Credible Discovery, Settlement, and Negative Expected Value Suits

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Abstract: This paper introduces the option to conduct discovery into a model of settlement bargaining and negative expected value (NEV) suits under asymmetric information. We find that the option to conduct discovery has important effects on the standard model of settlement under asymmetric information for several reasons. First, because discovery is typically cheaper than litigation, it reduces the defendant's incentive to settle under conditions of asymmetric information. Second, discovery only matters if it is credible. Because discovery is more valuable the greater the uncertainty that it can resolve, this introduces a credibility constraint on the feasible pre-discovery settlement offers. This can further reduce the probability and size of a defendant's pre-discovery settlement offer. Lastly, both of these factors tend to reduce the ability of NEV plaintiffs to use asymmetric information to extract significant settlements from defendants. Discovery sometimes reduces the probability of NEV suits being filed and it always reduces the expected settlement a NEV plaintiff can obtain, thereby mitigating the incentive effects of NEV suits on defendants' behavior.

I. Introduction

Asymmetric information has been the leading explanation of why pretrial bargaining does not always result in Pareto superior settlements rather than in costly litigation since Bebchuk (1984), Reinganum and Wilde (1986) and Nalebuff (1987). Asymmetric information is also put forth as an explanation of why plaintiffs may sometimes file negative expected value (NEV) suits. These are suits for which the expected cost of filing and litigating the suit exceeds the expected judgment the plaintiff would expect to receive should the case go to trial. If a defendant knows the plaintiff has a NEV suit, she should be unwilling to offer to settle the case because she would expect the plaintiff to drop the case rather than continue to litigate it. Knowing this, a plaintiff with a NEV case should not sue. As Katz (1990) and Bebchuk (1988) have argued, however, if the defendant cannot distinguish a NEV suit from a PEV (positive expected value) suit, however, she may be willing to risk the possibility of settling with a NEV plaintiff to avoid the litigation costs of going to trial with a PEV plaintiff.

Most analyses of the pretrial negotiating process, including those that specifically address NEV suits, treat any potential asymmetry of information as exogenous. The actual legal process, however, has many devices that enable parties to substantially reduce or eliminate these informational asymmetries. Collectively, we will refer to these devices as discovery. To the extent there is asymmetric information, this state is not fixed and final. Rather, the uniformed party has the choice to undertake discovery to equalize this informational imbalance.

Since an informed party can obtain information rents from its informational advantage, the uninformed party might be understandably reluctant to settle under this disadvantage. That said, discovery, like trial itself, is costly, providing both sides an incentive to settle prior to incurring these costs. Thus, while discovery might have the potential to greatly reduce or eliminate much informational asymmetry in pretrial settlement bargaining, its cost suggests that, at least in some cases, the parties might prefer to settle under conditions of asymmetric information rather than incur discovery costs.

In this paper, we add the possibility of discovery into a pretrial bargaining model that begins with a situation of asymmetric information. Importantly, we allow for settlement at two different stages. First, there is settlement bargaining right after a suit is filed (which, itself, is endogenous in our model) but before there has been any discovery.[1] Second, the uninformed party (in our model the defendant, so that we can explore the asymmetric information explanation for NEV suits) decides whether or not to conduct costly discovery.[2] Third, there is another opportunity to settle (whether or not there has been discovery). Finally, there is trial.

We use this model to explore how discovery, or, more precisely, the choice to undertake discovery, affects the incentive to file suit, to settle prior to discovery, and to settle under conditions of either symmetric or asymmetric information (depending on whether discovery was undertaken) after the discovery phase.[3] In so doing, we analyze the effect of

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[1] In both our bargaining periods we use a screening game, so the defendant makes an offer to the plaintiff. We discuss this in more detail in the next section.

[2] Our analysis would be similar in the case in which the defendant has the private information and the plaintiff does the screening. The main differences would be that the threat of discovery would not affect filing decisions and would tend to reduce the ability of the defendant type who is very liable from using her private information to settle for a small amount.

[3] For simplicity, in our model we assume discovery eliminates any asymmetric information.

discovery on the asymmetric information explanation for the profitability of NEV suits. The extent to which NEV suits can extract settlements from defendants has gained prominence largely because of the widespread concern that plaintiffs with weak cases are using the threat of "frivolous" litigation to impose large settlement costs on defendants. While the term "frivolous" is not precisely defined, the implication is that defendants may be deterred from socially valuable activity by the threat of having to settle frivolous claims. Of course, as Shavell (1982) noted long ago, there is no reason to believe that all PEV suits are socially desirable or that all NEV suits are socially undesirable. If the reason that a suit is NEV is that litigation costs are large relative to the amount that can be recovered, the plaintiff may be unable to suit profitably even if he is very likely to prevail (indeed, maybe even if he is certain to prevail). Our analysis demonstrates that the existence of asymmetric information offers little hope for such a plaintiff to nevertheless extract a significant settlement in such cases.

Despite the fact that there is no necessary connection between the private and social value of suit, there may be some positive correlation between the expected value of a suit and its social value. If so, then from a social welfare standpoint, our results suggest that one should not only be concerned with whether plaintiffs with NEV suits can obtain a positive settlement but also with how large those settlements are. If NEV suits happen frequently, but are settled for very small amounts, then they probably have very little effect on primary behavior. We mention this because while our results suggest that the threat of discovery may in some circumstances reduce the frequency of NEV suits, we also show that, to the extent discovery is cheaper than litigation, the threat of discovery always reduces the amount a NEV plaintiff can obtain in a settlement.

We show how the initial settlement phase affects the incentive to conduct discovery. Furthermore, we show that maintaining this discovery incentive is so valuable to the defendant that it can often limit the ability of the parties to settle prior to discovery (further reducing the profitability of NEV suits). Intuitively, the more settlement there is prior to discovery, the less uncertainty there is about the value of the plaintiff's claim at the time of discovery (because if most plaintiff types will settle, then a plaintiff that does not settle must be one of the few types with a very strong case). Since discovery eliminates the defendant's uncertainty about the strength of the plaintiff's claim, the less uncertainty there is the less incentive the defendant has to conduct discovery. But, if the defendant does not conduct discovery, then the plaintiff may have less incentive to settle early.

Finally, we analyze the comparative statics of the model to show how changes in filing costs, discovery costs, litigation costs, and the stake of the case influence the filing decision and the probability of early settlement (both of which have important implications for the profitability of NEV suits). Interestingly, we find these comparative statics results depend crucially on whether or not the credibility of the defendant's threat to undertake discovery is a binding constraint on the pre-discovery settlement offer (that is, on whether or not the defendant must lower her initial settlement offer below the level that would otherwise be optimal in order to still have an incentive to do discovery if the offer is rejected).

To preview our main results, we find first that the defendant never makes a pre-discovery settlement offer that undermines her threat to conduct discovery if the offer is rejected (this result is reminiscent of Nalebuff's (1987) result that a plaintiff never makes a settlement offer that undermines the credibility of the threat to sue if it is rejected). Second, we find that unless discovery costs are zero or large enough that the defendant's threat to

conduct discovery is only credible if all no plaintiff types accept early settlement (so there is maximal uncertainty in the discovery phase), there is positive probability of a pre-discovery settlement. This settlement either exceeds the filing cost (so all types of plaintiffs sue, including all NEV plaintiffs), or is exactly equal to the filing cost (so only some NEV plaintiffs sue but all PEV plaintiff's sue, none of whom settle). Which occurs depends largely on the plaintiff's filing costs and the discovery costs and the distribution of plaintiff types. If the probability of a NEV plaintiff is high, then settlement typically happen at the filing cost and many NEV types do not file. If there is no pre-discovery settlement, the defendant always conducts discovery and there is then settlement under symmetric information.

If the pre-discovery settlement exceeds the filing cost, there are two further cases, one in which the credibility constraint (that conducting discovery given that the pre-discovery settlement offer has been rejected) is not binding and one in which it is. If this constraint is not binding, then we find that the probability of a pre-discovery settlement is increasing in the discovery costs of either party and decreasing in the states of the case. These results are analogous to Bebchuk's (1984) results on settlement without discovery except that what matters are discovery costs rather than litigation costs. If the credibility constraint is binding, then the comparative statics are almost exactly the opposite because what makes pre-discovery settlement more likely is anything that makes it easier to satisfy this credibility constraint. These are lower discovery costs for the defendant, higher stakes, and higher litigation costs for either side. The fact that the comparative statics are very different when there is a binding credibility constraint is similar to what Nalebuff (1987) finds when he analyzes settlement without discovery when a different credibility constraint is binding (the plaintiff's threat to go to trial without settlement).

If the pre-discovery settlement occurs at the filing cost, then we find that the most NEV plaintiff types (the types with the lowest probability of winning) do not file suit. The probability that a suit is filed (which one can think of as a measure of the number of NEV suits) is decreasing in the plaintiff's filing costs and the plaintiff's litigation costs, but is increasing in the defendant's discovery costs. The probability that the case is *not* resolved prior to discovery is decreasing in the plaintiff's filing costs, discovery costs, and litigation costs, but is increasing in the stakes of the case.

