15 Settlement

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1. Introduction

This survey, which updates and expands upon an earlier *Encyclopedia* entry[1] on the modeling of pretrial settlement bargaining, organizes current main themes and recent developments.[2] The basic concepts used are outlined as core models and then several variations on these core models are discussed. As with much of law and economics, a catalog of even relatively recent research would rapidly be out of date. The focus here is on articles that emphasize formal models of settlement negotiation and the presentation is organized in game-theoretic terms, this now being the principal tool employed by analyses in this area. The discussion is aimed at the not-terribly-technical nonspecialist. In this survey some of the basic notions and assumptions of game theory are presented and applied, but some of the more recent models of settlement negotiation rely on relatively advanced techniques; in those cases, technical presentation will be minimal and intuition will be emphasized.[3]

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1 Daughety (2000).

2 There has now been a sequence of surveys in this area. An early review, in the context of a broader consideration of the economics of dispute resolution and the law, is Cooter and Rubinfeld (1989). Miller (1996) provides a non-technical review addressing policies that encourage settlement. Hay and Spier (1998) focus on settlement, while Spier (2007) addresses the broader area of litigation in general (for example, including models of courts). Finally, Daughety and Reinganum (2005) especially address multi-litigant settlement issues.

3 For the interested reader, a useful source on game theory applications in law and economics is Baird, Gertner and Picker (1994). Two quite readable books on game theory, modeling, and a number of related philosophical issues are Binmore (1992) and Kreps (1990). Finally, Chapters 7 through 9 of Mas-Colell, Whinston and Green (1995) provide the technically sophisticated reader with a convenient,

What is the basic image that emerges from the settlement bargaining literature? It is that settlement processes act as a type of screen, sorting amongst the cases, presumably causing the less severe (for example, those with lower true damages) to bargain to a resolution (or to do this very frequently), while the more severe (for example, those with higher damages) may proceed to be resolved in court. Furthermore, we now see that under some conditions the presence of multiple parties can readily cause bargaining to collapse, while under other conditions multiplicity can lead to increased incentives for cases to settle.

The fact that some cases go to trial is often viewed in much of this literature as an inefficiency. While this survey adopts this language, one might also view the real possibility of trial as necessary to the development of case law and as a useful demonstration of the potential costs associated with decisions made earlier about levels of care. In other words, the possibility of trials may lead to greater care and to more efficient choices overall. Moreover, the bargaining and settlement literatures have evolved in trying to explain the sources of negotiation breakdown: the literature has moved from explanations based fully on intransigence to explanations focused around information. This is not to assert that trials don't occur because of motives outside of game-theoretically-based economic analysis, just that economic attributes contribute to explaining an increasing share of observed behavior.

In the next few sections (comprising Part A), significant features of settlement models are discussed and some necessary notation is introduced; this part ends with a simplified example indicating how the pieces come together. Part B examines the basic models in use, varying the level of information that litigants have and the type of underlying bargaining stories that are being told. Part C considers a range of "variations" on the Part B models, again using the game-theoretic organization introduced in Part A.

A. BASIC ISSUES, NOTIONS AND NOTATION

2. Overview

In this part the important features of the various approaches are discussed and notation that is used throughout is introduced. Paralleling the presentation of the models to come, the current discussion is organized to

efficient and careful presentation of the basic techniques of modern (noncooperative) game theory, while Chapters 13 and 14 provide a careful review of the basics of information economics.

address: (1) players; (2) actions and strategies; (3) outcomes and payoffs; (4) timing; (5) information; and (6) prediction. A last section provides a brief example. Words or phrases in italics are terms of special interest.

3. Players

The primary participants (usually called *litigants* or *players*) are the plaintiff (P) and the defendant (D); a few models have allowed for multiple Ps or multiple Ds (see Section 15.3), but for now assume one of each. Secondary participants include attorneys for the two litigants (A_P and A_D, respectively), experts for the two participants (X_P and X_D, respectively) and the court (should the case go to trial), which is usually taken to be a judge or a jury (J). Most models restrict attention to P and D, either ignoring the others or relegating them to the background. As an example, a standard assumption when there is some uncertainty in the model (possibly about damages or liability, or both) is that, at court, J will learn the truth and make an award at the true value (that is, the award will be the actual damage and liability will be correctly established). Moreover, J is usually assumed to have no strategic interests at heart (unlike P, D, the As, and the Xs). Section 15.2 considers some efforts to incorporate J's decision process in a substantive way.

Finally, uncertainty enters the analysis whenever something relevant is not known by at least one player. Uncertainty also arises if one player knows something that another does not know, or if the players move simultaneously (for example, they simultaneously make proposals to each other). These issues will be dealt with in the sections on timing (6) and information (7), but sometimes such possibilities are incorporated by adding another "player" to the analysis, namely nature (N), a disinterested player whose actions influence the other players in the game via some probability rule.

4. Actions and Strategies

An *action* is something a player can choose to do when it is their turn to make a choice. For example, the most commonly modeled action for P or D involves making a *proposal*. This generally takes the form of a demand from P of D or an offer from D to P. This then leads to an opportunity for another action which is a *response* to the proposal, which usually takes the form of an acceptance or a rejection of a proposal, possibly followed by yet another action such as a *counterproposal*. Some models allow for multiple periods of proposal/response sequences of actions.

When a player has an opportunity to take an action, the rules of the game specify the allowable actions at each decision opportunity. Thus, in the previous example, the specification of allowed response actions did not include delay (delay will be discussed in Section 18). Actions chosen at one point may also limit future actions: if "good faith" bargaining is modeled as requiring that demands never increase over time,[4] then the set of actions possible when P makes a counterproposal to D's counterproposal may be limited by P's original proposal.

Other possible actions include choosing to employ attorneys or experts, initially choosing to file a suit or finally choosing to take the case to court should negotiations fail. Most analyses ignore these either by not allowing such choices or by assuming values for parameters that would make particular choices "obvious." For example, many analyses assume that the net expected value of pursuing a case to trial is positive, thereby making credible such a threat by P during the negotiation with D; this topic will be explored more fully in Section 16.1.

In general, a *strategy* for a player provides a complete listing of actions to be taken at each of the player's decision opportunities and is contingent on: (1) the observable actions taken by the other player(s) in the past; (2) actions taken by the player himself in the past; and (3) the information the player currently possesses. Thus, as an example, consider an analysis with no uncertainty about damages, liability, or what J will do, wherein P proposes, D responds with acceptance or a counterproposal, followed by P accepting the counterproposal or choosing to break off negotiations and go to court. A strategy for P would be of the form "propose an amount x; if D accepts, make the transfer and end, while if D counterproposes y, choose to accept this if y is at least z, otherwise proceed to court." P would then have a strategy for each possible x, y and z combination.

An analogy may be helpful here. One might think of a strategy as a book, with pages of the book corresponding to opportunities in the game for the book's owner to make a choice. Thus, a typical page says "if you are at this point in the book, take this action." This is not a book to be read from cover-to-cover, one page after the previous one; rather, actions taken by players lead other players to go to the appropriate page in their book to see what they do next. All the possible books (strategies) that a player might use form the player's personal library (the player's strategy set).

There are times when being predictable as to which book you will use is useful, but there can also be times when unpredictability is useful. A sports analogy from soccer would be to imagine yourself to be a goalie on the A team, and a member of the B team has been awarded the chance to make a shot on your goal. Assume that there is insufficient time for you to react fully to the kick, so you are going to have to move to the left or to the right as the kicker takes his shot. If it is known that, in such circumstances, you

4 See, for example, Ståhl (1972) and Schwartz and Wen (2007).

always go to your left, the kicker can take advantage of this predictability and improve his chance of making a successful shot. This is also sometimes true in settlement negotiations: if P knows the actual damages for which D is liable, but D only knows a possible range of damages, then D following a predictable policy of never going to court encourages P to make high claims. Alternatively, D following a predictable policy of always going to court no matter what P is willing to settle for may be overly costly to D. *Mixed strategies* try to address this problem of incorporating just the right amount of unpredictability and are used in some settlement models. Think of the individual books in a player's library as *pure* strategies (pure in the sense of being predictable) and think of choosing a book at random from the library, where by "at random" we mean that you have chosen a particular set of probability weights on the books in your library. In this sense, your chosen set of weights is now your strategy (choosing one book with probability one and everything else with probability zero gets us back to pure strategies). A list of strategies, with one for each player (that is, a selection of books from all the players' libraries), is called a *strategy profile*.

5. Outcomes and Payoffs

An *outcome* for a game is the result of a strategy profile being played. Thus, an outcome may involve a transfer from D to P reflecting a settlement or it might be a transfer ordered by a court or it might involve no transfer as P chooses not to pursue a case to trial. If the reputations of the parties are of interest, the outcome should also specify the status of that reputation. In plea bargaining models, which will be discussed in Section 17.4, the outcome might be a sentence to be served. In general, an outcome is a list (or vector) of relevant final attributes for each player in the game.

For each player, each outcome has an associated numerical value called the *payoff*, usually a monetary value. For example, a settlement is a transfer of money from D to P; for an A or an X the payoff might be a fee. For models that are concerned with risk preferences, the payoffs would be in terms of the utility of net wealth rather than in monetary terms. Payoffs that are strictly monetary (for example, the transfer itself) are viewed as reflecting risk-neutral behavior on the part of the player.

Payoffs need not equal expected awards, since parties to a litigation also incur various types of costs. The cost most often considered in settlement analyses is called a *court cost* (denoted here as k_P and k_D, respectively). An extensive literature has developed surrounding rules for allocating such costs to the litigants and the effect of various rules on the incentives to bring suit and the outcome of the settlement process; this is addressed in Section 17.2. Court costs are expenditures which will be incurred should the case go to trial and are associated with preparing for and conducting a trial; as such they are avoidable costs (in contrast with sunk costs) and therefore influence the decisions that the players (in particular P and D) make. Generally, costs incurred in negotiating are ignored, though some papers reviewed in Sections 11.2 and 18 emphasize the effect of negotiation costs on settlement offers and the length of the bargaining horizon. Unless specifically indicated, we assume that negotiation costs are zero. Finally, in Section 16.2, filing costs (that is, a cost incurred before negotiation begins) are considered.

The total payoff for a player labeled i (that is, i = P, D, . . .) is denoted πi. Note that this payoff can reflect long-term considerations (such as the value of a reputation or other anticipated future benefits) and multiple periods of negotiation. Generally, players in a game maximize their payoffs and thus, for example, P makes choices so as to maximize πP. For convenience, D's payoff is written as an expenditure (if D countersues, then D takes the role of a plaintiff in the countersuit) and thus D is taken to minimize πD (rather than to maximize $-\pi$D). While an alternative linguistic approach would be to refer to the numerical evaluation of D's outcome as a "cost" (which is then minimized, and thereby not use the word payoff with respect to D), the use of the term payoff for D's aggregate expenditure is employed so as to reserve the word cost for individual expenditures that each party must make.

Finally, since strategy profiles lead to outcomes which yield payoffs, this means that payoffs are determined by strategy profiles. Thus, if player i uses strategy s_i, and the strategy profile is denoted s (that is, s is the vector, or list $(s_1, s_2, \ldots, s_n)$, where there are n players), then we could write this dependence for player i as $\pi_i(s)$.

6. Timing

The sequence of play and the horizon over which negotiations occur are issues of timing and of time. For example: do P and D make simultaneous proposals or do they take turns? Does who goes first (or who goes when) influence the outcome? Do both make proposals or does only one? Can players choose to delay or accelerate negotiations? Are there multiple rounds of proposal/response behavior? Does any of this sort of detail matter in any substantive sense?

Early settlement models abstracted from any dynamic detail concerning the negotiation process. Such models were based on very general theoretical models of bargaining (which ignored bargaining detail and used desirable properties of any resulting bargain to characterize what it must be) initially developed by Nash (1950). More recent work on settlement negotiations, which usually provides a detailed specification of how bargaining is assumed to proceed (the strategies employed and the sequencing of bargaining play are specified), can be traced to results in the theoretical bargaining literature by Nash (1953), Ståhl (1972), and Rubinstein (1982). Nash's 1950 approach is called *axiomatic*, while the Ståhl/Rubinstein improvement on Nash's 1953 approach is called *strategic*; the two approaches are intimately related. Both approaches have generated vast literatures which have considered issues of interest to analyses of settlement bargaining; a brief discussion of the two approaches is provided in Sections 10 and 11 so as to place the settlement applications in a unified context. The discussion below also addresses the institutional features that make settlement modeling more than simply a direct application of bargaining theory.

When considered, time enters settlement analyses in two basic ways. First, do participants move simultaneously or sequentially? This is not limited to the question of whether or not P and D make choices at different points on the clock. More significant is whether or not moving second involves having observed what the first-mover did. Two players who make choices at different points in time, but who do not directly influence each other's choices (perhaps because the second-mover cannot observe or react to what the first-mover has done) are viewed as moving simultaneously: that my choice and your choice together influence what each of us receives as a payoff (symbolized in the payoff notation as $\pi_i(s)$ for player i) does not make moving at different points in time significant in and of itself. The real point here is whether all relevant decision-makers must conjecture what the others are likely to do, or whether some can observe what others actually *did*. This is because the second-mover is influenced by the first-mover's choice and because they *both* know this, the first-mover's choice is affected by his ability to influence the second-mover. Asymmetry in what choices depend upon (in this sense) is modeled as choices being made in a sequence; symmetry is modeled as choices being made simultaneously. As will be seen in the example to be discussed in Section 9, who moves when can make a very significant difference in what is predicted. Note that a sequence of simultaneous decisions is possible (for example, P and D both simultaneously make proposals and then both simultaneously respond to the proposals).

A second way that time enters is in terms of the length of the horizon over which decisions are made. The main stream of research in the strategic bargaining literature views the horizon as infinite in length; this is done to eliminate the effect of arbitrary end-of-horizon strategic behavior. Settlement models, on the other hand, typically take the negotiation horizon as finite in length (and often very short, say, two periods). This is done for two reasons. First, while some cases may seem to go on forever, some form of termination actually occurs (cases are dropped, or resolved through negotiation or meet a court date). While setting a court date is not an iron-clad commitment, few would argue that an infinite number of continuances is realistic. Second, in the more informationally complex models, this finite horizon restriction helps provide more precise predictions to be made than would otherwise be possible. Thus, in most settlement models there is a last opportunity to negotiate, after which either the case proceeds to trial or terminates (either because the last settlement proposal is accepted or the case is dropped). This is important because court costs are incurred only if the case actually proceeds to trial; that is, after the last possible point of negotiations. If negotiations were to continue during the trial, the ability to use the avoidance of these costs to achieve a settlement obviously is vitiated: as the trial proceeds, the portion of costs that is sunk becomes larger and the portion that is avoidable shrinks. This problem has not been addressed generally, though papers by Spier (1992), Bebchuk (1996), and Schwartz and Wicklegren (2009) consider significant parts of this issue; Spier is discussed in more detail in Section 18, while the other two articles are discussed in Section 16.2.

7. Information

In Shavell (1982), the range over which litigants might bargain when assessments about outcomes may be different is analyzed as a problem in decision theory (a game against nature, N); this raises the issue of who knows what, when, why and how. Shavell's paper indicated that differences in assessments by P and D as to the likelihood of success at trial, and the likely award, can lead to trial as an outcome. While Shavell's paper did not consider strategic interaction among the players (for the first paper to incorporate strategic behavior, see P'ng (1983)), the role of information has become a central theme in the literature that has developed since, with special emphasis on accounting for informational differences and consistent, rational behavior. Moving momentarily from theory to empirical analysis, Farber and White (1991) use data from a hospital to investigate whether seemingly asymmetrically distributed information influenced settlement rates and the speed with which cases settled; they find that it did.

Informational considerations involve what players individually know and what they must guess about (where such guessing presumably involves some form of organized approach). Many of the analyses in the literature use different informational structures (who knows what when) and in this survey a variety of such structures will be presented. As a starting example, consider Pat, who developed an improved framitz (a tool for making widgets). Pat took the tool to the Delta Company (D), with the notion that Delta would manufacture the tool and Pat would become rich from her share of the profits. Delta indicated that the tool was not likely to be financially viable and Pat went back to work on other inventions. Some years later Pat noticed that many people who made widgets were using a slightly modified version of her tool made by Delta. Pat (P) decided to sue Delta (D) for misappropriation of intellectual property, and for convenience assume that while D's liability is clear, the assessment of a level of compensation to P is less clear. D's familiarity with the profits made (and experience with creative accounting procedures) means that D has a better idea of what level of total profits might be proved in court. Both P's attorney and D's attorney have (potentially similar) estimates of what the court is likely to do with any particular evidence on the level of profits of the tool (how the court, J, might choose to allocate the costs and revenues of the tool to P and D). Simplifying, there are two sources of uncertainty operating here: uncertainty by P and D about J and uncertainty by P about what D knows.

First, both P and D cannot predict perfectly what J will choose as an award: here each faces an essentially similar level of uncertainty (there is no obvious reason to assert the presence of an asymmetry in what is knowable). Moreover, we will assume that this assessment of J's likely actions, while probabilistic, is *common knowledge*. Common knowledge connotes the notion that were P and D to honestly compare their assessments of J's likely actions for each possible set of details about the profits made by D, their assessments would be exactly the same, and P and D know that the other knows this, and P and D know that the other knows that the other knows this, and so on (see Aumann, 1976; Geanakoplos and Polemarchakis, 1982; and Binmore, 1992, for two early technical papers and a game theory text with an extensive prose discussion of common knowledge).

Thus, P and D have the same information with regard to J; we might call this *imperfect* or *symmetrically uncertain* information to contrast it with the clear asymmetry that exists between P and D with respect to the information about revenues and costs that D knows. This latter notion of uncertainty is referred to as *asymmetric* information, and it is a main attribute of much of the recent work on settlement. Finally, if actual damage was common knowledge and if P and D truly knew exactly what J would choose as an award and if that were common knowledge, the resulting information condition is called *perfect information*.

A nice story which makes the differences in informational settings clear is due to John Roberts of Stanford University. Consider a card game played by at least two people, such as poker. If all hands were dealt face up and no more cards were to be dealt, this would be a situation of perfect information. If, instead, hands are dealt with (say) three cards face up and two cards face down, but no one can look at their "down" cards, this is a setting of imperfect information. Finally, asymmetric information (also called *incomplete* information) would involve each player being able to look at their down cards privately before taking further actions (asking for alternative cards, betting, etc.). Note that in this last case we see the real essence of asymmetric information: it is not that one party is informationally disadvantaged when compared with the other (as in the case of Pat and Delta) as much as that the players have *different* information from each other.

One caution about the foregoing example. The perfect information case seems to be rather pointless: players without the best hand at the table would choose not to bet at all. Perfect information models are really not as trivial as this example might seem to suggest, since they clarify significantly what the essential elements of an analysis are and they provide a comparison point to evaluate how different informational uncertainties affect the efficiency of the predicted outcome.

Timing in the play of the game is also a potential source of imperfect information. If P and D make simultaneous proposals (which might be resolved by, say, averaging), then when they are each considering what proposal to make they must conjecture what the other might choose to propose: what each will do is not common knowledge. Even if all other information in the analysis were perfect, this timing of moves is a source of imperfect information.

The incorporation of informational considerations (especially asymmetric information) has considerably raised the ante in settlement modeling. Why? Is this simply a fad or an excuse for more technique? The answer is revealed in the discussion of the basic models and their variations. As indicated earlier, the problem with analyses that assumed perfect or imperfect information was that many interesting and significant phenomena were either attributed to irrational behavior or not addressed at all. For example, in some cases negotiations fail and a trial ensues, even though both parties may recognize that going to court is very costly; sometimes cases fail to settle quickly, or only settle when a deadline approaches. Moreover, agency problems between lawyers and clients, discovery, disclosure, various rules for allocating court costs or for admitting evidence have all been the subject of models using asymmetric information.

7.1 Modeling Uncertainty

Models with perfect information specify parameters of the problem with no uncertainty attached: liability is known, damages are known, what J will do is known, costs are known, and so on. Imperfect information models involve probability distributions associated with one or more elements of the analysis, but the probability distributions are common knowledge, and thus the occurrence of uncertainty in the model is symmetric. For example, damages are "unknown" means that all parties to the negotiation itself (all the players) use the same probability model to describe the likelihood of damage being found to actually have been a particular value. Thus, for example, if damage is assumed to take on the value d_L (L for low) with probability p and d_H (H for high) with probability $(1 - p)$, then the expected damage, $E(d) = pd_L + (1 - p)d_H$ is P's estimate $(E_P(d))$ as well as D's estimate $(E_D(d))$ of the damages that will be awarded in court. Usually, the court (J) is assumed to learn the "truth" should the case go to trial, so that the probability assessment by the players may be interpreted as a common assessment as to what the court will assert to be the damage level, possibly reflecting the availability and admissibility of evidence as well as the true level of damage incurred. Note that such models are not limited to accounting only for two possible events (for example, perhaps the damage could be any number between d_L and d_H); this is simply a straightforward extension of the probability model. On the other hand, since P and D agree about the returns and costs to trial, there is no rational basis for actually incurring them and the surplus generated by not going to trial can be allocated between the players as part of the bargain struck.

With asymmetric information, players have different information and thus have different probability assessments over relevant uncertain aspects of the game. Perhaps each player's court costs are unknown to the other player, perhaps damages are known to P but not to D, or the likelihood of being found liable is better known by D than by P. Possibly P and D have different estimates, for a variety of reasons, as to what J will do. All of these differences in information may influence model predictions, but the nature of the differences is itself something that must be common knowledge.

