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Abstract

In trials witnesses often gain by slanting their testimony. The law tries to elicit the truth from witnesses by cross-examination under threat of criminal prosecution for perjury. As a truth-revealing mechanism, perjury law is crude and ineffective. We develop a perfect truth-revealing mechanism, which exactly offsets the gain from slanted testimony by the risk of a possible sanction. Witnesses testify voluntarily under the mechanism. Implementing an effective truth-revealing mechanism requires a witness to certify accuracy by posting bond. If events subsequently prove that the testimony was inaccurate, the witness forfeits the bond. By providing superior incentives for telling the truth, truth-bonding could combat some distortions by factual witnesses and interested experts, including “junk science.”

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JEL Classification: D82, K41, K42

“There can be little doubt that a large proportion of the wrong decisions reached in our civil and criminal courts result from perjury, which we define as the deliberate giving of false evidence on oath by a contending party or his witnesses.”—first sentence of report by British Section of the International Commission of Jurists.

In deciding legal disputes, courts must rely on observers to report facts and experts to provide opinions. Some witnesses are neutral, but many witnesses have a material interest in the case and they often gain from slanting their testimony. To illustrate, the witness is neutral in Example 1 below, whereas the witness has a material interest in Examples 2–5.

Example 1. A pedestrian observes the collision of two automobiles driven by strangers. In a subsequent suit, the pedestrian testifies on the question, “Was the stoplight red?”

Example 2. An employee testifies in an antitrust suit on the question, “Was your boss at the cartel’s secret meeting?”

Example 3. A woman maintains a sexual liaison with a young poor man and an old rich man. When a child is born, the mother testifies in a paternity suit on the question, "Who is the child's father?"

Example 4. The plaintiff in an antitrust suit must prove the existence of a monopoly. The plaintiff retains an economist to testify on the question, "How large is the defendant's share of the market?"

Example 5. The side-effects of a drug injure a consumer who sues the pharmaceutical company in a civil law country. The judge appoints an expert to answer the question, "Was the drug defective?" If the answer is "Yes," then the expert must also answer the question, "How much harm did the defect cause the plaintiff?" The expert knows that the judge wants to end the trial quickly.

In Example 1, the decision of the court does not affect the material interests of the pedestrian who witnessed the accident, so the witness is neutral. In Example 2, the employee who testifies about his boss has an indirect material interest in the case, whereas in Example 3 the mother testifying about her child's paternity has a direct material interest in the case. In Examples 4 and 5, an expert witness increases his prospects for employment in subsequent legal cases by advancing the interests of the person retaining or appointing him in the present case.

Overwhelming evidence indicates that slanted testimony is endemic in courts. A classic study by lie detector experts concluded that more than 93% of 600 persons who testified under oath about sex in paternity suites had lied.¹ If a party testifies on his own behalf in a legal dispute, a judgment against him often implies that the court did not believe his testimony. In many trials, factual witnesses give opposite testimony, so one of them is lying, and expert witnesses for opposing sides often reach opposite conclusions from the same facts. Although difficult to document quantitatively, anyone who participates in U.S. trials knows that expert witnesses can slant testimony without fear of sanctions and some experts provide eccentric testimony that independent scholars describe as "junk science."² A British committee of jurists inquiring into perjury observed that expert witnesses "are normally selected because they are known to hold certain views on particular subjects."³ These facts indicate that existing legal mechanisms fail to deter slanted testimony by witnesses in courts.

The main formal mechanism for deterring slanted testimony is the threat of criminal prosecution for perjury. In recent decades economists have formulated mechanisms that provide incentives for telling the truth. In this paper, we describe a mechanism that induces witnesses to tell the truth. Under this mechanism the witness will *voluntarily* testify in the courtroom; we thus need no coercive measures. Comparing the truth-revealing mechanism to perjury law explains why it fails to deter slanted testimony and suggests how to reform the law. We propose an innovative legal institution called "truth-bonding," which requires the witness to forfeit a bond if subsequent facts prove that his testimony was inaccurate. Truth-bonding can potentially improve the quality of testimony by the plaintiff, defendant, experts, and other interested witnesses. In this paper we will critique perjury rules as a mechanism

to elicit the truth, describe the truth-revealing mechanism, and discuss its implementation through truth-bonds.

1. Perjury and other legal incentives for truthfulness

To prevent slanted testimony, courts probe the quality of a witness's testimony on cross-examination, searching for internal inconsistencies or contradictions with testimony by other witnesses. Poor performance under cross-examination can damage the witness's reputation, especially when the judge chastises the witness. Loss of reputation informally deters slanted testimony.

Instead of focusing on informal deterrents, however, we analyze private suits for false testimony and criminal prosecutions for perjury. Private suits for false testimony are forbidden in many countries and rare in all countries known to us. The same words that constitute slander or libel when spoken or written outside the courtroom are "strictly privileged" when spoken inside an American or British courtroom. "Strict privilege" means that false testimony cannot support a civil suit for damages, even for outrageous and damaging lies.⁴ A witness is immune from civil liability arising from false testimony at trial, so a victim of slander or libel in court has no private legal remedy. This proposition is so unchallenged that prominent torts professors have difficulty citing the authority for it.⁵

In common law countries outside the U.S., court testimony is mostly privileged against a civil suit,⁶ but strict privilege is not universal.⁷ In some civil law countries, false testimony sometimes causes civil liability. To illustrate, § 826 German Civil Code (BGB) states that the victim can recover damages where the injurer violated "good morals" with "intent to harm." Judges responding to this decision have developed case law on civil liability for false witnessing in court. The rules made by German judges, however, are so restrictive that they approximate "strict privilege" as found in common law. To illustrate, the German constitutional court ruled that parties should never be liable for statements made in court as long as they themselves perceive their statements to be true.⁸ A statute creates a significant exception, however, in antitrust law, where an expert witness who provides misleading testimony for a party in the dispute can be held liable for assisting unfair competition. Furthermore, liability does not require proving that the expert lied.⁹ A British committee of jurists were so alarmed by the frequency of perjury that they recommended changing the law to allow perjury victims to recover damages.¹⁰

Even where allowed, however, civil suits for false witnessing are rare and the law is esoteric. Everywhere the most common formal deterrent of slanted testimony is prosecution for the crime of perjury. By convention, the crime of perjury has four elements: (i) false testimony, (ii) testimony in court, (iii) materially relevant testimony, and (iv) *mens rea*. To illustrate, the Model Penal Code, Section 241.1, reads:

"A person is guilty of perjury, a felony of the third degree, if in any official proceeding he makes a false statement under oath or equivalent affirmation, or swears or affirms the truths of a statement previously made, when the statement is material and he does not believe it to be true."

