselves as a consequence of noncooperative behavior.[12] In the examples discussed earlier wherein delay-reduction appears to be a plausible motivation for the use of MFNs, the primary settlement issue is damages. For instance, in the MP3.com case a finding of liability was predictable and in the vitamins antitrust case there had been a government suit establishing liability. Thus, there was little uncertainty about whether the defendants would be paying the plaintiffs, just uncertainty about how much. On the other hand, some of the cases which we believe are more representative of the leverage motivation for MFNs have involved suits based on more innovative and potentially speculative legal theories. For instance, the tobacco case relied on the (still untested by the courts) theory that a state has a legal claim for restitution. The airlines case (for which no government suit was ever brought, and about which the Court expressed extreme skepticism[13]) relied on the theory that the airlines engaged in price-fixing through the common use of software to publish fares and schedules. In a situation involving a novel legal theory, one might well envision the non-repeat players having different beliefs (perhaps based on the receipt of different legal advice drawn from a common prior) about whether the defendant is likely to be found liable. In such situations a non-repeat player whose information strongly

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[12] There is a sizable literature on endogenous sequencing of firms in imperfectly competitive markets (see, for example, Daughety and Reinganum, 1994, and the references cited therein).

[13] See, *In re: Domestic Air Transportation Antitrust Litigation*, 148 F.R.D.297, p. 315.

indicates that the defendant will be found liable might move to sue and settle early (and, expecting others to follow her lead, to include an MFN), while one whose information indicates the defendant is unlikely to be found liable would prefer to wait and gather more information by observing the behavior and outcomes of the other non-repeat players. Thus, litigants could plausibly move in sequence even if the timing were endogenous.

The Effect of Correlation on the Probability of Settlement

Finally, we speculate on the impact of correlation of P_1 and P_2's expected damages on $\hat{r}_1(x_1)$, under the condition that $\hat{r}_1(x_1) < \hat{r}_0(x_1)$. Speculation is necessary here because of the complex dependence of D's rejection function (through the differential equation) on the expected MFN payment function.

If the types were positively correlated then, while an MFN will be binding if $x_1 < x_2$, intuitively, P_1 should expect a lower MFN payment than in the independent draws case, as the two draws in the positively-correlated case are more likely to be closer to one another. This should result in D's rejection function being somewhat higher for all types than in the independent-draws case, but still below D's rejection function for the no-MFN case.

If the types were negatively correlated, two cases arise. Should x_1 be relatively high (e.g., with respect to the mean expected damages), then negative correlation suggests a draw for P_2 that is likely to be lower; thus, the MFN would not be likely to bind and there would be a lower expected MFN payment. On the other hand, should x_1 be low, then negative correlation suggests a draw for P_2 that is likely to be higher, at least in comparison with the independent-draws case. Thus, low draws for P_1 are likely to imply high expected MFN payments, enhancing the incentive for P_1 to reveal her type and therefore allowing D to reject demands for such types less frequently. Thus, we would speculate that the resulting rejection function is likely to be below the independent-draws MFN rejection function when P_1's type is low, and above it when P_1's type is high, but still below the no-MFN rejection function.

6. Discussion and Conclusions

It is worth summarizing how these results compare with those of Spier (2002, 2003), and how these models, taken together, may inform judicial decision-making with respect to MFN clauses. Rather than thinking of these two analyses as competing models of the same cases, we view real-world bargaining as likely to have attributes of one, or the other, or both approaches.

There are several dimensions along which direct comparisons are possible. Since these models endow bargaining power to different agents, they differ with respect to who gains from an MFN. The defendant in Spier's screening model (who makes the offer) always gains, while the defendant in our signaling model (who responds to the plaintiffs' demands) is always fully-extracted and thus neither gains nor loses. In the screening model, plaintiffs are always affected similarly; their welfare is increased (decreased, unchanged) by an MFN when the density function is increasing (decreasing, constant). Thus, in Spier's screening analysis, if expected damages are uniformly-distributed, then the defendant gains and the plaintiffs are no worse off; an MFN can provide a Pareto improvement. On the other hand, if expected damages are exponentially-distributed, then the defendant gains at the plaintiffs' expense. In our signaling model, under either the uniform or the exponential distribution, the early plaintiff gains at the later plaintiff's expense: an MFN does not provide a Pareto improvement.

Spier finds that the frequency of settlement is increased (decreased, unchanged) by an MFN when the density function is increasing (decreasing, constant). Thus, the settlement rate is unchanged by an MFN if expected damages are uniformly-distributed, and it is decreased by an MFN if expected damages are exponentially-distributed. By contrast, we find that the settlement rate is increased by an MFN in both of these cases; indeed, it is increased independent of the form of the damages distribution as long as its support is sufficiently small.

Despite these differences in the prediction about an MFN's impact on the settlement rate, both papers find that expected litigation costs are reduced under an MFN if the expected damages distribution is either uniform or exponential. This is because an MFN shifts all settlement to the first period in Spier's model, thus saving delay costs. In our model, an MFN reduces the expected trial costs in both the early and later suits; moreover, every type of early plaintiff would prefer to include an MFN in her settlement offer to the defendant. Thus, an MFN can be implemented by an early plaintiff in order to exploit a future settlement between the defendant and a later plaintiff. Despite this essentially redistributive motive, this use of an MFN can reduce the expected social costs associated with trials.