Consider yourself as one of the players in the version of the earlier card game where you can privately learn your down cards. Say you observe that you have an Ace of Spades and a King of Hearts as your two down cards. What can you do with this information? The answer is quite a bit. You know how many players there are and you can observe all the up cards. You can't observe the cards that have not been dealt, but you know how many of them there are. You also know the characteristics of the deck: four suits, 13 cards each, and no repeats. This means that given your down cards you could (at least theoretically) construct probability estimates of what the other players have and know what estimates they are constructing about what you have. This last point is extremely important, since for player A to predict what player B will do (so that A can compute

Table 15.1 Hands of cards for A and B

	UP	DOWN
A	4♠, K♦	K♥
B	Q♥, A♣	2♣

Note: Entries provide face value of card and suit.

what to do), A also needs to think from B's viewpoint, which includes predicting what B will predict about what A would do.

To understand this, let's continue with the card game and consider a simple, specific example (we will then return to the settlement model to indicate the use of asymmetric information in that setting). Assume that there are two players (A and B), a standard deck with 52 cards (jokers are excluded) and the game involves two cards dealt face up and one card dealt face down to each of A and B; only one down card is considered to simplify the presentation. Table 15.1 shows the cards that have been dealt face up (available for all to see) and face down (available only for the receiver of the cards, and us, to see).

By a player's *type* we mean their down cards (their private information), so A is a K♥-type while B is a 2♣-type, and only they know their own type. A knows that B is one of 47 possible types (A knows B can't be a K♥ or any of the up cards) and, for similar reasons, B knows that A is one of 47 possible types. Moreover, A's model of what type B can be (denoted p_A (t_B½t_A)) provides A with the probability of each possibility of B's type (denoted t_B) conditional (which is the meaning of the vertical line) on A's type (denoted t_A). The corresponding model for B that gives a probability of each possibility of A's type is denoted p_B (t_A½t_B).[5]

In the particular case at hand t_A = K♥, so once A knows his type (sees his down card) he can use p_A(t_B½K♥) to compute the possibilities about B's down card (type). But A actually could have worked out his strategy for each possible down card he might be dealt (and the possible up cards) *before* the game; his strategy would then be a function that would tell him what to do for each possible down-card/up-card combination he might be dealt in the game. Moreover, since he must also think about what B will do

[5] Note that all the probability models are formally also conditioned on all the up cards. For example, if we are especially careful we should write p_A(t_B½t_A, 4♠, K♦, Q♥, A♣) and p_B(t_A½t_B, 4♠, K♦, Q♥, A♣), which we suppress in the notation employed.

and B will not know A's down card (and thus must use p_A (t_B½t_A), where t_A takes on a number of possible values, as his probability model for what A will use about B's possible down cards), then this seemingly extra effort (that is, A working out a strategy for each possible type) isn't wasted, since A needs to do it anyway to model B modeling A's choices. What we just went through is what someone analyzing an asymmetric information game must do for every player.

Finally, for later use, observe that these two probability models are *consistent* in the sense that they come from the *same* overall model $p(t_A, t_B)$ which reflects common knowledge of the deck that was used. In other words, the foregoing conditional probabilities in the previous paragraph both come from the overall joint probability model $p(t_A, t_B)$, using the usual rules of probability for finding conditional probabilities.

So what does this mean for analyzing asymmetric information models of settlement? It means, for example, that if there is an element (or there are elements) about which there is incomplete information, then we think of that element as taking on different possible values (which are the types) and the players as having probability models about which possible value of the element is the true one. For example, if P knows the actual level of damages, then P has a probability model placing all the probability weight on that realized value. If D only knows that the level of damages is between d_L and d_H, then D's model covers all the possible levels of damage in that interval. The foregoing is an example of a *one-sided* asymmetric information model, wherein one player is privately informed about some element of the game and the other must use a probability model about the element's true value; who is informed and the probability assessment for the uninformed player is common knowledge. *Two-sided* asymmetric information models involve both players having private information about either the same element or about different elements. Thus, P and D may, individually, have private information about what an independent friend-of-the-court brief (still in preparation for submission at trial) may say, or P may know the level of damage and D may know whether the evidence indicates liability or not (two-sided asymmetric information analyses will be discussed further in Section 12.4).

7.2 Consistent versus Inconsistent Priors

The card game examples above, in common with much of the literature on asymmetric information settlement models, involve games with consistent priors. Some papers on settlement bargaining use "divergent expectations" to explain bargaining failure, and this may reflect "inconsistent" priors. In this section, we discuss what this means and how it can affect the analysis.

A game has *consistent priors* if each player's conditional probability distribution over the other player's type (or other players' types) comes from the same overall probability model. In the card game example with A and B, we observed that there was an overall model $p(t_A, t_B)$ which was common knowledge, and the individual conditional probability models $p_A(t_B\tfrac{1}{2}t_A)$ and $p_B\ (t_A\tfrac{1}{2}t_B)$ could have been found by using $p(t_A\tfrac{1}{2}t_B)$.[6] This was true because the makeup of the deck and the nature of the card-dealing process were common knowledge. What if, instead, the dealer (a stranger to both A and B) first looked at the cards before they were dealt and chose which ones to give to each player? Now the probability assessments are about the dealer, not the deck, and it is not obvious that A and B should agree about how to model the dealer. Perhaps if A and B had been brought up together, or if they have talked about how to model the dealer, we might conclude that the game would have consistent priors (though long-held rivalries or even simple conversations themselves can be opportunities for strategic behavior). However, if there is no underlying $p(t_A\tfrac{1}{2}t_B)$ that would yield $p_A(t_B\tfrac{1}{2}t_A)$ and $p_B(t_A\tfrac{1}{2}t_B)$ through the standard rules of probability, then this is a model employing *inconsistent priors*.

For example, if P and D each honestly believe they will win for sure, they must have inconsistent priors, because the joint probability of both winning is zero. While such beliefs might be held, they present a fundamental difficulty for using models which assert rational behavior: how can both players be rational, both be aware of each other's assessment, aware that the assessments fundamentally conflict, and not use this information to revise and refine their own estimates? The data of the game must be common knowledge, as is rationality (and more, as will be discussed in the next section), but entertaining conflicting assessments themselves is in conflict with rationality. Alternatively put, for the consistent application of rational choice, differences in assessments must reflect differences in private information, not differences in world views. Presented with the same information, conflicts in assessments would disappear.

To understand the problem, consider the following example taken from Binmore (1992, p. 477). Let A and B hold prior assessments about an uncertain event (an election). A believes that the Republican will win the election with probability 5/8 and the Democrat will win it with probability 3/8. B believes that the Democrat will win with probability 3/4 and the

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[6] To be more precise, let $p(t_A)$ be the sum of the $p(t_A, t_B)$ values over all possible values of tB and, similarly, let $p(t_B)$ be the sum of the $p(t_A, t_B)$ values over all possible values of t_A. Then $p_A(t_B\tfrac{1}{2}t_A) = p(t_A, t_B)/p(t_A)$ and $p_B(t_A\tfrac{1}{2}t_B) = p(t_A, t_B)/p(t_B)$.

Republican with 20 probability 1/4. Now if player C enters the picture, he can offer A the following bet: A wins $3 if the Republican wins and pays C $5 if the Democrat wins. C offers B the following bet: B wins $2 if the Democrat wins and pays C $6 if the Republican wins. Assume that A and B are risk-neutral, are well aware of each other's assessments, and stick to the foregoing probabilities and that C pays each of them a penny if they take the bets. Then both A and B will take the bets and for *any* probability of the actual outcome, C's expected profits are $2.98 ($3 less the two pennies). This is derisively called a "money pump" and works because of the inconsistent priors; that is, neither A nor B updates his assessment in response to the assessments that the other is using. In an analysis employing incentives and rational choice, introducing something inconsistent with rational behavior creates a problem in terms of the analysis of the model and the comparison of any results with those of other analyses.

How important consistent priors are to the analysis has been made especially clear in work on analyzing asymmetric information games. Starting from basic principles of rational decision-making, anyone making a choice about something unknown must make some assumptions about what characterizes the unknown thing (usually in the form of a probability distribution). To have two players playing an asymmetric information game means, essentially, that they are playing a family of games, one for each possible pair of types (that is, one game for each pair of possible players). But which one are they playing? This is solved by superimposing a probabilistic choice by Nature (N), where each game is played with the probability specified by the overall distribution over types (denoted earlier in the card examples as $p(t_A ½ t_B)$). If this distribution doesn't exist (that is, if priors are inconsistent), we can't do this and players are left not properly anticipating which game might be played. This transformation of something that is difficult to analyze (an asymmetric information game) into something that we know how to analyze (a game with imperfect information) won John Harsanyi a share (along with John Nash and Reinhard Selten) of the 1994 Nobel Prize (the original papers are Harsanyi, 1967, 1968a, and 1968b).

Thus, while players may hold different assessments over uncertain events, the notion of consistent priors limits the causes of the disagreement to differences in things like private information, and not to alternative modes of analysis; thus, players cannot paper over differences by "agreeing to disagree." It is through this door that a literature, initially spawned by dissatisfaction with the perfect (and imperfect) information prediction that cases always settle, has proceeded to explain a variety of observed behavior with asymmetric information models of settlement bargaining.

Inconsistent priors may occur because one or both players thinks that the other player is irrational, and such beliefs need not be irrational. Laboratory experiments (see Babcock et. al., 1995) have found seemingly inconsistent priors that arise from a "self-serving" bias reflecting anticipated opportunities by players in a settlement activity. Bar-Gill (2006) develops a model employing evolutionary game theory to explain why a bias towards optimism on the part of lawyers and their clients might persist: optimism acts as a credible commitment device that leads to more favorable settlement (in this case, by shifting the "settlement range" – that is, the range of feasible bargained outcomes). However, as with other inconsistent-priors models, while each litigant knows the other's assessment of winning at trial (and even knows the degree to which both assessments are incorrect relative to a "true" assessment), each litigant is incapable of using such information to adjust his own assessment.[7]

One last point before passing on to prediction. Shavell (1993) has observed that when parties seek nonmonetary relief and the bargaining involves an indivisible item, settlement negotiations may break down, even if probability assessments are the same. An example of such a case would be child custody in a state with sole custody laws. This survey restricts consideration to cases involving non-lumpy allocations.

8. Prediction

The main purpose of all of the settlement models is to make a prediction about the outcome of bargaining, and the general rule is the more precise the prediction the better. The main tool used to make predictions in the recent literature is the notion of *equilibrium*. This is because most of the recent work has relied upon the notion of *noncooperative* game theory, whereas earlier work implicitly or explicitly employed notions from *cooperative* game theory. The difference is that in a cooperative game, players (implicitly or explicitly) bind themselves *ex ante* to require that the solution to the game be efficient ("no money is left on the table"), while the equilibrium of a noncooperative game does not assume any exogenously enforced contractual agreement to be efficient, and may end up not being efficient. We consider these notions in turn (for a review of laboratory-based tests of bargaining models, see Roth, 1995).

8.1 Nash Equilibrium in Noncooperative Games

A strategy profile provides an equilibrium if no individual player can unilaterally change his part of the strategy profile and make himself better

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[7] We rejoin this topic when we consider "divergent expectations" as an alternative to asymmetric information in Section 13.2.

off; this notion of equilibrium is often called *Nash equilibrium* (after Nash, 1951), but its antecedents go far back in history. Using the notation introduced earlier, let s^* be an *equilibrium profile*; for convenience, assume the game has two players, named 1 and 2, so $s^* = (s_1^*, s_2^*)$ and s_1 and s_2 are any other strategies that Players 1 and 2, respectively, could use. Then Player 1 is prepared to stay with s_1^* if:

$$\pi_1(s_1^*, s_2^*) \geq \pi_1(s_1, s_2^*)$$

for every possible s_1 Player 1 could choose; that is, if Player 1 expects Player 2 to use strategy s_2^*, then Player 1 can do no better than to choose strategy s_1^*. Similarly, Player 2 is prepared to stay with s_2^* if:

$$\pi_2(s_1^*, s_2^*) \geq \pi_2(s_1^*, s_2)$$

for every possible s_2 Player 2 could choose. As stated earlier, in an equilibrium no player can unilaterally improve his payoff by changing his part of the equilibrium strategy profile.

Without generating more notation, the above conditions for a Nash equilibrium in a perfect information setting can be extended directly to the imperfect information setting. Here, the payoffs shown in the above inequalities are replaced by expected payoffs (the expectation reflecting the presence of uncertainty in one or more elements in the payoff function). Finally, in the case of asymmetric information, strategies and expectations are dependent upon type (and, if action takes place over time, on previous actions by other players which might provide some insight about those other players' types), and thus the equations must now hold for every player type and must reflect the individual player's conditional assessment about the other player(s). This last version is sometimes called a Bayesian Nash equilibrium to emphasize the role that the conditional probability distributions have in influencing the strategies that players use (for more detail, see Mas-Colell, Whinston and Green, 1995, Chapter 8 when agents move simultaneously and Chapter 9 for a discussion of equilibrium notions when agents move sequentially).

Note that in all the variations on the definition of Nash equilibrium, there is a reference to no individual choosing to "defect" from the strategy profile of interest. What about coalitions of players? Class action suits involve forming coalitions of plaintiffs, joint and several liability impacts coalitions of defendants and successful ("real world") bargaining strategy sometimes requires building or breaking coalitions (see Lax and Sebenius, 1986). Issues of coalitions have been of great interest to game theorists and equilibrium notions have been developed to account for coalition defection from a putative equilibrium strategy profile (see Binmore, 1985; Bernheim, Peleg and Whinston, 1987; Binmore, 1992; Greenberg, 1994; and Okada, 1996, for a small sample of work on this topic), but this is still an area of interest. We return to discuss coalition formation in class action suits in Section 15.3.

8.2 Cooperative Solutions

If two people are to divide a dollar between them (and both get nothing if they do not come to an agreement), then *any* allocation of the dollar such that each player gets more than zero is a Nash equilibrium, meaning that there is no predictive "bite" to our definition of equilibrium in this bargaining context (prediction improvements, called refinements, exist and often have considerable bite; more on this later). In yet another seminal contribution, Nash (1950) provided a remarkable result that still provides context, and a reference point, for many analyses (cooperative and non-cooperative) of bargaining. His approach was to focus on the outcome of the bargaining game and to ignore the details of the bargaining process entirely, thereby also skipping the notion of requiring an equilibrium as the prediction mechanism. He posed the question: what desirable properties (called axioms) should a bargaining solution possess in order that a problem have a *unique* prediction? As mentioned earlier, by *solution* we mean that, *ex ante*, the two players would be prepared to bind themselves to the outcome which the solution provides. This approach is presented in more detail in Section 10 and is called the *axiomatic approach*, while bargaining models based on the analysis in Section 8.1 are called the *strategic approach*.

Nash's axioms can be summarized as follows (see Binmore, 1992). First, the solution should not depend on how the players' utility scales are calibrated. This means that standard models of utility from decision theory may be employed (see, for example, Baird, Gertner and Picker, 1994). If payoffs are in monetary terms, this also means that players using different currencies could simply use an exchange rate to convert everything to one currency. Second, the solution should always be efficient. Third, if the players agree to one outcome when a second one is also feasible, then they never agree to the second one when the first one is feasible. Fourth, in a bargaining game with two identical players, both players get the same payoffs. The remarkable result is that whether the game is in utilities or money terms, the four axioms result in a *unique* solution (called the *Nash Bargaining Solution* or *NBS*) to the bargaining game. We return to this in Section 10.

There is a very important linkage between predictions using refinements of Nash equilibrium and predictions using a cooperative solution. One of the most remarkable and far-reaching results of game theory which emerged during the 1970 and 1980 has been the delineation of conditions under which the equilibria for properly structured noncooperative games would be (in the lingo, would *support*) solutions to properly related cooperative games. In our particular case, there are conditions on the data for the strategic approach which guarantee that the equilibrium predicted for that model is the NBS of the associated bargaining problem. In other words, under certain conditions, the noncooperative equilibrium is an efficient outcome and under further conditions it is a particular efficient outcome.

Since we've not explored the axiomatic or strategic approaches in detail yet, let us consider an example likely to be familiar to most readers: the classic model of the conflict between group and individual incentives captured in the "Prisoner's Dilemma" (see Baird, Gertner, and Picker, 1994). While the one-shot version of the Prisoner's Dilemma leads to inefficiency, a variety of noncooperative formulations (for example, involving repetition of the Prisoner's Dilemma) have been developed wherein individual choices of strategies lead to the socially optimal outcome (that is, efficiency). The same techniques have been applied in a variety of settings, including bargaining. Thus, we now have a better understanding of how institutions, incentives, and behavior may or may not substitute for artificially imposed binding agreements in achieving an efficient outcome. This also means that sources of inefficiencies ("money left on the table," and thus wasted), brought about by institutional constraints, incentives, and noncooperative behavior, can be better understood.

9. An Example of a Model of Settlement Negotiation

Before venturing into the section describing the range of settlement models, a brief example will help clarify the concepts raised above. Reconsider Pat and Delta's negotiation with the following further simplifications and some numerical values. First, assume that the only source of uncertainty is Delta's liability (that is, whether Delta will be held liable) and that Pat and Delta are symmetrically uninformed about this and adopt the same estimate of Delta's likelihood of being found liable. Damages are known by all, as are court costs. Moreover, there are no attorneys or experts and J will simply award the actual damages if Delta is found to be liable. Second, we will consider two simple bargaining stories.

(1) P makes a demand of D, followed by D accepting or rejecting the demand. Acceptance means a transfer from D to P; rejection means that J orders a transfer from D to P (the two transfers need not be the same) and both parties pay their court costs. Third, it is also common

knowledge that if D is indifferent between accepting the proposal and rejecting it, D will accept it.

(2) D makes an offer to P, followed by P accepting or rejecting the offer. Acceptance means a transfer from D to P; rejection means that J orders a transfer from D to P (again, the two transfers need not be the same) and both parties pay their court costs. Third, it is also common knowledge that if P is indifferent between accepting the proposal and rejecting it, P will accept it.

Let $d = 100$ be the level of damages and $\ell = 0.5$ be the likelihood of D being found liable by J for the damage d. Let court costs be the same for both players with $k_P = k_D = 10$. Note that the expected compensation ℓd exceeds the plaintiff's court cost k_P, so that should D reject P's demand in case (1), or offer too little in (2), it is still worth P's effort to go to trial. Note also that this ignores the possibility of bankruptcy of D. All of the above, that both players are rational (that is, P maximizes, and D minimizes, their respective payoffs) and the bargaining story being analyzed are common knowledge. One final bit of notation: let s be a settlement proposal.

9.1 Analyzing the Case Wherein P Makes a Demand

The first task is to find out if settlement is possible (the *admissible* settlements). We start with D, as P must anticipate D's choice when faced with P's demand. D and P know that if the case goes to trial, D will expend either $d + k_D$ or k_D (110 or 10), the first with probability ℓ and the second with probability $(1 - \ell)$; thus D's expected expenditure at trial (payoff from the outcome go to trial) is $\ell d + k_D$ (that is, 60). Note that in this circumstance, P's payoff from the outcome labelled trial is $\ell d - k_P$ (that is, 40). Thus, D will accept any settlement demand not exceeding this expected expenditure at trial if the following inequality holds:

$$s \le \ell d + k_D. \tag{15.1}$$

P wishes to maximize her payoff which depends upon P's demand and the choice made by D: $\pi_P = s_P$ if D accepts the demand s_P or $\pi_P = \ell d - k_P$ if D rejects the demand.

More carefully, using our earlier notation that the indicated payoff depends upon the strategy profile, we would have $\pi_P(s_P, \text{accept}) = s_P$; that is, the payoff to P from her using the strategy "make the settlement demand s_P" and D using the strategy "accept" is the transfer s_P. Similarly, we would have $\pi_P(s_P, \text{reject}) = \ell d - k_P$. In the rest of this example, we will suppress this notation when convenient, but understanding it will be of value later.

Observe that the maximum settlement demand that P can make ($s_P = \ell d + k_D$, as shown in inequality (15.1)) exceeds P's payoff from court. Thus, P maximizes the payoff *from the game* by choosing $\ell d + k_D$ as her settlement demand, which D accepts since D cannot do better by rejecting the proposal and facing trial. Thus, to summarize: (1) the players are P and D; (2) the action for P is the demand s_P (this is also P's strategy), while the action for D is to accept or reject and D's optimal strategy is to accept if s_P satisfies inequality (15.1) and to reject otherwise; (3) the outcomes are settlement and transfer with associated payoffs $\pi_P = s_P$ and $\pi_D = s_P$, or proceed to trial and transfer with associated payoffs $\pi_P = \ell d - k_P$ and $\pi_D = \ell d + k_D$; (4) the timing is that P makes a demand and D chooses accept or reject; (5) information is imperfect in a very simple way in that P and D share the same assessment about the trial outcome with respect to liability. Note that it is unnecessary to model a choice for P about going to court if her demand were rejected because of the assumption that the expected compensation exceeds plaintiff trial costs. Moreover, since nothing in the settlement phase will influence the trial outcome itself should trial occur, J is not a player in a meaningful sense. The prediction (the equilibrium) of this game is that the case settles, the resulting transfer from D to P is $\ell d - k_D$ (in the numerical example, 60) and the game payoffs are $\pi_P = \pi_D = \ell d - k_D$ (60).

9.2 Analyzing the Case Wherein D Makes an Offer

We now start with P in order to find the admissible settlements. Given the foregoing, P will accept any settlement offer that yields at least what she would get in court:

$$s \geq \ell d - k_P. \tag{15.2}$$

D wishes to minimize his payoff, which depends upon the offer he makes and the choice made by P: $\pi_D = s_D$ if P accepts the offer s_D or $\pi_D = \ell d + k_D$ if P rejects the offer. Thus D minimizes his payoff from the game by choosing $\ell d - k_P$ as his settlement offer, which P accepts since P cannot do better by rejecting the proposal and going to trial. Thus, to summarize: (1) the players are P and D; (2) the action for D is the offer s_D (this is also D's strategy), while the action for P is accept or reject and P's optimal strategy is to accept if sD satisfies inequality (15.2) and to reject otherwise; (3) the outcomes are settlement and transfer with associated payoffs $\pi_D = s_D$ and $\pi_P = s_D$, or proceed to trial and transfer with associated payoffs $\pi_D = \ell d + k_D$ and $\pi_P = \ell d - k_P$; (4) the timing is that D makes an offer and P chooses to accept or reject; (5) information is imperfect in the same way as in the first case. The prediction (the equilibrium) of this game is that the case settles, the resulting transfer from D to P is $\ell d - k_P$ (40) and the game payoffs are $\pi_P = \pi_D = \ell d - k_P$ (40).

