Games, Information, and Evidence Production: With Application to English Legal History

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This paper studies the problem of how the legal system regulates activity outside the courtroom based on information supplied in court by interested and potentially dishonest parties. The supply of information is analyzed along a game-theoretic dimension: the extent to which the supplier has an interest in how the information will be used. Such analysis uncovers a basic trade-off in system design between the "fixed costs" of hearings (e.g., the productive activity forsaken by participation) and the cost of the evidence produced therein. This trade-off helps to explain and connect several trends in the historical evolution of English civil process.

Recent years have witnessed great progress in extending the economic analysis of law from substantive legal rules—as in property, tort, and contract law—to the system of civil litigation that gives those rules effect. Even so, relatively little has been written about what may be the fundamental question of civil process: *How does the legal system influence*

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activity outside of the courtroom on the basis of information supplied in court by interested and potentially dishonest parties? Though the literature on "suit, settlement, and trial" offers a detailed and insightful account of suit and settlement, in most models trial figures either as an occasion for the court's omniscience, or as some formless future event that the parties bargain to avoid. Thus while it is common to say that suit and settlement proceed "in the shadow of" trial, in terms of what has been written in the field, trial seems more in the shadow.[1]

This paper sets out a new framework for answering this foundational, yet largely unexamined, problem in the study of civil process. The framework is then tested by application to the historical evolution of civil process in England, yielding a new explanation for change that connects seemingly diverse historical trends.

The paper analyzes the supply of information to the court along a game-theoretic dimension: the extent to which the supplier has an interest in how the information will be used. When the supplier has such an interest—as the defendant, for example, has an interest in whether the court finds that she has been negligent—the supplier has an incentive to shade or even fabricate that information in a way that furthers these interests. The fact-finder cannot simply rely on the bare testimony of the party; it cannot suffice that defendant *says* she has exercised due care. Other means must be employed to ensure that the information supplied to the court has meaning beyond a simple expression of the party's interest.[2]

How then does the court extract meaningful information from interested parties? I have proposed elsewhere (Sanchirico, 1995, 1998) that the

1. In many existing studies of litigation, the court is implicitly assumed to be able to instantly and automatically deduce whatever factual knowledge it needs. See, for example, Arlen (1992), Brown (1973), Calabresi (1972), Ordover (1978, 1981), Polinsky and Rubinfeld (1988), Shavell (1980, 1999), and Spier (1994b). Other models collapse trial process into an exogenous probability that the court will determine the truth. See, for example, Bebchuk (1984), Daughety and Reinganum (1994), Nalebuff (1987), Png (1983, 1987), Shavell (1982, 1999), and Spier (1994a). Even models that focus on trial error posit an *exogenous* relationship between the probability of error and either the level of public spending (see, e.g., Craswell and Calfee, 1984; Kaplow and Shavell, 1994, 1996) or the preparation effort of the parties (see Katz, 1988; Landes, 1971; Rubinfeld and Sappington 1987). For more on related literature, see notes 4 and 6 and Sanchirico (1999).

2. The risk of perjury is no pat answer to this puzzle. Perjury itself must be proved. See, for example, Zelin (1999), section 82. This point is discussed in detail in Sanchirico (1999).

law uses an extension of Spence's (1974) well-known concept of "costly signaling." A defendant's evidence of due care, for example, becomes meaningful—despite defendant's evident interest—if the court can find and rely on evidence of a form that is (or at least tends to be) less "expensive" to produce for defendants that have indeed exercised due care. Liability as a function of evidence presented can then be structured in such a way that only those defendants for whom the evidence is of lower cost—in essence, defendants who have been careful—will find the potential decrease in liability worth the effort of presentation. Such evidence will then be a reliable signal of due care.[3]

But extracting useful information from interested parties by this means is a costly endeavor: the very signaling costs that give the evidence meaning are a loss to the system. Indeed, as will be shown, the greater the party's interest in how the information will be used—the larger the stakes for that party—the greater the cost of the signal that must be used to make that information meaningful.

This raises the question: why does the system not garner information from (relatively) disinterested "parties" so as to reduce these evidence costs? Indeed, early civil process in England seems to have operated much in this manner. The jury was essentially a bank of witnesses, and the ability of the parties themselves to present their own case was circumscribed.

Perhaps the reason that our modern system does not exhibit the same reliance on third parties lies in the fact that such reliance has its *own* costs. As will be explained, the efficacy of "third-party information" is tied to the breadth of circumstances triggering suit and the number of individuals participating in each action. This means that the cost of obtaining information in this manner accrues primarily in terms of the "fixed costs" of holding hearings—as opposed to the "variable costs" of the evidence therein "produced." The more often suits are filed and the greater the number of participants per suit, the greater the imputed rent on the space used, the greater the salaries and wages of staff, and, most importantly, the greater the opportunity cost, in terms of lost production and leisure, of participation by private parties.

3. More precisely, it is sufficient that trial payoffs tend to be higher for the careful. Given production cost differences, this can occur even when careful and careless present the *same* evidence. See Sanchirico (1999) for details.

A fundamental trade-off thus arises between the "fixed costs" of holding hearings and the cost of evidence produced therein, a trade-off that operates precisely along the dimension of the intensity of interest possessed by the supplier of the information. Relying on interested parties necessitates costly evidence production. Relying instead on less-interested observers necessitates more frequent hearings, or greater attendance at each, and so results in greater fixed costs.[4]

The "comparative statics"[5] of this trade-off may help explain the transformation of English civil process alluded to above. Historical increases in the opportunity cost of process, brought on by increases in the marginal product of labor, likely had an asymmetric effect on the costs of process. The fixed cost of attendance certainly increased, but, as will be explained, there is good reason to believe that the cost of using costly evidence production to extract information from interested parties did not. These changing circumstances exerted cost pressures on the system, and these pressures encouraged the essential abolition of the English civil jury and increased the system's reliance on evidence sponsored by parties to the action.

The rest of the paper is organized as follows: section 1 presents a nontechnical exposition of the framework; section 2 discusses the application

4. There is, of late, a small literature modeling evidence production as "strategic search" (Froeb and Kobayashi, 1996; Daughety and Reinganum, 1998). Parties to a suit sample from a distribution for "pieces of evidence," deciding when to stop sampling and what of their sample to show the court. This paper differs from the strategic search literature (SSL) in several ways. First, as in Milgrom and Roberts (1986), parties in the SSL may decline to report, but may not fabricate, observations. Here agents are not confined to omission, but may lie outright. Second, in the SSL, the court acts on evidence in a manner hardwired by the modeler. The issue is whether such limits on the court's capacity generate "biased" decisions. Here, the court takes into account the incentives of the parties in deciding what to believe and how to assign rewards. The issue is how it does this, and what determines the best method. Third, the SSL picks up the story at trial, after an accident has occurred and one party has filed suit. The model here accounts for behavior in the primary activity and for the choice of whether to file suit, treating them as decisions that are influenced by the endogenous structure of rewards and punishments. Fourth, in the model here, the objective of system design explicitly includes both the consequences of the induced primary behavior and the cost of inducing that behavior through the legal system. The implicit objective in the SSL is the generation of "unbiased" court decisions—presumably, a proxy for the criteria just identified.

5. "Comparative statics" is the study of how a system or the solution to a problem changes with changes in the underlying parameters.

of this framework to English legal history; and section 3 presents the model, the formal results, and a diagrammatic example. The proofs of all formal results, together with intuitive explanations, appear in the Appendix.

1. Discussion

In this section, I employ a series of numerical examples to illuminate the fundamental trade-off that arises when one views evidence according to the interest of the supplier. I first discuss the basic mechanic of costly evidence production necessitated by reliance on the information of interested parties. Then I consider the possibility of relying on information supplied by those who have less of an interest in the outcome of the suit. The discussion of each possibility is immediately followed by an explanation of the structure of the costs that it imposes on the system. I conclude the section by explaining why the trade-off "tilts" toward costly evidence production in response to across-the-board increases in the costs of process.

1.1. Relying on Information from Interested Parties

1.1.1. The Basic Mechanic. Suppose the state wishes to induce individuals to drive carefully, despite the fact that exercising care costs individuals $10. Suppose, for the moment, that the state regulates driving by means of a simplified form of process in which each individual must periodically appear before an administrative law judge and "present evidence" of how carefully she has been driving. Based solely on this evidence, the court assesses penalties and disburses rewards.

In the classic enforcement problem, and in most models of civil procedure, punishments and rewards are meted out according to some exogenous probability of detection. Here, I put aside the fiction that the civil law regulates by random audit. Rather, in this model, the state in its capacity as judge never gets up from behind the bench, basing its determination of reward and punishment solely on what evidence the driver *chooses* to present at this periodic hearing.