The signaling analysis shows that an MFN can reduce the expected trial costs in the second suit because of its moderating effect on demands made by P_2 that exceed P_1's demand. With respect to an early plaintiff, the prospect of a future rebate if the MFN is triggered makes this plaintiff less willing to risk trial by inflating her demand, thus providing increased incentives for revelation. As a consequence, any given demand by this plaintiff can be rejected with a lower probability.

Interestingly, both leverage and delay-reduction motivations for MFN can coexist in the same sequence of related cases; for instance, the tobacco cases have both elements. The early settlements, involving Mississippi, Florida, and Texas, seem designed (by the settling states) to exploit possible future settlements. Here the MFNs were triggered and each of these states did quite well, thanks to Minnesota's settlement. Mississippi received a payment of $550 million on top of their original settlement of $3.6 billion; Florida received a payment $1.8 billion on top of their original settlement of $11.3 billion; and Texas received a payment $2.3 billion on top of their original settlement of $15.3 billion (see Spier, 2003, and Viscusi, 2002, p. 37). On the other hand, the Master Settlement Agreement (covering the remaining forty-six states) also includes an MFN, presumably to keep all the remaining states in that agreement, thereby eliminating further delay. Thus, MFN clauses were used both to exploit future agreements and to bring about closure.

What guidance can these models provide for a judge who must decide whether to permit and/or enforce an MFN? If a judge's primary concern is with reducing expected trial costs, then both of these models suggest that MFNs are likely (though not guaranteed) to improve things, and it may not be important to determine whether the circumstances of the case are more consistent with one type of model or the other. On the other hand, if equity is an important consideration, then a judge should be especially skeptical of the proposed MFN if bargaining seems likely to be sequential and the (early) plaintiff has substantial bargaining power. This judicial choice also seems to turn on the issue of bilateral versus multilateral agreements in contexts where there are likely to be multiple litigants. A judge who is certifying a bilateral settlement in circumstances wherein there is likely to be further litigation by other parties needs to be convinced that overall social costs would be sufficiently reduced by the use of an MFN to compensate for likely distributional inequities. Alternatively, when all parties seem to be present, judges should expect that the question of enforcing an MFN lies more with the benefits of inducing quick settlement. Perhaps there really is safety in numbers.

Appendix

This Appendix contains the proofs of Propositions 2, 3, 5 and auxiliary results. The proofs of Propositions 2 and 3 verify that the strategies and beliefs provided in the text constitute a revealing equilibrium in their respective contexts. The proofs of uniqueness can be constructed as in Reinganum and Wilde (1986), and are omitted. The proofs of Propositions 1, 4 and 6 are in a Technical Appendix.

Proof of Proposition 2. To verify that these strategies and beliefs provide a revealing equilibrium, we demonstrate that (2.A) $r_2^*(S_2; S_1)$ is an optimal strategy for D, given the beliefs $b_2^*(S_2; S_1)$; (2.B) $S_2^*(x_2; S_1)$ is an optimal strategy for P_2, given $r_2^*(S_2; S_1)$; and (2.C) the beliefs are correct: $b_2^*(S_2^*(x_2; S_1); S_1) = x_2$ for $x_2 \in [\underline{x}, \overline{x}]$.

Proof of (2.A). Recall that if D settles with P_2 at $S_2 > S_1$, then D pays S_2 to P_2 and the amount $S_2 - S_1$ to P_1, while if D settles with P_2 at $S_2 \leq S_1$, then D simply pays S_2 toP_2. Given the beliefs $b_2^*(S_2; S_1)$, upon observing a demand $S_2 \in [\underline{S}, S_1]$, D expects to pay $b_2^*(S_2; S_1) + k^D = S_2 - k^D + k^D = S_2$ if he rejects the demand S_2 and D expects to pay S_2 if he accepts the demand S_2, so he is indifferent. Hence he is willing to randomize as specified by $r_2^*(S_2; S_1)$. Upon observing a demand $S_2 \in [S_1, \overline{S}_2(S_1)]$, D expects to pay $b_2^*(S_2; S_1) + k^D = 2S_2 - k^D - S_1 + k^D = 2S_2 - S_1$ if he rejects the demand S_2 and D expects to pay $2S_2 - S_1$ if he accepts the demand S_2 (since he settles with P_2 at S_2 and rebates the difference $S_2 - S_1$ to P_1). Thus, D is indifferent, and hence is willing to randomize as specified by $r_2^*(S_2; S_1)$ for $S_2 \in [S_1, S_1 + K]$, and is willing to reject for $S_2 \geq S_1 + K$. A demand $S_2 > \overline{S}_2(S_1)$ is believed to have come from type $\overline{x}$ so it is optimal for D to reject it (and pay $\overline{x} + k^D$ at trial) rather than to accept it (and pay $2S_2 - S_1 > 2\overline{S}_2(S_1) - S_1 = \overline{x} + k^D$ in settlement). Finally, a demand $S_2 < \underline{S}$ is believed to have come from type $\underline{x}$ so it is optimal for D to accept it (and pay $S_2 < \underline{S} = \underline{x} + k^D$ in settlement) rather than to reject it (and pay $\underline{x} + k^D$ at trial).