9.3 Bargaining Range and Bargaining Efficiency

A clear implication of the foregoing analysis is that who moves last has a significant impact on the allocation of the surplus generated by not going to court. One could think of the process in the following way. D pays ℓd to P no matter what procedure is used. P and D then contribute their court costs to a fund (called surplus) which they then split in some fashion. If the bargaining process involves P making a demand and D choosing only to accept or reject, then P gets all the surplus. If the roles are reversed, so are the fortunes. This might suggest that the two cases studied provide the extremes (the *bargaining range* or *settlement range*) and that actual bargaining will yield something inside this range. The answer, we shall see, is maybe yes and maybe no. In the preceding analysis, bargaining was efficient (no cases went to trial; again the reader is cautioned to recall the earlier discussion of the use of the word "efficiency") since all information was symmetric and the first mover could make a take-it-or-leave-it proposal (cognizant of the second-mover's ability to go to trial). Efficiency will fail to hold when we allow for asymmetric information. This will occur not because of mistakes by players, but because of the recognition by both players that information which is distributed asymmetrically will impose a cost on the bargaining process, a cost that often falls on the better-informed party.

B. BASIC MODELS OF SETTLEMENT BARGAINING

10. Perfect and Imperfect Information Models: Axiomatic Models for the Cooperative Case

The perfect-information model (and its first cousin, the imperfect-information model), versions of which appear in Landes (1971), Gould (1973), and Posner (1973), is an important starting place as it focuses attention on efficient bargaining outcomes. Many of the earlier models employed risk aversion, which will be addressed in Section 17.1. For now, and so as to make the presentations consistent with much of the more recent literature, payoffs will be assumed to be in dollar terms with risk-neutral players.

10.1 Perfect Information

We start with the perfect-information version. In keeping with the earlier discussion, the following model emphasizes final outcomes and suppresses bargaining detail. While the analysis below may seem like analytical overkill, it will allow us to structure the problem for later, more complex, discussions in this part and in Part C.

The players are P and D; further, assume that the level of damages, d, is commonly known and that D is fully liable for these damages. Court costs are k_P and k_D, and each player is responsible for his own court costs. Each player has an individual action he can take that assures him a particular payoff. P can stop negotiating and go to court; thus the payoff to P from trial is $\pi_P^t = d - k_P$ (note the superscript t for trial) and the payoff to D from trial is $\pi_D^t = d + k_D$. Under the assumption that $d - k_P > 0$, P has a *credible threat* to go to trial if negotiations fail. For the purposes of most of this chapter (and most of the literature), we assume this condition to hold (the issue of it failing will be discussed in Section 16.1). By default, D can "assure" himself of the same payoff by stopping negotiations, since P will then presumably proceed to trial; no other payoff for D is guaranteed via his individual action. The pair (π_D^t, π_P^t) is called the *threat* or *disagreement point* for the bargaining game (recall that D's payoff is an expenditure).

What might they agree on? One way to capture the essence of the negotiation is to imagine both players on either side of a table, and that they actually place money on the table (abusing the card-game story from earlier, this is an "ante") in anticipation of finding a way of allocating it. This means that D places $d + k_D$ on the table and P places k_P on the table. The maximum at stake is the sum of the available resources, $d + k_P + k_D$, and therefore any outcome (which here is an allocation of the available resources) that does not exceed this amount is a possible settlement.

P's payoff, π_P, is his bargaining outcome allocation (b_P) minus his ante (that is, $\pi_P = b_P - k_P$). D's payoff, π_D, is his ante minus his bargaining outcome allocation (bD); thus D's *cost* (loss) is $\pi_D = d + k_D - b_D$. Since the joint bargaining outcome ($b_P + b_D$) cannot exceed the total resources to be allocated (the money on the table), $b_P + b_D \leq d + k_D + k_P$, or equivalently, P's gain cannot exceed D's loss: $\pi_P = b_P - k_P \leq d + k_D - b_D = \pi_D$. Thus, in payoff terms, the outcome of the overall bargaining game must satisfy: (1) $\pi_P \leq \pi_D$; (2) π_P ³ π_P^t and (3) $\pi_D \leq \pi_D^t$. That is, whatever is the outcome of bargaining, it must be feasible and individually rational. In bargaining outcome terms, this can be written as: (1′) $b_P + b_D \leq d + k_D + k_P$; (2′) $b_P \geq d$ and (3′) $b_D \geq 0$. For the figures that follow, we restate (2′) as $b_P - d$ ³ 0.

Figure 15.1(a) illustrates the settlement possibilities. The horizontal axis indicates the net gain ($-\pi_D$) or net loss (that is, total expenditure, π_D) to D. The vertical axis indicates the net gain (π_P) or net loss ($-\pi_P$) to P. The sloping line graphs points satisfying $\pi_P = \pi_D$ while the region to the left of it involves allocations such that $\pi_P < \pi_D$. The best that D could possibly

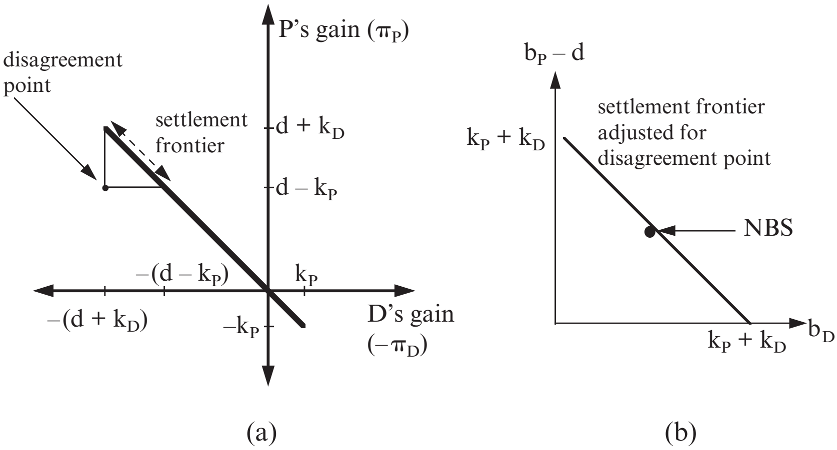

Figure 15.1 Settlement under perfect information

achieve is to recover his ante $d + k_D$ and get k_P, too; this is indicated at the right-hand lower-end of the line at the point (k_P, $-k_P$), meaning D has a net gain of k_P and P has a net loss of k_P. At the other extreme (the upper-left end point) is the outcome wherein P gets all of $d + k_P + k_D$, meaning P has a net gain of $d + k_D$, which is D's net loss.

Note also that points below the line represent inefficient allocations: this is what is meant by "money left on the table." The disagreement point ($-(d + k_D)$, $d - k_P$) draws attention (observe the thin lines) to a portion of the feasible set that contains allocations that satisfy inequalities (2) and (3) above: every allocation in this little triangle is individually rational for both players. The placement of the disagreement point reflects the assertion that there is something to bargain over; if the disagreement point were above the line $\pi_P = \pi_D$ then trial is unavoidable, since there would be no settlements that jointly satisfy (2) and (3) above. This triangular region, satisfying inequalities (1), (2) and (3), is the *settlement set* (or *bargaining set*) and the endpoints of the portion of the line $\pi_P = \pi_D$ that is in the settlement set are called the *concession limits*; between the concession limits (and including them) are all the efficient bargaining outcomes under settlement, called the *settlement frontier*. Another way that this frontier is referred to is that if there is something to bargain over (that is, the disagreement point is to the left of the line), then the portion of the line between the concession limits provides the *bargaining range* or the *settlement range*, which means that a range of offers by one party to the other can be deduced that will make at least one party better off, and no party worse off, than the disagreement point.

Figure 15.1(b) illustrates the settlement set as bargaining outcomes, found by subtracting the disagreement point from everything in the settlement set, so now the disagreement point is the origin. Doing this helps adjust the region of interest for asymmetries in the threats that P and D can employ. This leaves any remaining asymmetries in power or information in the resulting diagram. In the case at hand, the only power difference might appear in the difference between the costs of going to trial; other power differences such as differences in risk preferences or patience will be discussed in Section 17.1, while informational differences will be discussed in the sections on asymmetric information in Parts B and C.

Notice that, in view of (2′) and (3′), the vertical (non-negative) axis is labeled $b_P - d$, while the horizontal (non-negative) axis is labeled bD. Moreover, since aggregate trial costs determine the frontier in Figure 15.1(b), the bargaining problem here is symmetric. The Nash Bargaining Solution (NBS) applies in either picture, but its prediction is particularly obvious in Figure 15.1(b): recalling the discussion in Section 8.2, requiring the solution to be efficient (axiom 2) and that, when the problem is symmetric the solution is, too (axiom 4), means that splitting the saved court costs is the NBS in Figure 15.1(b). Thus, to find the NBS in Figure 15.1(a), we add the disagreement point *back into the solution from* Figure 15.1(*b*). Therefore, under the NBS, P's payoff is $\pi_P = d - k_P + (k_P + k_D)/2 = d + (k_D - k_P)/2$. D's net position is $-(d + k_D) + (k_P + k_D)/2$. In other words, D's payoff (his expenditure, π_D) is $\pi_D = d + (k_D - k_P)/2$. The result that players should "split the difference" *relative to the disagreement point* is always the NBS solution for any bargaining game with payoffs in monetary terms.

Observe that if court costs are the same, then at the NBS, P and D simply transfer the liability d (that is, $\pi_P = \pi_D = d + 0/2 = d$). If D's court costs exceed P's, P receives more from the settlement than the actual damages, reflecting his somewhat stronger relative bargaining position embodied in his threat with respect to the surplus that P and D can jointly generate by not going to court. A similar argument holds for P in the weaker position, with higher costs of going to court: he settles for less than d, since $k_D - k_P < 0$.

10.2 Imperfect Information

This is essentially the same model, so only the variations will be remarked upon. Assume that P and D have the same probability assessments for the two court costs and assume that they also have the same probability assessments over expected damages. This latter possibility could reflect that the level of damages is unknown (for example, as discussed in Section 7.1), but that liability is taken to be assured. Then they both see expected damages as E(d). Alternatively, perhaps damages are known to be d but liability is less clear but commonly assessed to be ℓ; that is, ℓ is the common assessment that D will be held liable for damages d and $(1 - \ell)$ is the common assessment that D will not be held liable at all. Then $E(d) = d\ell$ (an admitted but useful abuse of notation). Finally, if there are common elements influencing the values that d might take on and the likelihood of D being held liable, and if the assessments of the possible values and their joint likelihood is common knowledge, then again we will write the expected damages from trial as E(d). Again, this is abusing the notation, but avoids needless technical distinctions. The point is that in an imperfect information setting, we simply take the preceding analysis and replace all known parameters with their suitably constructed expectations, yielding the same qualitative results: no trials occur in equilibrium, strong plaintiffs (that is, those with lower trial costs than D) settle for somewhat more than their expected damages, and so forth.

10.3 Other Axiomatic Solutions, with an Example Drawn from Bankruptcy

Nash's solution to the bargaining problem inspired an enormous scholarly literature (actually, a veritable cottage industry of variations, alterations, and modifications) that continues to this day. In this section, we will discuss one of the alternative bargaining solutions and why it may be particularly relevant for some problems in law and economics research. To do this observe that in the foregoing material, once we adjusted for the disagreement point, the litigants appeared to be otherwise symmetric (see Figure 15.1(b)).

Now consider the following bargaining scenario. Two investors, A and B, have invested (respectively) I_A and I_B in a firm that has now gone bankrupt; that is, the (liquidated) value of the firm, V, is less than $I_A + I_B$, so the only issue is what shares of V should be allocated to A and to B. For the case at hand, also assume that V is larger than either standalone investment (that is, $V > \max[I_A, I_B]$) so that we can readily locate the settlement set in a diagram. Also, let the disagreement point be that both investors walk away with nothing if there is no agreement, and there are no costs of bargaining. Figure 15.2(a) illustrates the NBS when we ignore the size of the investments; here the problem is simply to allocate V between the two bargainers, so the NBS is where the 45º line from the origin crosses the frontier. Figure 15.2(b) now illustrates the incorporation of the original investments into the diagram, and reflects the intuitive constraint that no agent recovers more than what he invested when the value of the firm is less than the aggregate initial investment (or otherwise there may be moral hazard problems if an investor can influence the likelihood

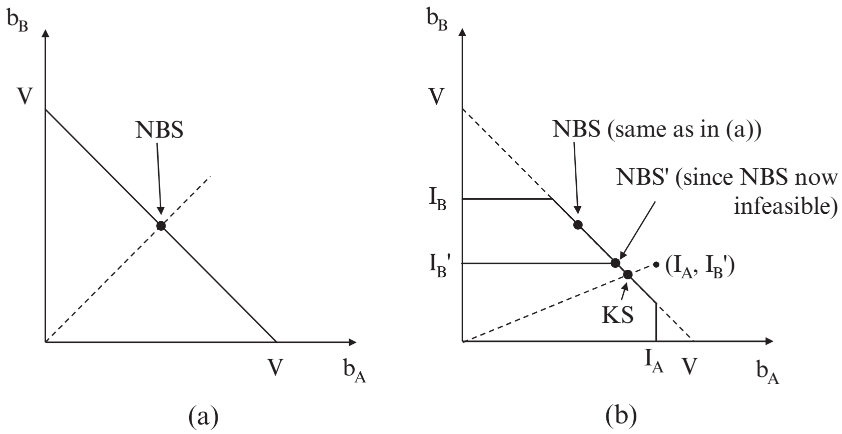

Figure 15.2 Alternative bargaining solutions under bankruptcy

of a bankruptcy). The bargaining set is more rectangular than in Figure 15.2(a), except that the downward-sloping line cuts off the upper corner of the set of possible bargains; this occurs because $V < I_A + I_B$. Alternatively, this settlement set is the same as Figure 15.2(a) except that two triangular sections have been cut off, one above I_B and one to the right of I_A.

From our earlier discussion of the NBS in Section 8.2 we know from Nash's third axiom ("Third, if the players agree to one outcome when a second one is also feasible, then they never agree to the second one when the first one is feasible.") that since the "chopping-off" of the two triangular regions did not cut away the original solution, it is still the solution to the bargaining problem. Notice this solution might be objectionable to A: as drawn, A has invested more than B, but B continues to get the same amount as in Figure 15.2(a). Let us take this one step further: if B's original investment is at I_B', we see in Figure 15.2(b) that now the original NBS is no longer feasible. It can be shown that the new solution is at the point indicated as NBSN.[8] This outcome seems even more unsatisfactory: B's recovery is now equal to his initial investment and A gets the residual ($b_A = V - I_B'$), even though A invested considerably more than B did. This is problematical because, when A and B are initially considering making investments in the firm, if the agreement made then is to use the NBS to resolve liquidation of the enterprise should that ever become

[8] The NBS is found by solving max $b_A b_B$ subject to $b_A + b_B \leq V$, $0 \leq b_A \leq I_A$, $0 \leq b_B \leq I_B$.

necessary, both investors now may choose to reduce the initial investments each makes, since using the NBS appears to be biased towards repaying the smaller investor and leaving the larger investor to simply pick up the residual.

The problem here is that both concession limits do not directly affect the bargaining solution, but one might think that they should.[9] In our earlier analysis (where the settlement set was a triangle, such as in Figure 15.1), this did not matter, but in the bankruptcy problem it clearly does. Kalai and Smorodinsky (1975) proposed a bargaining solution which employed an alternative to the third axiom, replacing it with one that makes both concession limits matter. Their axiom, which argues that a monotonic improvement in one bargainer's possible options without reducing the second bargainer's options should never work against the first bargainer, means that the "KS" solution is found by constructing the smallest rectangle that contains the settlement set (this smallest rectangle is obviously driven by the concession limits) and then finding the outcome where the upward-sloping diagonal of the rectangle (in Figure 15.2(b), this is the line joining the origin and the point (I_A, I_B')) crosses the downward-sloping frontier. When the settlement set resembles a triangle, as in Figure 15.1, then the KS solution and the NBS are the same. In the case of our bankruptcy example with the "trimmed brick," however, the KS solution will always end up in the interior of the downward-sloping frontier (that is, on the face of the trimmed side of the brick), so that each party is treated (qualitatively) similarly in that each receives a fractional share of their investment back, and not all of it.

The KS solution is but one of an enormous number of alternative bargaining solutions that have been proposed as scholars have examined different axioms, or modifications of different axioms.[10] Thus, the "bottom line" here is that some caution is needed before simply proceeding with any particular model of settlement bargaining; other solutions besides the NBS may be more appropriate. We'll see another caution about the use of the NBS in Section 12.

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[9] It is worth noting that this is not the only objection some scholars have raised to this axiom, but discussion of the other objections is likely to lead us too far afield.

[10] For example, relaxing the symmetry axiom (the fourth axiom above) wherein identical players should be treated identically, gives a generalized NBS that allows for other differences in bargaining power besides those we have considered. An example of such a difference that might otherwise be difficult to include in the analysis is if one bargainer is more patient than the other bargainer.

11. Perfect and Imperfect Information Models: Strategic Models for the Noncooperative Case

Again, we start with the perfect information case. Furthermore, since the actual bargaining procedure is to be specified, the length of the bargaining horizon now enters into the analysis. The generic style of the models to be considered is that one player makes a proposal followed by the other player choosing to accept or reject the proposal. Concatenating as many of these simple proposal/response sequences as we choose provides the basic story.

Some questions, however, remain. First, is the proposer the same player each time? In general, we will assume that if there is more than one round of proposal/response, then proposers alternate (an important exception is Spier, 1992, where the plaintiff always proposes; this will be discussed in Section 18). If there is more than one round, the next proposal is often thought of as a counterproposal to the one before it.

Second, how many periods of proposal/response will there be? This turns out to be a very significant question. Recall that in the cooperative model P and D were committed to finding an efficient bargaining outcome. Here, no such commitment is made; instead, we want to know when noncooperative bargaining will be efficient. However, certain types of commitments in strategic models still may occur. The reason this is of interest is that commitment generally provides some power to the player who can make a commitment. For example, if there is one round of proposal/response, then the proposer has the ability to make an all-or-nothing proposal (more carefully put, all-or-court proposal). As was seen in the examples in Section 9, this led to a settlement that was efficient but rather one-sided. In particular, the proposer was able to achieve the point on the settlement frontier that is the responder's concession limit. This is a reflection of the commitment power that the proposer enjoys of *not* responding to any counterproposals that the responder might desire to make: these are ruled out by the structure of the game analyzed when there is only one round of play. This is why this game is often referred to as an *ultimatum game*. A *random proposer game* is simply a random choice as to which ultimatum game is played. Ultimatum games form the basis for many of the asymmetric information settlement analyses we shall examine, and some papers proceed to then consider a random proposer game as a means of suggesting whether the overall analysis is likely to be robust to choice of proposer.

Almost at the other end of the spectrum of theoretical bargaining analyses is the Rubinstein infinite-horizon model (Rubinstein, 1982). In this model, an infinite number of rounds of proposal/response occur wherein the proposer's identity alternates. In the settlement setting, each round allows P to choose to break off negotiations and go to trial. Here there are two somewhat more subtle forms of commitment in place of the power to make all-or-nothing proposals. First, if there is a positive interval of time between one round and the next, and if "time is money," meaning (for example) that costs are accruing (perhaps experts are being kept available, or lawyers are accruing time), then the fact that during a round only one proposal is being considered (the proposer's) provides some power to the proposer.

Second, who goes first is still significant. Rubinstein considers a simple "shrinking pie" example wherein each player discounts money received in the future relative to money received now. This encourages both players to want to settle sooner rather than later (all else equal). Thus, delay here yields inefficiency. Rubinstein uses a notion of Nash equilibrium that incorporates the dynamics of the bargaining process (this extra property of equilibrium is called *sequential rationality*, which will be discussed in more detail in Section 11.1) which results in a unique prediction for the bargaining game. In particular, in equilibrium there is no delay and (if both players are identical) the player who goes first gets more than half of the amount at stake.

Models that shrink the time interval associated with each round find that both sources of power go away as the time interval between proposals becomes vanishingly small. Note that, even with positive intervals, the effect of commitment (in this case, a short-run commitment to a proposal) is not as strong as in the ultimatum game, since counterproposals can occur and players generally cannot bind themselves to previous proposals they've made. In other words, such infinite horizon models can generate efficient settlement at points on the frontier other than the concession limits. In fact, under certain conditions these analyses predict the NBS (or some variant) as the unique equilibrium of the strategic bargaining game. Note that the fact that a strategic model employs perfect information does not guarantee that the predicted outcome is efficient. A particularly striking example of this is contained in Fernandez and Glazer (1991), who consider wage negotiations between a union and a firm under perfect information and yet obtain inefficient equilibria. The source of the inefficiency is a pre-existing wage contract. In Section 15.3, we will see that settlement bargaining with multiple litigants can also give rise to inefficient equilibria, even though information is complete.

Another difference between settlement applications and the general literature on bargaining concerns the incentive to settle as soon as possible, all else equal. Generally, in the settlement context, P wants to settle sooner but D wants to settle later. While countervailing pressures, such as costs that increase with time, may encourage D to settle as early as possible, the fact that payment delayed is generally preferred by the payor (due to the time value of money) means that D's overall incentives to settle soon can be mixed and delay may be optimal. Moreover, as observed in Spier (1992), unlike the Rubinstein model, if both P and D have the same discount rate, then the pie itself is *not* shrinking (assuming no other costs of bargaining). This is because the effect of the opposed interests and the same discount rates is to cancel out. Therefore, in a multiperiod settlement model, delay due to the time value of money does not, in and of itself, imply inefficiency. We will return to this shortly.

