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ABSTRACT

We develop a model where products liability trials provide information to consumers who are not parties to the litigation. Consumers use this information to take precautions against dangerous products. A critical assumption is that consumers cannot differentiate between firms that have never been sued and firms that have been sued but settled out of court. In this framework, we show that perfectly accurate courts do not maximize information to consumers and thus welfare, contrary to Kaplow and Shavell (1994). More accurate courts provide more information only if producers go to trial. Greater accuracy, however, encourages producers of dangerous products to settle and hide their type. When courts are perfectly accurate, all low quality producers settle. And given the lack of any information from trials about bad types, consumers (rationally) fail to take precautions. If consumer precautions are relatively more efficient than producer precautions, our conclusion stands even when firms can invest in improving the safety of their products.

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1 Introduction

The value of accuracy in trials seems self-evident: a more accurate trial better distinguishes between the guilty and the innocent. And the greater is the wedge between the penalty for guilt and innocence, the better is the incentive to comply with the law. This, of course, does not mean that society should have perfectly accurate courts. Greater accuracy comes with greater administrative costs. For the most part, the literature says that the appropriate welfare calculation trades off the deterrence benefit of accuracy against the cost of investing in truth-enhancing procedures (See Kaplow (1994); Kaplow and Shavell (1994); Kaplow and Shavell (1996); Posner (2007)). The Supreme Court in *Mathews v. Eldridge*[1] endorsed a similar calculation. In evaluating a due process claim, the Court held that courts should weigh the value of the property, the probability of errorneous deprivation, and the cost of additional safeguards.

In this paper, we question the value of court accuracy even if there is no cost to making courts more accurate. The context is products liability, but the analysis generalizes to other types of cases.[2] The focus is on information trials provide to consumers who do not participate in the litigation. This is a large fraction of consumers, as few ever sue producers.[3] In this setup, non-litigating consumers learn something from trial outcomes about the underlying product and update their beliefs accordingly. Consumers use this information to decide whether to take precautions. While costly, these precautions provide protection. A key assumption is that consumers have trouble distinguishing firms that have never been sued and ones that have been sued and settled. This is in part because many settlements have non-disclosure clauses and in part because settlements are less newsworthy than guilty verdicts. This allows producers to use settlement to hide

[1] 424 U.S. 319 (1976).

[2] Our analysis applies to any legal cases where outsiders rely on trial outcomes to make inferences: licensors of patented technology, employers of convicted felons, etc. Moreover, the model may be extended to any situation where individuals learn from voluntary audits of third parties, e.g., consumers learning the quality of drugs voluntarily submitted for FDA review or new consumer products voluntarily provided to product testers for review.

[3] Our model only requires that most consumers not sue producers, not that most injured consumers not sue. This is obviously true. Indeed, there is evidence that in some markets, most injured consumers do not even sue. For example in the medical malpractice context, it has been reported that only 2% of injured patients sue their doctor (Localio et al. 1991).

information about the quality of their products. Under these conditions, we show that inaccurate courts elicit more information about producers and thus improve welfare over perfectly accurate courts.[4]

The logic behind our result is fairly straighforward. Consider the case where some producers make safe products ("good types") and others make dangerous products ("bad types"). Consumers are uncertain whether specific products are safe or not. Assuming some good type and some bad type producers are sued,[5] improving accuracy has two effects. The first effect is that, conditional on a producer opting to go to trial, a more accurate court produces more information about the product. On this dimension, accuracy benefits consumers and enhances welfare. There is, however, an offsetting selection effect. The more accurate a trial is, the more reluctant bad type producers will be to go to trial. Instead the bad type will settle to mask their product quality. On this "selection" dimension, increasing accuracy reduces information to consumers and lowers welfare.

When courts are perfectly accurate, no bad type goes to trial and, as a consequence, the legal process can't identify them. In contrast, if courts are flawed, bad types will occasionally risk litigation in the hope of a mistaken exoneration that will certified their product as safer than average. But the bad types won't always be so fortunate. Even with inaccurate courts, sometimes the bad types will be found out. And so long as the bad type is more likely than the good type to be found liable, that finding will provide useful information to consumers about the appropriate precautions to take. The lesson is that, to get any information whatsoever about the bad types, courts must be willing to exonerate some of them – to tolerate mistakes.

[4]This paper relates to Malani and Laxminarayan (2011), which demonstrates that more accurate tests for detecting disease outbreaks may discourage the voluntary reporting of disease outbreaks. This paper extends that analysis by endogenizing both victim precaution and injurer investment in safety.