Proof of (2.B). Given the strategy $r_2^*(S_2; S_1)$, a P_2 of type x_2 demanding S_2 anticipates a payoff of $\pi_2^P(S_2; S_1) = r_2^*(S_2; S_1)(x_2 - k^P) + (1 - r_2^*(S_2; S_1))S_2$. This payoff function is everywhere continuous in S_2, though there are some points of non-differentiability where the function r_2^* makes transitions. First note that any strategy $S_2 < \underline{S}$ is dominated by $S_2 = \underline{S}$ since both are accepted for sure. Moreover, any strategy $S_2 > \overline{S}_2(S_1)$ is (at least weakly) dominated by $S_2 = \overline{S}_2(S_1)$ since the former generates a payoff of $x_2 - k^P$ for sure, while the latter generates either $x_2 - k^P$ for sure (if $\overline{S}_2(S_1) \geq S_1 + K$) or a convex combination of $x_2 - k^P$ and $\overline{S}_2(S_1)$ (if $\overline{S}_2(S_1) < S_1 + K$, in which case $\overline{S}_2(S_1) > x_2 - k^P$). Thus, the optimal demand must belong to $[\underline{S}, \overline{S}_2(S_1)]$.

In order to determine P_2's optimal demand, we must find the best demand on each of the branches of P_2's payoff (corresponding to the three branches of $r_2^*(S_2; S_1)$) and choose between them. Notice that $r_2^*(S_2; S_1) = r_0^*(S_2)$ for $S_2 \leq S_1$. Thus, type x_2's best demand in $[\underline{S}, S_1]$ is given by $S_2^* = x_2 + k_D$, provided this does not exceed S_1; otherwise type x_2's best demand in $[\underline{S}, S_1]$ is given by $S_2^* = S_1$. Similarly, type x_2's best (interior) demand in $[S_1, S_1 + K]$ satisfies the first-order condition $\{[S_1 + K - S_2]/K\}\exp\{-(S_1 - \underline{S})/K\} - \{[S_2 - x_2 + k^P]/K\}\exp\{-(S_1 - \underline{S})/K\} = 0$, which has the unique solution $S_2^* = (x_2 + k^D + S_1)/2$. To see that this is a maximum, note that the second-order condition for a maximum is $\{-2/K\}\exp\{-(S_1 - \underline{S})/K\} \leq 0$, which is clearly satisfied. Thus, $S_2^* = (x + k^D + S_1)/2$ is type x_2's best demand in $[S_1, S_1 + K]$ provided it is at least S_1 and does not exceed $S_1 + K$; otherwise type x_2's best demand in $[S_1, S_1 + K]$ is either $S_2^* = S_1$ or $S_2^* = S_1 + K$. Type x_2 is indifferent among all demands that exceed $S_1 + K$, as they are all rejected with certainty; thus, if type x_2's best demand in $[S_1, S_1 + K]$ is $S_1 + K$, then this type is actually indifferent among all demands that will be rejected with certainty.

Consider P_2 types with $x_2 \in [\underline{x}, S_1 - k^D]$. Type x_2's best demand in $[\underline{S}, S_1]$ is $S_2^* = x_2 + k_D$, while type x_2's best demand in $[S_1, S_1 + K]$ is S_1 since (i) the aforementioned "interior" solution is not interior to the interval; that is, $S_2^* = (x_2 + k^D + S_1)/2 \leq S_1$, and (ii) the payoff associated with $S_2 = S_1 + K$ is $x_2 - k^P$, while that associated with $S_2 = S_1$ is $S_1[\exp\{-(S_1 - \underline{S})/K\}] + [1 - \exp\{-(S_1 - \underline{S})/K](x_2 - k^P) > x_2 - k^P$ for $x_2 \in [\underline{x}, S_1 - k^D]$. Thus, $S_2^*(x_2; S_1) = x_2 + k^D$ for $x_2 \in [\underline{x}, S_1 - k^D]$. Now consider P_2 types with $x_2 \in [S_1 - k^D, \overline{x}]$. Type x_2's best demand in $[\underline{S}, S_1]$ is $S_2^* = S_1$ since the "interior" solution is not interior to the interval (that is, $S_2^* = x_2 + k_D \geq S_1$), while type x_2's best demand in $[S_1, S_1 + K]$ is $S_2^* = \min\{(x_2 + k^D + S_1)/2, S_1 + K\}$. Since P_2's payoff is continuous, it follows that $S_2^*(x_2; S_1) = \min\{(x_2 + k^D + S_1)/2, S_1 + K\}$ for $x_2 \in [S_1 - k^D, \overline{x}]$. Let $\tilde{x}_2(S_1) \equiv S_1 + K + k^P$. This is the P_2-type who is just indifferent between settling at the demand $S_2 = (x_2 + k^D + S_1)/2$ versus demanding $S_1 + K$ and going to trial (and receiving $x_2 - k^P$). Thus, type x_2's optimal demand is uniquely defined by $S_2^*(x_2; S_1) = (x_2 + k^D + S_1)/2$ for $x_2 \in [S_1 - k^D, \tilde{x}_2(S_1)]$, and those types $x_2 \in (\tilde{x}_2(S_1), \overline{x}]$ are indifferent among all demands that exceed $S_1 + K$. Thus, those types $x_2 \in (\tilde{x}_2(S_1), \overline{x}]$ are willing to demand according to the function $S_2^*(x_2; S_1) = (x_2 + k^D + S_1)/2$, even though this demand will result in rejection for sure (the nearest demand with a positive probability of acceptance is $S_1 + K - \epsilon$, but this is worse than trial for $x_2 \in (\tilde{x}_2(S_1), \overline{x}]$).