This paper builds on the Bebchuk (1984) and Nalebuff (1987) models of settlement under asymmetric information and the Katz (1990) and Bebchuk (1988) models of NEV suits under asymmetric information. It is also related to more recent literature on discovery. Most closely related is Schrag (1999). He models the interaction of settlement and discovery to analyze the effect of judicial management of discovery. Because his focus is also on primary behavior (which we do not consider), in his model the defendant has the private information (about negligence). Thus, the filing decision is exogenous in his model. Another difference is that he only models the pre-discovery settlement bargaining game, using a reduced form analysis of the post-discovery outcome. Thus, he does not develop an endogenous link between discovery incentives and the pre-discovery settlement. Instead, he obtains this linkage through an assumption on the differential value of discovery against negligent versus non-negligent defendants. Furthermore, his results are somewhat different in that he finds that judicial limits on discovery can sometimes lead to more pre-discovery settlements, while we find that if the uninformed party could commit to discovery that both parties would (in almost all cases) be better off. Lastly, because he is focused on the effects of judicial

management of discovery and primary behavior, he does not examine the comparative statics effects that we find here.

Shavell (1989) and Sobel (1989) presented two of the first models of discovery as a mechanism for reducing information asymmetries and thereby increasing the likelihood of settlement. Cooter and Rubinfeld (1994), in an early model of the discovery process, considered its effect on settlement using the relative optimism or pessimism model of settlement, as opposed to the strategic asymmetric information model. Daughety and Reinganum (1993) add a decision to become informed prior to a settlement bargaining model in which both parties can make offers. Mnookin and Wilson (1998) use a mechanism design model of settlement that follows the choice of discovery. Farmer and Pecorino (2005) develop a model of mandatory versus voluntary disclosure and its impact on settlement using both signaling and screening models of settlement. Hay (1994) links discovery to a defendant's care behavior, enabling him to examine the optimal scope of discovery with a broader social welfare function. In all of these models, the issue of the credibility of the discovery threat does not arise either because there is only settlement bargaining after the discovery phase (whether mandatory or voluntary) and/or because discovery is costless or exogenously imposed. Furthermore, in all of these models, the decision to file suit is exogenous, thus, they are not models designed to analyze NEV suits.

The next section presents an intuitive description of our approach along with a simple numerical example that illustrates the model and the main results. Section III presents the general model and the equilibrium. Section IV presents the comparative statics results. Section V concludes by discussing the policy implications of our analysis. The Appendix contains proofs not in the text.

II. The Problem: Explanation and Example

Before proceeding with the general model, we provide the following intuitive explanation and simple numerical example to illustrate the effect of discovery and the importance of its credibility on settlement and NEV suits.

In a lawsuit, the defendant wishes to minimize its expected costs. These costs can come from litigation, in which case they include both the expected judgment and the expected costs of litigation. They can also come from settlement, in which case they include the amount of the settlement and any costs the defendant has incurred up until the point of the settlement. Trivially, the defendant chooses to settle if she believes the costs associated with settlement are less than the costs associated with litigation. If the defendant is unsure about the strength of the plaintiff's case (one major reason we might think a plaintiff with a NEV case might file in the hopes of receiving a settlement), then the lower costs of settlement must be traded off against the risk of paying more than necessary to get the plaintiff to settle (and more than this particular plaintiff might expect to receive in a judgment).

This is where the prior analyses of NEV suits under asymmetric information have stopped. A defendant that wants to settle a case, however, typically can choose whether to attempt to settle a case early, when there is likely to be substantial asymmetric information but before she has expended much in costs or to settle later after she has undergone discovery that is costly but may reduce or eliminate the plaintiff's informational advantage (because she will learn much of the plaintiff's private information). Our paper specifically analyzes this choice for how the defendant will minimize her expected costs.

It is important to note that the choice to settle early or late is not all or nothing. The defendant can attempt to settle early, usually for a small amount, and, if this fails, then undertake discovery to reduce or eliminate any asymmetric information, thereby enabling later settlement. If the defendant does undertake such a strategy, if the plaintiff has a weak case, he will accept the early settlement for fear of having the weakness of his case exposed in discovery. If the plaintiff has a stronger case, then he may prefer to wait to settle after discovery. Discovery, then is advantageous to the defendant in two ways. First, the threat of discovery induces a plaintiff with a weak case to settle for less (or, possibly, for nothing or to drop the case). Second, it enables the defendant to more accurately estimate the settlement offer that is necessary to induce a plaintiff with a stronger case to settle. In choosing the optimal initial offer, the defendant trades off the greater amount that she must pay with a higher offer with the greater likelihood of avoiding discovery costs. Notice, however, that this strategy only works for the defendant if the plaintiff really believes that she (the defendant) will undertake discovery if he (the plaintiff) rejects the settlement.

To see how the credibility of the discovery threat interacts with the settlement process, consider the following illustrative example. There are two players, P (he) and D (she). P can be of one of four types, measured by the expected award he can get if he goes to court against D. These four types are 15, 25, 30, and 40. P knows his type, D only knows that these four types occur with probability .1, .2, .4 and .3 respectively. P's cost of filing suit is 1. P decides whether or not to file suit in period 0. If he does so, then in period 1 D can decide whether to make a settlement offer to P or not, and if so, how much to offer. If D does not make an offer or P rejects the offer, then in period 2 P can choose to drop the case or not and D can decide whether or not to conduct discovery. Discovery costs both parties 5. If D conducts discovery, then D learns P's type. In period 3, D again makes another settlement offer to P. If P rejects then they go to trial. Trial costs both sides 15 and D pays P based on P's type (15, 25, 30 or 40).

Notice that our example allows D to combine the use of early settlement and discovery, if this early settlement fails, to minimize her expected costs from the suit. If D actually does conduct discovery, then since there is now symmetric information, there will always be settlement in period 3. Because we allow D to make the settlement offer (we justify this assumption in the next section), this settlement will be at exactly P's net payoff from going to trial. For example, if D learns that P is type 30, D will offer 15 and P will accept (at this point the filing costs and discovery costs are sunk, so we can ignore them).

If D chooses not to do discovery in period 2, then D can either make a settlement offer (25 in this example) that P will accept no matter what his type, or make a lower settlement offer (15, 10, or 0) and risk going to trial if P has a strong case. Thus, by not conducting discovery, D saves the discovery costs, but risks either paying too much to a plaintiff without a strong case or going to trial and wasting the trial costs. The extent of that risk depends on the degree of uncertainty that D has about P's type in period 2. For example, if D were to believe that only a P of type 40 would reject D's first period offer (we will get to why this might be the case shortly), then in period 3 D actually has no reason to do discovery since she already knows that 25 is her optimal offer whether she does discovery or not. On the other hand, if D believes that she could be facing a P of type 25, 30, or 40 in period 2, then discovery has some value since the result can help her determine her optimal offer in period 3.

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Of course, what *D* reasonably believes about *P*'s type in period 2 depends on what settlement offer *P* offers in period 1 and how *P* responds to that offer. For now, assume that *P* believes that if he rejects an offer in period 1 that *D* will conduct discovery in period 2. For this belief to be reasonable, *D* must want to do discovery given that *P* responds to *D*'s period 1 offer based on the belief that a rejection will generate discovery. As we will see, this presents a constraint on the possible settlements in period 1. We show in the next section that *D*'s optimal offer must satisfy this constraint in equilibrium. Given that *P* believes a rejection of the period 1 offer will induce discovery, then *P* will accept any period 1 offer that is at least 20 less than his type. This follows because rejection of the offer forces *P* to incur discovery costs of 5 and then *P* will accept a settlement offer in period 3 that is 15 less than his type. Thus, if *D* offers 20 in period 1, then this offer should be accepted by all types of *P*. If she offers 10, this should be accepted by *P* unless he is type 40. If she offers 5, this will be accepted by the bottom two types of *P*. Any offer below 5 will only be accepted by *P* if he is type 15.

Assuming *D* actually does discovery in period 2 (we will revisit this in a moment), we can compare each of these possible offers. An offer of 20 gives *D* an expected cost of 20 since it is accepted with probability one. An offer of 10 is accepted with probability .7 (since type 40 occurs with probability .3). If it is rejected, then *D* incurs a discovery cost of 5 and then makes a settlement offer of 25 which is accepted. Thus, *D*'s expected costs are .7*10+.3(25+5)=16. An offer of 5 is accepted with probability .3, thus has expected costs of .3*5+.4*(15+5)+.3(25+5)=18.5.[4] If *D* does not make a settlement offer in period 1, then type 15 drops the case, so *D*'s expected costs are .2*(10+5)+.4(15+5)+.3(25+5)=20. Thus, if *D* actually does discovery in period 2, her optimal period 1 offer is 10.