Finally, a yet further difference between settlement bargaining and many traditional models of bargaining between participants in a market is called the "common value" or "interdependent value" attribute of settlement bargaining.[11] In a traditional market-transaction model involving bargaining between a buyer and a seller, if bargaining fails for one reason or another, usually the buyer and the seller part ways, so that the only term of interest in the model of bargaining is the expected value of the transaction. In settlement bargaining, this term appears as the expected settlement value, but there is generally a second term which is what happens when settlement negotiations fail, namely trial. Thus, unlike the traditional market transaction model, in a settlement model there is a term that links the expected payoffs of the litigants (the expected transfer via trial). This plays a central role, as well, in the discussion of multiple litigants in Section 15.3.

11.1 Sequential Rationality

Note that in much of the preceding discussion an implicit notion was that a player's strategy anticipates future play in the game. A strategy is *sequentially rational* if it is constructed so that the player takes an *optimal* action at each possible decision opportunity that the player has in the future. Earlier, in the discussion of the disagreement point, sequential rationality was used by P. The threat to go to trial if bargaining failed to provide a payoff at least as great as what could be obtained at trial was sequentially rational: it was a credible threat because if P got to that point, he would choose to fulfill the threat he had made. Applying sequential rationality to the strategies players use, and to the analysis players make of what strategies *other* players might use, means that strategies based on threats that a rational player would not carry out (incredible threats) are

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[11] For discussions of interdependent values of bargainers in a market transactions setting, see Vincent (1989) and, more recently, Deneckere and Liang (2006).

ruled out. Many of the improvements in making predictions for asymmetric information models that have occurred over the last 25 years have involved employing sequential rationality, generally in conjunction with further amplifications of what rational behavior implies. Rubinstein finds a unique prediction in the infinite-horizon alternating offers game (for short, the Rubinstein game) because he predicts Nash equilibria which enforce sequential rationality (called *subgame perfect equilibrium*; for a discussion of some applications of subgame perfection in law and economics, see Baird, Gertner and Picker, 1994). In the Rubinstein game, even though the horizon is infinite, the (sequentially rational) Nash equilibrium is a unique, specific, efficient bargaining allocation which is proposed and accepted in the first round. Thus, efficiency (both in terms of fully allocating what is available to bargain over as well as doing it without delay) is a *result*, not an assumption.

11.2 Settlement Using Strategic Bargaining Models in the Perfect Information Case

The discussion in Section 9 provides the details of the ultimatum game version of settlement. Since that application technically involved imperfect information (the assessment about liability), a careful treatment means that we would take $\ell = 1$, yielding the payoffs for the ultimatum model with P as proposer (the P-proposer ultimatum model) to be $\pi_P = \pi_D = d + k_D$, while the D-proposer ultimatum model's payoffs would be $\pi_P = \pi_D = d - k_P$. The rest of this section is therefore devoted to the analysis in the infinite horizon case.

The tradeoff between D's natural interest to delay payment and any incentives to settle early (in particular, P's credible threat to go to court and any negotiation costs borne by D) is explored in the settlement context in Wang, Kim and Yi (1994); they also consider an asymmetric information case which will be discussed in Section 12.4. In the perfect information analysis, D proposes in the first round, but is subject in each round to an additional cost, c, which reflects per period negotiating costs but is charged *only* if the negotiations proceed to the next period. One could include a cost of this sort for P, too, but it is the difference between P's and D's negotiating costs that matters, so letting P's cost be zero is not a meaningful limitation.

Let δ (a fraction between zero and one) be the common discount rate used by the players for evaluating and comparing money flows at different points in time; that is, a player is indifferent between receiving \$1 next period and \$$\delta$ this period. Note that this effect could be undone if, at trial, damages were awarded with interest from the date of filing the suit; this does not occur in their model. Wang, Kim and Yi show that if $\delta c/(1 - \delta_2)$

$> d - k_P$, then the unique subgame perfect equilibrium is for D to offer $\delta^2c/(1 - \delta^2)$ to P; if instead $\delta c/(1 - \delta^2) < d - k_P$, then the unique subgame perfect equilibrium involves D offering $\delta(d - k_P)$ to P. For a careful proof of this, see Wang, Kim and Yi (1994); for our purposes, let us use some crude intuition (sweeping all sorts of technical details under the rug) to understand this result.

To see what is going on, consider D's viewpoint and think about three time periods. If s is what D would offer at time period three, then P knows that he can demand $\delta s + \delta c$ at period two ($\delta s + \delta c$ is what it will cost D to wait and make the offer s in period three). P will prefer this to going to trial if $\delta s + \delta c > d - k_P$. Thus, in period one, the maximum D must offer is $\delta(\delta s + \delta c)$. Since periods one and three look the same (that is, the three-period sequence repeats out to infinity in this model), s is the solution to $\delta(\delta s + \delta c) = s$; solving for s yields $s = \delta^2c/(1 - \delta^2)$. In this sense, $\delta c/(1 - \delta^2) > d - k_P$ really is a statement that the cost of delay is high from D's viewpoint, which is why D must offer something higher than the discounted value of going to trial, that is, $\delta(d - k_P)$.

Even if costs are low (that is, $\delta c/(1 - \delta^2) < d - k_P$), D must still worry about P's choice of going to court, but P can no longer exploit D's cost weakness to further improve the bargain in his favor. Thus, D can offer the discounted value of P's concession limit, namely $\delta(d - k_P)$, since P cannot choose to go to court until next period and therefore might as well accept $\delta(d - k_P)$ now.

To summarize, the players are P and D, actions in each period involve proposals followed by accept/reject from the other player, with P able to choose to go to court when it is his turn to propose. Payoffs are as usual with the added provisos concerning the discount rate δ reflecting the time value of money, and the per period cost c, for the defendant, which is incurred each time negotiators fail to agree. The bargaining horizon is infinite and information is perfect. The result is that: (1) P and D settle in the first period; (2) the prediction is unique and efficient; (3) if negotiation costs are sufficiently high, then the prediction is on the settlement frontier, between the discounted values of the concession limits and (4) otherwise it is at the discounted value of P's concession limit, reflecting the fact that D moved first.

11.3 The Imperfect Information Case

The extension of the ultimatum game results of Section 9 to the imperfect information case parallels the discussion in Section 10.2. This is similarly true for the multiperiod case, which is why this issue has not received much attention.

12. Analyses Allowing for Differences in Player Assessments due to Private Information

In this section, we consider models that account for differences in the players' assessments about items such as damages and liability based on the private information players possess when they bargain. We focus especially on two models: one developed by Bebchuk (1984) and one developed by Reinganum and Wilde (1986). Most of the analyses in the current literature are based on one of these two primary settlement models, both of which analyze ultimatum games and both of which assume one-sided asymmetric information; that is, there is an aspect of the game (typically a variable such as damages or liability, though it could also be the product of damages and the likelihood of being found liable) about which P and D have different information, and only one of the players knows the true value of the variable during bargaining. Since the model structure is so specific (the ultimatum game) and the distribution of information is so one-sided, we also consider what models with somewhat greater generality suggest about the reasonableness of the two prime workhorses of the current settlement literature. For a survey of asymmetric information bargaining theory, see Kennan and Wilson (1993).[12]

Before proceeding, however, one might wonder why we do not seem to consider the Nash Bargaining Solution as a means for solving the asymmetric information settlement games of interest. The most direct answer is to think back to the second of the four axioms (see Section 8.2): the bargaining solution should be efficient. When information is incomplete, efficiency is not possible to guarantee without the intervention of an all-knowing third party. Perhaps a court could fulfill this role, but the whole point of settlement negotiation is to reduce the likelihood of going to court. Perhaps we could expect the two litigants to exchange information, but if one of them relies on the honesty of the exchange, it does not strain credulity to believe that the other might take strategic advantage of this. Thus, while information can be exchanged, this is usually a costly discovery process, and discovery itself is likely to be an incomplete, or at least strategically manipulable, process that is costly to employ. In other words, even if an informed party would like to communicate some information to the other party, he can't in general do this costlessly and the presence of a disclosure cost means that some information will not be disclosed. Lack of complete disclosure, in turn, means that efficiency cannot be assured; money may be left on the table. In the context of labor-management relations, this means a

[12] For a discussion of the settlement frontier under inconsistent priors, see Chung (1996).

strike may occur even though it turns out that it would have been advantageous to all involved to achieve an agreement rather than weather a strike. Similarly in settlement bargaining, it may be necessary to engage in costly actions (intense discovery and deposition of experts, and possibly trial) due to the incompleteness of information and the inability of the parties involved to costlessly and credibly exchange the information that would be needed to be efficient. Thus, our analysis must allow for an inefficient outcome, so the approach used is via strategic, rather than axiomatic, analysis. Therefore, cooperative solutions, such as the NBS or KS solutions, will not address a primary problem associated with asymmetric information bargaining, namely inefficient outcomes wherein bargaining fails even though a surplus might exist to share. While the cooperative solutions have an appealing attribute, sharing the surplus, the strategic approach will focus on analyzing ultimatum games with take-it-or-leave-it offers. In view of this, some papers have tried to address this extreme analysis via the use of random proposer models that incorporate the polar-opposite ultimatum games, with the intuitive argument that if the two ultimatum games share similar qualitative results, then whatever bargaining process would actually occur is likely to also share those qualitative aspects.

12.1 Yet More Needed Language and Concepts: Screening, Signaling, Revealing and Pooling

Reaching back to Section 7, a one-sided information model is like a card game where only one player has a down card and knows the value of that card. That player is privately informed and, because of consistent priors, both players know that the probability model being used by the uninformed player is common knowledge.

Since the basic bargaining process (an ultimatum game) involves one round of proposal and response, the fact that only one of the players possesses private information about something that is important to both means that *when* the informed player acts is, itself, important. A *screening* model (also sometimes called a *sorting* model) involves the uninformed player making the proposal and the informed player choosing to accept or reject the proposal. A *signaling* model involves the reverse: the informed player makes the proposal and the uninformed player chooses to accept or reject it. Note that the word "signaling" only means that the proposal is made by the informed player, not that the proposal itself is necessarily informative about the private information possessed by the proposer. Bebchuk's model is a screening model and Reinganum and Wilde's model is a signaling model.

These are noncooperative models of bargaining, so our method of prediction is finding an equilibrium (rather than a cooperative solution).

Table 15.2 Hands of cards for A and B

	UP	DOWN
A	A♦, Q♦, J♦, 10♦	2♥
B	10♣, 10♠, 9♠, 5♦, 2♣	

Note: Entries provide face value of card and suit.

In both cases, sequential rationality is also employed. Generally, in the case of a screening model, this yields a unique prediction. In the case of a signaling model, sequential rationality is generally insufficient to produce a unique prediction. The reason is that since the uninformed player is observing the informed player's action in this case, the action itself may reveal something about the private information of the proposer. When this happens, further "refinement" of the set of predictions (set of equilibria) is used to hone in on a unique prediction.[13]

To understand this, consider a modification of the card game story from Section 7.1. Here are the hands for players A and B and, as before, only A knows his down card:

To fill out the story, all the above cards have just been dealt, after players put some money on the table, from a standard 52-card deck. The rules are that player A may now discard one card (if it is the down card, this is done without revealing it) and a new card is provided that is drawn from the undealt portion of the deck. A can also choose not to discard a card. If he does discard one, the new card is dealt face up if the discard was an up card and is dealt face down otherwise. After this, A and B can add money to that already on the table or they can surrender their share of the money currently on the table ("fold"); for convenience, assume that a player must fold or add money (a player can't stay in the game without adding money to that already on the table). The cards are then compared, privately, by an honest dealer, and any winner gets all the money while a tie splits the money evenly amongst those who have not folded. The comparison process in this case means that, for player A, a new down card that matches his Ace, Queen or Jack card with the same face value (that is, A ends up with two Aces or two Queens or two Jacks) will beat B's hand, as will any diamond in conjunction with A's up cards currently showing. Other draws mean that A will either tie (a 10©) or lose.

[13] See, for example, Chapters 9 and 13 of Mas-Colell, Whinston and Green (1995).

Before A chooses whether and what to discard, B knows that the down card could be any of 43 cards with equal likelihood. Now if A discards his down card, based on sequential rationality, B knows that it was not an Ace, a Queen, a Jack or a Diamond. This information can be used by B *before* he must take any action. He may choose to fold, or he may choose to add money, but this decision is now influenced by what he believes to be A's private information, A's new down card. These beliefs take the form of an improved probability estimate over A's type (adjusting for what has been observed). These assessments are called *beliefs*, and in an asymmetric information model, players form beliefs based upon the prior assessments and everything that they have observed before each and every decision they make. The addition of the need to account for what beliefs players can reasonably expect to hold makes the signaling game more complex to analyze than the screening game.

A few more observations about the card game are in order. First, even though this was a signaling game, the signal of discarding did not completely inform the uninformed player of the content of the private information. A strategy for the informed player is *revealing* if, upon the uninformed player observing the action(s) of the informed player, the uninformed player can correctly infer the informed player's type. In this sense, each type of player has an action that distinguishes it from all the other types. For example, in the settlement context, where P is privately informed about the true level of damages but D only knows the prior distribution, a revealing strategy would involve each possible type of P (each possible level of damages) making a different settlement demand, such as P demands his true damages plus D's court costs. If instead P always asked for the average level of damages, independent of the true level, plus court costs, then P would be using a *pooling* strategy: different types of P take the same action and therefore are observationally indistinguishable.

In the card game above, A choosing to discard his down card has some elements of a revealing strategy (not all types would choose this action) and some elements of a pooling strategy (there are a number of types who would take the same action). This is an example of a *semi*-p*ooling* or *partial pooling* strategy. Notice that if the deck had originally consisted of *only* the eleven cards A♦, K♦, Q♦, J♦, 10♦, 10♣, 10♠, 9♠, 5♦, 2♣, 2♥, then B could use the action "discard" to distinguish between the private information "initial down-card = K♦" and "initial down-card = 2♥" because discarding the down-card is only rational for the player holding a 2♥. Thus, discarding or not discarding in this special case is a fully revealing action. In this particular example, we got this by changing the size of the deck (thereby changing the number of types), but this is not always necessary. In many signaling models, extra effort placed on making predictions, even in the presence of a continuum of types, leads to fully revealing behavior; we will see this in the signaling analysis below.

Finally, a *revealing equilibrium* means that the equilibrium involves the complete transmission of all private information. In a revealing equilibrium, the privately informed player is employing a revealing strategy. In a *pooling equilibrium*, no private information is transmitted: at the end of the game, no more is necessarily known by the uninformed player than was known before play began. More generally, in a *partial pooling equilibrium*, some of the types have been revealed through their actions and some of the types took actions which do not allow us to distinguish them from one another.

12.2 Where You Start and Where You End

As will be seen below, a typical screening model produces partial pooling equilibria as its prediction; in fact, the equilibrium is often composed of two big pools (a bunch of types do this and the rest do that) and is only fully revealing if each pool consists of one type.[14] In other words, if the private information in the model takes on more than two values, some pooling will typically occur in the equilibrium prediction of a screening model. On the other hand, a typical signaling model has all three types of equilibria (revealing, fully pooling, partial pooling) as predictions, but with some extra effort concerning rational inference (called *refinements* of equilibrium), this often reduces to a unique prediction of a revealing equilibrium.

12.3 One-Sided Asymmetric Information Settlement Process Models: Examples of Analyses

In the subsections to follow, we will start with the same basic setting and find the results of applying screening and signaling models. Bebchuk's 1984 paper considered an informed defendant (concerning liability) responding to an offer from an uninformed plaintiff; Reinganum and Wilde's 1986 paper considered a plaintiff with private information about damages making a demand of an uninformed defendant. Initially, information will be modeled as taking on two levels (that is, a two-type model is employed) and a basic analysis using each approach will be presented and solved. The result of allowing for more than two types (in particular, a continuum of types) will then be discussed in the context of the alternative approaches.

Since most of the discussion earlier in this survey revolved around

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[14] Of course, if one of the pools involves types who go to court, and the court is perfectly informed, then any type in that pool is thereby "revealed" at trial.

damages, both approaches will be applied to private information on damages, suggesting a natural setting of an informed P and an uninformed D (note, however, that the earlier example of Pat and Delta was purposely posed with Delta as the informed party to emphasize that the analysis is applicable in a variety of settings). More precisely, the level of damages is assumed to take on the value d_L (L for low) or d_H (H for high), meaning that P suffers a loss and it takes on one of these two levels, which is private information for P. Moreover, $d_H > d_L > 0$. The levels are common knowledge as is D's assessment that p is the probability of the low value being the true level of damages. If the case were to go to trial, then J will find out the true level of damages (whether the damages were equal to d_L or equal to d_H) and award the true damages to P.[15] Thus $E_D(d) = pd_L + (1 - p) d_H$ is D's prior (that is, before bargaining or trial) estimate of the expected damages that he will pay if he goes to trial; P knows whether the damages paid will be d_L or d_H. Should the case go to trial, each player pays his own court costs (k_P and k_D, respectively) and, for simplicity again, assume that $d_L > k_P$; relaxing this assumption is discussed in Section 16.1. Finally, in each case, the structure of the bargaining process is represented by an ultimatum game. In particular, the player who responds will choose to accept the proposal if he is indifferent between the payoff resulting from accepting the proposal and the payoff resulting from trial. *Without any more information*, D's *ex ante* (that is, before bargaining) expected payoff from trial is $E_D(d) + k_D$; P's payoff from trial is $d_L - k_P$ if true damages are d_L, and $d_H - k_P$ if true damages are d_H.

12.3.1 Screening: a two-type analysis In this model D offers a settlement transfer to P of s_D and P responds with acceptance or rejection. For the analysis to be sequentially rational (that is, we are looking for a subgame perfect equilibrium), we start by thinking about what P's strategy should be for *any* possible offer made by D in order for him to maximize his overall payoff from the game. If $s_D \geq d_H - k_P$, then no matter whether damages are high or low, P should accept and settle at s_D. If $s_D < d_L - k_P$, then no matter whether damages are high or low, P should reject the offer and go to trial. If s_D is set so that it lies between these two possibilities, that is, $d_H - k_P > s_D \geq d_L - k_P$, then a P with high damages should reject the offer, but a P with low damages should accept the offer. This last offer is

[15] Note that this discussion is as if D's liability is assured ($\ell = 1$). Alternatively, D and P have a common assessment of D's liability and this has already been incorporated into the damage levels d_L and d_H. We factor out liability in this discussion so as to minimize unneeded notation.

said to *screen* the types; note that the offer results in the revelation of the private information. Thus P's optimal action is contingent upon the offer made; we have found P's strategy and it involves rational choice. D can do this computation, too, for each possible type of P that could occur, so from D's viewpoint, he models P as having a strategy that depends both on P's type and upon D's offer.

As always, D's objective is to minimize expected expenditure and he must make an offer before observing any further information about P; thus, D cannot improve his assessments as occurred in the card game. D knows, however, that some offers are better than others. For example, the lowest offer in the range $d_H - k_P > s_D \geq d_L - k_P$, namely $s_D = d_L - k_P$, is better than any other offer in that range, since it doesn't change the result that H-type Ps will reject and L-type Ps will accept, and its cost to D is least when compared to other possible offers in this range. The expected cost of screening the types is $p(d_L - k_P) + (1 - p)(d_H + k_D) = E_D(d) + k_D - p(k_P + k_D)$, since the offer elicits acceptance with probability p (the probability of L-types) and generates a trial and attendant costs with probability $(1 - p)$. The payoff from making offers that both types reject is $E_D(d) + k_D$. Finally, the expected cost from making an offer that both types will accept is simply the cost of the offer that the H-type will accept, namely $d_H - k_P$.

A comparison of the payoffs from the different possible offers that D could make indicates that it is always better for D to make an offer of at least the L-type's concession limit (that is, the value of s_D specified above, $d_L - k_P$). This is because the expected cost to D of screening the types, $E_D(d) + k_D - p(k_P + k_D)$, is less than the expected cost from making any offer less than s_D, since such an offer guarantees trial and has an expected cost of $E_D(d) + k_D$.

It may be optimal to pool the types; that is, to make an offer at the H-type's concession limit $(d_H - k_P)$, which will therefore be accepted by P independent of his actual damages incurred. To see if it is, compare the expected cost to D of the screening offer, $E_D(d) + k_D - p(k_P + k_D)$, with the expected cost to D of the pooling offer, $d_H - k_P$; it is optimal to screen (rather than pool) the types if $E_D(d) + k_D - p(k_P + k_D) < d_H - k_P$; that is, if:

$$p > (k_P + k_D)/(d_H - d_L + k_P + k_D). \qquad \text{(SSC)}$$

Inequality (15.3) is the *simple screening condition* (SSC) (simple because it considers two types only); it indicates that the relevant comparison between screening the types or pooling them involves total court costs $(k_P + k_D)$, the difference between potential levels of damages $(d_H - d_L)$ and the relative likelihood of H- and L-types. Given court costs and the gap between high and low damages, the more likely it is that P has suffered low damages rather than high damages, the more likely D should be to screen the types and thereby only rarely go to trial (and then, always against an H-type). If the likelihood of facing an H-type P is sufficiently high (that is, p is low), then it is better to make an offer that is high enough to settle with both possible types of plaintiff. Therefore, with pooling there are no trials, but with screening trials occur with probability $(1 - p)$. Condition (SSC) also suggests that, for a given probability of low-damage Ps and a given gap between the levels of damages, sizable trial costs auger for pooling (that is, settling with both types of P).