Proof of (2.C). For $x_2 \in [\underline{x}, S_1 - k^D]$, substitution yields $b_2^*(S_2^*(x_2; S_1)) = S_2^*(x_2; S_1) - k^D = x_2 + k^D - k^D = x_2$. Similarly, for $x_2 \in [S_1 - k^D, \overline{x}]$, substitution yields $b_2^*(S_2^*(x_2; S_1)) = 2S_2^*(x_2; S_1) - k^D - S_1 = 2(x_2 + k^D + S_1)/2 - k^D - S_1 = x_2$.

We say this equilibrium is "essentially" unique because types $x_2 \in (\tilde{x}_2(S_1), \overline{x}]$ are indifferent among demands that are rejected and hence could be assigned to a different revealing (i.e., monotonic) demand function that involves demands that are rejected. QED

Proof of claims regarding the function $g(S_1)$.
Recall that $T(S_1) \equiv [S_1 - k^D, \min\{\overline{x}, S_1 + K + k^P\}]$. This interval is non-degenerate as long as $S_1 < \overline{S} = \overline{x} + k^D$, while $T(\overline{S}) = [\overline{x}, \overline{x}]$.

(1) To see that $g(S_1) > 0$ for all $S_1 \in [\underline{S}, \overline{S})$ and $g(\overline{S}) = 0$, simply note that the integrand is a positive number for all $x_2 \in \mathrm{int}T(S_1)$. Since this interior is non-empty for $S_1 \in [\underline{S}, \overline{S})$ (and empty for $S_1 = \overline{S}$), the claimed results follow.

(2) To see that $1 + g'(S_1) > 0$ for all $S_1 \in [\underline{S}, \overline{S}]$, let $h(S_1; x_2) \equiv (x_2 + k^D - S_1)(S_1 + K + k^P - x_2)/4K$, and write $g(S_1) \equiv \int h(S_1; x_2)\exp\{-(S_1 - \underline{S})/K\}f(x_2)dx_2$, where the integral is taken over $x_2 \in T(S_1)$. The payment to P_1 if settlement occurs at S_1 is $S_1 + g(S_1)$, with derivative equal to $1 + g'(S_1)$.

$$g'(S_1) = \int[\partial h(S_1; x_2)/\partial S_1 - h(S_1; x_2)/K]\exp\{-(S_1 - \underline{S})/K\}f(x_2)dx_2,$$

where the integral is taken over $x_2 \in T(S_1)$. The difference $\partial h(S_1; x_2)/\partial S_1) - h(S_1; x_2)/K = (x_2 + k^D - S_1 - K)/2K - (x_2 + k^D - S_1)(S_1 + K + k^P - x_2)/4K^2$, which can be simplified to $[(x_2 + k^D - S_1)/2K]^2 - .5$. Thus,

$$1 + g'(S_1) = 1 + \int\{[(x_2 + k^D - S_1)/2K]^2 - .5\}\exp\{-(S_1 - \underline{S})/K\}f(x_2)dx_2$$

$$= 1 - .5F(T(S_1))\exp\{-(S_1 - \underline{S})/K\} + \int[(x_2 + k^D - S_1)/2K]^2\exp\{-(S_1 - \underline{S})/K\}f(x_2)dx_2,$$

where $F(T(S_1))$ is the measure of the set $T(S_1)$. Since .5 is strictly less than 1 and $F(T(S_1))$ and $\exp\{-(S_1 - \underline{S})/K\}$ are less than or equal to 1, the product of these three numbers is less than one. The remaining (integral) term is clearly non-negative. Thus $1 + g'(S_1) > 0$ for all $S_1 \in [\underline{S}, \overline{S}]$.

(3) To see that $g'(S_1) \leq 0.5$ for all $S_1 \in [\underline{S}, \overline{S}]$, note that $\{[(x_2 + k^D - S_1)/2K]^2 - .5\}\exp\{-(S_1 - \underline{S})/K\} \leq 0.5$ for all $x_2 \in T(S_1)$ and for all $S_1 \in [\underline{S}, \overline{S}]$. Then $g'(S_1) \leq (0.5)F(T(S_1)) \leq 0.5$. QED

Proof of Proposition 3. To verify that these strategies and beliefs provide a revealing equilibrium, we demonstrate that (3.A) $r_1^*(S_1)$ is an optimal strategy for D, given the beliefs $b_1^*(S_1)$; (3.B) $S_1^*(x_1)$ is an optimal strategy for P_1, given $r_1^*(S_1)$; and (3.C) the beliefs are correct: $b_1^*(S_1^*(x_1)) = x_1$ for $x_1 \in [\underline{x}, \overline{x}]$.