Notice, however, that if *D* does offer 10 and only type 40 rejects this offer because *P* believes *D* will conduct discovery, then *D* now has no incentive to conduct this discovery. She can make a settlement offer of 25 without doing any discovery and she has no reason to think she will want to make any other offer after conducting discovery. Because the first period settlement offer eliminated any uncertainty about *P*'s type, *D*'s threat to conduct discovery is not credible. More generally, the less uncertainty there is about *P*'s type after the period 1 settlement offer is rejected, the less valuable discovery is for *D*, which means the less likely *D*'s discovery threat will be credible. The larger the first period offer, the less uncertainty there will be in period 2 (because fewer plaintiff types would reject a larger offer). But, if the discovery threat is not credible, then *P* may reject this period 1 offer of 10 even if he is not type 40. As we show in the next section, it is never optimal to make an offer such as this one in which the threat to undertake discovery is not credible if *P* behaves as if *D* will conduct discovery.[5] Thus, the need to make the discovery threat credible prevents *D* from making what would otherwise be her optimal offer. In particular, it forces her to make a lower settlement offer that is more likely to be rejected in order to ensure that there is enough uncertainty in period 2 for it to make sense for her to undertake discovery.

In this case, the discovery threat is only credible if *D*'s first period offer is 5 or less. To see this, notice that with an offer of 5, then if *P* rejects this offer in period 2 *D* believes

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[4] Type 30 occurs with probability .4 and *D*'s costs for this type are 15 for the period 3 settlement and 5 for the discovery costs. Type 40 occurs with probability .3 and *D*'s costs for this type are 25 for the period 3 settlement and 5 for the discovery costs.

[5] The intuition for this result is simply that in equilibrium, enough lower types of *P* have to reject the period 1 offer to make the threat credible, but then *D* is better off making a lower offer in the first place.

that P is either type 30 or 40. The probability that P is type 30 (given rejection of the first period offer) is 4/7, thus if D conducts discovery her expected costs (from this point on) are (4/7)(15+5)+(3/7)(25+5)=24.3. If she does not conduct discovery then she can either settle with both types of P for 25 or offer 15 and litigate if P is type 40. Either is more costly than conducting discovery. Thus, given the need to maintain the credible threat of discovery, D will make a first period offer of 5 instead of 10.

We can now use this example to compare three different situations. First, consider the outcome if we rule out the possibility of discovery. It is easy to show that, given the high litigation costs in this example, D will simply offer 25 and settle for sure. Given this, P will file suit no matter what and NEV suits (if P is type 15) are quite profitable. When we introduce the possibility of discovery, but ignore issues of credibility (or, alternatively, assume D can somehow commit to undertake discovery), then D settles with all but type 40 in period 1 for 10. If P is type 40, then D conducts discovery and settles at 25. P still files suit no matter what and NEV suits are still profitable, but they are much less so (P with a NEV suit receives 10 instead of 25). If we further consider the fact that this discovery threat must be credible, then D settles only with the bottom two types in period 1 for 5 and conducts discovery and settles in period 3 if P type 30 or 40. Once again, P always files suit in this example, but the settlement amount is further reduced from 10 to 5. Notice that while in this example credible discovery does not change the number of NEV suits (but, see below, where it does), it still has important implications for the ultimate impact of these suits. To the extent one is worried about the incentive effects of NEV suits on defendants, the fact that credible discovery greatly reduces the amount defendants pay to NEV plaintiffs suggests that the ultimate impact of NEV suits on defendant behavior may not be nearly as great as it would appear if one doesn't consider issues of credible discovery.

Interestingly, if we increase the defendant's discovery costs to 6, things actually get worse for P. The reason is that now the discovery threat is not credible if D makes a first period offer of 5. To see this, notice that D expected costs (from period 2 on) if she conducts discovery would be (4/7)(15+6)+(3/7)(25+6)=25.3 instead of 24.3. So, she is better off foregoing discovery and offering 25 to ensure settlement in period 3. To have a credible threat of discovery in period 2, D must now refuse to settle at all in period 1. By doing that, if P does not drop the case, then D believes P is either type 25, 30, or 40. So, D's expected costs if she does discovery are (2/9)(10+6)+ (4/9)(15+6)+(3/9)(25+6)=23.2. This is clearly better than settling with everyone and better than any other screening offer an uninformed D could make in period 3 as well.[6] So, the D can maintain a credible discovery threat by refusing to settle in period 1 prior to discovery.

Because this makes discovery a sure thing, however, it also means that type 15 will not file suit since he would spend 1 to file the suit and then later drop it. Thus, in this case, credible discovery completely eliminates NEV suits. As we show in the next section, this is a special case, but the more general result is that there are situations where the threat of discovery does reduce, though not eliminate, the probability of an NEV suit. The other interesting thing to note is that larger discovery costs actually made suing less profitable for P because it reduces the amount D can offer in a pre-discovery settlement and still maintain a credible threat to conduct discovery. As we will see in the general model, this is a general result in situations in which the credibility constraint is binding (that is, in situations in which

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[6] Going to trial no matter what is clearly worse. Offering 15 and settling with types 25 and 30 and litigating with type 40 yields expected costs of 23.3.

the need to maintain the credible threat of discovery requires the defendant to make a period 1 settlement offer that is lower than she would otherwise like to make if she could commit to conduct discovery).

III. Model and Equilibrium

To analyze the effect of discovery on NEV suits, we generalize the example as follows. The plaintiff, P, has an expected award, a that is distributed according to a cumulative distribution function F (with an associated probability density function f) with support $[0,1]$. This is without loss of generality since we can simply measure all other variables in units of the maximum award.

In period 0, nature draws a from this distribution. P knows his precise value of a while D simply knows the distribution. In period 0, P decides whether or not to file suit against D at a cost of c_0. In period 1, if P has filed the case, then D makes a settlement offer, s_1, to P. If P accepts the game ends. If P rejects, the game moves to period 2 in which P can choose to drop or continue the case and D can choose to conduct discovery.[7] If D conducts discovery, this costs D c_D and also imposes a cost of c_P on P. If D conducts discovery, we assume she perfectly observes a.

In period 3, D has another opportunity to make a settlement offer. If D has not conducted discovery, D makes a settlement offer, s_2, to P. If P accepts, then the game ends. If P rejects, the case goes to trial in which P receives an award of a from D and each side incurs litigation costs of k_P and k_D respectively. If D has conducted discovery in period 2, then we assume (because we have complete information) that P accepts D's offer of $a - k_P$.

Notice that we have assumed that D gets to make a take it or leave it offer in both settlement periods whether or not there is asymmetric information. In the asymmetric information situations, we make this assumption primarily for tractability and because it allows us to examine the effect of the credibility of the discovery threat on D's settlement offer in period 1.[8] If there is symmetric information (because there has been discovery in period 2), then we continue to use this simple bargaining framework for consistency and also because it is consistent with our analysis in an earlier paper. There we analyzed NEV suits in a complete information setting and found that the outside option principle suggests the defendant would receive all of the surplus under complete information (Schwartz and Wickelgren 2007).

We first establish that P will follow a cutoff strategy in determining whether or not to accept the period 1 settlement offer (that is, P accepts any period 1 settlement offer if and only if his expected award is below some cutoff which varies with the size of the offer). In this, and in all that follows, we assume that players do not play weakly dominated strategies.

Lemma 1. (a) If a plaintiff with expected award a^0 accepts a settlement offer of s_1 in period 1, then any plaintiff with $a < a^0$ also accepts this offer. (b) If a plaintiff with expected award a^0 rejects a settlement offer of s_1 in period 1, then any plaintiff with $a > a^0$ also rejects this offer.

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[7] P never does drop the case in equilibrium since, as we will see, D always conduct discovery with probability one. As a result, we do not need to specify the timing of P's decision.

[8] Nalebuff (1989) also uses take it or leave it screening offers when analyzing the interaction of settlement with the credibility of the threat to go to trial.

Proof. (a) If $a < a^0$, then the payoff for a type a plaintiff from rejecting s_1 is strictly less than for a^0 if D does discovery. If D does not do discovery, then a's payoff is either identical to a^0's if both accept s_2 or less than a^0's if a^0 does not accept s_2. This proves that if a^0 accepts s_1 then a will as well or else one type is playing a weakly dominated strategy. The same argument in reverse proves part (b).

Next, we show that P will also follow a cutoff strategy in determining whether or not to file suit in period 0.

Lemma 2. (a)If a plaintiff with expected award a^0 file suit in period 0, then any plaintiff with $a > a^0$ also files suit. (b) If a plaintiff with expected award a^0 does not file suit in period 2, then any plaintiff with $a < a^0$ also does not file suit.

Proof. (a) If type a^0 files suit and accepts s_1 then type a can achieve the same payoff by accepting s_1 and possibly more by rejecting the offer. If a^0 files suit and rejects s_1, then if D does discovery then a can follow the same strategy and obtain a greater payoff. If D does not do discovery, then if a^0 accepts s_2 then a can obtain at least as great a payoff by following the same strategy (and possibly more with the option to reject). If a^0 rejects s_2 and goes to trial then a will obtain a greater payoff following this strategy. Thus, if a^0 files suit, a files also or else one of them is playing a weakly dominated strategy. (b) The same argument in reverse proves (b). Q.E.D.