Inducing the individual to drive carefully under these circumstances requires that the state identify some form of presentation or performance

before the judge, some form of "evidence," whose production costs for the individual vary appropriately according to how the individual has behaved on the road. Suppose, for example, that driving carefully happens to lower the cost to the individual of a particular presentation from \$14 to \$2. (What such a presentation might look like is discussed below.) Let the state announce ahead of time that it will fine the individual \$13, unless she makes this presentation. How does the individual react? First, consider her choice at the hearing, contingent on each of the two possibilities for how she has behaved on the road. If she has driven carefully, the evidence costs her \$2 to produce, but saves her \$13 in liability; hence, her "best case" will be to present the \$2 evidence and avoid the liability. If she has not driven carefully, the evidence costs her \$14 to produce, which is more than she saves in liability by presenting it; her best case now will be to rest immediately and incur the \$13 liability. Therefore, the individual's prospective payoffs at the hearing (given that she always makes the best case she can) will be −\$2 if she drives carefully, and −\$13 otherwise. Consequently, careful driving increases the individual's prospective hearing payoff by \$11. Stepping back to the individual's choice on the road, we see that this \$11 benefit outweighs the \$10 direct cost of care, and so the individual chooses to drive carefully.[6] Thus, the evidence cost advantage produced by careful driving (\$2 versus \$14) allows the state to create an \$11 "hearing-payoff advantage" for careful driving, which in turn weighs against, and in this case overwhelms, the additional \$10 cost of care incurred on the road.

1.1.2. Costly Evidence in Actual Process. Does such a mechanism inform actual process? To the extent that a party's own evidence is used to set her incentives in the primary activity, such a mechanism *must* be at work. If the court determined the individual's liability on the basis of evidence whose production cost was independent of the individual's

6. As noted, the mechanic here is a form of differentially costly signaling, à la Spence (1974). *The model differs from Spence's, however, in that signal costs ("types") are not exogenous, but rather depend on parties' choices in the primary activity*. See Sanchirico (1999) for a discussion of how *endogenous* cost signaling compares with other formal approaches to evidence, including the pure Bayesian approach (e.g., Finkelstein and Fairly, 1970), the classic moral hazard approach (e.g., Hermalin and Katz, 1991; Schrag and Scotchmer, 1994), and pure omission models (e.g., Milgrom and Roberts, 1986; Sobel, 1985).

care level, then the individual's choice as to whether to present this evidence—and, more directly, her anticipated hearing payoffs[7]—would be unaffected by her choice of care level. She would then choose care level without regard to prospective litigation—that is, she would drive carelessly.

A fresh look at the forms of evidence used in actual process indicates that differential production costs do indeed play an important role. Consider, for example, parties' sponsorship of eyewitness testimony subject to cross-examination. Why, precisely, would the current system lend credence to the production of three competent, unimpeachable, unrelated eyewitnesses who, with sincere demeanor, tell a mutually consistent story, even under cross-examination, that comports with the party's own allegations? It is certainly not impossible to fabricate such a performance; and no doubt, this has been done. Perhaps the reason for the credibility of such witnesses lies in something so mundane as production cost differences. *True* witnesses are chosen by fate, and their stories are mutually consistent by virtue of the fact that they are organized by the physical laws of time and space. False witnesses, by contrast, need intensive coaching in consistency and demeanor, and they demand compensation for their time and for the risks they face.

Consider, as well, expert testimony. Why, precisely, is any weight placed upon a party's ability to bring together three renowned experts in support of her case? Certainly not because anyone believes that these experts' opinions represent a random sampling of available knowledge, or that a party could not possibly find renowned experts willing to mislead and lie. If the court learns anything from such an event, it can only be because the cost of gathering such experts increases with both the idiosyncrasy of their views (via search costs, or the experts' market power) and the extent to which they must be induced to contradict their professional knowledge and judgment.

Media production operates in a similar manner. Any document can be forged, any photo can be doctored, any video can be staged. Technological advance is Sisyphean in this regard: the understanding required to invent each new technology of "proof" is likely sufficient to artfully manipulate it. The court must always therefore weigh the cost of forgery against the

7. See note 3.

magnitude of the party's stake in the case, taking into account the chance that genuine media of this sort would exist as a natural byproduct of what actually happened in the primary activity.

1.1.3. The Cost of Relying on Interested Parties. The cost of relying on the evidence of interested parties lies in the very production costs that lend such evidence meaning. The individual's expenditure of time and effort in putting her case together results in the production of no valuable goods or services. And unlike fines or liability, the loss to the individual is not someone else's gain. Thus, when the individual in the example is induced to drive carefully and then present evidence costing her \$2, this \$2 cost is the price society pays for setting incentives for care.

What determines the magnitude of this cost? The most important factor for our purposes is the size of the difference in hearing payoffs that evidence production is meant to produce. In general, the more that an individual's hearing payoffs are meant to turn on what she knows or has done, the greater the evidence costs of creating this dependence.

The reasoning behind this principle has two steps. First, evidence capable of producing a given hearing payoff difference is also capable of producing any smaller hearing payoff difference. Recall the example: liability (\$13) was placed between the two evidence costs (\$2 and \$14); the careful presented the evidence, and the careless did not; and hearing payoffs for the careful were evidence costs ($-\$2$), while hearing payoffs for the careless were liability ($-\$13$). The same general pattern would apply for *any* level of liability x between the two levels of costs, except that hearing payoffs for the careless would now be $-x$ rather than $-\$13$. In particular, as we lower x toward \$2, hearing payoffs for the careless move toward $-\$2$, hearing payoffs for the careful remain fixed, and the difference between them falls to zero.

If it is true that *any* evidence capable of producing a larger difference in hearing payoffs is also capable of producing a smaller difference, then this must in particular be true for the evidence that produces the larger difference *at least cost*. This means that the least-cost method of producing the *smaller* difference is never greater in cost and possibly even lower. Thus, imagine that the evidence in our example were in fact the cheapest way (at \$2) to produce a hearing payoff difference of \$11. As shown, such evidence could also be used to produce a hearing difference of \$5

(with liability, x, set to \$7). Potentially, other less expensive evidence is *also* capable of producing the \$5 difference, in which case the cost of producing it would actually be less than \$2. In any case, since the \$5 difference *can* be created for \$2, the minimal cost of producing it will certainly not be any greater than \$2.[8]

1.2. Relying on Information from Others

This analysis suggests that the state can reduce evidence costs by garnering information from others whose interests need not be as directly tied to what they report. To start with a limiting case, imagine that the judge in our example calls in a third-party "observer" and asks him whether *he* saw the "caretaker," the driver, exercise care. Since the judge will use this information to punish the caretaker, not the observer, it will be much less costly to ensure the observer's interest in telling the truth than it would be to ensure the caretaker's. Indeed, if the observer tells the truth when he is indifferent to doing so,[9] the court need only assure him that what he reports will have no effect upon him personally. The observer then will accurately relay what he knows to the court, and the court can use this information to set the caretaker's rewards and punishments so as to inspire careful behavior. Here the court is garnering information from an actor whose hearing payoffs are of no direct relevance to the objective of inducing careful driving.

1.2.1. The Party-Opponent as Other: Decoupled System. Use of "third party" information in lieu of costly evidence production is also possible in the more complicated setting of modern civil process—even as between the parties to the action. The simplest form of civil process is a "decoupled" system in which there is no requirement that plaintiff's recovery equal defendant's liability. Imagine now the caretaker as "defendant," the observer as "plaintiff," and the administrative law judge as civil process

8. The principle that larger differences are more costly to produce also applies in a probabilistic model with more than two primary-activity actions. A proof is available from the author.

9. The observer can be given an actual *positive* incentive to be truthful if costly evidence is fashioned for the *observer*. Consistent with the previous subsection, this would entail a less costly configuration of evidence than was necessary to induce the caretaker to take \$10 care.

fact-finder (judge and perhaps jury), whose job it is to mete out punishments and rewards to *both* sides. Because the plaintiff's and defendant's payoffs are decoupled, there is much scope for playing the individuals off against one another. The state can in effect use each party as an "observer" in setting the *other's* recovery or liability. The court simply asks each party what she knows, and makes it clear that what she reports will affect only what her *opponent* wins or pays at trial. Since the information provided by each party has no effect on that party's own payoffs, each party's incentive to lie is greatly reduced—and so then is the necessity for costly evidence production.

1.2.2. The Party-Opponent as Other: Coupled System. This sort of "cross-wiring" across opponents is not possible—at least not in so pure a form—in a coupled system. With coupling, if defendant's liability depends on what plaintiff tells the court, so must plaintiff's award; and that means that plaintiff no longer is disinterested in what she says.

Yet even in a coupled system cross-wiring still can operate. Instead of making the actual liability payment from one party to the other depend on what each party tells the court, we can make each party's *evidence production costs* depend on what the other party says. Evidence costs are as much a part of a party's trial payoffs as liability or recovery, and since evidence costs are not coupled even in a coupled system, there is still room for setting them by means of "cross-wiring."

Suppose, for example, that there are two possible pieces of evidence for the defendant. The first piece of "low cost" evidence costs the defendant $2 when her evidence costs are low and $14 when her costs are high. The costs for the second piece of "high cost" evidence are $13 and $33, respectively. Focus now on a defendant whose evidence costs are "cheap" for both pieces of evidence ($2 for low cost evidence, $13 for high cost). If the fact-finder announces that the defendant must pay $13.50 in liability unless she presents the *low*-cost evidence, then the cheap-cost defendant will indeed present the evidence: she pays $2 to avoid a $13.50 charge. The same result is obtained if the fact finder announces that $13.50 in liability can be avoided only by presentation of the *high*-cost evidence. Whichever evidence is used, the cheap-cost defendant's liability and choice of whether to present the required evidence are the same: she chooses to present the evidence and her liability is 0.