[5]In this paper we equate good firms with non-liable firms; firms that have met the relevant legal standard. e.g., firms that did not, say, develop a product with design defect. Continuing this example, we assume that products without a design defect can cause injury. As a result injury does not, by itself, demonstrate liability. Even under the strict liability standard for, say, a product defect injury itself does not necessarily lead to liability; the consumer still must prove causation. Given that a consumer, to start, may only know that she has suffered injury, there is likely to be suits against both good and bad type firms. We take up the issue that bad firms may be sued more often than good firms in Section 3.

The main result doesn't change if bad firms are sued more often than good firms. Because bad firms face a higher rate of suit, exoneration will not overcome the negative inference consumer associate with a firm that has been sued. Increasing accuracy – unless perfection can be achieved – is pointless because consumers suspect that every sued firm is bad. Anticipating this inference, both good and bad firms settle on the same terms and receive the same payoff. In this pooling equilibrium, additional court accuracy fails to generate gaps in the payoffs between the two types.

We next consider the case where producers of dangerous products can invest in product safety, i.e., bad types can transform themselves into good types. In this scenario, accuracy has a third effect – the production of safer products. The law and economics literature endorses accuracy primarily based on this deterrent effect. We weigh all three effects and show that, under some conditions, inaccurate courts still generate higher welfare. The conditions depend on two factors: (1) the efficiency of consumer precautions vis-a-vis producer precautions and (2) the proportion of firms that remain bad types even with perfect courts. Such a proportion is positive because for some firms the cost of complying with the legal standard is too high.

From these results we draw normative conclusions about legal procedure and find interesting connections between accuracy and other topics in law and economics. First, the more important is victim precaution relative to injurer precaution for preventing injuries, the more courts should tolerate mistaken exonerations. This suggests an analogy between the effects of accurate courts (versus inaccurate courts) and of strict liability (versus no liability), given that strict liability is beneficial when activity level shifts by injurers are relatively more efficient than activity level shifts by consumers (Posner 2007).

Second, we show that a rule that banned settlement or mandated the disclosure of settlement terms would be preferred by producers before they learned their type. Such a rule also improves social welfare. This result resembles an important finding from Shavell (1994) on the consequences of mandatory disclosure by sellers of verifiable information. Shavell shows that, before learning their type, firms would prefer mandatory disclosure over voluntary disclosure. The main distinction between the two results is that Shavell is concerned that voluntary disclosure encourages excessive acquisition of information about product quality by producers because it provides an option to hide bad information. In contrast, we are concerned that voluntary settlement discourages the dissemination of useful information through litigation.

Third, whereas mistaken exonerations (false negatives) encourage bad types to go to trial, mistaken convictions (false positives) discourage them from doing so. Criminal law demonstrates a greater tolerance for mistaken exonerations than for mistaken convictions, resting this bias on the value judgment that it is better to free ten guilty people than convict one innocent person (Blackstone 1769). We show that the same bias should be applied whenever there are informational gains to third parties from knowing which parties are bad actors.

The paper unfolds in five sections. Section 2 considers the case where producers cannot invest to improve the quality of their product. It focuses on equilibria in which bad types mix between trial and settlement and good types go to trial. Section 3 examines equilibrium when good firms are sued less often than bad firms. Section 4 expands the model to include investment. Section 5 concludes. The appendix contains proofs for each proposition in the main text.

2 The Model

Good and bad firms populate the market. The proportion of good firms is π_g; the proportion of bad firms is π_b. Products from bad firms cause harm at a higher rate than products from good firms. After accounting for the relatively low chance of injury, consumers attach a value of V to products from a good firm. They attach a value $V-\theta$ to consuming from a bad firm, where θ is the expected cost of additional injuries caused by the bad product. Without loss of generality, we set $\theta = V$ so the net value of consuming a product from a bad type is zero. Basically, good and bad types are differentiated only with respect to the probability of causing consumer injury. The value of buying the more dangerous product is zero; the value of buying the safer product is V.

The plaintiff faces a non-trivial signal extraction problem when she suffers a harm. The plaintiff does not know whether the harm was caused by the good product, the bad product, or some other source, including her own conduct. She files a lawsuit, hoping to catch the responsible party. If the firm is found not liable, the plaintiff recovers nothing. If the firm is found liable, the plaintiff recovers damages, d.