Lemmas 1 and 2 establish that there will be cutoff values a_1 and $a_2(s_1)$ such that if P has filed suit (is around in period 1) then $a \geq a_1$, and if P has rejected s_1 (is around in period 2 and 3) then $a \geq a_2(s_1)$. This means that D can simply update her belief about the distribution of P's type by simply truncating the original distribution of types below these cutoff values. Using these results, we analyze this game starting in period 3. We have assumed the answer if a is common knowledge (there is settlement at $a - k_P$). If a remains private information, because there was no discovery, then D is faced with the standard settlement bargaining problem analyzed in Bebchuk (1984). That is, she chooses her settlement offer to balance the benefit of settling for less with the cost of increasing the probability of litigation. Formally, she chooses s_2 to minimize her expected costs of:

$$s_2 \frac{F(s_2 + k_P) - F(a_2(s_1))}{1 - F(a_2(s_1))} + \int_{s_2 + k_P}^{1} (a + k_D) \frac{f(a)}{1 - F(a_2(s_1))} da$$

The first term represents the expected cost to D of settlement—the magnitude of the settlement offer multiplied by the probability that P accepts. P accepts if his value of a is less than $s_2 + k_P$, the level at which P's payoff is the same from accepting s_2 as it is from litigating. Given that P is present in period 3, we know from Lemma 2 that he must have $a > a_2(s_1)$, hence the probability that P accepts this offer given that he is around in period 3 is give by $\frac{F(s_2 + k_P) - F(a_2(s_1))}{1 - F(a_2(s_1))}$. The second term represents D's expected costs from litigating against a P who rejects the settlement offer. $a + k_D$ is D's cost of litigating against a defendant of type a. The density of types given that P is around in period 3 is $\frac{f(a)}{1 - F(a_2(s_1))}$.

Thus, the optimal settlement offer, s_2^*, satisfies the following first order condition:

$$\frac{F(s_2*+k_P)-F(a_2(s_1))}{1-F(a_2(s_1))} = (k_P + k_D)\frac{f(s_2*+k_P)}{1-F(a_2(s_1))} \tag{+}$$

We will use this implicit characterization of s_2* later to compare D's expected costs if she conducts discovery with her expected costs if she does not. This is critical to determining if she has a credible threat to conduct discovery in period 2, to which we now turn.

In period 2, if D conducts discovery then she can tailor her settlement offer perfectly to P's type. Thus, her expected costs if she conducts discovery is:

$$\int_{a_2(s_1)}^{1} (a-k_P)\frac{f(a)}{1-F(a_2(s_1))}da + c_D$$

Or, D can forego discovery and have an expected social cost of:

$$s_2* \frac{F(s_2*+k_P)-F(a_2(s_1))}{1-F(a_2(s_1))} + \int_{s_2*+k_P}^{1} (a+k_D)\frac{f(a)}{1-F(a_2(s_1))}da$$

This is simply expected costs of an uninformed D in period 3 who chooses the optimal settlement offer, s_2*, described above.

As we discussed in the context of the example and will prove below, discovery is more valuable the greater the uncertainty D has about P's type. To make the analysis interesting, we will assume that discovery is cheap enough that if the distribution of plaintiff types in period 2 is simply all plaintiff types that can profitably file suit given that they will be subject to discovery (say because $s_1=0$) then the defendant wants to conduct discovery. This is the most uncertainty that is feasible in period 2. That is, we assume:

Condition 1:
$$c_D < \frac{1}{1-F(c_0+k_P+c_P)}\{\hat{s}_2(F(\hat{s}_2+k_P)-F(c_0+k_P+c_P))$$
$$+ \int_{\hat{s}_2+k_P}^{1}(a+k_D)f(a)da - \int_{c_0+k_P+c_P}^{1}(a-k_P)f(a)da\}$$

Here, $\hat{s}_2$ is the optimal period 3 settlement offer if there is no discovery and $s_1=0$. Of course, since s_1 will typically exceed zero, this assumption does not guarantee that the defendant necessarily does discovery in period 2.

The next step is, then, to determine how the period 1 settlement stage affects D's discovery decision in period 2. Since discovery is valuable because it removes the plaintiff's informational advantage, it stands to reason that the less uncertainty that D has about P's type the less valuable discovery is for D. The next lemma proves that this is in fact the case.

Lemma 3. Let a_2 be the smallest P type that rejects s_1 and thus exists in period 2. Then for any $c_D>0$, there exists a unique $\hat{a}_2$ such that D conducts discovery in period 2 with probability one (zero) if and only if $a_2 < (>)\hat{a}_2$.

Proof. D will conduct discovery if and only if doing so lowers her expected costs. Thus, she conducts discovery if and only if the following inequality holds:

$$c_D \le \frac{1}{1-F(a_2)}\{s_2*(a_2)(F(s_2*(a_2)+k_P)-F(a_2))+\int_{s_2*(a_2)+k_P}^{1}(a+k_D)f(a)da - \int_{a_2}^{1}(a-k_P)f(a)da\} \tag{++}$$

We have assumed this if $a_2=c_0+k_P+c_P$ then this inequality holds. If $a_2=1$, then clearly it does not. Thus, by continuity there exists an $\hat{a}_2$ such that this inequality holds at equality. We now prove that this $\hat{a}_2$ is unique by showing at $a_2 = \hat{a}_2$ the right hand side of (++) is strictly

decreasing in a_2 at $\hat{a}_2$. This also proves that D conducts discovery with probability one (zero) if and only if $a_2 < (>)\hat{a}_2$. Notice that the right hand side of (++) is of the form $h(a_2)(g_1(a_2) - g_2(a_2))$. Taking the derivative of this with respect to a_2 yields $h'(a_2)(g_1(a_2) - g_2(a_2)) + h(a_2)(g_1'(a_2) - g_2'(a_2))$. Since $h(a_2) = 1/1 - F(a_2)$ then

$$h'(a_2)(g_1(a_2) - g_2(a_2)) = -\frac{f(a_2)}{1 - F(a_2)} h(a_2)(g_1(a_2) - g_2(a_2)) \quad \text{If we evaluate this at } \hat{a}_2 \text{ then}$$

$$h'(\hat{a}_2)(g_1(\hat{a}_2) - g_2(\hat{a}_2)) = -\frac{f(\hat{a}_2)}{1 - F(\hat{a}_2)} c_D < 0. \quad \text{Thus, it suffices to show that}$$

$g_1'(\hat{a}_2) - g_2'(\hat{a}_2) < 0$. Taking the derivative of the term inside the square brackets on the right hand side of (++) (and using the first order condition for s_2*) gives:

$$(\hat{a}_2 - k_P - s_2 * (\hat{a}_2))f(\hat{a}_2)$$

The first order condition for s_2* (equation (+)) shows that this is negative. Q.E.D.

Lemma 3 shows that D's incentive to conduct discovery is greater the greater is the range of possible plaintiff types that exist in period 2. That is, if the minimum plaintiff type in period 2 is a_2, then if $a_2 < \hat{a}_2$ D will conduct discovery with probability one. If $a_2 = \hat{a}_2$ D can conduct discovery with any probability between zero and one. If $a_2 > \hat{a}_2$ D will not conduct discovery. P's minimum type in period 2 is determined by the settlement offer that D makes in period 1. Making a larger settlement offer reduces P's incentive to reject this offer, so it raises the minimum type of P that will reject this offer and be present in period 2. Thus, the larger the first period settlement offer the less incentive D has to conduct discovery in period 2.

We now turn to examining the possible equilibrium period 1 settlement offers and P's responses to those offers. In so doing, we start by noting that if P's equilibrium strategy in period 1 is such that $a_2 > \hat{a}_2$ then, since D will not do discovery, it must be that $s_1 = s_2$*(a_2). Otherwise, if $s_1 < s_2$*(a_2), then if P is of type $a < a_2$ he will want to deviate by rejecting s_1. Similarly, if $s_1 > s_2$*(a_2), then there is a P of type $a > a_2$ that will want to deviate by accepting s_1. Notice, however, that for D this outcome is equivalent to offering $s_1 = 0$ and then making the offer s_2*(a_2) (which in general will not equal the optimal offer s_2*(0)). Under Condition 1, however, D's expected payment can be reduced if $s_1 = 0$ by doing discovery in period 2 relative to offering s_2*(0). Hence, we have just proved the following lemma.

Lemma 4. Under Condition 1, $a_2 > \hat{a}_2$ cannot be part of a Perfect Bayesian Equilibrium.

Lemma 4 says that in equilibrium D will always conduct discovery, at least with positive probability. That is, there is never an equilibrium in which the minimum P type that rejects D's period 1 offer is so high that D prefers to simply remain uninformed and make a screening offer in period 3.