Although her liability is the same in both cases, however, the cheap-cost defendant's *overall hearing payoffs* differ according to which evidence the court employs: when low cost evidence is used, it costs her $2 to avoid liability; when high cost is used, it costs her $13. However, because *liability* is the same, regardless of which evidence is used, *plaintiff* is indifferent toward the court's choice of evidence. Thus, by determining which evidence is employed according to plaintiff's testimony, the court can make defendant's hearing payoffs depend on what plaintiff has seen, without giving plaintiff an incentive to lie and therefore without having to incur significant evidence production costs.

This example shows how we can use an opponent's information to affect evidence cost without affecting liability. More generally, an opponent's information can be used to affect *both* liability/award and evidence costs. Of course, as soon as plaintiff's case affects his own award, he will have an incentive to lie, and his contribution to the hearing will have to be fortified with the sort of costly evidence production discussed above. This will, of course, impose costs on the system. What is gained in return for those costs, however, is that defendant's payoffs can now be more dramatically affected by plaintiff's case, since the dependence now extends beyond evidence costs to liability/award. This is a benefit because it means not having to rely so much on *defendant's* own costly evidence in setting defendant's incentives. There is, then, a trade-off between plaintiff's evidence costs and defendant's; and the degree to which this trade-off should be made will depend on the comparative structure of the parties' costs.

In sum, what is being described is an "adversarial process": a system in which both parties to the action put forward costly evidence, and liability/award is determined on the basis of the *mixture* of these two sources of information. In particular, the effect on liability/award of any given presentation by one party depends on what the other party has produced—just as, in actual process, the impact of each corroborating witness or document on the final order will depend on the array of corroborating witnesses and documents presented by the other side.

1.2.3. The Cost of Relying on Others. Although increasing reliance on third-party information reduces the need for costly evidence production, it imposes costs of its own. The structure of these costs can be explained in three steps.

(1). *The importance of informational precision.* The first step is to establish the importance of informational "precision" in setting incentives. In our example, the individual's choice in the primary activity was binary: care or no care. In reality, the legal system seeks to induce one action from many alternatives. Accomplishing this requires detailed information about what would have been seen by various others in a multitude of circumstances.

Suppose that care (which costs the individual $10) reduces the probability of an accident by ten percentage points. Assume for now that the observer sees and truthfully reports whether an accident has occurred. Then, if we fine the caretaker $110 for an accident, we induce her to take care: care reduces her expected fine by 10% of $110, or $11, which is less than the cost of care. In general, two signals (such as "accident," "no accident") suffice to implement an action over one alternative.

But now suppose that the individual may also choose to be "extremely careful," where this costs $9 more than regular caution and reduces the accident probability by an additional ten percentage points. Now fining $110 for an accident will induce the caretaker to be extremely careful, rather than cautious. As above, the fine makes care a better choice than carelessness, but according to the same reasoning it also makes extreme caution a better choice than care. Indeed, with these numbers, any fine that makes caution better than carelessness for the individual also makes extreme care better than care.

Suppose, however, that we also ask the observer about the severity of the accident (and he continues to report truthfully). Suppose, further, that extreme care has relatively little effect on accident severity: choosing caution over carelessness decreases the probability of a severe accident (given that some accident has occurred) by ten percentage points, but choosing extreme care over caution reduces this conditional probability by only five percentage points. In this world, we essentially have three signals: "no accident," "severe accident," and "non-severe accident." Three signals will almost always be enough to implement one action over two alternatives. As the reader can confirm, we implement care over both alternatives if we fine the caretaker $50 for any accident and an additional $500 if the accident is severe.

(2). *Precision as a function of the frequency of and attendance at hearings.* The second point is that the precision of the court's information

will depend in turn on the breadth of circumstances triggering suit and the number of individuals involved in each action. The state cannot distinguish among the various circumstances that do *not* inspire suit, but only among those that do: if no hearing is held, the state learns only that *one* of the circumstances under which hearings are not held has obtained; it does not learn *which* one. Thus, the fewer the circumstances that inspire suit, the smaller the set of potential signals, and the less the fact-finder stands to learn about the state of the world. Similarly, the state cannot glean information from those who do not attend. Consequently, the efficacy of obtaining information from others is tied to the fixed costs of hearings rather than to the costs of evidence production. The less frequently that hearings are held, or the fewer the individuals who attend each, the lower the fixed costs, but, correspondingly, the less the information obtained.

Continuing the example, suppose for the moment that we have control over the circumstances that inspire the observer to come to court and tell us what he has seen. Let us compare two possibilities: (1) he comes to court whenever there is an accident and once there reports on the accident's severity; (2) he comes to court only when accidents are severe. The first alternative is more costly, because suits are more frequent. On the other hand, the first alternative is more informative: if the observer does not come to court in (1), the court knows that there has been no accident. If the observer does come to court in (1), the court learns that there has been an accident and, by listening to the observer's report at the hearing, also learns whether that accident has been severe. In the end, the court learns precisely which of the three possible circumstances has occurred. Contrast this to case (2). Here, the observer stays home both when there has been no accident and when the accident has not been severe. Thus, the court never learns which of the two possible signals are inspiring the observer to stay home, and we are essentially back in a world with only two signals, which, as we have seen, may not be enough to induce caution over both carelessness and extreme care.[10]

(3). *The role of the private instigation of suits.* The foregoing example raises the question of how the state regulates which occurrences in the primary activity trigger hearings. Notice that in the example the state

10. This example illustrates how increasing the breadth of circumstances inspiring suit refines the information received by the court. Increasing the number of parties engaged in suits serves the same function.

based its decision whether or not to hold a hearing on what had occurred in the primary activity. Yet the state first learns about what has occurred in the primary activity only at such a hearing. This is, of course, self-contradictory. The system cannot function if the court must hold a hearing in order to discover whether the circumstances are such that it would want to hold a hearing. But this circularity may be avoided by endowing private individuals with the power to instigate hearings (i.e., file suits) and by providing a system of rewards and punishments, paid out at those hearings that are held, which influences when and against whom a given party will file. Thus, the third and final point to be made with regard to the cost structure of third-party information is that the state exercises partial, de facto control over both the circumstances that inspire suit and the individuals involved in each, by providing for and influencing the private instigation of suits.

Suppose in the foregoing example that the state wishes to implement alternative (1): hearings when there is an accident (severe or not), no hearing otherwise. Suppose further that both the observer and the caretaker see the true nature of the accident. In a decoupled system, it is a simple matter to induce careful behavior with this pattern of hearings. First, we allow the observer to file suit whenever he likes. Then at each hearing that is convened, we ask both parties to tell us whether there has been an accident and, if so, whether it was severe. We then cross-wire the two individuals' testimony, using the caretaker's report on the observer and the observer's report on the caretaker in order to avoid incentives to lie. We structure the fines for the caretaker just as we did in the discussion of the second point above: $50 if the observer reports an accident, with an additional $500 if the accident is severe. Given truth telling by the observer, this fine structure ensures that the caretaker is careful. To ensure that the observer files suit as desired, we key his payoffs at trial to the caretaker's report. If the caretaker says that there was an accident of some kind, we reward the observer enough to overcome the inevitable cost to him of bringing suit. If the caretaker says there was no accident, we reward the observer nothing, in which case bringing suit is a money-losing venture for the observer. Accordingly, the observer brings suit only when he knows that at that suit the caretaker will report that there was an accident of some kind. Knowing that the caretaker has no incentive to lie (recall that the caretaker reports on the accident once the hearing has

already been called, and at that time has no interest in lying, since what she says will now have no effect on her payoffs), the observer brings suit only when there has in fact been an accident.

As discussed above, coupling defendant liability and plaintiff reward limits the efficacy of relying on the information of others and complicates the calculation of incentive-setting devices. Thus, in the example just considered, coupling may require some amount of costly evidence production by either or both parties. The formal analysis to follow takes up this possibility in detail. Nevertheless, the same general principles pertain to a coupled system: the efficacy of information obtained from others depends on its precision, which in turn depends on the breadth of circumstances inspiring suit and the number of parties attending each, which *in turn* is regulated by endowing private parties with the right to file suit and setting their incentives to do so appropriately.[11]

1.3. The Asymmetric Effect of Across-the-Board Increases in Process Costs

The model of evidence laid out above contains a counterintuitive asymmetry, one that has implications for understanding the historical evolution of legal process. Suppose that the costs of process increase across the board. One's intuition is likely to be that an increase in *both* the production costs of evidence *and* the fixed costs of hearings would have a balanced effect on both methods of fact-finding. Not so. Unlike increases in the cost of attendance, increases in the costs of producing evidence can be mitigated, in part or whole, by relying on different, less costly evidence.