Finally, the model allows us to compute the efficiency loss and to recognize its source. To see this, imagine the above analysis in the imperfect information setting; in particular, for this setting both P and D do not know P's type, and they agree on the estimate of damages, $E_D(d)$, and that liability of D for the true damages is certain. In the imperfect information version of the D-proposer ultimatum game, D's optimal offer is $E_D(d) - k_P$, P's concession limit under imperfect information. Since in that setting P doesn't know his type, he would settle at $E_D(d) - k_P$ rather than require $d_H - k_P$ (which is greater than $E_D(d) - k_P$) to avoid trial if he is an H-type. Thus, the difference in D's payoff under imperfect information ($E_D(d) - k_P$) and that under the asymmetric information analyzed above ($E_D(d) + k_D - p(k_P + k_D)$) is $(1 - p)(k_P + k_D)$. This extra cost to D comes from the fact that D recognizes that P knows his own type and will act accordingly. Note that this is not a transfer to P; it is an efficiency loss. This loss is a share of the surplus that, under perfect or imperfect information, would have been avoided by settling rather than going to trial, and is a loss that is due to the presence of an asymmetry in the players' information.

12.3.2 Screening with many types The principle used above extends to settings involving finer distinctions among levels of private information. In particular, this subsection will outline the nature of the model when applied to a continuum of types, such as a plaintiff whose level of damages could take on any value between two given levels of damages (that is, d may take on values between, and including, d_L and d_H; $d_L \leq d \leq d_H$). This is formally equivalent to Bebchuk's original model (Bebchuk, 1984), even though his analysis presented a D who was privately informed about liability in a P-proposer setting with known damages. Thus, differences in the presentations between this discussion and Bebchuk's are due to the shift of the proposer and the source of private information; there are no substantive differences between the analyses.

As always, D's probability assessment of the likelihood of the different

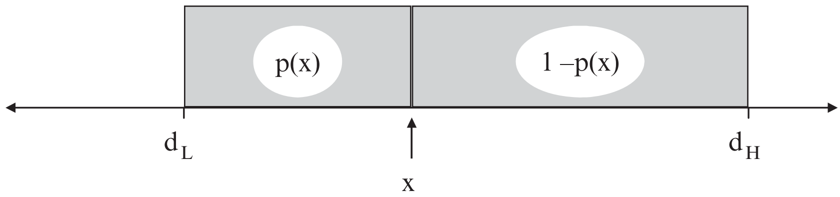

Figure 15.3 Screening with a continuum of types

possible levels of damages is common knowledge and is denoted p(d), which provides the probability that damages are no more than any chosen value of d. Figure 15.3 illustrates the intuition behind the analysis. The distribution of possible levels of damages as drawn implies equal likelihood, but this is for illustrative purposes only; many (though not all) probability assessment models would yield similar qualitative predictions. Figure 15.3 illustrates a level of damages, x, intermediate to the two extremes, d_L and d_H, and that the fraction of possible damage levels at or below x is given by p(x). Alternatively put, if D offers $s = x - k_P$, a P who has suffered the level of damages x would be indifferent between the offer and the payoff from going to trial. Moreover, this offer would also be accepted by any P with damages less than x, while any P with damages greater than x would reject the offer and go to trial. The expected expenditure associated with offers that are accepted is sp(x). Note that the particular value x that made the associated P indifferent between settling and going to trial depends upon the offer: $x(s) = s + k_P$. This is accounted for by explicitly recognizing this dependence: if D makes an offer s_D, then the expected expenditure associated with accepted offers is $s_D p(x(s_D))$.

Two observations are in order. First, as s_D increases, the "marginal" type $x(s_D)$ (also known as the "borderline" type; see Bebchuk, 1984) moves to the right and this would increase $p(x(s_D))$. Thus, this expected expenditure is increasing in the offer both because the offer itself goes up and as it increases, so does the likelihood of it being accepted. Second, while the types of P that reject the offer and go to trial are "revealed" by the award made by J (who learns the true d and awards it), as long as x ¹ d_L there is residual uncertainty in every possible outcome of the game: the offer pools those who accept, and their private information is not revealed (other than the implications to be drawn from the fact that they must have damages that lie to the left of x in Figure 15.3). The fact that the equilibrium will therefore involve only partial revelation is the main difference between the two-type model (where screening reveals types) and the model with a continuum of types.

To minimize expected expenditure,[16] D trades off the expected expenditure from settling with the expected expenditure for trial, where trial occurs with probability $(1 - p(x(s_D))$. Under appropriate assumptions on $p(x)$, this latter expenditure is declining in s_D, yielding an optimal offer (s_D^*) for D that makes the type of P represented by the level of damages $x(s_D^*)$ the marginal type.

As an example, if all levels of damages are equally likely, as illustrated in Figure 15.3 above, then as long as the gap between the extreme levels of damages exceeds the total court costs (that is, $d_H - d_L \geq k_P + k_D$), the equilibrium screening offer is $(s_D^*) = d_L + k_D$ and the marginal type is a P with level of damages $d_L + k_D + k_P$; Ps with damages at or below this level accept the offer, while those with damages in excess of this level reject the offer. Thus, "P has been screened." Note that should the gap in levels of damages be less than aggregate trial costs ($d_H - d_L < k_P + k_D$), then D simply pools all the types with the offer $d_H - k_P$.

12.3.3 Signaling: a two-type analysis This approach employs a P-proposer model in which P makes a settlement demand followed by D choosing to accept or reject the proposal: Given the assumptions made in the discussion before subsection 12.3.1, a rejection leads to P going to trial, at which J learns the true level of damages and awards P their value.

As discussed in Section 4, in the circumstances of this ultimatum game, D should use a mixed strategy: if demands at or below some level were always accepted, while those above this level were always rejected, some types of P would be compensated more than might be necessary and D would go to court more often than necessary. Here a mixed strategy should respond to the demand made: low demands should be rejected less often than high demands, if only because a high demand is more advantageous to a greater percentage of possible types of Ps, and therefore requires D to be more vigilant.

The notion that lower types (those with lesser damages) of P have an incentive to try to be mistaken for higher types (those with greater damages) – called *mimicry* – plays a central role in the analysis. D's use of a mixed strategy, dependent upon the demand made, provides a counter-incentive which can make mimicry unprofitable: a greedy demand at the settlement bargaining stage, triggering a greater chance of rejection, may

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[16] For those desiring a precise mathematical statement of what follows, D picks the value x that minimizes $p(x)(x - k_P) + \int_I (t + k_D)dp(t)$, where $I = [x, d_H]$ is the interval of types who would reject the offer and go to trial. If x^* is the optimum, then D's equilibrium offer is $s_D^* = x^* - k_P$. As long as $p'(x)/p(x)$ is monotonically decreasing, this optimization problem has a unique minimum.

therefore more readily lead to much lower payoffs at trial (where the true level of damages is revealed with certainty and P then must pay his court costs from the award) than would have occurred at a somewhat lower demand.

P's demand is s_P, which D responds to by rejecting it with probability $r_D(s_P)$ or accepting it, which occurs with probability $1 - r_D(s_P)$. Clearly, if the demand is $d_L + k_D$, then D should accept this demand as D can do no better by rejecting it. For convenience, we will define s_L to be this lowest-type demand, and thus, $r_D(s_L) = 0$. On the other hand, if P were to make a demand higher than what would be D's expenditure at trial associated with the highest type, namely $d_H + k_D$, then D should reject any such demand for sure. It is somewhat less clear what D should do with $d_H + k_D$, which for convenience we denote as s_H. As will be shown below (in both the two-type and the continuum of types models), D's equilibrium strategy will set $r_D(s_H)$ to be less than one. This will provide an incentive for greedy Ps to demand at most s_H (technically, this is for the benefit of specifying an equilibrium, and it turns out not to hurt D). Since P knows what D knows, P can also construct the $r_D(s_P)$ function that D will use to respond to any demand s_P that P makes. P uses this function to decide what demand will maximize his payoff.

While there are demand/rejection probability combinations that can generate all three types of equilibria (revealing, pooling and partial pooling), the focus here is on characterizing a revealing equilibrium. To do this, we take our cue from the appropriate perfect-information ultimatum game. In those analyses, if it was common knowledge that P was a high type, he could demand and get s_H, while if it was common knowledge that P was a low type, he could demand and get s_L. Making such demands clearly provides an action that could allow D to infer that, should he observe s_L, it must have come from a low type, while if he observed s_H, it must have come from a high type. While wishing doesn't make this true, incentives in terms of payoffs can, so that a low-damage P's best choice between s_L and s_H is s_L and a high-damage P's best choice between s_L and s_H is s_H. In particular, consider the following two inequalities (since $r_D(s_L) = 0$, the following inequalities employ the notation r for the rejection probability; we will then pick a particular value of r to be the value of D's rejection strategy, $r_D(s_H)$):

$$s_L \geq (1 - r)s_H + r(d_L - k_P) \qquad \text{(ICL)}$$

and

$$s_L \leq (1 - r)s_H + r(d_H - k_P). \qquad \text{(ICH)}$$

Inequality (15.4), called ICL for the *incentive compatibility condition for the low type*, states that D's choice of r is such that when P has the low level of damages, his payoff is at least as good when he demands s_L as what his payoff would be by mimicking the high-damages P's demand s_H, which is accepted with probability $(1 - r)$, but is rejected with probability r (resulting in the P of either type going to court). Note that, since J would learn the true type at court, a low-type P gets $d_L - k_P$ if his demand is rejected. In other words, on the right is the expected payoff to a P with the low level of damages from misrepresenting himself as having suffered high damages. Inequality (ICH) (*the incentive compatibility condition for the high type*) has a similar interpretation, but now it is for the high types: they are also no worse off by making the settlement demand that reflects their true type (the expected cost on the right side of the inequality) than they would be if they misrepresented themselves. When r, s_L and s_H satisfy *both* (ICL) and (ICH), then these strategies for D and the two types of P yield a revealing equilibrium.

Substituting the values for s_L and s_H and solving the two inequalities yields the following requirement for r:

$$(d_H - d_L)/[(d_H - d_L) + (k_P + k_D)] \leq r \leq (d_H - d_L)/(k_P + k_D).$$

While the term on the far right is, by an earlier assumption, greater than one, the term on the far left is strictly less than one. In fact, for *each* value of r (pick one arbitrarily and call it r' for now) between the value on the left and one, there is a revealing equilibrium involving the low-damages P demanding s_L, the high-damages P demanding s_H and D responding via the rejection function with $r_D(s_L) = 0$ and $r_D(s_H) = r'$. In the equilibrium just posited, a low-damage P reveals himself and always settles with D at $d_L + k_D$ and a high-damage P always reveals himself, possibly (that is, with probability $(1 - r')$) settling with D at $d_H + k_D$ and possibly (with probability r') going to court and achieving the payoff $d_H - k_P$. Note that the strategies for the players are very simple: P's demand is his damages plus D's court costs; D's strategy is to always accept a low demand and to reject a high demand with a given positive, but fractional, probability.

For what follows we will pick a particular value of r in the interval, namely, let $r_D(s_H) = (d_H - d_L)/[(d_H - d_L) + (k_P + k_D)]$, the smallest value. There are technical reasons (refinements) that have been alluded to earlier, concerning extensions of notions of rationality, to support this choice, but another motivation is that the smallest admissible r, $r_D(s_H)$, is the most efficient of the possible choices. All the r values that satisfy the incentive conditions (ICL) and (ICH) provide the same expected payoff to

D, namely $E_D(d) + k_D$. P's expected payoff (that is, computed before he knows his type) is $E_D(d) + k_D - (1 - p)(k_P + k_D)r$, for *any* r that satisfies both incentive compatibility conditions, so using $r_D(s_H)$ minimizes the efficiency loss $(1 - p)(k_P + k_D)r$. Note also that using the specified $r_D(s_H)$ as the rejection probability for a high demand means that the likelihood of rejection is inversely related to total court costs, but positively related to the difference between possible levels of damages. This is because, while increased court costs minimize the threat of going to court, an increased gap between d_H and d_L increases the incentive for low-damage Ps to claim to be high-damage Ps, thereby requiring more vigilance on the part of D. D accomplishes this by increasing $r_D(s_H)$.

12.3.4 Signaling with many types While the principle used above extends to the case of a continuum of values of the private information, the extension itself involves considerably greater technical detail.[17] The presentation here will summarize results in much the same manner as used in Section 12.3.2 to summarize screening with a continuum of types. This presentation is based on the analysis employed in Reinganum and Wilde (1986), though that model allows for non-strategic errors (that is, exogenously specified errors) by J and awards that are proportional to (rather than equal to) damages.

The basic results developed in the two-type model remain: (1) a revealing equilibrium is predicted; (2) P makes a settlement demand equal to damages plus D's court cost and (3) D uses a mixed strategy to choose acceptance or rejection. The likelihood of rejection is increasing in the demand made, and therefore in the damages incurred, and is decreasing in court costs. This means that the distribution of levels of damages that go to trial involves, essentially, the entire spectrum of damages, though it consists of preponderantly higher rather than lower damages (relative to the initial distribution).

Figure 15.4 shows an example which starts with the same assessment over damages as envisioned in the continuum screening model in Section 12.3.2. As is shown in the graph displayed in the upper left of Figure 15.4, again assume that each possible level of damages is equally likely. Following the gray arrow, the graph in the upper right shows the equilibrium settlement demand function for P: it is parallel to the 45º line (the

[17] For those desiring mathematical detail, P's maximization (in a revealing equilibrium) yields a first-order condition which characterizes D's rejection function via the differential equation $1 - r(x) - (k_P + k_D)r'(x) = 0$. The boundary condition is that $r(d_L) = 0$: the demand associated with the lowest type should not be rejected. P's equilibrium demand (for any damages x) is $s^*_P = x + k_D$.

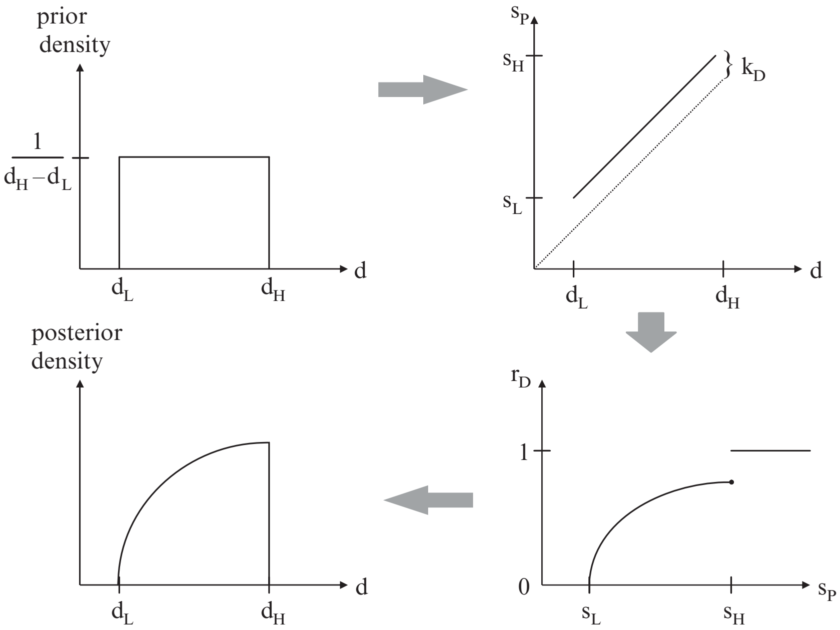

Figure 15.4 Signaling with a continuum of types

dotted line) and shifted up by the amount k_D. Thus, P's settlement demand function $s_P(d) = d + k_D$, where d is P's type (level of damages actually incurred). Thus, for example, $s_P(d_L) = d_L + k_D$ (this is s_L on the vertical axis). The graph below the settlement demand function (follow the fat gray arrow) displays D's rejection function. Demands at or below s_L are accepted and demands above s_L are rejected with an increasing likelihood up to the demand $s_H = d_H + k_D$. This is rejected with a positive but fractional likelihood (the dot is to show the endpoint of the curve); anything higher yet is rejected with certainty. Finally, following the gray arrow to the lower left of Figure 15.4, the posterior assessment of damages for cases going to trial is shown. The word posterior is used to contrast it with the assessment D used before bargaining commenced (the prior assessment). The effect of settlement bargaining is to create an assessment model at the start of the next stage of the legal process which is shifted upwards; that is, which emphasizes the higher-damage cases. This contrasts with the resulting distribution of cases that emerge from a screening process. The result of the screening model applied to the "box-shaped" prior assessment shown in Figures 15.3 and 15.4 would be a box-shaped posterior assessment model over the types that rejected the screening offer.

12.4 How Robust are One-Sided Asymmetric Information Ultimatum Game Analyses?

As the earlier discussion of the various approaches used in perfect information suggests, model structure and assumptions play an important role in the predictions of the analysis. Is this a problem of "tune the dial and get another station?" In some sense it seems to be. Such models seem to provide conflicting predictions which: involve proposing one or the other player's concession limit (not in between, as the Nash Bargaining Solution provided); sometimes fully reveal private information, other times do not; and strongly restrict when and if players can make proposals at all.

However, some consistent threads emerge. Asymmetric information will generally result in some degree of inefficiency in the bargaining process due to some use of trial by the players. The extent of inefficiency is related to the nature of the distribution of the information, the range of the possible values that the private information can take on and the level of court costs. Higher court costs encourage settlement and influence the transfer between P and D. Asymmetric information means that the relatively less informed player needs to guard against misrepresentation by the more informed player, and must be willing to employ the threat of court. The signaling model indicated another aspect of this: even though P was informed and made the proposals, it was P who bore an inefficiency cost (D's expected payoff was what it would have been under imperfect information). This is because the private information that P possesses cannot be credibly communicated to D without a cost being incurred by P via the signaling of the information.

Clearly, both models use a highly stylized representation of bargaining. How restrictive is this? While this question is difficult to address very generally, some tests of the robustness of the model structure and the predictions exist. These analyses are of two types. (1) Would changes in sequence matter (who moves when, whether moves must be sequential, what if there were many opportunities to make proposals)? (2) Is the one-sided nature of information important; would each player having information on a relevant attribute of the game affect the outcome in a material way?

Papers by Daughety and Reinganum (1993), Wang, Kim and Yi (1994) and Spier (1992) address aspects of the first question above. Daughety and Reinganum provide a two-period model that allows players to move simultaneously or sequentially. Here, P and D can individually make (or individually not make) proposals in the first period and then choose to accept or reject whatever comes out of the first period during a second period; a rejection by either individual of the outcome of the first period means going to court. What comes out of the first period is: (1) no proposal, which guarantees court; (2) one proposal, provided by whomever made it; or (3) an intermediate version of two proposals if both players make one; the intermediate proposal is a general, commonly known function of the two individual proposals. An example of such a "compromise" function would be one that averaged the proposals, but the analysis is not restricted to that particular assumption. Note that this means that if both players make proposals, then intermediate outcomes are possible candidates as equilibria of the overall game. The model allows one-sided asymmetric information, but examines both possible cases in which a player is informed. The general result is that players do not choose to wait: they both make proposals in the first period. Thus, formally, the ultimatum structure wherein only one player makes a proposal is rejected as inconsistent with endogenously generated timing. However, the unique equilibrium of the game has the same payoffs as either that of the ultimatum signaling game or the ultimatum screening game; which one depends only on the compromise function used and which player is informed. Thus, in this sense, the ultimatum game provides a valuable tool of prediction.

The Wang, Kim and Yi (1994) paper discussed earlier in Section 3.2.2 also contains a continuum-type, one-sided asymmetric information model based on Rubinstein (1985). Wang, Kim and Yi consider the case of an informed P and an uninformed D, with D as first proposer. In subsequent periods proposers alternate. They show that the settlement outcome is consistent with a one-period D-proposer screening ultimatum game as discussed above. Finally, Spier (1992) (discussed in more detail in Section 18 below) also employs a dynamic model (in this case, a finite horizon model) with negotiating and trial costs. In her model, if negotiating costs are zero, then all bargaining takes place in the last period. Together, the three papers provide some limited theoretical support for using the ultimatum game approach to represent one-sided asymmetric information settlement problems.

The second issue, concerning one-sided versus two-sided information, is addressed in papers by Schweizer (1989), Daughety and Reinganum (1994), and Friedman and Wittman (2006).[18] Both Schweizer and Daughety and Reinganum consider ultimatum games where P is privately informed about damages and D is privately informed about liability. Schweizer considers a P-proposer model with two types on both sides while Daughety and Reinganum consider both P- and D-proposer models with a continuum of types on both sides. The results are fundamentally the same: the proposer signals and uses the signal to screen the responder. Thus, proposer types

[18] Sobel (1989) also considers a two-sided model, but his interest is discovery; this paper will be discussed in Section 19.

are revealed fully and responders are partially pooled. Friedman and Wittman consider a simultaneous-move game wherein each side receives a private signal and makes a proposed settlement offer. Offers are averaged and if the transfer is feasible (D offers no less than P demands), then a transfer is effected, otherwise trial ensues, at which point the court learns the private signals, averages them and makes a transfer. Thus, a specific protocol is employed.[19] Again, trial can occur in equilibrium, increases in trial costs reduce the likelihood of trial, and the distribution of cases that proceed to trial is altered by the presence of settlement bargaining.

In sum, it would appear that the screening and signaling models have reasonably robust qualitative properties (especially when viewed as alternatives, with the likely model a composite such as might arise via a random-proposer analysis) that survive relaxation of some of the underlying structure and that the intuition derived from the separate analyses survives the integration of both types of models in a more comprehensive analysis.

13. Summing Up the Theory

13.1 Comparing the Two-Type Models: Imperfect and Asymmetric Information

This section provides two means of comparison. First, employing specific numerical values, Table 15.3 below presents computations for the same data from imperfect, screening and signaling analyses; it also acts as a convenient summary of the strategies and payoffs for the different models. While the results do not purport to indicate magnitudes of differences in the predictions made, it will suggest directional differences. The directional differences will be amplified, based on the two-type analyses provided earlier, as the second means of comparison.

Table 15.3 considers a two-type model wherein P is informed of the true level of damages and D is not. D's prior assessment on the two levels of damages is that they are equally likely (this is to make comparisons easier). Court costs are the same for the two players and liability by D for damages is certain. Specific values of the data are provided at the top of Table 15.3. Note that (15.3) holds as shown. D's expectation of damages ($E_D(d)$) is the common expectation under imperfect information.