We can now use the first four lemmas to narrow down the possible equilibrium settlement offers that D can make in period 1. Define $\hat{s}_1$ such that a P of type $\hat{a}_2$ is indifferent between accepting $\hat{s}_1$ and rejecting it if he believes that D will conduct discovery with probability one. That is, $\hat{s}_1 = \hat{a}_2 - k_P - c_P$. If $s_1 = \hat{s}_1$, then there is a continuation

equilibrium in which $a_2 = \hat{a}_2$ and D does discovery with probability 1. If $s_1 > \hat{s}_1$, notice that we still must have $a_2 = \hat{a}_2$ ($a_2 > \hat{a}_2$ is ruled out by Lemma 4). Thus, D must conduct discovery with probability less than one. With this continuation equilibrium, D pays more to a plaintiff of type $a < \hat{a}_2$ and has the same expected payoff for $a \geq \hat{a}_2$. We have now proved the following result.

Proposition 1. Under Condition 1, $s_1 \leq \hat{s}_1$ and if this offer is rejected then D conducts discovery with probability one.

The first proposition says that there cannot be too much settlement prior to discovery because doing so undermines the defendant's threat to undertake discovery. It is this threat that induces low value plaintiffs to accept the pre-discovery settlement in the first place.[9] This is a threat that D never wants to weaken because doing so will not actually lead to any more early settlements, it just leads to D paying more to those who settle. Furthermore, given that D does discovery with probability 1, this means that $a_2(s_1) = s_1 + k_P + c_P$.

We now examine D's optimal settlement offer in period 1. As long as $s_1 \leq \hat{s}_1$, D chooses s_1 to minimize its expected loss from the litigation of:

$$L(s_1) = \frac{1}{1-F(a_1)}\{s_1(F(Max[s_1 + k_P + c_P, a_1]) - F(a_1)) + \int_{Max[s_1 + k_P + c_P, a_1]}^{1}(a - k_P + c_D)f(a)da \quad (*)$$

The term in curly brackets is ex ante expected loss, it is multiplied by $\dfrac{1}{1-F(a_1)}$ to make this

the expected loss given that the case has been filed. The first term in the curly brackets is the expected cost of settling with the P types that accept the pre-discovery settlement offer of s_1. Notice that we allow for D to make a period 1 offer that no type of P that would file would accept. The integral term reflects the expected cost of doing discovery and then settling post-discovery with all P types that reject the pre-discovery settlement. The optimal s_1 (so long as $0 \leq s_1^* \leq \hat{s}_1$) is given by s_1^* which is implicitly defined by the following first order condition.

$$(F(s_1^* + k_P + c_P) - F(a_1)) - (c_D + c_P)f(s_1^* + k_P + c_P) = 0 \quad (**)^{10}$$

This looks very much like the standard first order condition for settlement under a simple screening game. The only difference is that the cutoff type is a function not just of the settlement offer and the litigation costs but also of the discovery costs. Furthermore, the value of settlement to the defendant is not the saving of litigation costs but the saving of discovery costs since the failure of pre-discovery settlement does not mean litigation occurs, rather it means discovery occurs and then settlement after that. Thus, equation (**) shows that, as long as the credibility constraint does not bind, the optimal pre-discovery settlement offer is such that the marginal cost of increasing this offer (paying more to the types of P that already accept this offer, those for whom $a \in [a_1, s_1^* + k_P + c_P)$) equals the marginal benefit (saving the discovery costs for the P type that just now accepts the offer).

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[9] This result has the same flavor as Nalebuff's (1989) result that if defendant's have private information, the plaintiff cannot make too low a settlement offer without undermining its credible threat to go to trial if the offer is refused.

[10] Strictly speaking, this is only the optimal settlement if $s_1 \geq a_1 - k_P - c_P$, but inspection of (**) reveals that the LHS is negative at $s_1 = a_1 - k_P - c_P$, so that that $s_1^* > a_1 - k_P - c_P$.

If we assume:

Condition 2: For any $a \in [0,1]$ $\dfrac{f(x)}{F(x) - F(a)}$ *is decreasing in x for all* $x \in [a,1]$

then s_1^* is unique.[11]

It is easy to see that the $s_1 \leq \hat{s}_1$ constraint can be binding (force D to lower her pre-discovery settlement offer below s_1^*). If c_D is large enough then $\hat{a}_2$ can be pushed all the way down to a_1, which clearly makes the left hand side of (**) negative at $s_1^* = \hat{s}_1$. Intuitively, if the defendant's discovery costs are large enough, then discovery only makes sense if there is maximal uncertainty about P's type in period 2, which requires that no type of P settles in period 1. Interestingly, this means that if discovery costs are large enough, then there are no settlements without discovery. Of course, if discovery costs get larger than this, then Condition 1 does not hold and D does not conduct discovery. This brings us back to the simple screening situation without discovery. This suggests that the comparative statics with discovery may be counter-intuitive and potentially non-monotonic. Before exploring these comparative statics, however, we first finish describing the equilibrium by analyzing the plaintiff's filing decision in period 0.

If P files in period 0, then his payoff is at least s_1-c_0, where $s_1 = Min\{s_1^*, \hat{s}_1\}$. If $s_1>c_0$, then P files suit no matter what his type because he can expect to get a settlement that exceeds the filing costs. If $s_1=c_0$, then for $a \leq a_2$, P is indifferent between filing suit and not, thus this type of P can file suit with any probability between zero and one. For $a > a_2$, P will file suit with probability one. If $s_1<c_0$, then P only files if $a > a_2$, and there is no settlement in period 1. As the following lemma shows, however, this last case is only possible in one very restrictive situation.

Lemma 5. Under Condition 1, $s_1<c_0$ if and only if $\hat{a}_2 = c_0 + k_P + c_P$.
Proof. If $\hat{a}_2 > c_0 + k_P + c_P$, then if $s_1<c_0$ is part of an equilibrium, P will only file suit if $a_2 - k_P - c_P \geq c_0$ (because P expects only to obtain a settlement after discovery). Given this, D can deviate by offering $s_1=c_0$ and reduce its expected costs against a P of type $c_0 + k_P + c_P$ without changing its expected costs against any other type P (because this offer does not violate the credibility constraint since $\hat{a}_2 > c_0 + k_P + c_P$). $\hat{a}_2 < c_0 + k_P + c_P$ violates Condition 1.[12] If $\hat{a}_2 = c_0 + k_P + c_P$, then by Lemma 4 we know that D cannot make any offer that any type of P that files would accept, which requires that $s_1<c_0$. Q.E.D.

Lemma 5 says that making an initial settlement offer less than the cost of filing suit is only optimal if not settling with any type of P that will file suit given that they will face discovery is

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[11] To see that we take the second derivative of D's expected payments with respect to s_1:

$$\frac{1}{1 - F(a_1)}\{f(s_1 + k_P + c_P) - (c_D + c_P)f'(s_1 + k_P + c_P)\}$$

At $s_1=s_1^*$ the term in curly brackets is positive under Condition 2. Thus, if
$$(F(\hat{s}_1 + k_P + c_P) - F(a_1)) - (c_D + c_P)f(\hat{s}_1 + k_P + c_P) \leq 0$$
then the optimal settlement offer is $\hat{s}_1$.

[12] If we were to relax Condition 1, then $\hat{a}_2 < c_0 + k_P + c_P$ would mean that D would have to conduct discovery with a positive probability less than one and P with $a < c_0 + k_P + c_P$ would file suit in the hopes of getting a settlement without discovery.

essential to maintain the credibility of the discovery threat in period 2. As long as D can settle wit some types of P that choose to file suit and still have a credible threat to conduct discovery then any type of P will have an incentive to file suit, since this settlement must exceed the filing costs. While very restrictive, notice that this lemma does suggest that there is at least one situation in which the threat of discovery can completely deter a NEV suit. By contrast, in a model without discovery, Katz (1990) finds that the defendant never makes a settlement offer below the plaintiff's filing cost.

Under Condition 1, $c_0 < \hat{s}_1$, so $s_1 > c_0$ if and only if the optimal settlement offer ignoring the credibility constraint exceeds c_0 given that all P types file (as they will if $s_1 > c_0$). From (**), this requires that $F(c_0 + k_P + c_P) < (c_D + c_P)f(c_0 + k_P + c_P)$. If this does not hold, then from Lemma 5 we know that $s_1 = c_0$ unless $\hat{a}_2 = c_0 + k_P + c_P$. For $s_1 = c_0$ to be optimal, P's filing strategy, file if and only if $a > a_1$, must adjust to ensure that $F(c_0 + k_P + c_P) - F(a_1) = (c_D + c_P)f(c_0 + k_P + c_P)$ so that the optimal first period settlement offer is exactly the filing costs ($s_1^* = c_0$).

By characterizing the entire equilibrium in this game, we have proven the following result.

Proposition 2. Under Conditions 1 and 2, then the following describes the unique Perfect Bayesian Equilibrium.