Suppose the cost of the $2 versus $14 evidence doubles across the board to $4 versus $28, respectively. By setting liability at $15, the state can still create a hearing payoff difference of $11 according to whether the caretaker has driven carefully. But now this hearing payoff difference costs the state $4 rather than $2. It seems, so far, that the increase in evidence costs makes inspiration of careful behavior more expensive. This conclusion ignores that the state need not continue to use the same piece of

11. In game theory parlance, the mechanic described here is one of "correlated types," (where an agent's type includes her hidden actions) *with the important wrinkle that the rank (precision) of the opponents' signal of the agent's action is endogenous to the mechanism*. See Sanchirico (1995, 1998).

evidence, however. Suppose that all along there has been another piece of evidence whose costs were initially $.50 versus $8 and have since doubled to $1 versus $16, respectively. Initially, such evidence would have been incapable of creating the requisite $11 difference in hearing payoffs: feasible hearing-payoff differences are bounded by evidence-cost differences, which here are only $7.50. After the general increase in costs, however, this evidence *does* have a sufficiently wide "spread": setting liability at $12 creates the requisite $11 difference in hearing payoffs. Indeed, the cost of this evidence is only $1, so evidence production costs actually decrease with the general increase in costs.

Unfortunately, the same dynamic does *not* work with respect to the *fixed* costs of the hearing. If the state tries to compensate for the increase in appearance costs by halving the frequency of trials and the number of individuals attending each, it effects a real reduction in the information content of third-party information. In the end, then, an increase in costs across the board (and *a fortiori*, of appearance costs only) generates a cost pressure on the system to rely more on costly evidence production and less on relatively disinterested parties in obtaining information about the primary activity.

1.3.1. The Choice of Which Action to Induce in the Primary Activity. This analysis so far implicitly has been restricted to the question of how the least-cost means of inducing a *given* action (careful behavior) in the primary activity shifts in response to increases in process costs. Of course, this is only part of the state's overall problem of regulating primary activities by means of legal process. The state must also decide *which* action (level of care) to induce. In principle, the state can first solve the problem we have been considering—of how to induce each action level at least cost—just as a firm might first solve the problem of how to produce each level of output most cheaply. The firm, knowing its "cost function," can compare these derived costs to revenues to decide how much to produce. Similarly, the state can use information on implementation costs as data in solving its overall problem of which action to induce, also taking into account the private and social costs of each action within the primary activity (e.g., the cost of precaution and harm).

Carrying the analysis to this next step has implications for how cost pressures affect the state's optimal regulation of the primary activity—

implications that inform the historical evolution of process. As is shown in section 3, if choice of the implemented primary activity action is included in the analysis, then increased process costs lead, again, to decreases in the use of third-party information. But now such decreases may be associated with *either* increased use of costly evidence *or* implementation of an inferior "quality" action (i.e., one with higher social costs in the primary activity), or both. Insight is gleaned by imagining a firm's optimal reaction to an increase in the cost of one of its factors of production. The firm will use less of that factor, and its cost of production will increase at all levels. This will cause some substitution into other factors and some cutbacks in production.

2. Application to English Legal History

In the traffic of parallel, overlapping developments that constitute English legal history, it is sometimes difficult to see regularity, let alone rationality. Yet, even though "evolution to the optimum" seems patently implausible, the comparative statics of rational system design may still help parse the historical record. Such an exercise is well suited to sorting out the "cost pressures" that may have been important among the set of vectors jointly steering legal change. In particular, the framework developed here helps identify and explain the gradual shift from the thirteenth century on, in the mix of fact-finding methods, away from third-party information and toward costly evidence production by the parties themselves. I propose that this shift may be due in part to increases in the opportunity costs of process, costs brought on by increases in labor productivity.

The productive activity that is forsaken by collecting and preparing evidence, or simply by appearing in court, is a major component of the cost of legal process. As is well known, this cost increased, in broad trend, over the course of English legal history following the thirteenth century, with marked acceleration during the first phase of the Industrial Revolution (1760–1840) because of productivity-enhancing technologies such as the spinning jenny and the power loom. As explained in section 1.3, this across-the-board increase in costs likely had an asymmetric effect on the elements of evidence, resulting in a shift away from reliance on information from others.

The transformation of the jury from supplier of fact to trier of fact is consistent with this analysis. From its origins in the twelfth century until perhaps the beginning of the fifteenth century, the jury operated as a bank of witness-investigators: twelve "freemen" from the neighborhood in which the case arose called upon either to employ their pre-existing knowledge of the matter at hand or to conduct their own investigation. By the sixteenth century, the jury resembled more the blank-slate panel of today (Baker, 1990, p. 89; Mitnick, 1988, section II).

While the legal historical literature is careful in documenting the existence and timing of this transformation, it fails to provide a clear explanation of its cause (Mitnick, 1988, p. 202). The view proposed here is to see the transformation as essentially a cost-saving measure, made urgent by the ever-increasing opportunity costs of process. Less productive activity is sacrificed when 12 people are chosen at large on the basis of whether they happen to be available at the moment, rather than on the basis of whether they live in a particular neighborhood or have prior knowledge of or the ability to investigate the events in question. When the opportunity costs of process are high, significant savings accrue in going from a jury composed of informed, local "freemen" to one composed of not-necessarily-informed, not-necessarily-local men, who happen to be free.[12]

Shorn of its role as a supplier of information, however, the jury now had no natural advantage over an uninformed professional judge from the center. Perhaps, then, the only surprising thing about the subsequent decline of the English jury is how long it took. In the sixteenth century, postverdict procedural devices, such as the motion for a new trial, subverted the jury's authority by essentially submitting its verdict to the veto power of the judge (Baker, 1990, pp. 97–101). Then, following the end of the first phase of the Industrial Revolution, the Common Law Procedure Act of 1854 allowed parties to waive jury process, and by 1900 juries were used in only half the cases before the High Court. During World War I, the jury was "temporarily" abolished in civil cases because of lack of juror supply. In fact, it was never really reinstated. A 1933 law allows

12. Mitnick (1988, note 22) describes the gradual erosion in the requirement that jurors be "next neighbors." Six were required on each jury in the thirteenth century, four in the fifteenth, two in the sixteenth, and finally none by an act of Parliament in 1705. The act indicates that the requirement finally was abolished as a result of "defaults" by these "next neighbors" and challenges based thereon.

jury trials only by leave of the court; in practice, leave is almost never granted (Baker, 1990, p. 109).[13]

The denouement of the jury's role as supplier of information raises the question of where Common Law courts turned for information about the case. Our analysis so far suggests an increased role for information supplied through some form of costly signaling by the parties themselves. There is some indication that this occurs. As the jury was being shorn of its informational role in the fifteenth century, witnesses (presumably sponsored by the parties, though this is not clear in the historical literature) came to play a more prominent role in trial process. Between 1555 and 1565, courts acquired the power to compel witnesses to testify, and perjury became a statutory offense (Landsman, 1983, p. 726).

In some respects, however, the Common Law hesitated for several centuries before perfecting a substitution into costly evidence production. The record indicates that at least until 1750, the parties themselves, along with other "interested" persons, were prohibited from testifying or even presenting documents of their own creation, however long ago they were drafted (Langbein, 1996). One might extrapolate that such restrictions on plain testimony indicate a general restriction on the parties' ability to present their case by more convincing (differentially costly) means.

Two possible explanations bring this hesitation in line with the model. The first explanation concerns shifts in the behavior that the legal system was meant to induce in the primary activity, as discussed in section 1.3.1. The decline of the jury as a supplier of fact, without a compensating increase in costly evidence production, is consistent with the model, if it also is true that part of the historical response to rising process costs was to use the system less overall (i.e., to induce an inferior-quality action). There is indeed some indication that this was happening. For instance, in connection with the prohibition against parties' own testimony, we read that "non-suits were constant, not because there was no cause of action,

13. In the United States, where the right to a jury trial in certain civil actions has been written into a constitution that is infrequently amended, the jury has at least been reduced in size by case law. Early cases interpreted the seventh amendment to lock in place the English common law jury of 12 members. In *Colgrove v. Battin* (1973), the U.S. Supreme Court abandoned this manner of historical interpretation (though, inexplicably, other aspects of the seventh amendment continue to be interpreted historically), ruling that six sufficed for civil actions brought in Federal District Court. Almost immediately, 17 of the 94 Federal Districts adopted the six-person jury.

but because the law refused the evidence of the only persons who could prove it" (Lord Coleridge in Baker, 1990, p. 108). Moreover, the decline of the jury roughly coincided with the ossification of common law peading rules, which, according to one interpretation, acted to constrict operation of the judicial system (Baker, 1990, pp. 90–96; Landsman, 1983, p. 729).

The second explanation for the seeming time-lag in the shift toward reliance on costly evidence production by interested parties looks to the full picture of legal process in England. The end of the jury's role as supplier of information was roughly concomitant with the ascendancy of an alternative form of process: equity operating through the office of the Chancellor. The historical record seems to indicate that the Chancellor relied no more heavily on third-party information than did the rival common law courts, but that in chancery there was much more scope and flexibility for parties to "prove" their own cases. Perhaps, then, the substitution of costly evidence production for third-party information was partly manifest in a parallel substitution of equity for (common) law (Baker, 1990, chapter 6).