Proof of (3.A). Given the beliefs $b_1^*(S_1)$, upon observing the demand $S_1 \in [\underline{S}, \overline{S}]$, D expects to pay $b_1^*(S_1) + k^D + ECV^D = S_1 + ECV^D$ if he rejects the demand S_1 and D expects to pay $S_1 + ECV^D$ if he accepts the demand S_1, so he is indifferent. Hence he is willing to randomize as specified by $r_1^*(S_1)$. A demand $S_1 > \overline{S}$ is believed to have come from type $\overline{x}$ so it is optimal for D to reject it (and expect to pay $\overline{x} + k^D$ at trial + ECV^D) rather than to accept it (and pay $S_1 > \overline{S} = \overline{x} + k^D + ECV^D$ in settlement). Finally, a demand $S_1 < \underline{S}$ is believed to have come from type $\underline{x}$ so it is optimal for D to accept it (and pay $S_1 + ECV^D < \underline{S} + ECV^D = \underline{x} + k^D + ECV^D$ in settlement) rather than to reject it (and pay $\underline{x} + k^D$ at trial plus ECV^D).

Proof of (3.B). Given the strategy $r_1^*(S_1)$, a P_1 of type x_1 demanding S_1 anticipates a payoff of $\pi_1^P(S_1) = r_1^*(S_1)(x_1 - k^P) + (1 - r_1^*(S_1))(S_1 + g(S_1))$. Since $d(S_1 + g(S_1))/dS_1 = 1 + g'(S_1) > 0$, higher demands yield higher overall payments if accepted. Thus, any strategy $S_1 < \underline{S}$ is dominated by $S_1 = \underline{S}$ since both are accepted for sure. Moreover, any strategy $S_1 > \overline{S}$ is dominated by $S_1 = \overline{S}$ since the former generates a payoff of $x - k^P$ for sure, while the latter generates a convex combination of $x - k^P$ and $\overline{S} + g(\overline{S}) > x - k^P$. Thus, the optimal demand must belong to $[\underline{S}, \overline{S}]$. Maximizing the expression $r_1^*(S_1)(x_1 - k^P) + (1 - r_1^*(S_1))(S_1 + g(S_1))$ with respect to S_1 yields the first-order condition:

$$-(S_1 + g(S_1) - x_1 + k^P)[(1 + g'(S_1))/(K + g(S_1)]\exp\{-\int_{[\underline{S}, S_1]}(1 + g'(t))/(K + g(t))\,dt\}$$

$$+ (1 + g'(S_1))\exp\{-\int_{[\underline{S}, S_1]} (1 + g'(t))/(K + g(t))\,dt\} = 0,$$

which has the unique solution $S_1{}^*(x_1) = x_1 + k^D$. To see that this is a local maximum, note that the second-order condition for a maximum is satisfied:

$$- (S_1 + g - x_1 + k^P)r_1{}^{*\prime\prime} - 2r_1{}^{*\prime}(1 + g') + (1 - r_1{}^*)g'' < 0 \text{ at } S_1 = x_1 + k^D.$$

This inequality follows from the facts that:

$$1 - r_1{}^* = \exp\{-\int_{[\underline{S}, S_1]} (1 + g'(t))/(K + g(t))\,dt\},$$

$$r_1{}^{*\prime} = [((1 + g')/(K + g)]\exp\{-\int_{[\underline{S}, S_1]} (1 + g'(t))/(K + g(t))\,dt\},$$

and

$$r_1{}^{*\prime\prime} = \{d[(1 + g')/(K + g)]/dS_1 - [(1 + g')/(K + g)]^2\}\exp\{-\int_{[\underline{S}, S_1]} (1 + g'(t))/(K + g(t))\,dt\}.$$

Plugging these into the second-order condition above, evaluating the resulting expression at $S_1 = x_1 + k^D$, collecting terms and simplifying implies that the second-order condition for a maximum holds at $S_1 = x_1 + k^D$ if and only if $-(1 + g')/(K + g) < 0$, which has been shown to hold.

If another maximum were to exist on the boundary (that is, at $\underline{S}$ or $\overline{S}$), there would have to be a local minimum between it and $S_1{}^*(x_1)$, but no other interior stationary point exists, since $S_1{}^*(x_1)$ is the unique interior solution to the first-order condition. Thus $S_1{}^*(x_1)$ provides the global maximum to P's payoff.

Proof of (3-C). Substitution yields $b_1{}^*(S_1{}^*(x_1)) = S_1{}^*(x_1) - k^D = x_1 + k^D - k^D = x_1$ for $x_1 \in [\underline{x}, \overline{x}]$; thus the beliefs are correct in equilibrium. Moreover, the equilibrium strategies are robust to arbitrary out-of-equilibrium beliefs. QED

Proof of Proposition 5. First note that, for any given x_1, $\hat{\pi}_2^P(x_2; x_1)$ is a continuous function of x_2. (i) When $x_2 \in [\underline{x}, x_1]$, P_2's optimal demand is $S_2{}^*(x_2; S_1{}^*(x_1)) = x_2 + k^D = S_0{}^*(x_2) \leq S_1{}^*(x_1)$, so the MFN does not bind, and $\hat{r}_2(x_2; x_1) = \hat{r}_0(x_2)$. Thus, this part follows immediately by substitution.