To start, suppose that bad firms and good firms are sued with the same probability s. This assumption is important. If only bad firms are sued, consumers will make a negative inference from any trial outcome, including exoneration. Trial accuracy becomes irrelevant, as will show in section 3 below.

At a cost of c, consumers can take a precaution that eliminates the possibility of additional harm from the bad product, raising the net surplus from a bad product to $V - c$. Suppose that $V > c$, so that precautions are efficient when the product comes from a bad firm.

We depart from the literature and assume settlement decisions are made in anticipation of both the expected damage award and the consequences of a verdict for future sales. Intuition suggests that bad firms might settle to avoid the negative publicity of a verdict finding liability, a verdict more likely against a bad firm. At the same time, a good firm might benefit from going to trial because the finding of no-liability certifies that the firm is better than the average firm in the market (a market that, remember, is populated by both good and bad firms). The equilibrium described below confirms that this is indeed true.

The court makes errors, which come in two flavors. The court might mistakenly exonerate a bad firm or the court might mistakenly convict a good firm. Formally, let these errors be represented as

$$
\begin{aligned}
1 - a_1 &= \Pr\{\text{bad type found not liable}\} \\
1 - a_2 &= \Pr\{\text{good type found liable}\}
\end{aligned}
$$

The type I error (the false positive or mistaken exoneration) is $1 - a_1$; the type II error (the false negative or mistaken conviction) is $1 - a_2$. As a_1 or a_2 increase, the court becomes more accurate. We assume trials are minimally informative, so $a_1 > \frac{1}{2}$ and $a_2 > \frac{1}{2}$.

We assume consumers know not only V, c and d, but also the rate of suit s and the level of court accuracy, a_1 and a_2. To focus on the information value of trials, suppose that firms cannot signal their type in the absence of suit. This means we ignore warranties and the use of other third party monitors. The restriction on third party monitors is not a severe one since our analysis of the value of accuracy in trials can be extended to the value of accuracy of any third party monitors. We also assume that firms cannot "volunteer" for suit and increase s.

Finally, trials are costless for firms and can be made more accurate at zero cost. The deck is thus stacked in favor of a system of perfectly accurate courts because we assume away the the usual reasons given for tolerating judicial mistakes.

A. Consumer Purchases

Consumers make purchasing decisions based on the results of the trial process and the equilibrium strategies of the firms. Consumers receive one of three signals: a court finding of "no liability", a court finding of "liability", or no finding whatsoever. Let τ be the consumer's belief the firm is bad if he observes a court finding of "not liable"; let λ be the consumer's belief the firm is bad if he observes a court finding of "liable"; and let μ be the consumer's belief that a firm is a bad type if he observes no trial finding at all.

Consumer beliefs determine what price they are willing to pay for the product and whether they take precautions. If consumers do not take precautions, they obtain the expected value of the good, given their beliefs about firm type. This value is just the consumer's belief that the firm is a good type times V. If consumers take precautions, they get $V - c > 0$ whether the firm turns out to be good or bad. Precautions are well spent if the firm is a bad type, but wasted if the firm is a good type.[6] Consumers will take precautions if

$$V - c > (1 - \beta) V \text{ or } c \leq \beta V$$

where $\beta \in \{\tau, \lambda, \mu\}$ is the consumer's posterior belief that the firm is a bad type.

Firms make take-it-or-leave-it offers that extract all the consumer surplus. The

[6] In the precaution case, the price following a unfavorable verdict is constant at $V - c$. This simplification eases the notation. If consumer precautions resulted in say $V - \lambda c$ instead of V after a negative verdict, price would fall as the consumer's beliefs become more pessimistic. However, our results would not change. Although there is a constant price following an unfavorable verdict, the welfare effects of consumer precautions depend on the precision of the beliefs. More specifically, as the precision of the beliefs following an unfavorable verdict increase, the chance of consumers misfiring – spending resources on precautions when the firm is, in fact, a good type – goes down.

price firms charge anticipates the precaution taken by the consumer. If it is in the consumer's interest to take a precautions in a particular state of the world, the firm charges $V - c$. If it is not in the consumer's interest to take a precaution in a specific state of the world, the firm charges $(1-\beta)V$, where again $\beta \in \{\tau, \lambda, \mu\}$. Combining the firm's take it or leave it offer with the consumer's rational deployment of precautions, prices for future sales can be written as:

$$\begin{aligned} P^{NL} &= \max\{V - c, (1-\tau)V\} = V - \min\{c, \tau V\} \\ P^{M} &= \max\{V - c, (1-\mu)V\} = V - \min\{c, \mu V\} \\ P^{L} &= \max\{V - c, (1-\lambda)V\} = V - \min\{c, \lambda V\} \end{aligned}$$

P^{NL} is the price following a court finding of "no liability"; P^{L} is the price following a court finding of "liability"; and P^{M} is the price following no court finding, what we term the market price.