Federal perjury law in the U.S., as found in 18 U.S.C. § 1621–1623, resembles the Model Penal Code.¹¹

18 U.S.C. § 1001 defines an offense similar to perjury that consists in making false statements to the U.S. government. Unlike perjury, however, this crime extends to affirmative acts of concealment, even when the statement is not in court or under oath.¹²

US courts construe perjury as requiring a statement to be false when strictly and narrowly interpreted, not merely misleading in the context in which it is given.¹³ To illustrate, in impeachment proceedings President Clinton admitted making misleading statements about his sexual conduct while steadfastly denying that he committed perjury.¹⁴ In U.S. law, a statement that is literally true and utterly misleading in the context of its utterance is not perjury. The practical implication is that cross-examination must elicit a precise statement by the witness that is false when considered in isolation.

When *mens rea* combines with a strict interpretation of false testimony, perjury is so hard to prove that prosecutions seldom occur. Thus in 1997 federal prosecutors launched 87 perjury cases out of nearly 50,000 criminal cases.¹⁵ This percentage has changed little over 40 years.¹⁶ Prosecution for perjury committed in a civil suit is especially rare. A search of computer records turned up 25 cases of federal prosecutions for perjury in civil cases in 1998.¹⁷ When witnesses contradict each other in court, or when a person who pleaded innocent is found guilty, perjury charges almost never result.¹⁸ In a report on perjury, a committee of British jurists wrote,

"The actual number of prosecution appears to be very small as compared with the number of occasions on which perjury is clearly committed, and in which evidence is given which is sufficiently misleading to influence the verdict, but would not rank as perjury as it is at present defined. . . ."¹⁹

Examining individual cases suggests the circumstances that provoke prosecutions for perjury. First, prosecutions for perjury may occur because the prosecutor could not obtain a conviction for the underlying crime. To illustrate by an infamous case, the U.S. government could not convict Alger Hiss of spying for the USSR, but he was convicted of lying to Congress.²⁰ Second, government officials such as policemen who lie repeatedly or emphatically in court risk prosecution for perjury. To illustrate, in a continuing scandal in New York City, police engaged in a pattern of perjury so common that they called it "testilying."²¹ Third, witnesses who commit perjury in civil suits risk prosecution for perjury when clear proofs exist that they lied in court to gain an advantage. To illustrate, an orthopedic surgeon who testified as an expert was prosecuted for repeatedly inflating his credentials; a lawyer was prosecuted for lying under oath about a potential conflict of interest in representing his client; and a clergyman was prosecuted for perjury that he committed in a civil suit against a newspaper that ran a story about his homosexual affair.²²

The heavy burden of proof in perjury trials precludes bringing prosecutions with sufficient frequency to deter slanted testimony. As explained in the next section, a better truth-revealing mechanism lowers the burden of proof by replacing a legal standard of fault with a rule of strict liability for mistaken testimony.

2. Perfect truth-revealing mechanism

In 1954 Paul Samuelson provided the first formal definition of a "public good."²³ Economists immediately recognized that financing public goods by a tax on the beneficiaries involves a problem of "preference revelation." Twenty years later, economists generalized this problem to "truth revelation" and they sought to discover incentives for truth-telling that no strategy could defeat.²⁴ A few scholars have applied such mechanisms to problems in law,²⁵ but not to witnesses in courts. The role of the expert witness in court has been discussed outside this framework.²⁶

We begin to apply this framework to courts by describing the assumptions of our model. We assume that a defense witness observes a fact that is relatively good or relatively bad for the defendant. The witness is either certain or uncertain about the observation's accuracy. In more technical language, a witness receives a signal that is better or worse with high or low precision. When testifying in court, a witness reports on the signal's *content* (better/worse) and *precision* (high/low). As indicated in Table 1, an *honest* witness reports truthfully about content and a *dishonest* witness reports falsely about content.

As indicated in Table 2, a *candid* witness reports accurately about precision and a *misleading* witness reports inaccurately about precision.

We use the term "truthful" to mean honest and candid, and we use "slanted" to mean dishonest or misleading.

After a witness testifies, subsequent events during or after the trial may prove that the testimony was right or wrong. To illustrate by Example 1, after the pedestrian testifies that the stoplight was red, someone may discover a photograph proving conclusively that the stoplight was green.²⁷ In Example 2, the employee may testify that the boss was not at the cartel's secret meeting, and, as the case develops, the boss may admit that he was at the meeting. In Example 3, the mother may testify that the rich man is the child's father and, after the trial, subsequent developments in biology may prove that she was right.

Table 1. Signal's content and witness's report.

Content	Report	
	Better	Worse
Better	Honest	Dishonest
Worse	Dishonest	Honest

Table 2. Signal's precision and witness's report.

Precision	Report	
	High	Low
High	Candid	Misleading
Low	Misleading	Candid

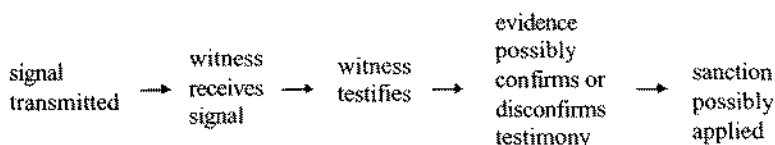


Figure 1. Time-line for truth-revealing mechanisms.

Our model stylizes these facts. We assume that a signal, which is characterized by content and precision, is transmitted to the witness. The witness testifies about the signal before a court or similar body. Subsequently the court receives a signal tending to confirm or disconfirm the witness's testimony. If the court's signal disconfirms the witness's testimony, then the truth-revealing mechanism imposes a sanction. Figure 1 depicts the order of events.