(ii) When $x_2 \in (x_1, \min\{\overline{x}, x_1 + 2K\}]$, P_2's optimal demand is constrained by the MFN and $S_2{}^*(x_2; S_1{}^*(x_1)) = (x_2 + x_1 + 2k^D)/2$ and $\hat{r}_2(x_2; x_1) = 1 - \{[x_1 + 2K - x_2]/2K\}\exp\{- (x_1 - \underline{x})/K\}$. After substitution and simplification, $\hat{\pi}_2^P(x_2; x_1) = x_2 - k^P + [(x_1 + 2K - x_2)^2/4K]\exp\{- (x_1 - \underline{x})/K\}$, while $\hat{\pi}_0^P(x_2) = x_2 - k^P + K\exp\{- (x_2 - \underline{x})/K\}$. Let $z \equiv x_1 + 2K - x_2$. For $x_2 \in (x_1, \min\{\overline{x}, x_1 + 2K\}]$, $z \in [0, 2K)$. Then $\hat{\pi}_2^P(x_2; x_1) < \hat{\pi}_0^P(x_2)$ for $x_2 \in (x_1, \min\{\overline{x}, x_1 + 2K\}]$ if and only if $m(z) \equiv (ez/2K)^2 - \exp\{z/k\} < 0$ for all $z \in [0, 2K)$, which can be shown to hold.

(iii) Finally, consider $x_2 \in (\min\{\overline{x}, x_1 + 2K\}, \overline{x}]$. For these values of x_2, P_2 goes to trial for sure since $\hat{r}_2(x_2; x_1) = 1$, and thus $\hat{\pi}_2^P(x_2; x_1) = x_2 - k^P$. On the other hand, $\hat{\pi}_0^P(x_2) = x_2 - k^P + K\exp\{- (x_2 - \underline{x})/K\} > x_2 - k^P$. QED

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Technical Appendix (to be made available by the authors on the web)

This Technical Appendix contains the proofs of Propositions 1, 4 and 6.

Proof of Proposition 1. To verify that these strategies and beliefs provide a revealing equilibrium, we show that (1.A) $r_0^*(S)$ is an optimal strategy for D, given the beliefs $b_0^*(S)$; (1.B) $S_0^*(x)$ is an optimal strategy for P, given $r_0^*(S)$; and (1.C) the beliefs are correct: $b_0^*(S_0^*(x)) = x$ for $x \in [\underline{x}, \overline{x}]$.

Proof of (1.A). Given the beliefs $b_0^*(S)$, upon observing the demand $S \in [\underline{S}, \overline{S}]$, D expects to pay $b_0^*(S) + k^D = S$ if he rejects the demand S and D expects to pay S if he accepts the demand S, so he is indifferent. Hence he is willing to randomize as specified by $r_0^*(S)$. A demand $S > \overline{S}$ is believed to have come from type $\overline{x}$ so it is optimal for D to reject it (and pay $\overline{x} + k^D$ at trial) rather than to accept it (and pay $S > \overline{S} = \overline{x} + k^D$ in settlement). Finally, a demand $S < \underline{S}$ is believed to have come from type $\underline{x}$ so it is optimal for D to accept it (and pay $S < \underline{S} = \underline{x} + k^D$ in settlement) rather than to reject it (and pay $\underline{x} + k^D$ at trial).

Proof of (1.B). Given the strategy $r_0^*(S)$, a P of type x demanding S anticipates a payoff of $\pi^P(S) = r_0^*(S)(x - k^P) + (1 - r_0^*(S))S$. First note that any strategy $S < \underline{S}$ is dominated by $S = \underline{S}$ since both are accepted for sure. Moreover, any strategy $S > \overline{S}$ is dominated by $S = \overline{S}$ since the former generates a payoff of $x - k^P$ for sure, while the latter generates a convex combination of $\overline{S} > x - k^P$ and $x - k^P$. Thus, the optimal demand must belong to $[\underline{S}, \overline{S}]$. Maximizing the expression $r_0^*(S)(x - k^P) + (1 - r_0^*(S))S$ with respect to S yields the first-order condition: $-\{[S - x + k^P]/K\}\exp\{-(S - \underline{S})/K + \exp\{-(S - \underline{S})/K = 0$, which has the unique solution $S_0^*(x) = x + k^D$. To see that this is a local maximum, note that the second-order condition for a maximum is $\{[S - x + k^P - 2K]/K^2\}\exp\{-(S - \underline{S})/K \leq 0$, which is satisfied at $S_0^*(x) = x + k^D$. If another maximum were to exist on the boundary (that is, at $\underline{S}$ or $\overline{S}$), there would have to be a local minimum between it and $S_0^*(x)$, but no other interior stationary point exists, since $S_0^*(x)$ is the unique interior solution to the first-order condition. Thus $S_0^*(x)$ provides the global maximum to P's payoff.