B. Settlement

The defendant makes a take it or leave it settlement offer to the plaintiff.[7] The settlement offer will be lowest one that the plaintiff will accept. As will be demonstrated below, only bad firms settle in equilibrium. Since the simple act of engaging in settlement talks perfectly reveals that a firm is bad, the lowest offer the plaintiff will accept is $a_1 d$ – the plaintiff's expected value from taking the bad type to trial.

A central assumption we make is that, while consumers know the rate of suit s, consumers cannot observe whether a specific firm was sued. Thus the consumer cannot distinguish between a firm that was not sued and one that was sued and settled. To make this assumption robust, we also assume that consumers cannot observe whether firms engage in settlement talks.

Finally, we assume that litigation is costless so that settlement is driven by its effect on consumer beliefs about type, and thus prices, rather than by litigation costs. This assumption will also allow us to ignore the cost savings from litigation in welfare calculations. We do not deny there are in fact savings from settlement

[7] The results carry over if the plaintiff rather than the defendant makes the settlement offer. The difference is that the gains to the bad type from hiding its type via settlement flow to the plaintiff rather than the defendant.

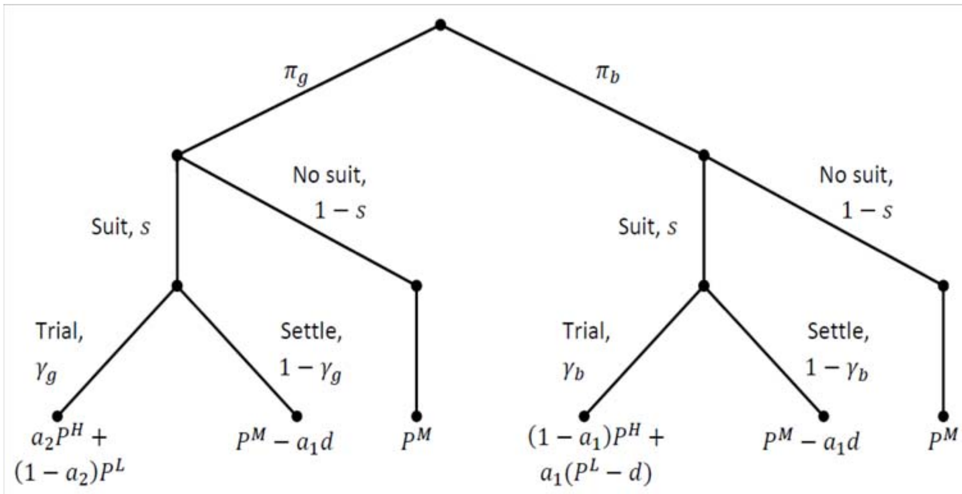

Figure 1: Settlement game without investment

in the real world. However, those savings are unrelated to our inquiry into the information value of court accuracy.

C. Timing and Equilibrium Definition

Putting all this together, the timing of the game is as follows:

1. Nature selects the initial distribution of types.
2. Firms are sued with probability, s
3. Firms decide whether to settle and, if so, make the plaintiff an offer.
4. Firms make consumers a take it or leave it offer depending on the signal received from trial or no signal at all.
5. Consumer decide how much to pay for the product and whether to take precautions.

Figure 1 illustrates the extensive form game.

Let γ_g and γ_b be the probabilities that good and bad firms, respectively, go to trial rather than settle. A perfect Bayesian equilibrium consists of a set of consumer beliefs β and a strategy profile, $\{\gamma_b, \gamma_g\}$ such that:

(a) no firm type can deviate given the consistent consumer beliefs and the equilibrium strategy of the other firm type and

(b) where possible, beliefs are derived using Bayes rule from the equilibrium strategies and the error rate in the courts.

Before analyzing the equilibria and doing the comparative statics, we make the following assumption about the cost of precautions.

(A1) $c > (2\pi_b - \pi_b^2)\,V$

This assumption has two implications. First, it ensures that consumers take precautions, if at all, only after observing a finding of liability. That is, there exist a sufficiently large number of good types in the initial pool that consumer precautions are not cost-justified absent some additional evidence about the dangerousness of the product.[8] Second, the assumption ensures that a higher probability of finding the bad type liable does not increases the bad type's return from going to trial.