In discussing the model, we will simplify by assuming that the court discovers with positive probability whether the *content* of the testimony was right or wrong. If the testimony was wrong, then the mechanism imposes a sanction. Unlike content, the court gets no independent information about the precision of the signal observed by the witness. Note that evidence about the content does not prove unambiguously the quality of the testimony. Proof of the poor man being the father makes it only more likely that the mother did not tell the truth when testifying that the rich man fathered the child.²⁸

By definition, a *perfect* truth-revealing mechanism induces honest and candid testimony in all circumstances.²⁹ This mechanism, which we derive formally elsewhere, has an intuitive interpretation.³⁰ In some circumstances, an interested witness gains from slanted testimony. Against this gain, the witness must balance the probability and magnitude of a sanction. An expected sanction greater or equal to the gain from slanted testimony provides sufficient incentive to tell the truth.

We explained that a perfect truth-revealing mechanism provides an expected sanction greater or equal to the gain from slanted testimony. The expected sanction equals the probability times the magnitude of the sanction. The sanction's probability equals the probability that the evidence obtained after the witness's testimony disconfirms it. With a perfect truth-revealing mechanism, the sanction's magnitude depends on the testimony's precision. The court assesses a higher sanction for inaccurate testimony that the witness offered with certainty rather than uncertainty.

To illustrate, consider the mother in Example 3. Assume that she believes that the poor man is the father. She will, however, enjoy a larger court award by asserting falsely that she believes that the rich man is the father. Furthermore, her *expected* award from a false assertion is larger if she makes it with certainty rather than uncertainty. False testimony, however, runs a risk. Perhaps officials will eventually discover the truth through advances in biology. With the perfect truth-revealing mechanism, such a discovery triggers a sanction. By definition, the *expected* sanction equals the probability that such events will trigger a sanction multiplied by the sanction's magnitude. With minimum sanctions necessary to induce honest and candid testimony, the expected sanction exactly equals the mother's gain from a false or misleading report. In so far as the mother's gain from a false report is higher when she asserts that she is certain rather than uncertain, the sanction must be higher when her dishonest testimony is given with certainty rather than uncertainty.

As another illustration, consider the medical expert in Example 5. Assume that her tests indicate that the drug is not defective, but she is *uncertain* about these tests. By assumption, the judge who retains her prefers to end the trial quickly. To promote her future business, the expert can please the judge by testifying falsely that she is *certain* that the drug is not defective. By doing so, however, the expert runs the risk that someone will subsequently present irrefutable proof that the drug is defective. When applying the perfect truth-revealing mechanism to this case, the expected sanction increases when the expert who is uncertain asserts that she is certain, and the increase exactly equals the gain to the expert from more business in the future.

Some testimony, such as an expert *opinion*, is almost impossible to disconfirm. To illustrate, the concept of "market share" in Example 4 is imprecise. An economist who asserted, say, that the defendant's market share did not exceed 20%, could defend this opinion by quibbling about the definition of "market share." The possibility of sanctioning the economist for inaccurate testimony requires eliciting sufficiently precise testimony to judge its accuracy. In other words, using the perfect truth-revealing mechanism requires shaping testimony so that disconfirmation is possible.

To make disconfirmation possible, the attorney cross-examining the economist in Example 4 might ask him to testify that his opinions are not eccentric or bizarre relative to other economists. For example, the cross-examining attorney might ask the economist whether at least 50% of industrial economists at major universities, when confronted with the same evidence that he relied upon, would conclude that the defendant's market share did not exceed 20%.

In Table 3 we use numbers to illustrate the perfect truth-revealing mechanism for the true signal "worse & low." The first row of numbers indicates the witness's gain from testifying "better" rather than "worse." Also note that the witness gains from testifying that his certainty is "high" rather than "low." As indicated by Table 3, the minimum expected sanction that induces honest and candid testimony at least offsets the gains from slanted testimony. With perfect offsetting, all false testimony earns the same or lower net payoff than the truth. In Table 3, honest and candid testimony "weakly dominates" the alternatives. (By an appropriate increase in the schedule of sanctions, "weak dominance" becomes "strong dominance.")

In Table 3, the sanction is zero when the witness provides the least advantageous testimony relative to his own interest. Setting this sanction at zero assures that the mechanism uses the minimum sanctions to elicit the truth.

According to Table 3, the witness expects to gain at least as much from testifying truthfully as from not testifying. Specifically, the witness expects to gain 5 from testifying truthfully

Table 3. Perfect truth-revealing mechanism for the signal "worse & low".

	Better & high	Worse & high	Better & low	Worse & low
Payoff to witness	17	11	7	5
Expected sanction	22	6	2	0
Net payoff	-5	5	5	5

Table 4. Expected sanction for the signal "worse & low".

	Better & high	Worse & high	Better & low	Worse & low
Probability of sanction	2/3	1/3	2/3	1/3
Severity of sanction	33	18	3	0
Expected sanction	22	6	2	0

and 0 from not testifying. Consequently, the witnesses will testify voluntarily and truthfully. In general, the perfect truth-revealing mechanism is *individually rational* in the sense that witnesses will testify voluntarily. The perfect truth-revealing mechanism does not "chill" testimony in the sense of discouraging witnesses who would otherwise testify.

One implication of individual rationality is the optimal sanction for a *neutral* witness who makes a mistake is nil. In other words, the optimal mechanism imposes a sanction of zero for wrong testimony by a witness who gains nothing from testifying. Otherwise, neutral witnesses who are self-interested would not testify voluntarily.³¹

To understand better the construction of Table 3, consider the probabilities underlying the expected sanction. Assume the witness observes the signal "worse & low." Further assume that the court will subsequently observe "worse" with probability 2/3 and "better" with probability 1/3. According to the first row of numbers in Table 4, the probability that honest testimony ("worse") will appear wrong and trigger a sanction equals 1/3, whereas the probability that dishonest testimony ("better") will appear wrong and trigger a sanction equals 2/3. According to the third row of numbers in Table 4, the sanction increases from 0 to 18 for changing the precision of an honest report from low to high. Similarly, the sanction increases from 3 to 33 for changing the precision of a dishonest report from low to high. The expected sanctions in the third row of Table 4, which equal the probability of a sanction multiplied by the sanction's severity, correspond to the expected sanctions in the second row of Table 3.

For our simple truth-revealing mechanism to exist, the payoff must (weakly) increase when the report changes from "worse" to "better" or from "low" to "high." We call this condition "monotonicity." Notice that we can switch labels between the columns "worse & high" and "better & low" in Tables 3 and 4 without violating monotonicity. In general, transposing the payoffs for "worse & high" and "better & low" does not affect the existence of a perfect truth-revealing mechanism.