In any event, at the close of the first phase of the Industrial Revolution, amid a flurry of legal reform spearheaded by Jeremy Bentham and others, restraints on interested parties' ability to testify in common law procedure were finally lifted by legislative acts of 1843 and 1851. And in the modern era, parties' own presentation of costly evidence—including sponsored eyewitnesses, expert witnesses, plain testimony at risk of perjury, and media production—clearly constitutes the major source of information for the fact-finder. As a general rule, *all* the information received by the court is sponsored by one of the parties in interest, and as a result use of third-party information operates only across parties to the action, as described in section 1.2.2.

3. Formal Analysis

I begin this section by laying out the formal model. I then consider the problem of inducing individuals to behave in a particular way in the primary activity at minimal cost to the legal system. In particular, I analyze the effect of increased process costs on the solution to this problem for both coupled and decoupled systems, explaining the basic mechanic with

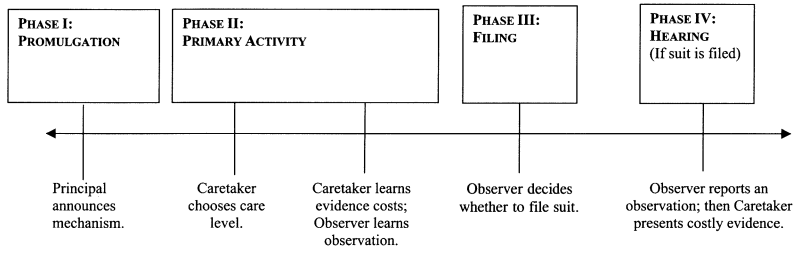

Figure 1. Timeline

reference to a diagrammatic example. Lastly, I provide the same comparative static analysis for the "overall" problem of choosing not just how best to induce a particular behavior, but what sort of behavior to induce.

3.1. Model

The formal model has four phases, as shown in Figure 1.[14] Consider first the second phase, the primary activity, a version of the classic torts model. A risk-neutral agent, the caretaker, chooses whether to be careless, cautious, or extremely careful in a hazardous activity, such as driving. Denote the caretaker's choice as $i = O, C$, or X, respectively, and her primary activity cost as $a_c(i) = a_c(O), a_c(C), a_c(X)$. This cost includes both the cost of precautionary effort and the expected harm that she herself bears. The caretaker's activities also impose expected costs on others, denoted $a_e(i) = a_e(O), a_e(C), a_e(X)$.

The caretaker's choice of care affects, probabilistically, what happens "on the road," including the physical details of any accident or near miss, as well as the character of such "evidentiary by-products" as who sees what and what physical media are generated for later presentation. The model is explicit with regard to two particular aspects of the "evidentiary state of the world": the observations of a second risk-neutral agent, the observer, and the cost to the caretaker of producing evidence of varying intensity. The observer may have one of three mutually exclusive observations: positive observations of the caretaker's care, a neutral observation, and observation of the occurrence of an accident (potentially, but not necessarily, one in which the observer is harmed). Importantly, these are

14. The model presented here is a special case of a more general model developed in earlier versions of this paper (Sanchirico 1995, 1998).

the observer's actual observations, as opposed to what he reports later at the hearing. I will refer to the observer's true observation as his "type" j_o and denote the possibilities $j_o = C, N, A$, respectively. Only the observer knows his type, though others may infer it from his behavior, depending on the reward structure in place. The caretaker's evidence costs j_c, her "type," also is probabilistically determined by her care level. She can be high or low, denoted $j_c = H, L$. Only the caretaker knows her type, though others may make deductions based on her behavior.

Given the caretaker's choice i of care level, the *joint* probability that the caretaker will be of type j_c and the observer of type j_o is denoted as $p(i)(j_c, j_o)$. Thus, for each fixed care level i, we have a probability distribution over the six possible pairs of types. Given care level i, the *marginal probability* that, for example, the observer is of type j_o is $p(i)(j_o) = p(i)(H, j_o) + p(i)(L, j_o)$. Given care level i, the *conditional probability* that, for instance, the caretaker is of type j_c, given that the observer is of type j_o, is $p(i)(j_c|j_o) = p(i)(j_c, j_o)/p(i)(j_o)$, assuming $p(i)(j_o) > \varnothing$. These probabilities are common knowledge, gleaned from past experience.

This probabilistic structure allows for two sorts of probabilistic dependence: (a) the dependence of both evidence costs and observations on care level; and (b), for any level of care, the interdependence of evidence costs and observations. For instance, the probability of the type pair "high, accident" might be decreasing in the caretaker's level of care. Then too, fixing the caretaker's level of care at "caution," the probability of an accident conditional on the caretaker's having high evidence costs might be higher than the probability of an accident conditional on caretaker's having low evidence costs. The possibility of correlation between what the observer observes and how difficult it is for the caretaker to make various presentations in court is both natural (as both phenomena derive from the same set of physical occurrences) and instrumental to the model.

Once both agents have privately learned their own types, the observer decides whether or not to file suit against the caretaker. If the observer does file suit, a hearing is held, and the attendance of both agents is mandatory. The hearing is presided over by the principal (the state/court system/fact-finder) and proceeds as follows. First, the observer publicly reports one of the three possible observations $r = C, N, A$. Next, the caretaker presents evidence. The caretaker chooses evidence e from the

continuum $[0, \infty)$. Higher levels of e might, for example, correspond to the production of more corroborating media. Given the caretaker's type j_c, the cost of evidence e is the product $\varsigma j_c e$. The scalar $\varsigma > 0$ is a scaling parameter that will enable comparative statics on evidence costs.

Based solely on the caretaker's presentation and the observer's report, the court determines how much, l_c and l_o to transfer away from each agent. These transfers may be positive, as in the case of liability or fines, or negative, as in the case of recovery or award. In a coupled system, the transfer from the caretaker must equal the transfer to the observer: $l_c = -l_o$.

If there is a hearing, the caretaker's *hearing payoffs* are the negative of the sum of her liability payments, her evidence costs, and her opportunity cost of attendance, F: $-l_c - \varsigma j_c e - F$. If the observer does not file, the caretaker's hearing payoffs are zero. The caretaker's *overall payoffs* also include primary activity costs, and are written: $-a_c(i) - l_c - \varsigma j_c e - F$. The observer's hearing payoffs are $-l_o - F$, and his overall payoffs are $-a_o(i) - l_o - F$.

Before all this begins, the principal specifies the hearing-phase liability of each agent as a joint function of the caretaker's evidence and the observer's report. This is the first, promulgation phase. Promulgation might occur by means of either explicit announcement or accumulated experience. Let $l_c(e, r)$ be the caretaker's transfer and $l_o(e, r)$ be the observer's. The pair of these functions taken together forms the liability schedule.

Let us now fix a liability schedule $(l_c(e, r), l_o(e, r))$ and examine its incentive effects at each phase of the model. We will do so by working backwards from the hearing, to the filing phase, to the primary activity. In order to analyze incentives at the hearing, we also work backwards therein, beginning with the caretaker's presentation of evidence. Given that the observer has reported r and the caretaker is of type j_c, the caretaker will present the evidence e that maximizes her prospective payoffs: $-l_c(e, r) - \varsigma j_c e - F$. One may view the caretaker's choice of evidence in each contingency as a function $e(j_c, r)$ of j_c and r: that is, as an evidence plan. The observer wants to maximize payoffs in making his report, as well, and he realizes that his payoffs depend not only on his own report but also on the evidence subsequently produced by the caretaker. Because the observer knows the liability schedule and understands

that the caretaker maximizes payoffs, he knows how a caretaker of any given type will respond to his report.[15] In other words, the observer can infer the caretaker's evidence plan $e(j_c, r)$. The observer, does not know the caretaker's type, however, and so does not know which evidence she will actually present following each possible report. Thus, the observer presents the report r that maximizes his *expected* hearing payoffs $E[-l_o(e(\tilde{j}_c, r), r) - F]$, where the expectation is taken with respect to random element $\tilde{j}_c$. The observer's beliefs regarding the caretaker's type are based on both the observer's own type and his subjective prior beliefs $q(i)$ about the caretaker's care level.

A reporting plan $r(j_o)$ indicates the observer's report contingent on his type. Given hearing plans $e(j_c, r)$ and $r(j_o)$, the caretaker's (type-pair-contingent) hearing payoffs are $h_c(j_c, j_o) = -l_c(e(j_c, r(j_o)), r(j_o)) - sj_c e(j_c, r(j_o)) - F$, and the observer's are $h_o(j_c, j_o) = -l_o(e(j_c, r(j_o)), r(j_o)) - F$.

At the filing stage, the observer chooses whether to file suit, knowing his own type and looking forward to what he expects his payoffs will be at the hearing. Thus he files if and only if $E[h_o(\tilde{j}_c, j_o)] \geq 0$. Write $f(j_o)$ for observer's filing plan, where $f(j_o) = 1$ if the observer files and 0 otherwise. The agents' (type-pair-contingent) litigation payoffs, calculated prospectively from the start of the filing stage are then $f(j_o)h_c(j_c, j_o)$ and $f(j_o)h_o(j_c, j_o)$.