Proof of (1.C). Substitution yields $b_0^*(S_0^*(x)) = S_0^*(x) - k^D = x + k^D - k^D = x$ for $x \in [\underline{x}, \overline{x}]$; thus the beliefs are correct in equilibrium. Moreover, the equilibrium strategies are robust to arbitrary out-of-equilibrium beliefs. QED

Proof of Proposition 4. Recall the definition of $h(S_1; x_2)$, namely that $h(S_1; x_2) \equiv (x_2 + k^D - S_1)(S_1 + K + k^P - x_2)/4K$. In what follows, for the exponential distribution, take $\overline{x}$ to be infinite. From the definitions of $\hat{r}_1(x_1)$ and $\hat{r}_0(x_1)$, it is clear that $\hat{r}_1(\underline{x}) = \hat{r}_0(\underline{x})$, and that $\hat{r}_1(x_1) < \hat{r}_0(x_1)$ for all $x_1 \in (\underline{x}, \overline{x}]$ if and only if

$$\int_{[\underline{x}, x_1]} (1 + g'(S_1^*(x)))/(K + g(S_1^*(x)))dx < \int_{[\underline{x}, x_1]} (1/K)dx \quad \text{for all } x_1 \in (\underline{x}, \overline{x}].$$

If $(1 + g'(S_1^*(x)))/(K + g(S_1^*(x))) < 1/K$ (or, equivalently, $g'(S_1^*(x)) < g(S_1^*(x))/K$) for all $x \in [\underline{x}, \overline{x})$ then the inequality in the displayed equation above holds for all $x_1 \in (\underline{x}, \overline{x}]$.

Since $g'(S_1) = \int[\partial h(S_1; x_2)/\partial S_1 - h(S_1; x_2)/K]\exp\{-(S_1 - \underline{S})/K\}f(x_2)dx_2$, it follows that $g'(S_1^*(x)) < g(S_1^*(x))/K$ if and only if:

$$H(x) \equiv \int[\partial h(S_1^*(x); x_2)/\partial S_1) - 2h(S_1^*(x); x_2)/K]\exp\{-(x - \underline{x})/K\}f(x_2)dx_2 < 0,$$

where the integral is taken over $x_2 \in T(S_1^*(x)) = [x, \min\{\bar{x}, x + 2K\}]$. Note that $T(S_1^*(x))$ is non-degenerate whenever $S_1^*(x) < \bar{x} + k^D$; that is, whenever $x < \bar{x}$.

i) One sufficient condition for $H(x) < 0$ for all $x \in [\underline{x}, \bar{x})$ is that $F(\bullet)$ is the uniform distribution. To see this, substitute $f(x_2) = 1/(\bar{x} - \underline{x})$, integrate and simplify to obtain:

$$H(x) = [\exp\{-(x - \underline{x})/K\}/2K^2(\bar{x} - \underline{x})]Y\{Y^2/3 - YK/2 - K^2\}, \text{ where } Y \equiv \min\{\bar{x} - x, 2K\}.$$

The term in square brackets is positive, as is Y itself, so $H(x) < 0$ so long as $M(Y) \equiv Y^2/3 - YK/2 - K^2 < 0$ for all $Y \in (0, 2K]$, which can be shown.

ii) A sufficient condition for $H(x) < 0$ for all $x \in [\underline{x}, \infty)$ is that $F(\bullet)$ is the exponential distribution. To see this, substitute $f(x_2) = \lambda\exp\{-\lambda(x_2 - \underline{x})\}$, integrate and simplify to obtain:

$$H(x) = -[\exp\{-\lambda(x - \underline{x})\}/2K^2\lambda^2][(\exp\{-2K\lambda\})(K\lambda + 1) + (K\lambda - 1)][K\lambda + 2].$$

The term in each square bracket is positive, for all $K > 0$ and $\lambda > 0$, so $H(x) < 0$ for all $x \in [\underline{x}, \infty)$.

(iii) A sufficient condition for $H(x) < 0$ for all $x \in [\underline{x}, \bar{x})$ when $F(\bullet)$ is arbitrary is that:

$$[\partial h(S_1^*(x); x_2)/\partial S_1) - 2h(S_1^*(x); x_2)/K] < 0 \text{ for all } x_2 \geq x \text{ and for all } x \in [\underline{x}, \bar{x}).$$

This integrand can be shown to be $[(x_2 - x)^2 - K(x_2 - x) - K^2]/2K^2$, which implies the result. QED.

<u>Proof of Proposition 6</u>. We fix a value of x_1 and argue that, if $F(\bullet)$ satisfies (i), (ii) or (iii), then the expected trial costs for the second period are lower under an MFN. Since this will be shown to be true for all values of x_1 (except $x_1 = \bar{x}$, in which case the MFN never binds for any x_2), the expected trial costs for the second period are lower under an MFN.