Table 15.3 concentrates on the ultimatum game predictions, but the

[19] This model also uses a special version of the notion of common value settlement bargaining since, rather than discover the "true" value of the parameter of interest (such as d), the court only learns the litigants' private signals, which it then averages. If these signals are unbiased, then the court's decision, in expectation, is the same as what normally occurs in the rest of the settlement bargaining literature.

Table 15.3 Ultimatum game results under imperfect and asymmetric information

Data: $d_H = 75$, $d_L = 25$, $\ell = 1$, $k_P = k_D = 10$, $p = 0.5$.
Thus, $E_D(d) = 50$ and (SSC) is met: $p = 0.5 > (k_p + k_D)/(d_H - d_L + k_P + k_D) = 0.29$

Model	*D-proposer*	*NBS*	*P-proposer*
Imp. Information	$s_D = E_D(d) - k_P = 40$	$s_D = s_P = 50$	$s_P = E_D(d) + k_D = 60$
	$\pi_D = 40$	$\pi_D = 50$	$\pi_D = 60$
	$\pi_P = 40$	$\pi_P = 50$	$\pi_P = 60$
	efficient	efficient	efficient
	no trials	no trials	no trials
Asy. Information: Screening	$s_D = d_L - k_P = 15$		
	$\pi_D = ps_D + (1-p)(d_H + k_P) = 50$		
	$\pi_L = d_L - k_P = 15$		
	$\pi_H = d_H - k_P = 65$		
	inefficient:		
	loss $= (1 - p)(k_P + k_D) = 10$		
	$\pi_D = E_D(d) + k_D - (1 - p)(k_P + k_D)$		
	$= 50$		
	$\pi_P = p\pi_L + (1 - p)\pi_H = 40$		
	probability of trial $= (1 - p) = 0.5$		

Asy. Information: Signaling	$s_L = d_L + k_D = 35$ $s_H = d_H + k_D = 85$ $r_D(s_L) = 0$ $r_D(s_H) = (d_H - d_L)/(d_H - d_L + k_P + k_D)$ $= 0.71$ $\pi_D = ps_L + (1 - p)[(1 - r_D(s_H))s_H + r_D(s_H) s_H]$ $= 60$ $\pi_L = s_L = 35$ $\pi_H = (1 - r_D(s_H))s_H + (r_D(s_H))(d_H - k_P)$ $= 70.71$ inefficient: $\text{loss} = (1 - p)(k_P + k_D)r_D(s_H) = 7.14$ $\pi_D = E_D(d) + k_D$ $= 60$ $\pi_P = p\pi_L + (1 - p)\pi_H$ $= 52.86$ $\text{probability of trial} = (1 - p)r_D(s_H) = 0.36$

relevant imperfect information NBS is also provided, as shown near the top. Given the information endowments, the only asymmetric information D-proposer model is a screening model and the only P-proposer asymmetric information model is a signaling model. The table provides the proposer's proposal, the responder's strategy in the signaling case and the payoffs to the players. Note that π_L provides the payoff to a P with low damages, while π_H provides the payoff to a P with high damages. Finally, in the asymmetric information case, π_P provides the expected payoffs to a P before damages are observed so that *ex ante* efficiency can be evaluated. The statement "efficient" means that the outcome is on the settlement frontier, while "inefficient" means that the solution lies below the frontier, with the efficiency loss calculated as shown. Finally, the source of inefficiency, that some cases go to trial, is indicated by providing the probability of trial derived from the model used.

The example and the formulas in the table indicate that the efficiency losses predicted by the screening and signaling models, as compared with the efficient solutions in the imperfect information model, differ from one another. More generally, as long as p meets the simple screening condition (SSC) of Section 12.3.1, the signaling model predicts less of an efficiency loss than the screening model. This is because while a low-damages P settles out of court in both models, a high-damages P always goes to court under a screening model, while he only go to court with a fractional likelihood under the signaling model. Note also, however, that when p does not satisfy (SSC), then the screening model's prediction is fully efficient (since all cases settle) while the signaling model still predicts an inefficient outcome.

A similar type of comparison could be performed for the ultimatum games involving asymmetric information about the likelihood of liability (with damages commonly known) or about the expected payoff from trial (that is, the product of damages and the likelihood that D is found liable). Typically, such analyses assume that D has private information about the true likelihood of being found liable. In the screening model, the higher-likelihood Ds settle and the lower-likelihood Ds reject P's offer and proceed to trial. In the signaling model, the higher-likelihood D makes an offer that P accepts, while the lower-likelihood D makes a lower offer that P rejects with an equilibrium rejection probability. Most notably, in the case wherein there is a continuum of types, the distribution of cases that go to trial include essentially all the D-types (with the preponderance of types being less likely to be held liable).

13.2 Asymmetric Information versus Other Models of Settlement Bargaining

It is worthwhile to take a moment to contrast the settlement bargaining literature using asymmetric information with the vast literature which has grown out of a paper by Priest and Klein (1984). Thoroughly reviewing the literature in this area (mainly empirical studies with a variety of predictions) would take us too far from our main purpose, but a few words are appropriate. The Priest-Klein model employs an inconsistent priors approach to examine the selection of cases that proceed to trial; the approach is often referred to as "divergent expectations" and generally assumes that the two litigants have inconsistent priors such that if both litigants' priors are "optimistic," then settlement can fail (the plaintiff's reservation value based on the expected payoff from trial will exceed the defendant's reservation value based on the expected cost of trial). The Priest-Klein model implies that the selection of cases that go to trial involves cases wherein the likelihood of either side winning approaches 50%. Waldfogel (1998) uses data from federal civil cases filed between 1979 and 1986 in the Southern District of New York, and compares a divergent expectations model with a one-sided asymmetric information screening model. Since a screening (or signaling) model with one-sided asymmetric information predicts that only the "strong" cases go to trial, then this model tends to shift the distribution of cases away from the 50% point, towards the extremes, a contrast with the Priest-Klein model.[20] Waldfogel reports that the divergent expectations model is generally consistent with the data, while the asymmetric information model is not. He also reports that asymmetric information modeling appears to be consistent with cases that terminated "early" (that is, where adjudication occurred before the complaint by the plaintiff was responded to via discovery and trial).

Note, however, that this "horse race" is not on a level playing field in the sense that the divergent expectations model is a two-sided model, while the asymmetric information model that is used for comparison purposes is one-sided. As Gertner and Miller (1995) argue, since it is difficult to understand how divergent opinions about each litigant's likelihood of success are likely to be communicated (as a standard divergent expectations model implicitly assumes), then such divergent opinions may be best thought of as private information, making the divergent expectations model more of

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[20] As Shavell (1996) shows for the two-type screening case (and as is clearly also true for the signaling case and the continuum screening case), by varying parameters one can get essentially any prediction about the plaintiff win rate that is desired.

a special version of an asymmetric information model![21] Thus, the "horse race" should presumably reflect the differences that might come about between a two-sided inconsistent priors asymmetric information model and a two-sided consistent priors asymmetric information model.

Two papers discussed earlier (see Section 12.4) as part of the asymmetric information settlement bargaining literature that assume two-sided asymmetric information are Friedman and Wittman (2006) and Daughety and Reinganum (1994). As Friedman and Wittman note (see pp. 109–10), their predictions from a model of simultaneous offers are not distinguishable from those arising from a Priest-Klein model. In the Daughety and Reinganum analysis, each litigant has private information, but an ultimatum game model is analyzed. In that paper, the first-mover signals and the second-mover is screened. So if the private information for P(respectively, D) is about liability, and P's (respectively, D's) private information is ℓ_P (respectively, ℓ_D), then weak Ps (those with low values of ℓ_P) and weak Ds (those with high values of ℓ_D) will be more likely to settle, trimming the distribution from both ends – again, resembling the primary characteristic of the Priest-Klein approach.

Summing up, we are left with two essential points to consider. First, a divergent expectations model is probably best treated as an (inconsistent priors) asymmetric information model, as argued by Gertner and Miller, so that the issue is not so much asymmetric information as it is how priors arise. Second, (consistent priors) asymmetric information models with two-sided information exist; they are not intensively employed in theoretical analyses because they are considerably more complex than the one-sided models *and* because a random-proposer model, consisting of randomized selection between the two single-sided models, appears to cover the range of possible bargaining payoffs (though there is no theorem to this extent). Therefore, an empirical "horse race" on a level playing field may be difficult to achieve, since it will be a test of which information is taken as private and whether priors over that information are consistent or inconsistent.

Again, all this is not to say that inconsistent priors models are unworthy of exploration, just that the nature of the inconsistency needs to be developed very precisely. A nice example of such an analysis occurs in two recent papers by Yildiz (2003, 2004). In Yildiz (2003), bargainers play a modified version of the Rubinstein game: at each stage, Nature picks who will make an offer in each period, so that strict alternation of moves need not occur. The bargainers hold assessments over the likelihood that they will be picked ("recognized" by Nature) to make an offer in a period,

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21 In Section 19.3, we provide more detail on Gertner and Miller (1995).

and such assessments can reflect optimism in the sense that the sum of the players' assessments as to being recognized by Nature and being allowed to make the offer next period could exceed one. Making an offer entails the ability to exploit a rent by forcing the other bargainer to accept or face a diminished pie in the next period. While delay is a possible outcome, Yildiz shows that (if the degrees of optimism are common knowledge) if both litigants are sufficiently optimistic, delay will *not* occur. This is because optimism about large rents to be extracted in the future leads to less room to bargain and therefore lower rents to be extracted in the current time period, so that it is better to settle than wait. Thus, excessive optimism does not, in and of itself, lead to inefficiency. However, as Yildiz (2004) shows, learning over time about the likelihood of being the next one to make an offer can lead to delay.

C. VARIATIONS ON THE BASIC MODELS

14. Overview

This part locates and briefly reviews a number of recent contributions to the settlement literature. Two cautions should be observed. First, no effort will be made to discuss unpublished work. This is motivated primarily by the fact that such work is, generally, not as accessible to most readers as are the journals in which published work has appeared. There are some classic unpublished papers (some of which have significantly influenced the existing published papers) that are thereby slighted, and our apologies to their authors. Potentially, such a policy also hastens the date of the succeeding survey.

Second, the selection to be discussed is a subset of the existing published papers: it is not meant to be comprehensive. Instead, the selection is meant to show ideas that have been raised, or how approaches have been revised. A limited number of papers that address relevant issues, but which are not focused on settlement itself, are also mentioned.

Following the outline of Part A, papers will be grouped as follows: (1) players; (2) actions and strategies; (3) outcomes and payoffs; (4) timing and (5) information. Not surprisingly, many papers could conceivably fit in a number of categories, and a few cross-references will be made.

15. Players

15.1 Attorneys

Watts (1994) adds an attorney for P (denoted A_P) to the set of players in a screening analysis of a P-proposer ultimatum game; D is privately informed about expected damages at trial (for a discussion of agency problems in contingent fee arrangements, see Miller, 1987). The main role of A_P is expertise: A_P can engage, at a cost, in discovery efforts which release some predetermined portion of D's information. The cost to A_P is lower than the cost of obtaining the same information would be to P. Moreover, more precise information about D's likely type costs more to obtain (for either P or A_P) than less precise information (precision is determined exogenously in this model). Before bargaining with D, P can choose whether or not to hire A_P, and attorneys are paid on a contingency basis. If hired, A_P obtains information about D's type and then makes a settlement proposal to D. Given the precision of obtainable information and the expertise of A_P (that is, A_P's cost of obtaining information as a fraction of P's cost of obtaining the same information), Watts finds a range of contingency fees that P and A_P could agree upon (a settlement frontier for *P and* A_P to bargain over); she also finds that their concession limits decrease as the expected court award in the settlement problem with D increases.

Kahan and Tuckman (1995), Polinsky and Rubinfeld (2002), and Chen and Wang (2006) also provide models in which, once hired under a contingent-fee contract, A_P chooses the settlement demand, whether to proceed to trial, and how much to spend at trial, if negotiations fail. Kahan and Tuckman examine the impact of split-award statutes (this paper is discussed further in Section 17.3 below). Polinsky and Rubinfeld examine the impact of contingent fees; they find that the common intuition that A_P will settle too often and for too little may be overturned when litigation costs are endogenous. Since A_P will choose lower effort at trial, litigation costs may actually be lower under contingent fees, which tends to make A_P a tougher pretrial bargainer.[22] Chen and Wang examine the impact of fee-shifting based on the trial outcome; they find that A_P will bargain more aggressively under the "loser pays" rule than under the "pay your own" rule.

In all of these papers, there is an "agency" problem in the sense that A_P's choices would not coincide with those that maximize the plaintiff's side's payoff (call these the "benchmark outcome" choices), due to the fact that under a contingency fee, A_P receives a fraction of the award or settlement but pays all of the costs in the event of trial. Polinsky and Rubinfeld (2003) propose a compensation scheme for plaintiffs' lawyers that would align the incentives of lawyers with those of their clients. In order to achieve

[22] See also Rickman (1999) for a somewhat different model wherein an attorney can be a tougher bargainer when compensated via a contingent fee.

this alignment, it is necessary for A_P to bear the same share of the costs as he receives of the award (or settlement); let this share be denoted α. By hypothesis, the client cannot pay a share of the costs (which is the main rationale for using a contingent fee) so this must be paid by a "third-party administrator." Essentially, the attorney contracts with a third-party administrator under the following terms: the third-party administrator will pay the attorney the share $1 - \alpha$ of the attorney's expected litigation costs based on his actual choices (leaving the attorney to bear the share α of these costs). In exchange, the attorney makes a lump-sum up-front payment to the third-party administrator that is equal to the amount $(1 - \alpha)$ times the attorney's expected litigation costs in the *benchmark* outcome. Since this contract induces the attorney to make the benchmark outcome choices, the attorney's and client's interests are aligned and the third-party administrator breaks even.

15.2 Judges and Juries

As mentioned earlier, J is generally modeled in this literature as learning the truth and making awards equal to the true damages. Some models have allowed for unsystematic error on the part of J. For instance, Hylton (2002) and Landeo, Nikitin and Baker (2006) model the life-cycle of a tort (from the choice of precaution through the occurrence of harm, filing suit, settlement negotiations and trial) under the assumption that the court makes random errors. Hylton's court errs with respect to the defendant's liability, and this has an ambiguous effect on the settlement rate, while Landeo, Nikitin and Baker's court errs with respect to the level of the award, which turns out to promote settlement.

In the basic asymmetric information models described earlier, the informed player usually computes payoffs at trial on the basis that their true type will be fully revealed in court. Thus, a useful extension of the basic model would indicate how J learns the true type or, if J doesn't learn the true type, what J does in that event. In general, what the parties anticipate that J will know (and how J might learn it) could influence the settlement strategies and outcomes.

Daughety and Reinganum (1995) consider a J whose omniscience is parametric (that is, with an exogenously specified probability, J learns the truth; if not, J must infer it based upon P and D's observable actions) in a continuum-type ultimatum game signaling model, wherein P is informed about damages and D is not. J is a second "receiver" of a signal. If all that is observable to J is the failure of settlement negotiations (for example, because the content of failed settlement negotiations is inadmissible as evidence at trial), then when J observes that a case comes to trial, he can infer the distribution of such cases (using the posterior model shown in

Figure 15.4) and pick a best award (note that this means that all the elements of the settlement game are common knowledge to J, as is this fact to P, D and J). If J can also observe P's settlement demand, then he uses that information, too. The result is that this feeds back into the settlement process, resulting in P making demands to influence J.[23] As J's dependence on such information increases (omniscience decreases), revelation via the settlement demand disappears as more and more types of P pool by making a high demand (P "plays to the judge"). The result can be that, for sufficiently high reliance on observation instead of omniscience, J has even less information than if he couldn't observe P's settlement demand at all (and must rely on the posterior distribution of unsettled cases).

Influencing J is also the topic of Rubinfeld and Sappington (1987) which, while not focused on settlement *per se*, does model how effort by players can inform J. The setting is nominally a criminal trial, but the point potentially applies to civil cases, too: if innocent Ds should be able (more readily than guilty Ds) to obtain evidence supporting their innocence, then the amount of effort so placed can act as a signal to J of D's innocence or guilt. This is not a perfect signal, in the sense that the types of D are not fully revealed. As in much of the literature dealing with criminal defendants (this is discussed in more detail in Section 17.4 below), J here maximizes a notion of justice that trades off the social losses from punishing the innocent versus freeing the guilty and accounts for the costs incurred by D in the judicial process.

One final note on this topic. There is an enormous literature on jury and judicial decision-making spread across the psychology, political science, sociology and law literatures that has yet to have the impact it deserves on formal models of settlement bargaining.

15.3 Multiple Litigants

Many settings involve multiple litigants (for example, airline crashes, drug side-effects, etc.).[24] Che and Yi (1993) consider a game in which D faces two Ps sequentially. The model is a sequence of two D-proposer ultimatum games, where D faces informed Ps in the two games. The outcome

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23 Kim and Ryu (2000) reconsider the admissibility issue under somewhat different assumptions; they use a screening model (so the uninformed defendant now makes the offer) and the judge is assumed to receive a noisy signal about damages. They find that when the judge observes D's offer and P's rejection, then P will reject a larger set of offers in order to influence to her advantage the judge's subsequent beliefs about the level of damages.

24 See Daughety and Reinganum (2005) and Spier (2007) for a more in-depth discussion of multi-litigant models.

in the first trial may be precedential for the second trial in the following sense: if the first plaintiff (P_1) wins (respectively, loses) her case, then the second plaintiff (P_2) has a higher likelihood of winning (respectively, losing) her case. D can avoid setting a precedent by settling with P_1. They find that there is a critical value of D's likelihood of winning the first case such that, if D's likelihood of winning exceeds this critical level, then he is less willing to settle with P_1 (because he anticipates setting a favorable precedent for the second case), while if D's likelihood of winning is less than this critical level, then he is more willing to settle with P_1 (because he anticipates setting an unfavorable precedent for the second case).[25]

Yang (1996) also uses a sequence of two D-proposer ultimatum games where D faces informed Ps, but now the damages are correlated. Note that when D plays the second ultimatum game, the correlation of levels of damages over plaintiffs means that learning in game one affects D's strategy in game two, thereby feeding back into D's game one strategy choice. Yang includes the decision by both informed Ps to initially file their respective cases. Thus, D's actions with respect to P_1, and the likely outcome from going to trial, may deter P_2 from filing. Yang finds conditions under which this causes D, in dealing with P_1, to be more or less aggressive than the one-p model would find. While more aggressive play (being "tough") against P_1 may seem intuitive, less aggressive play is also reasonable if going to trial will reveal information that would encourage P_2 to file (such as, that P_1 had high damages). Why would this encourage P_2, who knows his own damages? Assume that P_2 is a low-level-of-damages plaintiff. By making a pooling offer to P_1, D does not learn P_1's type, and P_2 would be aware of this ignorance. Thus, P_2 knows that D is still uninformed, and cannot capitalize on D having received "bad news" that P_1 is a high-level-of-damages plaintiff, shifting upward D's prior assessment about P_2 (recall that D takes damages as correlated). There is a strategic advantage to not being informed if the knowledge of the information places you at a disadvantage. If D remains uninformed, then if P_2 is low she can't expect D to overestimate her as high and make a second pooling offer.

Several other issues become salient when there are multiple litigants on one (or both) sides of a case. For instance, suppose that a single plaintiff is suing multiple defendants who are subject to "joint and several liability;" that is, each defendant may (in principle) be held liable for the full

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[25] Briggs et al. (1996) consider a government antitrust suit, which may be followed by a private suit for damages. They show that the government suit will settle less often when there is the potential for a follow-on suit. This is because settlement is taken as an admission of liability in their model (which invites the follow-on suit), while there is a chance of winning at trial (which deters the follow-on suit).

amount of the plaintiff's harm, even though each defendant may have contributed fractionally to the occurrence of that harm.[26] Kornhauser and Revesz (1994a, 1994b) provide a complete-information model in which two defendants (D_1 and D_2) have contributed equally to a plaintiff's harm. P has a probability of prevailing against each defendant separately, as well as a probability of prevailing against both defendants in a single trial; the latter probability may exhibit some degree of correlation. Specifically, suppose that p is the probability that P will prevail against D_1 alone and that δp is the probability that P will prevail against D_2, having prevailed against D_1, in a trial against both defendants. If $\delta = 1$, then the cases are uncorrelated (two coins are flipped, each with probability p of coming up Heads), while if $\delta = 1/p$, then the cases are perfectly correlated (a single coin flip, with probability p of coming up Heads, applies to both cases). The plaintiff makes simultaneous settlement offers to D_1 and D_2, who decide noncooperatively whether to accept or reject their respective offers (if only one defendant settles, then the amount of the settlement is deducted from the total damages, and the second defendant is only responsible for the residual). Although one might expect all cases to settle under conditions of common knowledge, Kornhauser and Revesz show that both cases go to trial when the correlation is sufficiently low, and both cases settle when the correlation is sufficiently high.

Spier (2002) uses a related model to analyze the problem of two plaintiffs (P_1 and P_2) facing a single potentially insolvent defendant. In this model, D makes simultaneous offers to the two plaintiffs, who decide noncooperatively whether to accept or reject their respective offers. If only one plaintiff accepts, then the amount of her settlement is deducted from D's available wealth. Again, each plaintiff has a probability of prevailing against D separately, and a probability of prevailing against him when they both go to trial; again, this latter probability may involve some correlation. In this model, it turns out that both cases go to trial when the correlation is sufficiently high, while both cases settle when the correlation is sufficiently low. Again, it is worth noting that both the Kornhauser and Revesz papers, and the Spier paper, show that the presence of multiple litigants alone can cause bargaining failure; both papers involve complete information (though information is imperfect in the sense that simultaneous moves occur).