In the primary activity, the caretaker chooses her care level, looking forward to the chance that she will be sued and to her expected hearing payoffs in court should that happen. Thus, given hearing payoffs $h_c(j_c, j_o)$ and filing plan $f(j_o)$, the caretaker chooses care level i to maximize $-a_c(i) + E_i[f(\tilde{j}_o)h_c(\tilde{j}_c, \tilde{j}_o)]$, where the subscript i on the expectation operator indicates that the probability distribution on j_c and j_o depends on choice of i.

The principal chooses the liability schedule with knowledge of both the probability structure $p(i)(j_c, j_o)$ and the fact that agents maximize payoffs in the manner just described. This prescience is embodied in the notion of "implementation." The liability schedule $(l_c(e, r), l_o(e, r))$ simultaneously *implements* the evidence plan $e_c(j_c, r)$, the reporting plan $r(j_o)$,

15. As is standard, when more than one plan maximizes an agent's payoffs, I assume that the principal specifies which the agent will use and that the choice is common knowledge.

the filing plan $f(j_o)$, and the care level i, if the following conditions obtain: (1) For every type j_c and observer report r, presenting evidence $e(j_c, r)$ would maximize the caretaker's hearing payoffs (as described above); (2) given that the caretaker would employ evidence plan $e(j_c, r)$, the report $r(j_o)$ would maximize the observer's hearing payoffs for every type j_o, regardless of the observer's prior $q(i)$ on the caretaker's care level;[16] (3) given that the caretaker and the observer would behave at the hearing according to $r(j_o)$ and $e(j_c, r)$, the filing plan $f(j_o)$ would maximize the observer's litigation payoffs for every type j_o, again regardless of $q(i)$; (4) given that the agents would behave according to $f(j_o)$, $r(j_o)$, and $e(j_c, r)$ in litigation, care level i maximizes the caretaker's payoffs in the primary activity. Apropos of the focus on care level, let us refer to $(l_c(e, r), l_o(e, r))$, $e(j_c, r)$, $r(j_o)$, $f(j_o)$ as an implementation of care level i, if $(l_c(e, r), l_o(e, r))$ implements i, $e(j_c, r)$, $r(j_o)$, and $f(j_o)$.

In specifying how the principal chooses among liability schedules, we may break the problem into two pieces. First, there is the minimal cost implementation of each given care level. Here, the principal seeks the particular implementation of this care level that imposes the lowest cost on the system. There are two types of costs: the caretaker's evidence costs and both agents' opportunity costs of hearing attendance. Both costs are affected by agents' filing and hearing plans. Specifically, if care level i is implemented with $(l_c(e, r), l_o(e, r))$, $e(j_c, r)$, $r(j_o)$, and $f(j_o)$, the cost is

$$E_i\left[f(\tilde{j}_o)\left(\underbrace{s j_c e(\tilde{j}_c, r(\tilde{j}_o))}_{\text{evidence costs}} + \underbrace{2F}_{\substack{\text{attendence}\\ \text{costs}}}\right)\right]$$

$$= \underbrace{Pr_i[f(\tilde{j}_o) = 1]}_{\text{probability suit is filed}}\left(\underbrace{E_i[s\tilde{j}_c e(\tilde{j}_c, r(\tilde{j}_0)) \,|\, f(\tilde{j}_o) = 1]}_{\text{expected evidence costs, if suits is filed}} + \underbrace{2F}_{\substack{\text{attend.}\\ \text{costs}}}\right), \quad (1)$$

where $Pr_i[X]$ is the probability of event X given caretaker's choice of care.

The principal minimizes this expression (1) among all implementations of i. This yields for i a (minimal) implementation cost C_i. Having

16. This is implementation by iterated dominance. See Sanchirico (1995, 1998) for details.

calculated C_i for each care level i, the principal solves its overall problem of deciding which care level to implement: it chooses i to minimize the sum $a_c(i) + a_e(i) + C_i$ of primary activity costs and implementation costs.

In choosing a liability schedule, the principal may be subject to a coupling constraint $l_c(e, r) = -l_o(e, r)$. The addition of the coupling constraint makes court fees relevant (see proposition 2 and its proof). Court fees, denoted C_c and C_o, are charges assessed to the agents in the event of a hearing. These charges may differ across agents, but not across evidence and reports; in other words, they are not contingent on the outcome of the suit.[17]

3.2. Minimal Cost Implementation and Increasing Process Costs

The next two propositions show that when the opportunity cost of attending hearings increases, then—whatever may be the accompanying trend in evidence costs—the principal will rely more on costly evidence production and less on third-party information in efficiently implementing any given level of care. This substitution will manifest itself in the observer's filing suit subsequent to fewer observations and in the caretaker's presenting more costly evidence whenever hearings do occur.

Proposition 1. Suppose that the cost of hearing attendance increases from F to $F' > F$ and evidence costs change from $\varsigma j_c e$ to $\varsigma' j_c e$. Let $(l_c(e, r), l_o(e, r))$, $f(j_o)$, $r(j_o)$, $e(j_c, r)$ and $(l'_c(e, r), l'_o(e, r))$, $f'(j_o)$, $r'(j_o)$, $e'(j_c, r)$ be minimal cost implementations of i for old and new process costs, respectively. Under the new implementation, suit is filed less often, and evidence costs are higher: $\Pr_i[f'(j_o) = 1] \leq \Pr_i[f(j_o) = 1]$ and $E_i[\varsigma' \tilde{j}_c e'(\tilde{j}_c, r'(\tilde{j}_0))| f'(\tilde{j}_o) = 1] \geq E_i[\varsigma \tilde{j}_c e(\tilde{j}_c, r(\tilde{j}_0))| f(\tilde{j}_o) = 1]$.

Proposition 2. If court fees are feasible, proposition 1 also holds when the coupling constraint is imposed.

3.2.1. Diagrammatic Example. The following example illustrates the basic trade-off between costly evidence production and third-party information. The example describes two liability schedules that implement

17. The notational adjustments necessary when court fees are imposed are obvious.

caution—one having more frequent filings and less evidence production than the other. In order to keep the example manageable, I assume that suits are decoupled, and I examine only increases in fixed costs. Primary activity costs for the caretaker are \$60, \$100, and \$120 for carelessness, caution, and extreme care, respectively. Evidence costs are \$$e$ if the caretaker is a low type and \$2e if the caretaker is a high type. Table 1 shows the joint and marginal probability distributions over agents' types.

I begin by showing how caution may be implemented with a liability schedule under which the observer files suit for all observations except care, and under which the caretaker presents no evidence, liability being determined solely on the basis of the observer's report. Let us begin with the caretaker's incentives, as depicted in Figure 2.

To understand the diagram, suppose that the principal charges the caretaker \$100 if the observer files suit and then reports an accident, and charges nothing otherwise. Assume for the moment that the observer files only when there is an accident and then truthfully reports the observation at the hearing. Then, based on the italicized marginal probabilities shown in Table 1, the caretaker's expected hearing payoffs from carelessness, caution, and extreme care would be $-\$70$, $-\$35$, and $-\$10$, respectively. Important for implementing caution is its *relative* advantage over carelessness and extreme care: here this is \$35 $(= -\$35 - (-\$70))$ and $-\$25$, respectively. I represent $(\$35, -\$25)$ in Figure 2 as the darkest solid vector (pointing southeast from the origin) and refer to this vector as the *hearing advantage* of caution under this "basic" liability schedule. The other two solid vectors of lighter grey-scale are the hearing advantages for the other two observations under analogous basic liability schedules. The space of all possible hearing advantages that can be created by conditioning solely on the observer's report is the set of all linear combinations of these three vectors. (For example, if the caretaker pays \$50 for neutral observations and \$200 for accidents, the resulting hearing advantage of caution would be the head-to-tail addition of the vector for neutral shrunk to half its length and the vector for accidents expanded to twice its size.)

The dashed right angle has its corner at the point $(\$40, -\$20)$, which is the *additional primary activity* cost of caution over carelessness $(\$100 - \$60 = \$40)$ and extreme care $(\$100 - \$120 = -\$20)$, respectively. The set of points northeast of this dashed corner are precisely those that exceed $(\$40, -\$20)$ in both coordinates.