    A. *If $\hat{a}_2 = c_0 + k_P + c_P$, P files suit in period 0 if and only if $a \geq c_0 + k_P + c_P$. In period 1, D offers $s_1 < c_0$ and P rejects. In period 2, D conducts discovery with probability one. In period 3, D offers $s_2 = a - k_P$.*

    B. *If $\hat{a}_2 > c_0 + k_P + c_P$ and $F(c_0 + k_P + c_P) < (c_D + c_P)f(c_0 + k_P + c_P)$, then P files suit in period 0 for any value of a. In period 1, D offers $s_1 > c_0$ where $s_1 = Min\{s_1^*, \hat{s}_1\}$. P accepts if and only if $a \leq s_1 + c_P + k_P$. In period 2, D conducts discovery with probability one. In period 3, D offers $s_2 = a - k_P$.*

    C. *If $\hat{a}_2 > c_0 + k_P + c_P$ and $F(c_0 + k_P + c_P) \geq (c_D + c_P)f(c_0 + k_P + c_P)$, then P files suit in period 0 if $a \geq a_1^*$ where a_1^* satisfies $F(c_0 + k_P + c_P) - F(a_1^*) = (c_D + c_P)f(c_0 + k_P + c_P)$. In period 1, D offers $s_1 = c_0$. P accepts if and only if $a \leq c_0 + c_P + k_P$. In period 2, D conducts discovery with probability one. In period 3, D offers $s_2 = a - k_P$.*

Case A is the equilibrium in which D only has a credible threat to conduct discovery if she does not settle at all pre-discovery. Thus, she must make an initial offer that P will not accept given that P has filed suit. Any offer less than the filing cost achieves this end. This case is a knife-edged case in that any change in any one parameter will either cause condition 1 to fail (because now discovery is not optimal even D does not settle at all pre-discovery) or will move the equilibrium into either case B or C (because discovery is now optimal with at least a little settlement pre-discovery).

Case B occurs when, absent the credibility constraint, the optimal settlement offer, even if all P types file, exceeds the filing cost. This happens, for example, if the probability of a NEV plaintiff is quite small. In this case, in period 1 D offers either the optimal pre-discovery settlement amount ignoring the credibility constraint or the maximum settlement amount that satisfies this constraint, whichever is smaller. Since both exceed the filing cost, P files suit no matter what and if he has a weak claim, then he settles early, otherwise he settles after discovery for more than he could have gotten prior to discovery.

Case C occurs when the optimal pre-discovery settlement amount (ignoring the credibility constraint) would be less than the filing cost if all P types filed (say, because there are potentially a lot of NEV plaintiffs). Given this, however, all P types will not file since a NEV P would lose by

doing so. If no NEV types of P filed suit, however, then D would want to make a pre-discovery settlement offer that exceeds the filing cost, which would induce all types of P to file. To get an equilibrium, D makes a pre-discovery settlement offer of exactly the filing cost, so that NEV P are indifferent to filing or not. To ensure that this offer is optimal, NEV P file only if they are close enough to PEV so that making this offer is optimal. All NEV P accept this offer (here we mean NEV including the filing cost, after sinking the filing cost some of these types are no longer NEV). All PEV P reject and settle after discovery.

Notice that the credibility constraint on discovery determines the equilibrium in case A. In case B, the credibility constraint may also play a role depending on the relative sizes of $s_1{}^*$ and $\hat{s}_1$. In case C, the credibility constraint never binds because D's optimal settlement offer without it, $s_1 = c_0$, is small enough that (under Condition 1) she always wants to conduct discovery.

Notice that if we define a NEV suit prior to the filing decision as one in which $a < c_0 + k_P + c_P$, then the equilibrium in case A is one in which introducing discovery into the model completely eliminates the incentive to file an NEV suit. This case, however, is a very restrictive one. In case B, all NEV suits are filed but all are settled prior to discovery. The magnitude of the settlement, however, is likely substantially less than were discovery not possible both because discovery costs may be less than litigation costs and because the plaintiff's incentive to settle is greater since doing so involves saving both discovery and litigation costs. Furthermore, in some situations the settlement amount is further reduced by the credibility constraint. In case C, only the NEV claims that are closest to PEV are filed and these claims are settled simply at the filing cost.

IV. Comparative Statics

Proposition 2 describes generally how discovery affects the plaintiff's decision to file suit and the defendant's decision to settle prior to discovery when she is at an informational disadvantage or to incur discovery costs and settle when there is symmetric information. Practically, however, the impact of discovery depends not just on its availability but also on its cost. In this section, we describe how the probability of early settlement, that is, a settlement before discovery takes place, the probability of litigation, and the probability of filing suit are affected by filing costs, discovery costs, trial costs, and the stakes of the case. As the next proposition shows, the results depend crucially whether the discovery credibility constraint is binding (whether $s_1{}^* > \hat{s}_1$ or not) and on whether P files suit no matter what or only if $a > 0$ (whether we are in case B or case C of Proposition 2). If the credibility constraint is binding, then the comparative statics tend to be the opposite of what one would expect. The reason for this is that the amount of early settlement is limited by the need to make discovery credible. So, anything that tends to make discovery cheaper or more valuable allows D to settle with more types of P while still maintaining the credibility of the discovery threat. Case C of proposition 2 has different comparative statics from Case B because in case C the filing decision is subject to change when the parameters change. In Case B, everyone files, so small changes in the parameter values do not change the possible plaintiff types that the defendant might be facing in period 1.

Proposition 3. (A) Say $\hat{a}_2 > c_0 + k_P + c_P$ and $F(c_0 + k_P + c_P) < (c_D + c_P)f(c_0 + k_P + c_P)$.
(i)If $s_1{}^* < \hat{s}_1$, then the probability of settlement before discovery is increasing in the discovery costs of either P or D. The probability of settlement before discovery is decreasing in the stakes of the case. The probability of pre-discovery settlement is not affected by trial costs or filing costs.

(ii) If $s_1* > \hat{s}_1$, then the probability of settlement before discovery is decreasing in the discovery costs D. The probability of settlement before discovery is increasing the litigation costs of either P or D, and the stakes of the case. The probability of pre-discovery settlement is not affected by P's discovery costs or filing costs.
(B) Say $\hat{a}_2 > c_0 + k_P + c_P$ and $F(c_0 + k_P + c_P) \geq (c_D + c_P)f(c_0 + k_P + c_P)$. The ex ante probability of post-discovery settlement is decreasing in P's discovery, litigation costs, and filing costs but is increasing in the stakes of the case. It is not affected by D's discovery or litigation costs. The probability of P filing suit is decreasing in P's filing costs and P's litigation costs, but is increasing in D's discovery costs. It is not affected by D's litigation costs.

Proof. See Appendix.

Case (A) of Proposition 3 provides the comparative statics for the equilibrium described in case (B) of Proposition 2, and case (B) of Proposition 3 provides the comparative statics for case (C) of Proposition 2. Because case (A) of Proposition 2 applies only for one particular parameter configuration, any change in the values of the parameters will move the equilibrium from this case to either case (B) or (C).

Case (A) describes the comparative statics when the optimal pre-discovery settlement offer exceeds the plaintiff's filing costs. In this case, there are two contrasting set of comparative statics depending on whether the discovery credibility constraint is binding. If it is not binding, so that the optimal settlement offer is not affected by the need to make the threat of conducting discovery credible, then we obtain the more intuitive results that the larger are the discovery costs the more the defendant wants to obtain a settlement before either side incurs these costs. Thus, the probability of an early settlement increases. Similarly, if the stakes of the case increase, then discovery costs are relatively less important, so the probability of settlement pre-discovery declines. As long as filing costs are not so large as to move the equilibrium into case (C) of Proposition 2, filing costs do not affect the probability that the case settles before discovery. Litigation costs also do not affect this probability since even if there is no settlement prior to discovery, because discovery is perfect there will be settlement after discovery, though an increase in the plaintiff's litigation costs will reduce the settlement amount the defendant has to offer to maintain the same probability of pre-discovery settlement.

The comparative statics are almost exactly the opposite when the credibility constraint is binding. The reason is that what limits settlement in this case is that if there is too high a probability of settlement then the defendant has less incentive to conduct discovery if there is no pre-discovery settlement (because there is less uncertainty to be resolved). When settlement is limited by the credibility of the discovery threat, settlement then becomes more likely as parameters change to make discovery more desirable, thus allowing more discovery even as there is less uncertainty that it can resolve. So, if the defendant's discovery costs decline, then she can credibly threaten discovery for a higher probability of pre-discovery settlement. Similarly, because discovery guarantees settlement, and thus the saving of litigation costs (which the defendant captures in this model), higher litigation costs for either party increase the attractiveness of discovery and hence the probability of pre-discovery settlement. If the stakes of the case increase, then discovery is also more valuable, and this allows for a higher probability of an early settlement. The filing costs nor the plaintiff's discovery costs affect the probability of early settlement since neither affect the defendant's incentive to conduct discovery.