Class action lawsuits involve situations wherein the plaintiff's side (or the defendant's side, or both sides) consists of several litigants whose cases

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[26] A recent review of the current status of joint and several liability is contained in Marcus (2007).

are consolidated through class certification because the issues in dispute are sufficiently similar (for example, the defendant's liability, the extent of damages, or both). Individual litigants may opt out of the class and pursue their own suits separately. One reason for opting out is to avoid "damages averaging;" if each member of a plaintiff class will be awarded the average damages associated with the class membership, then a plaintiff with high damages may prefer to pursue an individual suit. Che (1996) provides a model of class formation in which plaintiffs may have high or low damages, and any settlement or award obtained by the class is divided equally among the class members. Although each plaintiff's harm is known within the class, D is unable to observe the plaintiffs' types (that is, their damages levels). Che finds that the class must include both high- and low-damaged plaintiffs; moreover, some high-damaged plaintiffs and some low-damaged plaintiffs must opt out of the class. This is because if only plaintiffs of one type chose the same action (whether that action is to join the class or to opt out of it), then that action would serve as a perfect signal of the plaintiff's type, and others (of both types) would be induced to send the same signal, or avoid sending it, depending on the inference drawn. For example, if only high-damaged plaintiffs opt out of the class, then D would be willing to make a high settlement offer to opt-outs; but then a low-damaged plaintiff could opt out and receive a high settlement offer, upsetting the hypothesized equilibrium. Che (2002) reconsiders this model under the assumption that the plaintiffs' damages are their individual private information even within the class, so the class must use an internal allocation mechanism to induce its members to reveal their types truthfully. In this case, the class will require a higher settlement offer (than if it did not have this internal information problem) because the settlement will also have to cover the information rents that are necessary to induce truthful revelation.

Che and Spier (2008) examine a dynamic model of settlement bargaining between a defendant and the members of a plaintiff class. There are scale economies in litigation, so that more plaintiffs reduce the cost per plaintiff of trial. If no single plaintiff would proceed to trial on her own, then Che and Spier demonstrate how a defendant can use sequential bargaining with different offers to different plaintiffs to undermine the credibility of suit by the plaintiff class. Essentially, when D settles with a given plaintiff, she drops out of the suit, thus raising the cost per plaintiff for those who remain in the class. Eventually, continuing on to trial becomes too expensive for the remaining class members, who then drop their suit. This result is robust to changing the timing of moves, as now plaintiffs "compete" for settlement offers, and (at least to some extent) to private information on the part of the plaintiffs. However, some collective strategies on the part of the class members can be effective at preventing the class from unraveling; these include considering only non-discriminatory offers, requiring a unanimous vote to accept an offer, or making side payments within the class.

Some lawsuits need not involve multiple litigants, but end up doing so because of litigant-generated externalities. Two prominent examples are the use of confidentiality agreements and most-favored-nation clauses in settlements. If a single defendant (with private information about his likelihood of being found liable) has harmed multiple plaintiffs, then the existence and outcome of an early plaintiff's case can be informative to a later plaintiff. If suppressing this information is of value to D, then the early plaintiff can charge D (in terms of a higher settlement demand) for providing confidentiality. Daughety and Reinganum (1999, 2002) provide models in which the parties in an instant case may engage in confidential settlement; this is to the detriment of future plaintiffs, but confidentiality reduces litigation costs overall by increasing the likelihood that the early suit settles and by reducing the likelihood that the later suit is filed. These models differ in the degree to which D's liability is correlated across cases; when it is weakly correlated, then the early plaintiff is able to extract the full value of confidentiality to D, leaving his incentives for care intact, but when it is strongly correlated, then D retains some of the value of confidentiality (that is, he receives an information rent) and his incentives for care are undermined.

A "most-favored-nation" (MFN) clause in a settlement agreement between a defendant and one or more early-settling plaintiffs specifies that, should the defendant subsequently settle with another plaintiff on more favorable terms, then the early-settling plaintiffs are retroactively entitled to the same (more favorable) terms. Spier (2003a, 2003b) considers a defendant facing many plaintiffs, each of whom has private information about her harm. D has the opportunity to make an offer in each of two periods (thus, this is a screening model since the uninformed player moves first). A plaintiff can accept the first offer or wait for the second offer; then she can accept the second offer or choose trial. When bargaining without an MFN, Spier shows that D will make an increasing sequence of offers. Anticipating this, some plaintiffs who prefer the first offer to trial will nevertheless wait for the higher second offer, and D will incur bargaining and delay costs for two periods. However, if the first offer includes an MFN, then in equilibrium D's second offer will never be higher than the first (for then D would have to retroactively compensate those plaintiffs who settled in the first period, and this serves as a deterrent to raising his second-period offer). Thus, D can use an MFN to commit himself to a first-and-final settlement offer; knowing this, plaintiffs have no strategic reason to delay settlement, and D's bargaining and delay costs are confined to one period. Depending on the distribution of damages, the use of an MFN may result in a higher or lower frequency of trial; that is, there are some distributions for which the use of an MFN reduces expected litigation costs.

Daughety and Reinganum (2004) examine the use of an MFN by an early-bargaining plaintiff who anticipates the subsequent arrival of another plaintiff. Again, the plaintiffs have private information about their harms, but now the plaintiffs make the settlement demands (thus, this is a signaling model since the informed player moves first). Recall that in the signaling model, the privately-informed plaintiff has an incentive to inflate her demand, so the defendant must reject higher demands with a higher probability in order to deter this behavior. Daughety and Reinganum find that an early-settling plaintiff will find it optimal to include an MFN with her settlement demand for two reasons. First, if D accepts the demand, then the early plaintiff has the opportunity to receive a retroactive payment should D settle with the later plaintiff on better terms (and this will occur in equilibrium with positive probability). Second, because the early plaintiff puts this extra payment at risk if she makes a higher demand, D need not reject the early plaintiff's demand as often in order to deter her from inflating it. This use of an MFN by the early-settling plaintiff leaves D's equilibrium payoff unchanged, while the early plaintiff benefits at the expense of the later plaintiff. Overall, expected litigation costs are lower when an MFN is used, again for two reasons. First, as mentioned above, D rejects the early plaintiff's demand less often. Second, with an MFN in place, the later plaintiff moderates her demand when it would trigger the MFN, and lower demands are rejected less often by D.

16. Actions and Strategies

16.1 Credibility of Proceeding to Trial should Negotiations Fail

In the screening examples in Section 12.3 above, an uninformed D made an offer to an informed P, with liability commonly known but the level of damages the source of the informational asymmetry. For convenience of exposition, consider the reversed setting, with D informed about the likelihood of being found liable at trial, P uninformed, but both commonly knowledgeable about the level of damages (this is the original Bebchuk example). Thus, a screening analysis means a P-proposer ultimatum model. In this context, Nalebuff (1987) examines the assumption that P is committed to proceeding to trial after bargaining fails (alternatively put, he relaxes the assumption that there is a minimum positive likelihood of liability that, multiplied by the level of damages, would exceed P's court costs; this is the analogy to our earlier assumption that $d_L > k_P$ holds).[27]

Nalebuff considers cases that, initially, have "merit": $E_P(d) > k_P$. He appends a second decision by P (concerning whether or not to take the case to trial) to the P-proposer ultimatum game screening model. After observing the response by D to the screening demand made by P, P recomputes $E_P(d)$ using his posterior assessment; denote this as $E_P(d|$ D's response), meaning P's expectation of the level of damages which will be awarded in court given D's choice to accept or reject the offer. Since all types whose true likelihood of liability implied levels of expected damages in excess of that associated with the demand (that is, the more likely-to-be-liable types of D) have accepted the demand, the collection of types of D who would reject the demand by P are those with stronger cases (that is, those that are less likely to be held liable). Thus, P's new expected payoff from proceeding to trial, $E_P(d|$ D's response) $- k_P$, is lower than before the bargaining began ($E_P(d) - k_P$). The decision by P as to whether or not to actually litigate *after* seeing the outcome of the screening offer results in a reversal of some of the predictions made by the original screening model about the impact that changes in the levels of damages and court costs will have on settlement demands and the likelihood of trial.

For example, Nalebuff shows that the settlement demand in the relaxed model is *higher* than that in the model with commitment. Why would this happen? To see why, consider what happens in stages. When P is making his settlement demand, he is also considering the downstream decision he will be making about going to trial and must choose a settlement demand that makes his later choice of trial credible. If P can no longer be committed to going to trial with any D who rejects his screening demand, this means that he will use $E_P(d|$ D's response) to decide about going to trial, and this is now heavily influenced by the presence of "tough" types; those types that are "weak," that is, who have high likelihoods of liability, have accepted P's offers. Thus, if P raises his settlement demand, some of the intermediate types will pool with the tough types, resulting in $E_P(d|$ D's response) $- k_P > 0$, making the threat of trial credible. Thus, the effect of relaxing the assumption that P necessarily litigates any case that rejects his settlement demand actually results in an increased demand being made.

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[27] Several papers discussed below have integrated a Nalebuff-inspired credibility constraint into their analyses of related issues.

16.2 Filing and Pursuing a Claim

One potential effect of a cost associated with filing a suit is to provide a disincentive for a P pursuing what is known as a "nuisance" suit. The definition of what a nuisance is varies somewhat, but generally, such a suit has a negative expected value (NEV) to P; that is, $E_P(d) < k_P$; such a suit is not one that P would actually pursue to trial should negotiations fail (note that this ignores any psychic benefits that P may derive from "having his day in court" which might make such a suit have a positive expected utility). Clearly, the reason for consideration of NEV suits is the perception that plaintiffs can pursue NEV suits and obtain settlements: the asymmetry of information between an informed P and an uninformed D allows plaintiffs with NEV suits to mimic PEV suits (positive expected value suits) and extract a settlement. Two questions have arisen in this context: what contributes to the incentive for plaintiffs to pursue NEV suits and what attributes of the process might reduce or eliminate it?

An example may be of use at this point. Consider a D facing three possible types of P, with possible damages $d_N = 0$, $d_L = \$10{,}000$ and $d_H = \$50{,}000$, respectively and with associated likelihoods $p_N = 0.1$, $p_L = 0.3$ and $p_H = 0.6$ (N here stands for "nuisance"). Further assume both P and D have court costs of $2,000. The screening equilibrium involves the firm offering $8,000 and settling with the nuisance and the low-damages type and going to court against the high-damages type: the nuisance-type benefitted from the presence of the low-damage type and the expected costs to the firm are higher (an average expected cost of $34,400 per case) than would obtain if the nuisance type had not been present (an average expected cost of $33,600 per case).

P'ng (1983), in one of the earliest papers to consider strategic aspects of settlement bargaining, endogenizes both the choice by P to file a case and the choice to later drop the case should bargaining fail; NEV suits are considered, but the level of settlement is exogenously determined in this model. Rosenberg and Shavell (1985) found NEV suits can occur if filing costs for P are sufficiently low when compared with D's defense costs and if D must incur these costs before P must incur any settlement or trial costs. Bebchuk (1988) provides an asymmetric information (P is informed), D-proposer ultimatum game that specifically admits NEV suits (that is, no assumption is made that all suits are PEV). Filing costs are zero. Bebchuk shows how court costs and the probability assessment of the possible levels of damages influences settlement offers and rates. He finds that when NEV suits are possible, a reduction in settlement offers in PEV cases and an increase in the fraction of PEV cases that go to trial, when compared with an analysis assuming only PEV suits, is predicted.

Katz (1990) considers how filing and settlement bargaining affects incentives for frivolous lawsuits. By a frivolous suit, Katz means one with zero damages and positive court costs; the numerical example above involved a frivolous suit. Katz appends a filing decision made by an informed P to a D-proposer ultimatum game. This is a two-type model (the paper also includes a continuum-type extension) with $d_L = 0$. The modification of the D-proposer model is that the offer is either the high-damage P's concession limit or zero, so the strategy for D becomes the probability of making the high-damage concession limit offer. P's filing strategy is whether or not to file; if he files, P incurs a cost f_P. Of course, once incurred, this cost is sunk. Under the assumption that $d_H - k_P - f_P > 0$, and if a condition similar in notion to (SSC) is violated, then in equilibrium both types of Ps file cases, D pools the Ps by offering the high-damage P's concession limit, $d_H - k_P$, to all Ps and all Ps accept. Katz also addresses a case selection issue: such a policy by D will attract frivolous cases, changing the likelihood that a randomly selected case is frivolous. Thus, the profits from filing a frivolous case will be driven to zero. In this "competitive" equilibrium, Katz shows that the likelihood of trial is not a function of p or k_D, but it is increasing in f_P and decreasing in $E_D(d)$.

Rosenberg and Shavell (2006) suggest that, once P files suit, D should have the option to petition the court not to enforce any settlement agreement that D might conclude with the instant P. D would exercise this option when he expects that P's suit has negative expected value; anticipating this, such a P would be deterred from filing suit. Absent this commitment, D would be unable to prevent himself from settling with P. Of course, this procedure would facilitate the deterrence of even valid NEV suits (not just frivolous suits). Moreover, if D is uncertain about whether the suit is NEV or PEV and he exercises this option, then he would not be able to settle the case upon learning subsequently that it is PEV.

A recent line of research reconsiders whether an NEV suit can be pursued credibly, even when it is common knowledge that it is an NEV suit. Bebchuk (1996) argues that some NEV suits can be made credible if litigation costs are divisible and can be sunk strategically during the pretrial time period.[28] The key is to ensure that, at every pretrial stage, the next installment of litigation costs is sufficiently small as to render credible the plaintiff's threat to proceed to the next stage (and, ultimately, to trial).

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28 Klement (2003) argues that Bebchuk's result is not robust to the inclusion of private information on the part of D about his expected liability. The uninformed party P is assumed to make a series of settlement demands, each of which entails sinking more of the total litigation costs; by rejecting P's demands, D signals that his expected liability is low. It is shown that this "stonewalling" by D can deter many NEV suits regardless of the extent of cost divisibility.

At the last pretrial stage, if P has already sunk enough of the litigation costs, then she will have a credible threat to go to trial, and the parties will settle; Bebchuk uses a random-proposer model to determine the amount of the settlement. Anticipating that settlement will occur should the parties reach the last pretrial stage, if the next installment of litigation costs is less than the expected settlement, then the parties will settle in the penultimate pretrial stage. This backward induction continues with the result that, if each installment of litigation costs is not too large, then settlement will occur in the first pretrial stage, despite the fact that it is common knowledge that the expected value of P's suit is less than P's total litigation costs.

Schwartz and Wickelgren (2009) argue that plaintiffs cannot use this "cost-sinking" strategy in order to render NEV suits credible. The crux of their argument is that Bebchuk has assumed a random-proposer model in which one litigant makes the offer, while the other can only accept or reject; that is, there is no opportunity to make a counteroffer. In the random-proposer model, P will receive none of the surplus when D is the proposer and P will receive all of the surplus when she is the proposer. Schwartz and Wickelgren argue that bargaining is better-modeled as a sequence of alternating offers in which P has the outside option of going to trial; moreover, in their model, the parties can make as many offers and counteroffers as they like within each pretrial stage. They then assert that, at *every* stage, D only needs to offer P an amount that is just sufficient to make her prefer settlement to her outside option, giving P essentially none of the surplus from settlement. Schwartz and Wickelgren argue that, whatever P demands, D should simply counteroffer with this "just sufficient" offer (and keep on doing so indefinitely). It is credible for D to do this since he does not lose from delay (while the plaintiff does). Although both parties have equal formal bargaining power in the sense that each party can always make a counteroffer, their asymmetric time preferences allow D to push P to her concession limit (the value of her outside option). Thus, under this bargaining protocol, it is not possible for the plaintiff to extract a settlement when it is common knowledge that her suit is NEV.

A crucial difference between the Bebchuk model and that of Schwartz and Wickelgren is that Bebchuk assumes a fixed finite number of offers; for example, if making and responding to offers is costly and there is a deadline, then there is a "last" offer and there is a positive probability that P will make the last offer. Schwartz and Wickelgren assume an indefinite number of offers; for example, if it is possible to make offers and respond to them arbitrarily quickly, then there is no "last" offer. In this case, D's ability always to make a counteroffer results in P receiving simply the value of her outside option, which is negative by hypothesis. Clearly, both of these underlying "stories" about bargaining are abstractions to some extent; the careful analysis provided by these two articles indicates that whether one believes that cost-sinking can be used to render an NEV suit credible will depend on which of these stories one deems more representative of "real" settlement bargaining. This also suggests that a game wherein the proposal/response-period length and frequency are determined endogenously would be of interest. For instance, suppose that every proposal requires careful evaluation by an attorney, which is a costly and time-consuming activity. Would it be optimal for a party to hire a busy lawyer (that is, one with other clients in the queue with equally pressing issues) in order to make credible a certain amount of delay (and perhaps thereby generate a "last" period)?

16.3 Counterclaims

Using an imperfect information model, Landes (1994) shows that counterclaims (suits filed by D against P as part of the existing action by P against D, rather than filed as a separate lawsuit) do not always reduce P's incentive to sue, and may (by raising the stakes in the game) actually increase the likelihood of the case going to trial. This is based on mutual optimism about each player's own claim (mutual optimism involves each player expecting to win the action that they initiated; this need not involve inconsistent priors, as discussed in Section 6). Under these conditions, the counterclaim reduces the size of the settlement frontier (and possibly eliminates it).

17. Outcomes and Payoffs

17.1 Risk Aversion

Most of the earliest analyses allowed for risk aversion by assuming that payoffs were in utility rather than monetary terms. The Nash Bargaining Solution can be applied to such problems (now all four axioms come into play), again yielding a unique solution, though not necessarily where the 45° line crosses the frontier. The solution is efficient (due to axiom 2; see Section 8.2) in perfect and imperfect information cases. The divergence of the solution from the 45° line reflects the relative risk aversion of the two players, with the more risk-averse player receiving a smaller share of the pie (see, for example, Binmore, 1992, pp. 193–4).

There is a similar analysis in the perfect information strategic bargaining literature, where risk is introduced into an infinite horizon game by ignoring the time value of money but incorporating a probability of negotiations breaking down. Once again, for players whose preferences over outcomes reflect aversion to risk, the less risk-averse player gets the greater share of the pie (see Binmore, Rubinstein and Wolinsky, 1986).

In the settlement context, Farmer and Pecorino (1994) view a player's risk preferences as private information. While trial outcomes are uncertain, the likelihood of the outcomes themselves is common knowledge. P is taken to be risk averse (that is, privately informed of his risk preferences) and D is risk neutral and uninformed; the model allows for two types of P (extension to three types is also considered). This is a D-proposer ultimatum model; if the roles of proposer were reversed, then P's risk aversion would not interfere with an efficient settlement solution, so the order here is crucial to obtaining the possibility of trial. A standard screening condition is found (not unlike (SSC)), but more interesting is the result that increases in the uncertainty of the trial outcome result in the screening condition being more readily met, thereby increasing the likelihood of trial (a result consistent with the earlier analysis involving risk aversion). This occurs because it is the most risk-averse Ps that settle, and the greater the uncertainty, the more they are prepared to accept a settlement in lieu of court, which encourages D to make tougher offers.

17.2 Offer-Based Fee-Shifting Rules

Many settlement papers consider the allocation of court costs (fee-shifting) as part of their overall analysis. Typically, comparisons are made between the "American" system (each player pays their own costs) and the "British" system (the loser pays all costs). The very common association in the literature of loser pays with Britain potentially understates the contrast; see Posner (1992), who uses the term "English and Continental" to emphasize that a significant portion of the world uses loser pays. All the discussions in this survey have employed the pay-your-own system. The allocation of court costs is an extensive topic, with a typical result being that the loser-pays system discourages low-probability-of-prevailing plaintiffs more than the pay-your-own system (see Shavell, 1982), but other observations are that it may (or may not) adversely affect the likelihood of settlement (see Bebchuk, 1984, and Reinganum and Wilde, 1986). A more recent extension of the basic fee-shifting discussion to making fee-shifting dependent upon the magnitude of the outcome is discussed in Bebchuk and Chang (1996). Finally, Klement and Neeman (2005) ask what settlement procedure and litigation cost allocation system minimizes expected litigation cost subject to maintaining a constant level of deterrence. They find that the optimal procedure involves an upper bound on the allowable rate of settlement (excessive settlement undermines deterrence). Moreover, any procedure that achieves this upper bound must involve the "loser pays" cost-shifting arrangement. Since the general area of fee-shifting is a separate topic in its own right (which is likely to be addressed in a number of other surveys in these volumes), this survey will not attempt to cover it.

A related issue is recent work on Rule 68 of the US Federal Rules of Civil Procedure, as an example of a variety of *offer-based* fee-shifting rules which directly address settlement offers made by defendants and rejected by plaintiffs. First, it should be noted that, under long-standing practice, and also under many state rules of evidence and US Federal Rule of Evidence 408, information on settlement proposals and responses is not generally admissible as evidence at trial; a similar type of restriction usually applies in criminal cases to information about plea bargaining. Rule 68 includes restrictions on the use of settlement proposals at trial.

Thus, in the case of offer-based fee-shifting, offers are not used in court to infer true damages or actual liability; rather they influence the final payoffs from the game *after* an award has been made at trial. Rule 68, for example, links settlement choices to post-trial outcomes by penalizing a plaintiff for certain costs (court costs and, sometimes, attorney fees) when the trial award is less favorable than the defendant's "final" proposal (properly documented). As Spier (1994a) points out, the stated purpose of such a rule is to encourage settlement (Spier also provides other examples of offer-based rules similar in nature to Rule 68). Spier employs screening in a D-proposer ultimatum game. In comparison to the likelihood of settlement without Rule 68, she finds that under Rule 68: (1) disputes by P and D over damages are more likely to settle; and (2) disputes over liability or the likelihood of winning are less likely to settle. Spier also finds that the design of a bargaining procedure and fee-shifting rule that maximizes the probability of settlement yields a rule that penalizes either player for rejecting proposals that were better than the actual outcome of trial, providing some theoretical support for offer-based fee-shifting rules such as Rule 68.