3. Contrasting perjury and truth-revealing mechanisms

Perjury contrasts with the perfect truth-revealing mechanism in several respects. First, with the perfect truth-revealing mechanism, facts coming to light that contradict the testimony triggers the sanction. Inaccuracy, however, is only one criterion for perjury. In addition, the prosecution in a perjury case must prove that inaccuracy was intentional. This proof involves difficult probabilistic inferences that we analyze elsewhere.³² Given the difficulty of proving intent, only an extreme sanction for perjury will deter it.

Table 5. Actual versus ideal.

Perjury	Optimal mechanism
Fault rule (<i>mens rea</i>)	Strict liability rule
Invariant sanction	Sanction varies with
	1. Payoff to slanting testimony
	2. Enforcement probability

Second, the optimal mechanism conforms to the familiar principle that deterrence requires punishment to increase in proportion to the gain from wrongdoing and the probability that the wrongdoer will escape punishment.³³ We define a *simple* perjury rule as imposing an invariant sanction relative to the probability of its application and the gain from wrongdoing. Conversely, we define a *sophisticated* perjury rule as imposing a sanction that varies with the probability of its application and the gain from wrongdoing. Actual perjury rules resemble simple rules more than sophisticated rules.³⁴

Because of these limitations summarized in Table 5, a perjury rule is an imperfect truth-revealing mechanism, even when supplemented by a private suit for false witness. If reporting truthfully advances the interests of the witness, he can overstate his confidence in his report without fear of prosecution. If reporting falsely advances the interests of the witness, he can report falsely and reduce the probability of prosecution by saying that that he is uncertain about the facts. In either case, an interested witness has an incentive to distort testimony to obtain a better result at trial.

A different kind of imperfection in perjury rules applies to neutral witnesses. Even an honest, candid witness runs a very small risk of being sanctioned for perjury due to a court error. Since a court is more likely to find perjury when testimony was given with certainty rather than uncertainty, a neutral witness who tells the literal truth also minimizes the probability of being sanctioned for perjury by understating his certainty. To illustrate, consider Example 1 in which a neutral pedestrian believes that she saw a green light when two motorists collided. The pedestrian knows that witnesses and courts make mistakes. The probability of being sanctioned for perjury is lower if she testifies that she is uncertain rather than certain. In general, enforcement of a perjury rule provides an incentive for a neutral witness to understate the precision of the signal received.³⁵

The incentive for neutral witnesses to understate their certainty diminishes with the frequency of perjury prosecutions. In practice the probability of prosecuting a neutral witness for perjury is close to zero. (We could not find any such cases.) In this respect, the actual law of perjury approximates the perfect truth-revealing mechanism.

The reason usually given for prosecuting perjury so seldom is the fear of chilling witnesses.³⁶ As our analysis demonstrates, this fear is real for neutral witnesses who have nothing to gain from testifying. Assuming self-interested rationality, a neutral witness would prefer not to testify rather than face a small possibility of mistaken prosecution for perjury. If compelled to testify, such a witness would minimize the chances of prosecution for perjury by understating his certainty. The situation, however, is different for interested witnesses. The fear of chilling witnesses with much to gain from testifying is misplaced. Under

the perfect truth-revealing mechanism, the expected sanction never exceeds the advantage gained by the witness from testifying. This is the requirement of "individual rationality" imposed on the design of the perfect truth-revealing mechanism. The perfect truth-revealing mechanism never deters a witness from giving testimony.

These facts suggest extending our analysis and reformulating the problem of chilling witnesses as a tradeoff. In some circumstances, a witness will benefit himself by slanting testimony and harm himself by truthful testimony. In these circumstances, his first preference is to slant his testimony, his second preference is not to testify, and his third preference is to testify truthfully. Under a perjury rule, such a witness will voluntarily provide slanted testimony. Under a perfect truth-revealing mechanism, such a witness will not testify voluntarily. If the law compels the witness to testify under a perfect truth-revealing mechanism, the court will hear testimony against the interests of the witness. When the law cannot compel a witness to testify, as is often the case, a tradeoff occurs between the quantity and quality of testimony. If the court employs a truth revealing mechanism, some witness will not testify and those who do will tell the truth. If the court only employs a perjury rule, more witnesses testify and more of them will slant their testimony. Emons (2001) deals with this problem. The rational court anticipates the low quality of testimony under perjury. Therefore, from an *ex ante* point of view all parties prefer the truth revealing mechanism to perjury.

4. Truth-bonding

The perfect truth-revealing mechanism can be implemented in a variety of ways. The obvious implementation requires the judge to impose the optimal sanction whenever events disprove the witness's testimony. The obvious implementation, however, ignores the limits on the court's information. A better implementation interprets the optimal sanction as a bond posted by the witness and forfeited in the event that evidence disconfirms his testimony. The amount of bond is negotiated between the parties. Bonding is a better interpretation of the optimal mechanism than sanctioning because bonding requires the court to have less information than sanctioning. This paper, however, does not analyze the market for truth bonds. In a future paper we hope to analyze thoroughly the intuitions that we now sketch.³⁷

We use the example in Tables 3 and 4 to explain how a market for truth-bonds might implement our truth-revealing mechanism. Having observed "worse & low," the witness considers whether to testify truthfully or slant testimony by reporting, say, "better & low." Assume that courts treat truth-bonding agreements as enforceable contracts. If the witness slants testimony by reporting "better & low," the opposing side might ask the witness to post bond. For now assume that the opposing side would ask for *optimal* bond, which, according to Table 4, equals 3 for the false report of "better & low." (Later we explain why the two sides might prefer the optimal bond.) After the witness posts bond, the court might subsequently learn that the testimony was wrong, which, according to Table 3, happens with probability $2/3$. In this example, the witness foresees that testifying "better & low" falsely will cause him to post bond of 3 and lose it with probability $2/3$, yielding an expected loss of 2.

The expected loss of 2, according to Table 3, exactly offsets the increase in his payoff from slanting testimony. So the witness expects to do just as well by testifying truthfully

as by slanting testimony. Foreseeing these facts, the witness truthfully reports "worse & low." According to Table 4, the other side does not request bond when the witness reports "worse & low." This example illustrates a typical outcome of truth bonding: The *threat* that the opposing side will ask for bond evokes the truth without the posting of bond.