Case (B) describes the comparative statics when the optimal pre-discovery settlement is fixed at the filing cost, which is necessary to ensure that some, but not all, plaintiff types file. In this case, by Condition 1, the credibility constraint is never binding. Since in this case the filing decision is affected by the parameter changes, we focus on the effect not on the probability of early settlement but rather on the probability of late (post-discovery) settlement, and the probability of a suit being filed. The results for the probability of late settlement are similar, though not identical, to what they were in case (A)(i), in which the probability of late settlement was simply one minus the probability of early settlement (since all cases were filed and none are litigated). One difference is that in this case the plaintiff's filing and litigation costs both decrease the probability of a post-discovery settlement, whereas in case (A)(i) they had no affect on this outcome. The other difference is that the defendant's discovery costs do not affect the probability of a post-discovery settlement, whereas this probability was decreasing in the defendant's discovery costs in case (A)(i).

In case (B) the probability that the plaintiff files suit is also influenced by parameter changes. Since any suit that is not filed has its expected award as less than the filing, discovery, and litigation costs, it is necessarily a NEV suit. Thus, these results suggest, not surprisingly, that NEV suits are less likely to be filed if the filing cost increases, the defendant's discovery costs decrease, or as the plaintiff's litigation costs increase.

Also, notice that case (B) occurs if s_1^* would otherwise be below the c_0 if all plaintiff types filed. Thus, factors that tend to reduce the probability of a pre-discovery settlement in case (A)(i) also tend to push the equilibrium towards the comparative statics of case (B).

Proposition 3 also allows one to analyze the effect of discovery on P's payoff from suit. The following corollary provides the result.

Corollary 1. If discovery is cheaper than litigation ($c_P + c_D < k_P + k_D$), then if P would have settled if discovery were not possible, he obtains a strictly lower payoff if the defendant has the option to undertake discovery. If P would have gone to trial if discovery were not possible, then he obtains the same payoff through settlement after discovery as he would receive if discovery were not possible.
Proof. If there is no discovery, then the defendant will make a settlement offer of s_2^* implicitly defined by equation (+) in which $a_2 = a_1$ (because there is no initial settlement offer). If there is discovery, then the maximum pre-discovery settlement is s_1^* which is implicitly defined by (**). Notice that if $a_2 = a_1$, then we can write (+) as follows:

$$\frac{1}{(k_P + k_D)} = \frac{f(s_2^* + k_P)}{F(s_2^* + k_P) - F(a_1)}$$

And (**) can be written as:

$$\frac{1}{(c_P + c_D)} = \frac{f(s_1^* + k_P + c_P)}{F(s_1^* + k_P + c_P) - F(a_1)}$$

Since the left hand side of the first equation is smaller than the second and $\dfrac{f(x)}{F(x) - F(a_1)}$ is

decreasing in x by Condition 2, this means that $s_2^* > s_1^*$. Thus, if P would have accepted s_2^* were discovery not possible, then with discovery he either accepts s_1^*, so he gets less, or he settles after discovery for the same payoff he would have gotten had he gone to trial. This is also less than s_2^* by revealed preference (without discovery he prefers to settle for s_2^* than go to trial). If P would have

rejected s_2* were discovery not possible, then he gets his trial payoff, which is exactly the payoff he receives if he settles after discovery in a model with discovery. Q.E.D.

Corollary 1 demonstrates an important implication of discovery for the "problem" of NEV suits. Because discovery reduces the payoff to plaintiff types that would settle without discovery (this includes all NEV types), it mutes the incentives that a defendant has to avoid facing litigation from these types. To the extent that we are concerned that the threat of NEV suits is distorting primary behavior, this corollary suggests that discovery mitigates this problem.

One of the most surprising implications of Proposition 3 is that it raises the possibility of a non-monotonic effect of many of the parameters on the probability of a pre-discovery settlement.

Corollary 2. Under Condition 1, there exists a $\bar{c}_D(c_P, k_P, k_D)$ *such that both the probability of a pre-discovery settlement and the amount of this settlement is increasing in* c_D *if and only if* $c_D < \bar{c}_D(c_P, k_P, k_D)$.

Proof. If $c_D = 0$ then $s_1^* < \hat{s}_1$. For large enough c_D Condition 1 holds at equality and so $s_1^* > \hat{s}_1$. Proposition 3 shows that $\hat{a}_2$ (and thus $\hat{s}_1$) is decreasing in c_D while s_1^* is increasing in c_D. Hence, there is a unique c_D such that $s_1^* = \hat{s}_1$, call this $\bar{c}_D(c_P, k_P, k_D)$. For $c_D < \bar{c}_D(c_P, k_P, k_D)$, then, since $s_1^* < \hat{s}_1$, $s_1 = s_1^*$ which is increasing in c_D. If $c_D > \bar{c}_D(c_P, k_P, k_D)$, then $s_1 = \hat{s}_1$. Since $\hat{s}_1$ is increasing in $\hat{a}_2$, and $\hat{a}_2$ is decreasing in c_D, for $c_D > \bar{c}_D(c_P, k_P, k_D)$ s_1 is increasing in c_D. Q.E.D.

This corollary presents a surprising result concerning the relationship between discovery costs and pre-discovery settlements. When discovery is possible, undertaking discovery is valuable for the defendant because allows her to bargain under symmetric rather than asymmetric information. Thus, the only reason the defendant wants to settle prior to discovery, when she is at an informational disadvantage, is to save on discovery costs. One would expect, then, that the larger the discovery costs the greater the defendant's incentive to settle and hence the larger the pre-discovery settlement offer. This is true so long as discovery costs are low. Once discovery costs become large enough, however, that the constraint on the credibility of the defendant's discovery threat is binding, then the relationship between pre-discovery settlements and (the defendant's) discovery costs is reversed. In this situation, larger discovery costs undermine the defendant's threat to conduct discovery. To maintain the credibility of this threat, the value of discovery must increase, which requires greater uncertainty about the plaintiff's type in period 2. To ensure the value of discovery matches the greater cost, the defendant must settle with fewer plaintiff types in period 1, requiring a lower settlement offer. As discovery costs get very large, however, then the defendant will not want to undertake discovery even if there is maximal uncertainty about the plaintiff's type (Condition 1 does not hold). In this case, we have only pre-discovery settlements as in the simple screening model without discovery.

Not surprisingly, in many situations the credibility constraint can hurt the defendant. That is, she would be better off if she could commit to conducting discovery if the first settlement offer were rejected whether or not doing so turns out to be ex post optimal. More surprisingly, however, this lack of commitment also often hurts the plaintiff as well, as the next proposition shows.

Proposition 4. Under Conditions 1 and 2, if $\hat{a}_2 > c_0 + k_P + c_P$, then enabling the defendant to commit to undertake discovery in period 2 would result in a Pareto improvement. That is, both the defendant and all types of plaintiffs would be better off if the defendant could commit to discovery.

Proof.   If $\hat{a}_2 > c_0 + k_P + c_P$, then committing to discovery does not change P's filing decision. In this case, $L(s_1)$ in equation (*) is D's unconstrained loss function under the assumption that D always conducts discovery in period 2. If $s_1{}^* \leq \hat{s}_1$, then D does always conduct discovery in period 2, so allowing commitment has no effect on the outcome. If $s_1{}^* > \hat{s}_1$, then if D cannot commit to do discovery, then she offers $\hat{s}_1$ and still does discovery with probability one if the offer is reject. Hence, her loss is given by $L(\hat{s}_1)$. Notice that $s_1{}^*$ minimizes $L(s_1)$. So, if she could commit to discovery she could offer $s_1{}^*$ and reduce her loss from $L(\hat{s}_1)$ to $L(s_1{}^*)$.

Similarly, allowing D to commit to discovery either does not change s_1, in which case there is no effect on P since the equilibrium is unchanged (D does discovery anyway), or it allows D to increase s_1 from $\hat{s}_1$ to $s_1{}^*$ while still conducting discovery with probability one in period 2. This benefits all types of P that would accept the offer of $s_1{}^*$ and does change the payoff of all those types that reject. Q.E.D.

This result has its analogue in Nalebuff (1987). Allowing commitment removes a constraint upon D, so it makes her better off. It also benefits P because it enables D to make a higher settlement offer which can only benefit P. Interestingly, however, there is one case in which this commitment would not make D better off. If $\hat{a}_2 = c_0 + k_P + c_P$, the discovery credibility constraint can actually serve as a commitment device for D. Because the credibility constraint forces D not to make a settlement offer that exceeds the filing cost, if D were to commit to undertake discovery, she would not be able to commit to making such a low settlement offer that deters the filing of suit. This only happens if $\hat{a}_2 = c_0 + k_P + c_P$ because this is the only situation in which D must have no settlement to ensure the credibility of the discovery threat.

Notice, however, that D's expected costs are strictly lower in case (A) of Proposition 2 than in case (C). D conducts discovery and settles after doing so against the same set of P types, those with $a > c_0 + k_P + c_P$ or PEV types, in either case. But, in case (A), all NEV types do not file while in case (C) some fraction of them do and receive a settlement equal to their filing cost. Thus, we have proved the following proposition.