17.3 Damage Awards

In previous sections of this summary, the award at trial has been the level of damages associated with the plaintiff who goes to court. This, minus court costs, becomes P's threat. This is based on J choosing an award that best approximates P's damages. Other criteria for choosing awards are also reasonable. For example, J might choose awards that maximize overall social efficiency or that minimize the probability of trial.

Polinsky and Che (1991) study decoupled liability: what D pays need not be what P receives. By decoupling, incentives for plaintiffs to sue can be optimized, while incentives for potential defendants to improve the level of care can be increased; that is, both goals can be pursued without necessarily conflicting. In particular, they show that the optimal payment by D will equal his wealth and the optimal award to P will be somewhat lower, as long as D is not too wealth-constrained (when D's wealth is too small, then the optimal award to P may exceed D's wealth). Choi and Sanchirico (2004) show that when effort at trial is also endogenous, then the optimal payment by D may well be less than his wealth, since raising the payment by D induces a more vigorous (and expensive) defense. Moreover, the optimal recovery by P may well exceed the optimal payment by D. Finally, Chu and Chien (2007) use a screening model to argue that, if settlement negotiations take place under asymmetric information, then the optimal award to P cannot be lowered beyond a certain threshold (which depends on the specified payment by D) without undermining P's ultimate threat to take the case to trial. As in Nalebuff (1987), when the credibility of P's threat is in doubt, P must make a higher demand and induce more defendant types to reject it, so as to retain a sufficiently rich defendant pool to justify taking the case to trial. Thus, lowering P's award beyond this threshold does not have the intended effect of reducing trials; indeed, it has the opposite effect. The optimal decoupled liability rule in this context involves setting P's award at the threshold level (which establishes a specific relationship between P's award and D's payment) and then choosing D's payment optimally; the authors provide conditions under which the optimal payment by D is greater than, but approximately proportional to, P's harm.

Kahan and Tuckman (1995), Daughety and Reinganum (2003) and Landeo and Nikitin (2006) consider the effect of a split-award statute (whereby a state takes a fraction of any punitive damages award) on incentives to file suit and settle. Kahan and Tuckman employ a complete-information model wherein trial effort is endogenous and P's lawyer receives a contingent fee. They find the effect of a split-award statute on settlement to be mixed. Although P's side receives only a fraction of the award at trial, this reduction in the stakes reduces equilibrium trial effort, thus making trial less expensive to pursue. Daughety and Reinganum provide an incomplete-information model of settlement with exogenous trial costs; again P's lawyer receives a contingent fee. Both a screening and a signaling version of the model are considered; in both versions, they find that a split-award statute results in a higher likelihood of settlement and a lower expected settlement amount for a given case. However, the fact that P is more willing to settle can make a plaintiff's lawyer more willing to take the case, with the result that some weaker cases may be filed under a split-award statute. Landeo and Nikitin add a further prior stage in which the (potential) D chooses care; they find that a split-award statute reduces care and they provide conditions under which a split-award statute will reduce the equilibrium probability of trial (including its effects on both filing and settlement).

Spier (1994b) considers coupled awards in an asymmetric information setting, and finds that the level of settlement costs influences the nature of the award that minimizes social cost (precaution costs plus litigation costs plus harm). Note that, here, precaution is one-sided: precaution on the part of a potential P is not included. Spier considers a two-type screening D-proposer ultimatum game and allows for two awards, a_H and a_L, for circumstances where the level of damages is High or Low, respectively, and thus the payoff from trial is the award minus court costs. Spier uses a condition such as (SSC) and shows that, if total court costs are low enough, the socially optimal award is equal to the level of damages *plus* P's court costs (as D will make a screening offer in those circumstances), while if total court costs are sufficiently high, the optimal award is the *expected* damages plus P's court costs (as D will be making a pooling offer). Therefore, simply compensating for actual damages is not socially optimal (recall also that court costs are fixed). Moreover, "fine tuning" the award to reflect P's actual level of damages is socially optimal only if total court costs are not too high.

17.4 Other Payoffs: Plea Bargaining

As an example of a significantly different payoff measure, consider negotiations between a defendant (D) in a criminal action and a prosecutor (P). This type of settlement bargaining, called plea bargaining, has been addressed in a number of papers. Early papers in this area are Landes (1971), Grossman and Katz (1983), and Reinganum (1988). In Landes' model, the payoffs are expected sentence length for P versus expected wealth (wealth in two states: under conviction and under no conviction) for D, who is guilty. In Grossman and Katz' model, D may be innocent, and he knows (privately) whether he is guilty or innocent (a two-type model). D seeks to minimize the disutility of punishment (he is risk averse), while the uninformed prosecutor maximizes a notion of justice that trades off the social losses from punishing the innocent versus freeing the guilty; the Grossman and Katz analysis is a screening model, with innocent defendants choosing trial.

Reinganum's model involves two-sided asymmetric information: D knows (privately) whether he is guilty or innocent (two types), while P knows (privately) the strength of the case; that is, the probability that the case will yield a conviction at trial (a continuum of types). Guilt and evidence are correlated, so there is a relationship between the two sets of types. A special case of this relationship appears in Grossman and Katz and was also employed in Rubinfeld and Sappington (1987), discussed in Section 15.2: innocent defendants can more readily obtain supporting evidence than can guilty ones. P's payoff is social justice minus resource costs, while D's payoff to be minimized is the expected sentence plus the disutility of trial. Reinganum finds that P's plea offer (which signals the strength of his case) is accepted by a mixture of innocent and guilty defendants; thus, defendant types are not screened perfectly in equilibrium.

Baker and Mezzetti (2001) extend the Grossman and Katz plea bargaining model to include P's costly evidence generation following failed plea negotiations; evidence can help filter out innocent defendants and increase the likelihood that a guilty defendant will be convicted. This modification results in an equilibrium in which all innocent defendants and some guilty defendants reject the plea bargain. Since the defendant types are not screened perfectly, it is optimal for P to try a fraction of the cases in which plea bargaining failed.

Bjerk (2007) also envisions a role for evidence generation following plea bargaining, but this evidence is not observed by P prior to trial, but rather by the jury during trial. The prosecutor has an initial observation on evidence, and this initial strength of P's case against D is common knowledge to P and D. Furthermore, it is common knowledge that the evidence observed by the jury at trial will be even stronger (respectively, weaker) if D is guilty (respectively, innocent). The jury observes neither the initial evidence nor the offer made by P to D. If the initial evidence against D is sufficiently strong, then in equilibrium P makes a plea offer that is rejected by all Ds. On the other hand, if the initial evidence against D is weaker, then in equilibrium P makes an offer that is accepted only by guilty Ds. When a case comes before them, jurors cannot know whether it involves an innocent defendant (who rejected a screening offer) or a defendant of either type (who rejected a harsh pooling offer); thus, jurors will convict (respectively, acquit) those Ds against whom the evidence realized at trial is sufficiently strong (respectively, weak).

Kobayashi (1992), Reinganum (1993), Miceli (1996), and Franzoni (1999) examine the effect of plea bargaining on the decision to commit a crime. Kobayashi considers conspiracies: there are two defendants (for example, a price-fixing case) who face different (exogenously determined) initial probabilities of conviction based on the existing evidence. Each D can, however, provide information on the other D which increases that second D's likelihood of conviction. Kobayashi assumes that the D with the higher initial conviction probability (the "ringleader") also has more information on the other D (the "subordinate"). Here P makes simultaneous offers to each D so as to maximize the sum of the expected penalties from the two Ds. Litigation costs are taken to be zero so as to focus on plea bargaining as information gathering. He finds that "unfair" plea bargains, wherein the ringleader receives a smaller penalty than the subordinate, can improve deterrence. Reinganum's model takes all Ds as guilty and therefore takes P's payoff as expected sentence length minus resource costs. In this model, the level of enforcement activities (as chosen by the police) and the expected sentence (as determined by plea bargaining) both influence D's initial choice to engage in criminal behavior. Miceli considers two possible objectives for a prosecutor; he finds that a P who maximizes the expected sentence minus resource costs effectively implements a legislature's preferences over sentencing (that is, a low probability of a long sentence), while a P who trades off the social losses from punishing the innocent versus freeing the guilty is unwilling to implement such a policy and instead offers a substantial sentence discount in plea bargaining. Finally, Franzoni assumes that P first bargains with D and then, if D rejects the plea offer, P decides how much to spend on an investigation. The investigation is assumed (always) to verify innocence, and to verify guilt with a probability that increases with the amount spent. Since innocent Ds always reject plea offers, P's offer must induce enough guilty D's to reject in order to make the subsequent pursuit of an investigation credible (recall Nalebuff, 1987, discussed in Section 16.1). This credibility requirement results in less thorough investigations, lower sentences, and more crime than would occur if P was able to commit *ex ante* to the extent of investigation.

18 Timing

Five theoretical papers have focused especially on the implications of changing the timing assumption in the models used: Spier (1992), Daughety and Reinganum (1993), Wang, Kim and Yi (1994), Bebchuk (1996), and Schwartz and Wickelgren (2009). The papers by Daughety and Reinganum and by Wang, Kim and Yi were discussed in Section 12.4 above. These two papers (along with Spier's) analyzed models that contributed some support for the one-sided asymmetric information ultimatum games. The papers by Bebchuk, and Schwartz and Wickelgren examine what happens if the settlement interval is subdivided and litigation costs are sunk over multiple periods; this has important implications for the credibility of lawsuits, and these two papers were discussed in Section 16.2.

Spier (1992) considers a finite-horizon sequence of P-proposer ultimatum games, with D informed about the damages for which he is liable (a continuum-type model). She finds a "deadline effect" in which there is a high likelihood of settlement in the last period. Moreover, the distribution of settlements over time can be U-shaped in the sense that there is a high likelihood of settlement in both the first and the last periods, with a low likelihood of settlement in the intervening periods. P is viewed as incurring two costs: (1) each extra period incurs a negotiating cost (this accounts for the high likelihood of early settlement) and (2) going to trial incurs a court cost (this accounts for the high likelihood of settlement just before trial).

D incurs neither cost, which is not a restrictive assumption in this analysis. Both P and D discount money in future periods at the same discount rate. Thus, the analysis involves subdividing the bargaining period into a sequence of periods and associating a delay cost for each period that settlement is not reached. Since the pie itself is not shrinking, the delay cost provides a clear incentive to P to settle sooner. On the other hand, P is uninformed and may need to use the approach of the end of the horizon to get D to reveal information through his rejection policy. This tradeoff leads to some settlements being made immediately and some being made in the last possible period when D faces the imminent possibility of trial.[29] Fenn and Rickman (1999) extend Spier's model to reflect the English cost allocation system and obtain similar results.

Two empirical papers have documented deadline effects. Fournier and Zuehlke (1996) test the predictions of Spier's finite horizon model with data from a survey of civil lawsuits from 1979–1981 in US federal courts. They find results that are consistent with computer simulation predictions based on Spier's analysis. Deffains and Doriat (1999) examine several different case classifications within two jurisdictions in France, where settlement is relatively rare (overall, about one quarter of cases settle). They find that, for several combinations of case type and jurisdiction, a deadline effect arises, though there are other combinations that do not appear to be subject to a deadline effect.

Kessler (1996) and Fenn and Rickman (2001) do not look for a deadline effect *per se*, but seek to identify causes of settlement delay. Kessler notes that approximately half of the states impose prejudgment interest on the theory that a defendant cannot thereby gain by delaying settlement. However, if the interest rate is equal to the common discount rate of the parties, then both P and D are indifferent about the timing of settlement (and otherwise at least one party may have an incentive to delay, though, under complete information, settlement occurs immediately and the effect of prejudgment interest is simply to shift the settlement amount). If there is private information, then prejudgment interest may actually result in more delay, since it increases the mean and variance of the stakes. Kessler's empirical analysis of US automobile bodily injury claims also incorporates other attributes of the prejudgment interest statutes, which may have independent effects on settlement delay. He finds that prejudgment interest

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[29] Spier also considers an infinite-horizon extension, where P may choose to go to court in each period; this provides a model that allows for an endogenous date for trial. The model yields a range of equilibria (this is not unusual in strategic bargaining games with outside alternatives); the range runs from efficient to fully inefficient (all cases go to trial in the second period).

statutes do increase delay in settlement (an unintended consequence), as does a measure of the court's backlog (this hints at a deadline effect since a shorter backlog suggests a shorter time-to-trial, that is, an earlier deadline), and the use of comparative negligence (an indicator of the complexity of the case). Fenn and Rickman (2001) use a database of motor vehicle accidents in the UK. They find that delay is longer when the insurance company (defendant) is more convinced that it is not responsible, when the case is of high value and when the bargaining costs are low.

19. Information

19.1 Acquiring Information from the Other Player: Discovery and Disclosure

Shavell (1989) examines the incentives for informed players to voluntarily release private information in a continuum-type, informed-p, D-proposer ultimatum game. Before D makes a proposal, P can costlessly reveal his hidden information to D; he may also choose to stay silent. Shavell shows that silence implies that P's information involves low types (for example, that P's level of damages is low). Shavell considers two possibilities: claims by P are costlessly verifiable by D or some types of P cannot make verifiable claims; for convenience, call the first analysis an *unlimited verifiable claims* (UVC) model and the second a *limited verifiable claims* (LVC) model (in the LVC model, those types of P unable to make verifiable claims is an exogenously specified fraction u). In the UVC model, all Ps whose true type is less than or equal to a given value stay silent, while all those above that value make their claims. Since the claims are verifiable, D settles with those types by offering their concession limit and settles with the silent types by offering a settlement offer designed to reflect this group's types. Thus, there are no trials in equilibrium. Under discovery rights for D that provide mandatory disclosure, all types of P reveal, resulting in a reduced expenditure for D: each type of P settles for their concession limit.

In the LVC model, there will be trials. The reason is that the silent Ps now include those types who cannot make verifiable claims; some of these will have higher levels of damages than the offer made to the group of silent types, and will thus reject the offer and then go to trial (this relies on the assumption that u is independent of the level of damages). The rest of the silent types will settle, as will those whose claim is both greater and verifiable. Discovery now means that D can settle with $(1 - u)$ of the possible types of P at their concession limit and must screen the silent types, all of whom have unverifiable claims and, thus, some of whom will proceed to court (if the continuum-type version of (15.3) holds). Again, total D expenditures will generally be reduced from the original LVC payoff.

Mandatory disclosure in the LVC case raises the screening offer for the silent group, since those lower types with verifiable claims have settled at their concession limit. Thus, the probability of trial will be reduced relative to the original LVC outcome. Moreover, those with verifiable claims would have settled with or without mandatory disclosure.

Sobel (1989) provides a two-sided asymmetric information model that examines the impact of discovery and voluntary disclosure on settlement offers and outcomes; significantly, discovery generates costs and this affects results. He sandwiches one of two possible discovery processes between an initial D-proposer ultimatum game and a final P-proposer ultimatum game. Settlement in the D-proposer model ends the game, while rejection leads to the possibility of either mandatory discovery or no discovery of D's private information by P. This is then followed by the P-proposer ultimatum game. The cost of disclosure to D is denoted c. In a voluntary disclosure setting, D's choice to disclose is costly, and therefore might be used by D to signal that the information was credible. By making P the final proposer, P is able to extract all the surplus from settlement. Thus, D has no reason to voluntarily disclose information if $c > 0$. This contrasts with results, for example, by Milgrom and Roberts (1986), who model costless voluntary disclosure and find that such disclosure can be fully revealing. As Sobel observes, this suggests that such a conclusion is sensitive to the assumption that $c = 0$. Sobel also finds that mandatory disclosure reduces the probability of trial and may bias the selection of cases that go to trial, generating a distribution in which P wins more often.

Cooter and Rubinfeld (1994) use an analysis based on an axiomatic settlement model with prior assessments that may be inconsistent; discovery may or may not eliminate inconsistency. For example, discovery may reveal a player's private information or it may cause a player to adopt an alternative perspective about what may come out of a trial. Either way, an NBS is applied to a settlement frontier adjusted by the difference in expected trial payoffs. One of the main results is the proposal of an allocation of discovery costs so as to provide disincentives for abuse by either player. The proposed allocation assigns discovery costs to each party up to a switching point, at which point incremental costs are shifted to the requesting player.

Farmer and Pecorino (2005) consider both screening and signaling models of settlement in which the plaintiff has private information about her damages. In both cases, the plaintiff has the option to disclose her private information (at a cost) and the defendant has the option to force mandatory disclosure (at a cost) before settlement negotiations. In the screening model, the defendant makes the settlement offer; in this case, the plaintiff will never disclose voluntarily, since the defendant will then offer her only her concession limit, but the defendant may engage in mandatory disclosure. On the other hand, in the signaling model the plaintiff makes the demand and the demand reveals her true damages; in this case, the defendant will never engage in mandatory disclosure, but a plaintiff with high damages may disclose voluntarily, since this allows her to push the defendant to his concession limit.

19.2 Acquiring Information from Experts

As discussed in Section 15.1, Watts (1994) considers a model with an agent that provides expertise in the sense that they can acquire information for a player more cheaply than the player can themselves. She shows how to view the problem as one of bargaining between the player and the agent and provides some comparative statics about their settlement frontier.

In Daughety and Reinganum (1993), a model allowing simultaneous or sequential moves by both players (this is discussed in more detail in Section 12.4) is embedded in a model which allows uninformed players to acquire information from an expert before settlement negotiations begin. The information, which is costly, is what an informed player would know. Thus, a player may start the game already informed (called *naturally informed*) or start uninformed but able to acquire the information at a cost $c > 0$; for convenience, assume that court costs are the same for the two players and denote them as k. If both players are uninformed, then, in equilibrium, neither will choose to buy the information. This is because informational asymmetry results in some possible cases going to trial, while symmetric uncertainty involves no trials. With one of the players naturally informed and one uninformed, then, as discussed earlier, depending on the form of the compromise function, the equilibrium involves either payoffs consistent with an ultimatum screening model or payoffs consistent with an ultimatum signaling model. In those conditions which lead to the screening game payoffs, the uninformed player will choose to buy the information if $c \leq k$. Alternatively, in those conditions which lead to signaling game payoffs, the uninformed player will *not* acquire the information. Thus, uninformed players will not always choose to "re-level the playing field" by purchasing information; signaling will provide it if a revealing equilibrium is anticipated.

19.3 Procedures for Moderating the Effects of Private Information

Gertner and Miller (1995) examine the impact of settlement escrows on the likelihood and timing of settlement. A settlement escrow involves a particular bargaining protocol wherein P submits a demand and D submits an offer to a neutral third party (the escrow agent). If the offer exceeds the demand, then the escrow agent imposes the average of the demand and the offer as the settlement amount. On the other hand, if the demand exceeds the offer, the third party simply reports back that there was no overlap. The parties can then proceed to bargain further or go to trial. There are two crucial features of this protocol. First, if the offer exceeds the demand, then the settlement is imposed on the parties; thus, if D learns that P's case is weak because P accepted D's offer, it is too late for D to make use of this information, as settlement is imposed. Second, while the failure to settle is informative to each party about the other's private information, it is not fully revealing. Thus, the incentive to distort one's demand or offer is muted and the parties tend to make more "reasonable" demands and offers. The authors predict that more cases will be settled (and settled earlier) when a settlement escrow is used.

Babcock and Landeo (2004) conduct an experimental study of settlement escrows. The experiment involves P having private information about her damages. In the no-escrow treatment, P makes a demand of D; D can accept the offer or reject it and make a counteroffer. Since D can take advantage of any information that P signals through her demand, every type of P will be tempted to make a high pooling demand (or no demand at all), simultaneously reducing the information content of her demand and inducing a higher likelihood of rejection by D. They find that the escrow treatment, which is predicted to mute these incentives and result in more "reasonable" demands, does indeed perform as predicted. When there was asymmetric information about P's damages, a case was more likely to settle, to settle sooner, and to settle for an amount that is closer to true damages, when a settlement escrow protocol was used.

D. CONCLUSIONS

20. Summary

The modeling of settlement bargaining has been influenced primarily by law, economics and game theory. In many ways, it is still developing and expanding, and hopefully deepening. The more recent analyses employ, primarily, a mix of information economics and bargaining theory (both cooperative and noncooperative) to examine, understand and recommend improvements in legal institutions and procedures. Mechanism design, behavioral economics, and considerations of settlement in the context of judicial decision-making have started to add further concepts and context to the research.

There has been a tug-of-war between the desire to address interesting behavior and the current limited ability to relate seemingly irrational acts to rational choice. As the development of technique has progressively allowed this to be accomplished, and as the intuition as to why seeming irrationality may be rational has driven improvement in technique, a broader picture of what elements contribute to, or impede, dispute resolution has evolved.

Issues have led techniques, a good thing. There is an aspect that could use improvement: empirical or laboratory studies of the details of the settlement process are still comparatively rare (though this review has touched on some). In an area where 97% of the outcomes are partially or totally unobservable by researchers, empirical studies are hard to do, and the few that have been done have undoubtedly involved hard work. The development of improved data sources (such as the medical malpractice databases in Florida and Texas) bodes well, as does the development of econometric techniques for carefully analyzing dynamic processes.

Laboratory studies (experimental economics and related efforts in sociology and psychology) are expanding, but the more subtle predictions of some of these models mean that laboratory studies have to walk a fine line between being a test of a particular model's prediction or ending up mainly gauging a subject's IQ. Such studies are still very labor-intensive (on the part of the researcher), though software development and the further entry of researchers into this area bodes well.

The previous version of this survey, in 2000, ended with the following observation:

> Most of the work in this area (covering the last quarter century) has occurred in the last dozen years (and most of that has occurred in the last half-dozen years), indicating an accelerating interest and suggesting that the next survey will have a lot more new, useful theory and detailed empirical and laboratory tests to report, a good thing, too. (Daughety, 2000)

In the intervening years, there has been a progression of surveys of this material (see footnote 2) which reflects the expanding scholarly interest in understanding the forces that affect settlement in both simple and complex litigation settings. The above forecast appears to have been borne out and also appears to be as valid to make about tomorrow as it was to make about today.

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