The optimal bond for truthful testimony, however, can be positive rather than zero. Regardless of whether the optimal bond for truthful testimony is zero or positive, a threat prevents the witness from slanting testimony. The threat is that slanting testimony will cause the other side to request a change in the bond that increases its expected payoff. Increasing the expected payoff typically requires increasing the bond. Consequently, the threat that the other side will ask for *more* bond typically evokes the truth.

We have explained how optimal bonding makes the witness tell the truth. Now we explain why the opposing side might ask the witness to post *optimal* bond, rather than asking for more or less bond. We assume that the party asking for bond must pay a *statistically fair price*, by which we mean that the bond's price equals its expected payoff. To illustrate, if the bond pays x with probability p , then the statistically fair price equals px . The party who pays a statistically fair price for bond expects to break even, regardless of the bond's size.

Who gets the price of the bond paid? Not the witness who posts the bond. The witness cannot receive the price paid by the party who requests bond. Paying the bond's price to the witness who posts the bond destroys the incentives to tell the truth. The truth-revealing mechanism requires an increase in the bond to offset any increase in the witness's payoff from slanting testimony. If the statistically fair price were paid to the witness, he would be equally well off regardless of the bond's size. If the witness were equally well off regardless of the bond's size, then an increase in the size of the bond could not offset an increase in the witness's payoff from slanting testimony. Given these facts, someone other than the witness who posts bond must receive the price of the bond. In negotiating bond, the parties should agree that the price will be paid to a third party such as the court.³⁸

Now we explain why the opposing sides in our example should ask the witness who testifies "better & low" to post the *optimal* bond. If the opposing side requests bond that is less than the optimum, the witness can gain from slanting testimony in a direction that harms the opposing side. The opposing side, consequently, will not ask for bond that is less than the optimum.

The trick is explaining why the opposing side does not ask for more than the optimum bond. One possibility is that the opposing side wants to elicit the truth from the witness without imposing an unnecessary burden. This possibility is simple and straightforward but not very convincing. This possibility is unconvincing because reasonable institutional assumptions result in incentives for the opposing side to ask for excessive bond. To illustrate, if testimony and bonding are simultaneous, then the opposing side can ask for excessive bond and the result will elicit the truth or possibly cause the witness to slant testimony in a direction favoring the opposing side. Alternatively, if the testimony is given first and bond set second, then the expected bond influences the testimony and the actual bond does not influence the testimony. In these circumstances, the opposing side may ask for excessive bond to disadvantage the witness.

A judge with insight could prevent excessive bond. There are various possibilities depending on institutional detail. To illustrate, in a free contract regime, the witness is free to reject

the opposing side's request for bond. Rejecting bond, however, affects the credibility of the witness's testimony. We assume that rejected requests for bond get reported to the court. We also assume that the court distinguishes between reasonable and unreasonable requests for bond. If the witness rejects a reasonable request for bond, the court heavily discounts the witness's testimony. To maintain credibility, the witness cannot reject a reasonable request for bond. Conversely, if the witness rejects an unreasonable request for bond, the court does *not* discount the witness's testimony. Rejecting unreasonable requests for bond does not undermine the witness's credibility. Given these assumptions, the opposing side will only request reasonable bond. In so far as reasonable bond is optimal, the opposing side will request optimal bond. To illustrate by our example, if the court believes that 3 is reasonable bond and more than 3 is unreasonable, then the opposing side will ask the witness to post bond of 3.

To illustrate how these processes might operate in court proceeding, we will modify our example. Before we assumed that the witness observes "worse & low." Now assume that that the witness observes "better & low." Otherwise the example is unchanged. We make this change in assumptions so that the optimal bond for truthful testimony as given by Table 4 is positive rather than zero. When testifying, the witness anticipates correctly that he will be requested to post the optimal bond, so he tells the truth and report "better & low." The other side, who suspects that the witness observed "worse & low," requests a pause in the trial to negotiate bond. In negotiations the witness initially offers to post bond of 2 and the other side demands bond of 4. After discussing the facts, both sides recognize that the optimal bond for testifying "better & low" equals 3, and the statistically fair price equals 1. Both sides recognize that a hearing before the court would convince it that 3 is reasonable bond and 1 is a fair price. Consequently, both sides agree that the witness will post bond of 3 and the other side will pay a price of 1 to the court. The parties present the court with this contract. If the court subsequently learns that the testimony was wrong, the witness will pay 3 to the other side.

Instead of a free contract regime, assume that the judge must approve truth bonds just as with bail bonds. A contract for a truth-bond is unenforceable unless approved by the judge, and assume the judge will only approve the minimum truth-revealing bond. Under these assumptions, the parties must present arguments to the judge about the level of the bond that is the minimum for inducing the revelation of the truth. By assumption, the judge can arrive at the truth by hearing the arguments. The task is simplified by the judge only having to evaluate a limited number of arguments. The arguments are limited in our model because the judge only needs to arrive at the minimal bond required to induce the truth under circumstances where the incentive to slant testimony would be strongest.

To illustrate, suppose the witness for the plaintiff has reported "better & low." The plaintiff then has to argue as follows: It is possible that the witness has actually observed "worse & low." If this is the case and the witness truthfully reports "worse & low," he gets 5, whereas he gets 7 from falsely reporting "better & low." If he reports falsely "better & low," the probability that the evidence disconfirms his testimony equals $2/3$. Therefore, if the truth bond equals 3, he faces an expected sanction of 2 which exactly offsets the monetary gain from falsely reporting "better & low." The witness can then try to argue that the bond is too high which is, however, impossible in the example just given.

We have sketched a bargaining mechanism for implementing truth bonds. If truth-bonding became common, bargaining might become embedded in competitive markets. To illustrate by analogy, people accused of crimes in the US are routinely released on bail while awaiting trial. Most people who post bail borrow the money from a bail bondsman. The market for bail substitutes private for public monitoring of criminals awaiting trial. Similarly, a market for truth-bonds might develop in which professional lenders would assess the credibility of witnesses. The development of such markets would effectively privatize perjury law.

5. The mechanism's limits

Here we mention some of our mechanism's limits. Our mechanism prevents the witness from slanting his testimony, but our mechanism does not prevent the witness from withholding testimony. If a witness stands to lose by testifying on a particular question and the opposing side asks the right question, our mechanism causes the witness to tell the truth. If, however, the other side does not know what question to ask, our mechanism will not cause the witness to reveal the relevant facts. To extend truth-revelation to omitted evidence, the witness would have to bond the proposition that he did not omit any materially relevant facts. See Emons (2001).