It should be acknowledged that assumption (A1) is actually stricter than what is required to obtain the above two implications. It has the virtue, however, of generating both implications at once and being couched in primitives of the model. Assumptions that separately and more directly capture the two implications would have to be written as conditions on consumer beliefs, which in turn would depend on which specific equilibrium holds.

2.1 Equilibria and Comparative Statics

In comparing perfect and imperfect courts, the first task is to identify the equilibria in each situation. The next proposition presents the equilibrium with perfect courts. Following that, attention turns to courts that make errors.

[8] If consumers took precautions even without a signal from the courts, bad types would prefer trial to settlement. At trial, the bad firm might be mistakenly exonerated, obtaining the higher payoff associated with the no liability finding. At the same time, the bad firm receives $V - c$ whether it settles the case and cloak itself with the market or goes to court and is found liable. These two effects combine to make trial the best course of action for the bad type. While they exist, equilibria where the bad type goes to trial for sure are not that interesting.

Proposition 1 *With perfect courts, there always exists a separating equilibrium where good firms go to trial and bad firms do not. Formally, we have* $(\gamma_g = 1, \gamma_b = 0)$ *and* $(\tau = 0, \lambda = 1, \mu = \pi_b / [\pi_b + (1 - \pi_b)(1 - s)])$.

Proposition (1) provides a benchmark. When courts are perfect, good types always go to trial because they are guaranteed to be found not liable and can therefore charge a price V. On the other hand, bad types don't go to trial because trial guarantees a liability finding, meaning they can charge a price $V - c$. By settling, the bad type instead cloaks itself among the good firms that have not been sued, meaning they can charge the market price of $(V - \mu V)$, where A1 guarantees that $c > \mu V$.

The fact that not every good type is sued plays a critical role. To see why, suppose not. Every good firm would get sued; all would go to trial and be found not liable. The consumers would then infer from the absence of a trial outcome that the firm must be bad. In short, without this constraint, the market unravels and all the private information is revealed.

Turning now to inaccurate courts, a semi-separating equilibrium exists in which the good type goes to trial and the bad type randomizes between settling and going to trial.[9] For bad types to mix, they must be indifferent between going to trial and settlment. Given the error rates in the courts, expected prices, and the settlement offer, this indifference condition can be written as

$$(1 - a_1)P^{NL} + a_1[P^L - d] = P^M - a_1 d \tag{1}$$

The LHS of equation (1) is the bad firm's payoff to trial. The firm reaps a return on future sales of P^{NL} when found not liable and a return on future sales of P^L when found liable. In addition, the liability finding triggers the demand payment d. The RHS is the bad type's return from settling the case. Settlement leads to future sales at the market price, but requires a settlement payment of $a_1 d$. The next proposition characterizes the semi-separating equilibrium.

Proposition 2 *If courts are imperfect and assumption (A1) is satisfied, there*

[9] For other models of litigation where bad types randomize and good types go to trial, see Baker & Mezzetti (2001) and Wickelgren and Friedman (2010).

exists a semi-separating equilibrium where good firms always goes to trial and bad firms randomize between going to trial and settlement. Formally, for any $(a_1, a_2) \in \Theta = (1/2, 1) \times (1/2, 1)$*, we have* $\left(\gamma_g = 1, \gamma_b = \gamma_b^*\right)$ *and*

$$\tau = \frac{\pi_b \gamma_b^* (1 - a_1)}{\pi_b \gamma_b^* (1 - a_1) + \pi_g a_2} \qquad \lambda = \frac{\pi_b \gamma_b^* a_1}{\pi_b \gamma_b^* a_1 + \pi_g (1 - a_2)}$$

$$\mu = \frac{\pi_b (1 - s\gamma_b^*)}{\pi_b (1 - s\gamma_b^*) + \pi_g (1 - s)}$$

where γ_b^* *is the solution to equation (1).*

The upside to trial for the bad type is that they may incorrectly obtain a verdict of no liability. This signal increases the firm's revenue because consumers incorrectly infer the firm is a good type when it is, in fact, bad. The downside to trial is that the bad type may receive a liability finding and revenues might decline. Bad types randomize for a chance at the upside. Bad types do not go to trial for sure because the price bump from being found not liable decreases as more bad types go to trial. As bad types comprise a higher fraction of the trial pool, consumers have more pessimistic view of product quality after any verdict and thus pay a lower price. Eventually the revenue boost from a "not liable" finding fails to offset the downside risk of a liability verdict.