Table 1. Joint and Marginal Distribution of Types

	Carelessness			**Caution**			**Extreme Care**		
	Caretaker's Type			**Caretaker's Type**			**Caretaker's Type**		
Observer's Type	**Low Cost**	**High Cost**	**Marginal**	**Low Cost**	**High Cost**	**Marginal**	**Low Cost**	**High Cost**	**Marginal**
Accident	**0**	.7	*.7*	**.15**	.2	*.35*	**0**	.1	*.1*
Neutral	.1	.1	.2	.15	.15	.3	.2	.2	.4
Care	.1	.0	.1	.25	.1	.35	.5	.0	.5
Marginal	.2	.8		.55	.45		.7	.3	

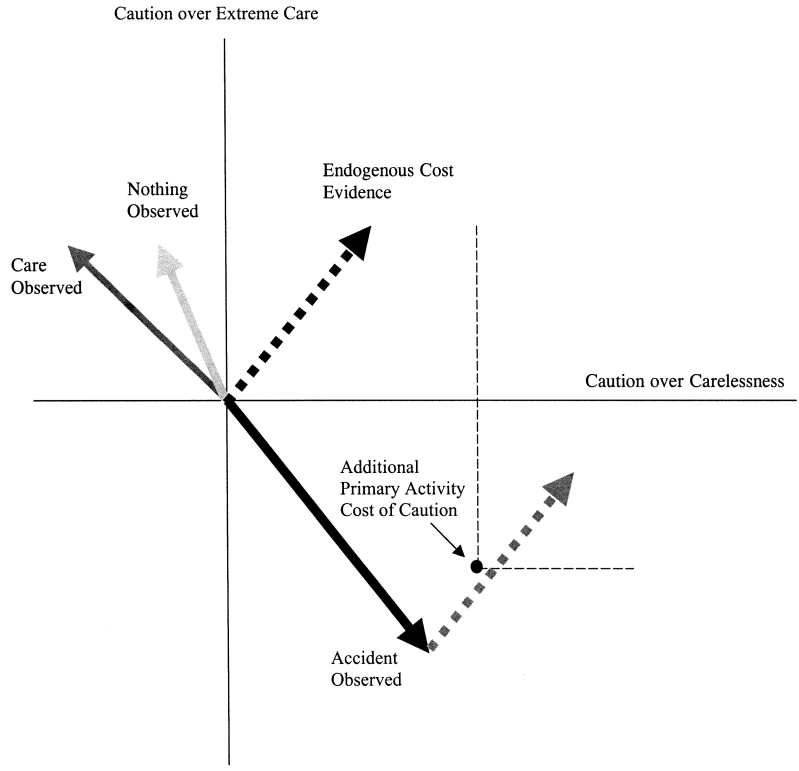

Figure 2. Implementing caution: the caretaker's incentives

Since the hearing advantage vectors for accidents and neutral span the space, we can find a linear combination vector that reaches into the region northeast of the dashed corner. This means that it is possible to set rewards (combine multiples of the accident and neutral vectors) so that the hearing advantages of caution (the coordinates of the resulting linear combination vector) jointly exceed its additional primary activity costs (the coordinates $[40, -20]$ of the dashed corner). If the principal does this—and can otherwise ensure that the observer files suit only in these two circumstances and then truthfully reports his observation—the principal will have implemented cautious behavior.

Here is how the principal may ensure the *observer's* compliance. Let the principal reward the *caretaker* \$1 for presenting evidence of $e = .90$. Since the caretaker will present e only when her evidence costs are low

($e), the presentation will serve as a signal of the caretaker's type; and since the dollar amounts are small, this collateral reward structure will not alter the primary activity incentives discussed in the previous paragraph. Let the principal then award the *observer* $F + \$1$ when the caretaker does not present the evidence (is of high type), and $F - \$.90$, otherwise. One can calculate that however careful the observer thinks the caretaker has been, he will file suit only when he sees an accident or a neutral observation. (For example, if the observer thinks the caretaker has been cautious but he still observes an accident, then his posterior belief that the caretaker is of low type is $.15/.35 = .43$. Thus, his expected payoff from the hearing will be $.57(F + 1 - F) + .43(F - \$.90 - F) = \$.183 > 0$, so he will file.)

This handles the observer's *filing* incentives. But what about his hearing incentives? Once at the hearing, the observer's payoffs do not turn on what he reports, but on what evidence the caretaker presents. Having no positive incentive to lie, he will report what he actually has seen. (He can be given a strict incentive to tell the truth if we enrich the model to allow for his presentation of slightly costly evidence.)

So far in our discussion of this example, we have been examining the implementation of care when hearings are held in two of the three circumstances that might be witnessed by the observer. Alternatively, the principal can implement caution under a liability schedule in which the observer files suit *only* when he sees an accident. This, however, will mean that the principal must also rely on the caretaker's presentation of substantially costly evidence. By inducing hearings in one rather than two circumstances, the principal stands to learn less about what the observer has seen.

This point, which was made in general terms in section 1, can be illustrated quite dramatically in Figure 2. The principal will not be able to distinguish between neutral and care, the two circumstances that do not inspire suit, since all it sees is *that* the observer has not filed, not *why*. The liability schedule for the caretaker must therefore be constant (e.g., zero) across the observations "Care" and "Neutral." As the reader can confirm, any vector that is a linear combination of care and neutral and that assigns the same coefficient to each is here (and will in fact always be) a scalar multiple of the accident vector. Clearly, the principal cannot get northeast of the dashed box solely by shrinking and expanding the accident vector.

In explaining this second implementation, I begin again with the caretaker's incentives. The explanation of these incentives has in itself two steps. First, consider the dashed vector (labeled "Endogenous Cost Evidence") emanating from the origin. The point of this vector is at (\$15, \$15), which represents the expected hearing advantage of caution when: (1) hearings are held only after accidents; and (2), at those hearings caretaker receives $\$200 + F - \$.10$ if she presents evidence of $e = 100$, and F otherwise. To see why, note that once at the accident hearing, only a low-evidence-cost caretaker will present $e = 100$. As a result, the low-evidence-cost caretaker ends up with hearing payoffs of roughly $(\$200 + F) - (\$100 + F) = \$100$, and the high cost with payoffs of $F - F = \$0$. Thus, it is as if the principal rewards the caretaker \$100 in the *joint* event that there is an accident *and* she has low-cost evidence. Now, as indicated by the "Accidnet/Low Cost" entries in Table 1 (shown in bold), if the caretaker is cautious rather than careless, she increases the chance of this joint event by .15 $(= .15 - 0)$. Thus, the expected hearing advantage of caution over carelessness is \$15. A similar calculation reveals that the hearing advantage of caution over extreme care also is \$15.

The second step in setting caretaker's incentives is to combine the costly evidence scheme just described with a baseline punishment of \$100, just for the fact that the observer has filed suit. Diagrammatically, the principal is adding the vector (\$15, \$15) head-to-tail to the accident vector. That the summed vector enters the dashed box indicates that the hearing advantages of caution jointly exceed the accompanying additional primary activity costs. The caretaker is thereby induced to be cautious.

What remains is to ensure that the observer files only when he sees an accident and that he then reports this observation truthfully. The reader can confirm that this can be accomplished by rewarding the observer $2F + \$1$ if the caretaker fails to present evidence $e = \$100$, and \$0 if the caretaker does make the presentation.

All told, this second liability structure is as follows. If the observer files suit against the caretaker and the caretaker fails to produce exonerating evidence $(e = \$100)$, the observer receives $2F + \$1$ and the caretaker pays $\$100 - F$. If the caretaker does produce the evidence, the observer gets nothing, whereas the caretaker pays nothing and is reimbursed \$100 and F for her evidence and attendance costs, respectively. The caretaker,

anticipating the possibility of suit, including the possibility that she will find it worthwhile to present exonerating evidence, decides that it *is* worthwhile to be cautious but that there is no reason to be extremely careful.

Let us now compare the system costs of the two implementations that we have been considering. In the first, the observer files suit in two circumstances, "Accident" and "Neutral," the probabilities of which are determined by the fact that the caretaker chooses "Caution." Evidence production costs are *de minimis*. The cost of this two-hearing implementation is thus roughly $(.3 + .35)2F = 1.5F$. In the second implementation, the agents appear before the court only when there is an accident. Given the caretaker's cautious behavior, this happens with probability .35. Therefore, the opportunity costs of attendance are $.35(2)F = .7F$, substantially lower than in the first scheme. With probability .15, however, the caretaker will find herself in court (an accident having occurred) and desirous of producing \$100 of evidence (i.e., of low-cost type). Expected evidence-production costs are thus \$15. Total costs for this second method then are $.7F + \$15$.

Clearly, if fixed costs are low, the least costly implementation will be the first, the one with two hearings. On the other hand, if fixed costs are high, then the fact that the first implementation requires more hearings makes it less efficient. Here, the best alternative would be to suffer the evidence-production costs in exchange for a reduction in hearing frequency.

3.3. The Overall Problem and Increased Process Costs

I have already discussed in section 1.3 what happens if one accounts for the principal's choice of which level of care to implement. The formal results are contained in the following two propositions.

Proposition 3. Suppose that the cost of hearing attendance increases from F to $F' > F$ and evidence costs change from $\varsigma j_c e$ to $\varsigma' j_c e$. Let $i, (l_c(e,r), l_o(e,r)), f(j_o), r(j_o), e(j_c,r)$ and $i', (l'_c(e,r), l'_o(e,r)), f'(j_o), r'(j_o), e'(j_c,r)$ solve the principal's overall problem for each set of process costs. Under the new implementation, suit is filed less often: $\Pr_i[f'(j_o) = 1] \leq \Pr_i[f(j_o) = 1]$. Moreover, if reliance on evidence production does not increase, then primary activity costs

do: $E_i[\varsigma' \tilde{j}_c e'(\tilde{j}_c, r'(\tilde{j}_0))|f'(\tilde{j}_o) = 1] \geq E_i[\varsigma \tilde{j}_c e(\tilde{j}_c, r(\tilde{j}_0))|f(\tilde{j}_o) = 1]$ or $a_{i'} < a_i$.