A party to a dispute who stands to gain from another's false testimony might offer to pay any sanction imposed on the witness. Such side payments increase the sanction required for perfect truth-revelation and also complicate the task of estimating the optimal sanction. If these problems prove severe, criminal law has a solution. Suborning a witness to commit perjury is a crime. Perhaps a party who pays the sanction of a witness should be regarded as suborning perjury.

In our model, discovery of facts triggering the sanction is exogenous. Thus in figure 1, the confirming or disconfirming evidence simply appears at some point after the witness testifies. In reality, the trigger may be endogenous to the trial. Thus, for example, when two witnesses testify in court, the second witness may provide the information that triggers the bond of the first witness. An endogenous trigger raises strategic problems for our model. For example, with endogenous triggers it is usually better to testify later rather than earlier in the trial. Similarly, if a finding of fact by a judge triggers a bond, the judge might become less willing to find the fact.

Our truth-revealing mechanism suffers a technical failure for some patterns of gains to witnesses. In Examples 3 and 5, the witness's lowest payoff apparently comes from testifying "worse & low," and the highest payoff comes from testifying "better & high." To illustrate, in Example 3 the mother gains most from testifying with certainty that the rich man is the father. Next, she gains from testifying with certainty that the poor man is the father. The worst possibility for her is that she cannot testify with certainty about the father's identity. Thus payoffs increase whenever the witness testifies with higher certainty. With this pattern of gains to witnesses, which we call "monotonicity," our mechanism always works.

In situations like Examples 2 and 4, however, the witness sometimes gains more from reporting uncertainty rather than certainty. To illustrate by Example 2, if the employee

must testify against his interests that his boss was at the meeting, then he is better off to be uncertain rather than certain. In Example 4, if the expert *must* testify against his interests that the alleged monopolist actually had a *low* market share, the expert benefits from testifying that he is uncertain rather than certain. When a witness loses from testifying with certainty rather than uncertainty, our truth-revealing mechanism suffers a technical failure from the absence of monotonicity. This technical problem, however, has a technical fix.³⁹

We assume that after the witness testifies, disconfirming or confirming information appears with positive probability, but we do not ask the question, "What level of disconfirming evidence provides the best trigger for the sanction?" The simplest trigger is a finding of fact by the court that contradicts the witness's testimony. To illustrate, the sanction could apply to the employee in Example 2 if the court found that the employee's boss was at the cartel meeting, or the sanction could apply to the mother in Example 3 if the court found biological proof that the poor man is the father.

In some circumstances, however, the simplest trigger may not be best. To illustrate, when a finding of fact involves a difficult judgment by the court, making the witness forfeit bond because the court disbelieved him could create perverse incentives. Such a rule puts the witness in the position of a judge in Keynes's beauty contest, where each judge on the panel gets a prize for picking the winner. Thus a witness with weak credentials might not want to risk truthful testimony that contradicts another witness with strong credentials. This problem partly involves the level of proof at which the court should conclude that the testimony was inaccurate. If court has to find a fact in a case that would trigger the bond, then the preponderance of the evidence standard might be inappropriate. A complete model would investigate the burden of proof that is best for triggering the sanction.⁴⁰

The trigger for the sanction depends on how the testimony is framed. Instead of testifying to facts, experts often offer opinions. When an expert offers an opinion, the sanction is best applied to the level of scientific support for the opinion. To illustrate, the economist in Example 4 offers an expert opinion concerning the defendant's market share. The interrogator should ask a question like, "Given the facts that you relied upon, would at least 50% of randomly chosen, disinterested industrial economists agree with your conclusion about the defendant's market? 'How about 50%? Or 30%? At what level will you bond your testimony?'" The threat of a sanction for inaccuracy would force the expert to accurately characterize the level of support among scientists for his opinions.⁴¹ By this means, unusual or eccentric opinions are exposed as such. Having admitted that his opinion is unusual or eccentric, the expert is free to argue that he is right and other experts are wrong.

To sum up the limits of our analysis: We analyze the problem to induce the witness of one party to a dispute to reveal the truth. We show that we can reveal the truth with a mechanism under which the witness testifies voluntarily. We assume that obtaining the truth is socially desirable. We do not analyze whether the other party to the dispute gains or loses from truth revelation. Furthermore, we do not model how the other party can contribute to finding out the truth. We highlight only one aspect of the problem and we do not provide a full analysis of the adversarial system.⁴² Accordingly, our results are of partial equilibrium nature. Nevertheless, given the current state of the literature we are convinced that we cover

new grounds. In particular, we think to point in the direction where future research might go: applying mechanism design theory to the courtroom.

An interesting question is who actually wants to reform the current system. There is now a thriving business of experts testifying in the courtroom.⁴³ Obviously, these experts gain from the current perjury system and they will, most likely, oppose any change. Nevertheless, growing dissatisfaction with the current system, especially in the U.S., seems to indicate that there is a need for reform. Accordingly, we conjecture that a proposal to improve the quality of testimony finds the necessary political support.

6. Conclusion

In discussing the problem of evaluating the testimony of witnesses in court, Fisher writes:

We do not leave our jurors wholly unequipped for this task of lie detecting. They come to court, as we so often tell them, with their common sense and may reject any evidence that defies it. Inside court, we give them three more lie-detecting tools: the oath, demeanor evidence, and cross-examination.⁴⁴

This "tool box" resembles the emperor's new clothes in Hans Christian Andersen's story. Slanted testimony often leaves courts so perplexed that rules allocating the burden of proof determine outcomes. What the tool box lacks is a truth-revealing mechanism. As far as we can tell, Solomon was the only judge to employ a truth-revealing mechanism, and it is strategically vulnerable.⁴⁵