Recall that $\hat{r}_2(x_2; x_1) = 1 - \{[x_1 + 2K - x_2]/2K\}\exp\{-(x_1 - \underline{x})/K\}$ for $x_2 \in [x_1, \min\{\bar{x}, x_1 + 2K\}]$, while $\hat{r}_2(x_2; x_1) = 1$ for $x_2 \in (\min\{\bar{x}, x_1 + 2K\}, \bar{x}]$. Without an MFN, $\hat{r}_0(x_2) = 1 - \exp\{-(x_2 - \underline{x})/K\}$ for all $x_2 \in [x_1, \bar{x}]$. Thus, multiplying by the cost per trial and taking the expectation over $x_2 \in [x_1, \bar{x}]$ (where the probability of a trial differs with and without an MFN) yields:

$$\begin{aligned} ETC_2(x_1) - ETC_0 &= K\int_{[x_1, \bar{x}]} \hat{r}_2(x_2; x_1)f(x_2)dx_2 - K\int_{[x_1, \bar{x}]} \hat{r}_0(x_2)f(x_2)dx_2 \\ &= K\int_{[x_1, \bar{x}]} \exp\{-(x_2 - \underline{x})/K\}f(x_2)dx_2 \\ &\quad - K\exp\{-(x_1 - \underline{x})/K\}\int_{[x_1, \min\{\bar{x}, x_1 + 2K\}]} [(x_1 + 2K - x_2)/2K]f(x_2)dx_2. \end{aligned}$$

Clearly, $ETC_2(\bar{x}) - ETC_0 = 0$, since the domains of integration are then degenerate. Thus, consider values of $x_1 < \bar{x}$ in the remainder of the proof.

i) Consider $F(\bullet)$ to be the uniform distribution; substitute $f(x_2) = 1/(\bar{x} - \underline{x})$, integrate and simplify to obtain:

$$ETC_2(x_1) - ETC_0 = [K/(\bar{x} - \underline{x})]\exp\{-(x_1 - \underline{x})/K\}$$

$$\times [K(1 - \exp\{-(\bar{x} - x_1)/K\}) - (Z - x_1)(x_1 + 4K - Z)/4K],$$

where $Z = \min\{\bar{x}, x_1 + 2K\}$. There are two cases to consider.

Case 1. Assume that $x_1 + 2K < \bar{x}$, so $Z = x_1 + 2K$. Substituting and simplifying yields

$$ETC_2(x_1) - ETC_0 = [K/(\bar{x} - \underline{x})]\exp\{-(x_1 - \underline{x})/K\}[K(1 - \exp\{-(\bar{x} - x_1)/K\}) - K],$$

which is clearly negative. So $ETC_2(x_1) - ETC_0 < 0$ for all $x_1 < \bar{x} - 2K$.

Case 2. Assume that $x_1 + 2K \geq \bar{x}$, so $Z = \bar{x}$. Substituting and simplifying yields

$$ETC_2(x_1) - ETC_0 = [K/(\bar{x} - \underline{x})]\exp\{-(x_1 - \underline{x})/K\}$$

$$\times [K(1 - \exp\{-(\bar{x} - x_1)/K\}) - (\bar{x} - x_1)(x_1 + 4K - \bar{x})/4K].$$

Let $v \equiv \bar{x} - x_1$. Then $\mathrm{sgn}\,\{ETC_2(x_1) - ETC_0\} = \mathrm{sgn}\,\{[K(1 - \exp\{-v/K\}) - v(4K - v)/4K]\}$. Since $x_1 \in [\bar{x} - 2K, \bar{x})$ implies that $v \in (0,2K]$, we need only verify that $K(1 - \exp\{-v/K\}) - v(4K - v)/4K < 0$ for all $v \in (0,2K]$. This inequality holds for the specified values of v. Thus, $ETC_2(x_1) - ETC_0 < 0$ for $x_1 \in [\bar{x} - 2K, \bar{x})$, as claimed.

ii) Consider $F(\bullet)$ to be the exponential distribution; substitute $f(x_2) = \lambda\exp\{-\lambda(x_2 - \underline{x})$, integrate and simplify to obtain:

$$ETC_2(x_1) - ETC_0 = \exp\{-(x_1 - \underline{x})(1 + K\lambda)/K\}[(1 - \exp\{-2K\lambda\})/2\lambda - K/(1 + K\lambda)].$$

This expression is negative for all $x_1 \in [\underline{x}, \infty)$ because the term in square brackets is negative for $K > 0$ and $\lambda > 0$.

iii) Now consider $F(\bullet)$ to be an arbitrary distribution on $[\underline{x}, \bar{x}]$. A sufficient condition for $ETC_2(x_1) - ETC_0 < 0$ for all $x_1 \in [\underline{x}, \bar{x})$ is that (assuming $\bar{x} - \underline{x} < 2K$) the integrand is point-wise negative:

$$\exp\{-(x_2 - \underline{x})/K\} - \exp\{-(x_1 - \underline{x})/K\}[(x_1 + 2K - x_2)/2K] < 0$$

for all $x_2 \in [x_1, \bar{x}]$ and $x_1 \in [\underline{x}, \bar{x})$. This will be true as long as $\bar{x} - \underline{x} \leq \alpha K$, where α is the solution to the equation $\exp\{-\alpha\} + \alpha/2 = 1$. QED.