Proposition 4. If court fees are feasible, Proposition 3 also holds when the coupling constraint is imposed.

4. Conclusion

The law and economics of litigation elected early on to put to one side the analysis of trial process in order to get directly at such pressing policy issues as how the allocation of costs affects settlement bargaining and the decision to file suit. Today's standard model of litigation packs all of trial process into an exogenous probability that the defendant will be held liable in court. Nothing specific to the information exercise of trial remains; the parties might just as well be bargaining over *any* uncertain outcome. To be sure, this approach has had many benefits, as a reading of the literature makes clear. Nonetheless, this paper has held that there are also rewards to be gained from explicitly modeling how courts garner the information necessary for their decisions. First, there is the purely explanatory benefit of gaining insight into the strategic architecture of civil process. Second, such insights help to identify, explain, and connect such puzzling historical trends as the transformation of the jury's role and the ascendancy of own-party evidence production.

Appendix

Lemma 1. Suppose the coupling constraint does not hold. Suppose further that $(l_c(e, r), l_o(e, r))$ implements $e(j_c, r), r(j_o), f(j_o)$, and i when process costs are (F, ς). For all alternative process costs (F', ς'), there exists a new liability schedule $(l'_c(e, r), l'_o(e, r))$ and a new evidence plan $e'(j_c, r)$ such that: (1) $(l'_c(e, r), l'_o(e, r))$ implements $e'(j_c, r), r(j_o), f(j_o)$, and i under new process costs (F', ς'), and (2) evidence costs for the *new* implementation under *new* process costs equal evidence costs for the *old* implementation under *old* process costs.

The general idea of the proof, which follows, is to (1) mitigate the increase in attendance costs by reducing both agents' liability; and

(2) "sterilize" the effect of evidence-cost changes by adjusting the evidence corresponding to each level of liability so that the new evidence costs the caretaker, under the new evidence costs, what the old evidence cost under the old evidence costs. If we do this, the caretaker has the same incentive to present the substituted evidence as she did to present the old evidence, the observer's incentive to report does not change, and so hearing payoffs for both do not change. Since hearing payoffs do not change, observer's filing incentives do not change; and since the prospect of litigation remains fixed so does the caretaker's incentive to take care.

Proof: Let $l'_k(e, r) = l_k((\varsigma'/\varsigma)e, r) + (F - F')$ for both $k = C, O$. Let $e'(j_c, r), (\varsigma/\varsigma')e(j_c, r)$. Given f, r, and i, e''s expected cost under ς' equals e's under ς. (To conserve notation I sometimes abbreviate functions with single letters.) To show that l'_c, l'_o implements e', f, r, and i under (F', ς'), I first claim that e' maximizes caretaker's hearing payoffs. For any j_c and r, and any alternative *piece* of evidence $\hat{e}$ (a number):

$$
\begin{aligned}
&-l(e'(j_c, r), r) - \varsigma' j_c e'(j_c, r) - F' \\
&\quad = -l(e(j_c, r), r) - \varsigma j_c e(j_c, r) - F && \text{(Definition of } l', e') \\
&\quad \geq -l\left(\frac{\varsigma'}{\varsigma}\hat{e}, r\right) - \varsigma j_c \frac{\varsigma'}{\varsigma}\hat{e} - F && (l \text{ implements } e) \\
&\quad = -l'(\hat{e}, r) - \varsigma' j_c \hat{e} - F'. && \text{(Definition of } l', e')
\end{aligned}
$$

A similar argument shows that r maximizes observer's hearing payoffs, given e'. Next, note that e', r generates the same hearing payoffs for both agents as e, r. This implies that f' maximizes observer's filing-phase payoffs, given e', r, and that i maximizes caretaker's primary activity payoffs given f, e', r. QED

Lemma 2. Lemma 1 holds as well with the coupling constraint, so long as the court may charge court fees. Further, even if court fees are bounded from below by $\overline{C}$ (possibly negative), then Lemma 1 holds if the aggregate increase in fixed costs does not exceed the aggregate initial slack with respect to this lower bound: in essence $(2F' - 2F) \leq (C_o + C_c) - 2\overline{C}$, where C_c, C_o in this expression are court fees used in the original mechanism.

The general idea of the proof is as follows. In Lemma 1, liability for both agents was reduced across the board by the increase in attendance costs. This is impossible with the coupling constraint, because one agent's reduction in liability must equal the other's increase. Instead, both agents' *court fees* are reduced.

The lemma goes beyond the results discussed in the text by considering the case in which court fees are bounded from below. The point is that such a constraint is less stringent than one might think. Suppose, for instance, that because of external constraints, one agent's court fees cannot be reduced far enough to compensate for increased attendance costs. An alternative is to reduce only the *other* agent's court fees and simultaneously increase this agents' liability (across the board) by an equal amount. This increases the first agent's hearing payoffs across the board in the same manner as reducing his court fees. Thus, the constraint on being able to sterilize the increase in attendance costs depends on a comparison of *aggregate* fixed costs and *aggregate* slack with respect to the lower bound on court fees.

Proof: I prove that an appropriate adjustment to court fees and liability exists if the inequality in the statement of the lemma obtains. The proof is designed to readily generalize to models with more than two agents. In terms of increases, we seek $\Delta C_c, \Delta C_o$ and $\Delta l_c, \Delta l_o$ (an "across-type" increase in court fees and liabilities) such that for both agents $k = C, O$

$$-\Delta C_k - \Delta l_k = F' - F \qquad \text{(net increase in } F \text{ is neutralized)}$$

$$-\Delta C_k \leq C_k - \overline{C} \qquad \text{(court fees don't fall below bound)}$$

$$-\Delta l_c = -\Delta l_o \qquad \text{(coupling preserved)}$$

An application of Farkas' lemma (omitted) establishes that the inequality in the statement of the lemma is sufficient for the existence of a solution. Given these adjustments to liability and court fees for all hearings, an argument similar to that in the proof of Lemma 1 may be applied. QED

Proposition 1 and 2. The general idea of the proof of these propositions is as follows. Imagine an "old" minimal-cost implementation under "old" process costs and a "new" minimal-cost implementation under "new" process costs. Let new process costs entail higher attendance costs. The lemmas above establish that the principal *could have* used the new

implementation under the old process costs, when appearance costs were low. Doing so would have required the adjustments discussed, but these adjustments would not have changed the evidence costs in the implementation. But even though the principal *could have* had the evidence costs and the filing frequency of the new implementation, it *chose* the evidence costs and filing frequency of the old implementation. Conversely, with *new* process costs, which entail higher attendance costs, the principal chose the evidence costs and filing pattern of the new implementation over those of the (suitably altered) old. The first thing to conclude from these revealed preferences is that neither implementation has both lower evidence costs and less frequent filings; otherwise, the principal would have chosen that implementation in both instances. The second conclusion is that moving to the new implementation does not raise filing frequency while lowering evidence costs. If, under the *new* process costs, wherein the cost of each appearance is high, the principal were willing to take on more filings for the sake of lowering evidence costs, then it would have *also* been willing to make the same trade-off under the old process costs when the cost of each appearance was lower. It must be, then, that moving to the new implementation lowered the frequency of filings and raised evidence costs.

Proof: Let $A(F, \varsigma)$ and $V(F, \varsigma)$ be appearance and evidence costs under the old mechanism. Define $A(F', \varsigma')$ and $V(F', \varsigma')$ similarly for the new mechanism. Start with old mechanism and old process costs (F, ς) and imagine changing process costs to (F', ς'). We know from Lemmas 1 and 2 that we can find some alternative liability per evidence schedule (not necessarily (l', e')) with old evidence costs $V(F, \varsigma)$, which, when combined with the old filing plan, implements i under new process costs (F', ς'). Since this is an alternative implementation of i under new costs (F', ς'), and the new implementation is a *minimum*-cost implementation under (F', ς'), we may conclude that $V(F', \varsigma') + F'A(F', \varsigma') \leq V(F, \varsigma) + F'A(F, \varsigma)$. By the same argument, starting with the *new* mechanism and *new* process costs, we have $V(F, \varsigma) + FA(F, \varsigma) \leq V(F', \varsigma') + FA(F', \varsigma')$. Combining, $(F - F')(A(F, \varsigma) - A(F', \varsigma')) \leq 0$. Since $F < F'$, we have $A(F, \varsigma) \geq A(F', \varsigma')$. Substituting yields $V(F', \varsigma') \geq V(F, \varsigma)$, and then the rest of the proposition follows easily. QED

Proof of Proposition 3 and 4: The proof is essentially the same as for Proposition 1 and Proposition 2, with the implemented level of care also changing and the notation $V(F, \varsigma)$ now representing *both* evidence costs and primary activity costs. QED

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