Proposition 5. If $F(c_0 + k_P + c_P) \geq (c_D + c_P)f(c_0 + k_P + c_P)$, then if D could commit not to settle prior to discovery, this would deter all NEV suits, make D strictly better off, and not change the payoff for all PEV suits.

This suggests that, at least in some circumstances, even better than committing to discovery is a commitment not to settle prior to discovery. Notice, however, that this operates only through deterring NEV plaintiffs from filing, so there is no post-filing mechanism that can achieve this objective. Furthermore, even if it were feasible to commit in this way prior to the filing of any particular case, it is not necessarily optimal for the defendant if $F(c_0 + k_P + c_P) < (c_D + c_P)f(c_0 + k_P + c_P)$. So, it is far from clear if enabling this commitment is

socially desirable, even if one assumes (as is not necessarily the case) that deterring NEV suits is necessarily desirable.

V. Conclusion

Discovery has an important qualitative and quantitative effect on the profitability of NEV suits. If discovery were impossible, one would predict both that NEV suits would be filed more often and receive larger settlement amounts than is the case when the defendant can conduct discovery to reduce or eliminate the plaintiff's informational advantage. While a defendant may still wish to make a pre-discovery screening offer to avoid discovery costs, this offer will be much lower than it would be were discovery impossible. This is because the cost of having this offer rejected is only the loss of the discovery costs, the benefit is that the defendant can now settle the case without substantial asymmetric information. Thus, the defendant is much more willing to risk rejection of a settlement offer when she can then conduct discovery and settle later than if rejection means she must go to trial. Furthermore, because the defendant must actually want to conduct discovery after her initial offer is rejected, she may even be forced to make a lower initial offer than she would otherwise want if she could commit to discovery. Lastly, because discovery is often substantially cheaper than going to trial, the defendant may only wish to make a positive settlement offer if the probability that a claim is NEV is not to large. This suggests that in equilibrium the fraction of NEV cases that are filed cannot be too large. If the initial fraction of NEV cases is great, then the pre-discovery settlement must be no larger than the filing cost so that plaintiff's with NEV cases do not file with probability one.   All of this suggests that while introducing discovery into a model of NEV suits does not eliminate such suits, it does greatly reduce the cost such suits impose upon defendants.

The paper also shows that the credibility of the discovery threat plays a crucial role in the settlement outcome. A defendant does not want to make a pre-discovery settlement offer that is too large because doing so undermines her discovery threat. If a large enough fraction of plaintiff types would accept a settlement offer, then the remaining uncertainty may not be sufficient to justify discovery by the defendant. Knowing this, low value plaintiffs may not accept the early settlement offer in hopes of getting a better offer later because the defendant has decided not to conduct discovery after all. To avoid this outcome, the defendant never makes such a high early settlement offer. When this constraint is binding, moreover, the comparative statics results are very different from when this constraint is not binding. In particular, we have shown that the defendant's discovery costs have a non-monotonic effect on the probability of an early settlement. If these costs are very low, then there is very little early settlement (making a NEV suit less attractive), but initially, as these costs increase the probability of an early settlement increases. Once the defendant's discovery costs get quite large, however, the credibility constraint binds. When this happens, further increases in discovery costs reduce the probability of an early settlement so that the remaining uncertainty after the initial settlement phase is large enough to justify discovery. If discovery costs are large enough, there may be no early settlement at all (in which case NEV suits are not profitable).

Lastly, our analysis sheds considerable light on the more general question of whether extensive discovery increases or decreases the overall cost of litigation. It is true that the discovery authorized by modern procedural systems can be very costly. On the other hand, the ability of defendants to better discriminate among claims both reduces the likelihood of trial by reducing informational asymmetries and reduces plaintiffs incentives to file suit by reducing the possibility of obtaining a positive settlement for a NEV claim. In these situations, and in situations in which settlement occurs prior to discovery, the costs of discovery are never actually incurred.

Appendix

Proof of Proposition 3. (A). (i) If $s_1* < \hat{s}_1$, then by $s_1 = s_1*$, so we use equation (**) to determine the comparative statics. We can rewrite (**) as follows:

$$\frac{f(s_1*+k_P+c_P)}{F(s_1*+k_P+c_P)-F(a_1)} = \frac{1}{c_D+c_P}$$

By Condition 2, we know that if either discovery costs increase (causing the right hand side to decrease) then $s_1*+k_P+c_P$ must increase. Thus, increasing either the plaintiff or defendant's discovery costs increases the probability of early settlement if we hold the filing decision constant, as we should since we are in case B of Proposition 2. Because neither k_P nor k_D nor c_0 affect the right hand side of this equation, neither affects the probability of early settlement, $s_1*+k_P+c_P$ must be constant if the right hand side is constant.

To examine the affect of changing the amount of the award, A (and we now interpret a as simply the probability the plaintiff receives A at trial), we can simply rewrite (**) as:

$$\frac{f(s_1*+k_P+c_P/A)}{F(s_1*+k_P+c_P/A)-F(a_1)} = \frac{A}{c_D+c_P}$$

Using the same argument as above, increasing A must cause the left hand side to increase, which, by Condition 2, means that $s_1*+k_P+c_P/A$ must decrease, which, holding a_1 constant, must decrease the probability of settlement.

If $s_1* > \hat{s}_1$, then $s_1 = \hat{s}_1$, thus the comparative statics are given by $\hat{a}_2$ which is implicitly determined by expression (++) when it holds at equality. If c_D increases, then the right hand side of (++) must increase. By lemma 3, this means that $\hat{a}_2$ must decrease. A decrease in $\hat{a}_2$ means a lower probability of settlement in period 1. Expression (++) does not depend on c_P, so it does not affect the settlement probability or amount in this case. Differentiating the right hand side of expression (++) with respect to k_P yields:

$$1 - F(\hat{a}_2) - (k_P+k_D)f(s_2*+k_P)$$

Using the first order condition for s_2* one can see that this is positive. Thus, increases in k_P require an increase in $\hat{a}_2$, thus increasing the probability of early settlement, to continue to satisfy (++) at equality.

Differentiating the right hand side of expression (++) with respect to k_D yields:

$$1 - F(s_2*+k_P) > 0$$

So, increasing k_D increase $\hat{a}_2$, increasing the probability of early settlement.

To determine the effect of the award, we can rewrite (++) in absolute terms as follows:

$$c_D = \frac{1}{1-F(a_2)}\{s_2*(\hat{a}_2)(F(s_2*(\hat{a}_2)+k_P/A)-F(\hat{a}_2))+\int_{s_2*(\hat{a}_2)+k_P/A}^{1}(aA+k_D)f(a)da - \int_{\hat{a}_2}^{1}(aA-k_P)f(a)da\}$$

Differentiating the curly bracket term on the right hand side with respect to A gives:

$$\frac{(k_D+k_P)(s_2*(\hat{a}_2)+k_P)f(s_2*(\hat{a}_2)+k_P/A)-A^2\int_{\hat{a}_2}^{s_2*(\hat{a}_2)+k_P/A}af(a)da}{A^2}$$

Using the first order condition for s_2*, we can write this as:

$$\frac{\int_{\hat{a}_2}^{s_2*(\hat{a}_2)+k_P/A}(s_2*(\hat{a}_2)+k_P-aA)f(a)da}{A}$$

This is positive, so increases in A increase the probability of early settlement.

(B).   In this case, s_1 is fixed at c_0, but the filing threshold is given by:

$$F(c_0 + k_P + c_P) - F(a_1*) = (c_D + c_P)f(c_0 + k_P + c_P)$$

Thus, an increase in c_D must decrease a_1*. This increases the probability of settlement, though it does not change the total amount of post-discovery settlement ($1 - F(c_0 + k_P + c_P)$), it only increases the probability that P files and settles as opposed to not filing at all. An increase in c_P or k_P decreases the total amount of post-discovery settlement since $c_0 + k_P + c_P$ increases. An increase in k_P decreases $\dfrac{f(c_0 + k_P + c_P)}{F(c_0 + k_P + c_P) - F(a_1)}$ for fixed a_1 (by Condition 2) without changing $c_D + c_P$, thus it must increase a_1*, resulting in a lower probability of filing suit. Because neither a_1* nor $c_0 + k_P + c_P$ is affected by k_D it does not affect either the probability of early settlement or the settlement amount. An increase in c_0 clearly increases $c_0 + k_P + c_P$, thus decreasing the probability of post-discovery settlement. By Condition 2, for fixed a_1 increasing c_0 decreases $\dfrac{f(c_0 + k_P + c_P)}{F(c_0 + k_P + c_P) - F(a_1)}$, thus it must increase a_1*.

  To examine the effect of the award amount, A, we rewrite the filing threshold condition in absolute terms as follows:

$$F(c_0 + k_P + c_P / A) - F(a_1*) = (\frac{c_D + c_P}{A})f(c_0 + k_P + c_P / A)$$

Increases A must increase the total amount of post-discovery settlement since this is given by $1 - F(c_0 + k_P + c_P / A)$. Q.E.D.

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