Solving a problem presupposes recognizing it, and scholars of perjury have not recognized the possibility of a truth-revealing mechanism for courts. Scholarship on perjury and lying seems unaware of truth-revealing mechanisms. Some scholars seek to unify perjury law by harmonizing differences in statutes and practices.⁴⁶ Another topic of scholarly concern is the fairness of prosecuting someone who perjured himself in his own unsuccessful defense against a criminal charge.⁴⁷ In addressing this topic, scholars delicately dissect the issues of double jeopardy and collateral estoppel.⁴⁸ Scholars have also explored the history of perjury law.⁴⁹ Another topic, whose reforming spirit resembles our paper without its analytical apparatus, is whether to confine perjury to literal lies or broaden the crime to encompass misleading statements.⁵⁰ Sociological studies of lying, which occasionally add interesting observations, lack analysis or theory.⁵¹

In contrast, economists have devoted much effort to developing truth-revealing mechanisms without applying them to courts.⁵² This paper applies results from the theory of mechanism design to investigate the smallest sanctions for inaccuracy that make accurate testimony best for a self-interested witness. In brief, we investigate the minimal, perfectly truth-revealing sanctions. The optimal sanction for testimony that proves inaccurate equals or exceeds the gain to the witness from slanted testimony. In principle, the optimal sanction could deter distortions by factual witnesses and exaggerations by experts, including "junk science."

Theorists who imagine that economic incentives are the law's "hidden logic" will be disappointed to learn that the law of perjury is grossly sub-optimal. Perjury law is fault based, whereas our mechanism involves strict liability for inaccurate testimony. Furthermore, the optimal mechanism bases sanctions on the gain to the injurer and the probability of escaping the sanction, whereas perjury law is unresponsive to these considerations.

Adjusting legal rules of procedure and liability to provide an optimal truth-revealing mechanism requires legal reform. We discuss implementation through truth-bonding. Perhaps modest changes in contract law would enable truth-bonding to develop through negotiations and markets, thus substituting private law for perjury law. Or perhaps truth-bonding requires a heavily regulated contract market. In spite of many practical obstacles, truth-bonding has the promise of improving the quality of testimony in court. We hope that our framework will enable future research will identify useful ways to implement truth-bonds.

Economists often study the effect of policies on efficiency and distribution. In contrast, this paper investigates the effect of legal process on truthfulness. We implicitly assume that trials achieve better outcomes when witnesses tell the truth. The maxim of our paper is that the best guarantee of truth in court is the relatively costliness of a lie.

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Notes

1. "For 16 years a number of judges of the Chicago Municipal Court have consistently availed themselves of the lie-detector technique to assist them in their decisions. . . . On the basis of a six-year study of the 312 disputed paternity cases at the Chicago laboratory of John E. Reid and Associates, it was determined that 93 percent of the tested parties lied in some respect when they testified in court as to their sexual relationship! The lying ranged from the defendant's complete denial of any intercourse with the complainant, when he actually did have it with her during the conception period, to the complainant simply exaggerating the number of times intercourse did take place with the defendant during the conception period." Arthur and Reid (1954) at p. 215. Also see Zimring (1999).
2. Martha Nussbaum's testimony in *Romer v. Evans* seems to be an example of expert perjury. She seems to have misleadingly cited the long superseded 1897 edition of a Greek-English lexicon listing no pejorative connotation of the Greek word *tolmēma* whereas in the later 1940 edition, which she normally cites in her academic work, "shameless act" is included as a possible translation of *tolmēma*. See Lingua Franca, Sept/Oct. 1996, <http://www.linguafranca.com/9609/stand.html>.
3. Hunter (1973).

4. If the false witness is the criminal, however, restitution statutes may give the court the occasion to compensate the victim for the total consequences of the crime.
5. Keeton et al. (1984) at p. 872 supports this proposition citing "Civil Remedies for Perjury," *Arizona Law Review*, 19, 349.
6. In a personal communication to Cooter, Anthony Ogus asserts that English law takes the same approach as US law to the issue of perjury (*Hargreaves v. Bretherton* (1959) 1 QB 45).
7. South Australia has legislation making perjury in civil proceedings actionable. See Wrongs Act 1936 (SA) s 36. Thanks to Megan Richardson for this information.
8. BVerfGE (1987). We are grateful to Stefanie Schmid for providing us with a valuable research note on civil liability for false witnessing in German law.
9. See Sections 1 and 3 of the Unfair Competition Act (UWG) and Baumbach and Hefermehl (1996), commentary ad UWG § 1 (p. 417, no. 28) and ad § 3 (p. 882, no. 83 and p. 926, no. 175).
10. Hunter (1973).
11. Kislak and Donoghue (1999).
12. Fitzpatrick and Torracco (1999).
13. The leading case is *Bronston v. United States*, 409 U.S. 352, 357–358 (1973). Tiersma (1990) argues against the "literal truth" defense of *Bronston* and in favor of a conception of truth based on a "speech-acts" theory. Also see Nagel (1998) and Tiersma (1990).
14. Suro and Miller (1998) and Cooper (1999).
15. Suro and Miller (1998).
16. In 1956 and 1957 out of 56,859 federal criminal cases, only 161 were perjury prosecution. See Note 1 in "Perjury by Defendants: the uses of double jeopardy and collateral estoppel," *Harvard Law Review*, 74, 752.
17. Marcus (1998).
18. Says Zimring (1999) at page A15, "In view of the number of direct testimonial conflicts in civil and criminal trials, perjury prosecutions are rare events in the United States. Whole categories of testimony where self-serving evasions are regarded as normal are almost never the foundation for a perjury charge. When a criminal defendant denies the charges on the witness stand and is nonetheless convicted, we do not expect the prosecutor to bring a new perjury. When witnesses under oath say they cannot remember events, this convenient amnesia is discounted by judges and juries, and few will face perjury charges."
19. Hunter (1973) at p. 3.
20. Rappaport (1993) and Reuben (1983).
21. If a trial were scheduled for a day that a policeman was off duty, an police who was on duty would lie in court by saying that he witnessed the events actually witnessed by the off-duty policeman. In some cases, however, "testifying" was also used to cover-up police crimes. See Kocieniewski (1997), Sexton (1994). Also see Chin and Wells (1998), Dripps (1996), McClurg (1999) and Slobogin (1996).
22. Marcus (1998).
23. Samuelson (1954, 1955).
24. For an introductory review of mechanism design literatures, see Emons (1994); for a formal survey, see Myerson (1985).
25. Hoffman and Spitzer (1985), Emons and Sobel (1991), Spier (1994) and Sanchirico (2000).
26. Mandel (1999), Posner (1999) and Thornton and Ward (1999).
27. During the World Cup 2002 the Argentine referee Angel Sanchez claimed that the Portugal forward Joao Pinto punched him in the stomach after being shown the red card. Portuguese soccer officials denied this. The next day Fifa discovered a video that showed Pinto striking the official. See http://news.bbc.co.uk/sport3/worldcup2002/hi/team_pages/portugal/newsid_2047000/2047782.stm.
28. We do not model what happens to the original trial if the witness is found to have lied. We assume the same institutional framework which applies under perjury law; any incentives that the witness might get thereof are subsumed in her payoffs.
29. Our aim throughout the paper is to reveal the truth. From a societal point of view there may be cases where lies are better than the truth, e.g., if somebody lies to protect a lady's honor, or if a government official lies about foreign policy event to protect ongoing dealings. In Fluet (2003) a court maximizes the ex ante surplus from a contractual relationship by not seeking the truth ex post. See Posner (1999b) for a comprehensive economic analysis of the law of evidence with efficiency being the ultimate aim.

30. Cooter and Emons (2003).
31. One could argue that the incentives of an intrinsically motivated witness might be crowded out by the monetary sanctions used by our truth-revealing mechanism. This is, however, not the case. If there is intrinsic motivation to tell the truth, the witness is neutral and the sanctions in our mechanism are zero.
32. Cooter and Emons (2003).
33. An exposition of this familiar argument from law and economics is in Chapter 11 of Cooter and Ulen (1999).
34. Kislak and Donoghue (1999) at pp. 980–981 and Fitzpatrick and Torracco (1999) at pp. 624–626 discuss various enhancements to perjury sentences under federal guidelines. None of the enhancements include the probability that the crime will go unpunished. In fact, few wrongs are sanctioned according to the requirements of the rule of the reciprocal. Thus Craswell (1999) at p. 2188 writes: "Significantly, few legal regimes follow the traditional multiplier in this respect, for few (if any) use multipliers that are calculated case-by-case. Often no multiplier is used and only compensatory damages are awarded, as in most civil suits under the common law. When the law does use a multiplier, it is often set at a single value that is the same for all defendants, as in the treble damage rule of antitrust law. And when criminal or administrative penalties are used, it is common to set a single fine for all violations of a certain type (e.g., \$100 for failing to stop at a stop sign), regardless of either the harm caused or the probability of punishment. Obviously, none of these systems of punishment satisfies the traditional, case-by-case multiplier principle." Also see Polinsky and Shavell (2000). In England the judge can issue a restitution order after a criminal conviction for perjury, and US judges also have some scope to do the same. Restitution has the advantage that the sanction increases with the injurer's gain, as required by a "sophisticated rule," but the problem remains that the sanction does not increase with the probability that the wrong will go unpunished.
35. An interested witness voluntarily undertakes this risk for personal gain. Why does a disinterested witness undertake this risk? Possibly a disinterested witness feels compelled to testify by law, social pressure, or a sense of civil responsibility.
36. "... the necessities of a free trial demand that witnesses are not to be deterred by fear of tort suits, and shall be immune from liability." Quotation from "Civil Remedies for Perjury," *Arizona Law Review*, 19, 349, cited favorably by Keeton et al. (1984) at p. 872. Suro and Miller (1998) offers this rationale: "It is so common for honest witnesses to remember events differently or to get confused or make mistakes that you need a law that only punishes lies that are deliberate and have real consequences," said Ephraim Margolin, a criminal defense lawyer in San Francisco. "Otherwise, every witness would be exposed to prosecution." ... "For centuries, Anglo-American courts have erected stiff hurdles against perjury prosecutions in part so that witnesses will not fear that a misstatement would expose them to prosecution."
37. Our basic assumption here is that the transaction cost of negotiating the optimal bond is lower than the court's cost of getting the necessary information to determine the optimal sanction.
38. The court could subsequently distribute the revenues from all bonds to each witness as a lump sum payment. In any case, payment to a third party creates a bargaining problem that we do not solve in this paper. To illustrate, incentives for truthful testimony requires the witness to anticipate that the other side will request the optimal bond and pay its price to the court. After the testimony is given, however, both sides can benefit from an alternative arrangement that cuts out the payment to the court. Consequently, the threat is not credible that the other side will request optimal bond and pay it to the court. Avoiding this credibility problem requires revising the truth-revealing mechanism that this paper relies on.
39. Cooter and Emons (2003).
40. A start on analyzing a related problem is found in Bernardo, Talley and Welch (2000).
41. Recall Keynes's beauty contest, a judge receives a prize for predicting the contest's winner. Truth-bonding of expert opinion situates the party offering bond much like a judge in Keynes's beauty contest.
42. Ongoing research (Emons and Fluet, forthcoming) indicates that in an adversarial system the court may find out the truth even if both witnesses lie. Yet if there is a cost of lying, everybody is better off with a truth-revealing mechanism as developed in this paper.
43. For the rapid growth of economists acting as expert witnesses see Posner (1999a), Thornton and Ward (1999), Mandel (1999) and Slotje (1999). This form of consulting is now designated "forensic economics." Several associations such as, e.g., the National Association of Forensic Economics (NAFE) as well as a couple of journals like, e.g., the *Journal of Forensic Economics* have emerged due to this boom in the demand for economists as experts.

44. Fisher (1997) at p. 578. This paper acknowledges the difficulty of a jury detecting false witness and endorses the rightness of assigning them this task.
45. Two women both claimed to be the mother of the same baby. Solomon invited the two women to a tug-of-war with the baby's body, then he proclaimed the mother to be the woman who let go first. A mechanism is "strategy proof" if a person who understands it cannot circumvent it. Solomon's mechanism is not strategy proof because the false mother who understood the mechanism refuse to tug on the baby just like the true mother.
46. Mandel (1999), Posner (1999) and Thornton and Ward (1999).
47. Aycock (1993) and Kainen (1992); "Constitutional law: collateral estoppel held inapplicable to subsequent perjury prosecution of criminal defendant," *Minnesota Law Review*, 60, 597-609.
48. "Constitutional law: collateral estoppel held inapplicable to subsequent perjury prosecution of criminal defendant," *Minnesota Law Review*, 60, 597-609; Shellenberger (1988).
49. Gordon (1980) and Underwood (1996, 1998).
50. Tiersma (1990).
51. Barnes (1994).
52. An exception is Sanchirico (2000).

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