Since there is a semi-separating equilibrium for each value of a_1 and a_2, it is possible to explore how improving accuracy affects the probability bad types go to trial. When doing so, there are two scenarios to consider. One is where consumers take precautions following a liability finding and the other where consumers do not take precautions following a liability finding. In equilibrium, consumers take precautions when the beliefs that liability signals a bad type is so strong that precautions become cost-justified (i.e., $c < \lambda(a_1, a_2, \gamma_b^*)V$).

Proposition 3 *(A) Suppose consumers take precautions after a liability finding. In any semi-separating equilibrium of Proposition 2, the probability that bad firms go to trial (i) increases as mistaken exonerations* $(1 - a_1)$ *rise and (ii) decreases as mistaken convictions rise* $(1 - a_2)$*.*

(B) Suppose consumers do not take precautions after a finding of liability. In any semi-separating equilibrium of Proposition 2, the probability that bad firms go

to trial (i) increases as mistaken exonerations $(1 - a_1)$ *rise and (ii) may increase or decreases as mistaken convictions* $(1 - a_2)$ *rise.*

The intuition for the case where consumers take precautions after a liability finding follows: Raising a_1, the probability that court finds a bad type liable, has two competing effects. The first effect is to reduce the fraction of bad types among those who are found not liable, making consumers more confident that exoneration means that the firm is good. The resulting increase in the price following a finding of no liability induces bad types to go to trial. The second effect is to reduce the probability that bad types will accidentally receive the no-liability signal and thus fetch the higher price associated with exoneration. This encourages bad types to go to trial. Assumption (A1) ensures the second effect more offsets the first.[10] As a result, increasing a_1 discourages bad types from going to trial.

In contrast, raising a_2, the probability that a good type receives a finding of no liability, makes the consumer more confident that the no-liability finding tracks good types and the liability finding tracks bad types. The resulting increase in the price paid after a no-liability finding raises the payoff to a bad type from an mistaken exoneration. Because consumers take precautions following a liability finding, the payoff from conviction, however, remains constant at $V - c$. Thus reducing mistaken convictions of good types encourages bad types to go to court.

The intuition for the case where consumers do not take precautions after a liability finding differs only with respect to the effect of mistaken convictions. In this case, reducing mistaken convictions increases the price following a no-liability finding and *decreases* the price following a liability finding. Whether a greater number of bad types go to trial depends on which effect is larger. Appropriately discounted by the chance the bad type receives each price, if the bump up in the no-liability price exceeds the bump down in the liability price, reducing mistaken convictions draws bad firms into court. Otherwise, reducing mistaken convictions drives bad firms away from court.

[10] Indeed, it would be somewhat perverse if increasing the probability of conviction benefitted bad types.

2.2 Welfare

As noted in the introduction, the existing literature suggests the optimal amount of trial accuracy balances the benefit of more accurate adjudication against the financial and administrative cost of procedures that improve the accuracy of trials. Because of those costs, scholars suggest that perfectly accurate courts are suboptimal. In our model, the cost to improving procedure is zero. Nevertheless we find that perfectly accurate courts are suboptimal.

Proposition 4 *(A) If consumers take precautions after a liability finding, the welfare associated with courts that mistakenly exonerate bad types is higher than the welfare associated with courts that are perfect. Lowering mistaken convictions, however, improves welfare from imperfect courts. (B) If consumers do not take precautions after a liability finding, accuracy has no impact on welfare.*

The reason for the new welfare result is the positive externality associated with trials. Getting bad types to go to trial reveals their type to consumers, albeit imperfectly. If consumers take precautions after a liability finding, even imperfect revelation facilitates welfare-enhancing deployment of precautions. But getting bad types into trial requires the prospect of mistaken exoneration.

Of course, with inaccurate courts, precautions misfire when good types are mistakenly found liable. Such misfires waste precautions. One might suspect that the potential for wasted precautions could mean the inaccurate courts reduce welfare. Not so. The reason is that consumers only take precautions when their expected value is positive after accounting for this misfiring.

In contrast to mistaken exonerations, mistaken convictions reduce welfare. To see this, note that expected welfare with inaccurate trials is

$$W = \pi_g V + \pi_b s \gamma_b a_1 [V - c] - \pi_g s (1 - a_2) c \tag{2}$$

The first term is the welfare from consuming good products, the second term is the welfare from consuming products from bad firms that are found liable, and third term is the welfare loss from misfiring precautions at good firms that are mistakenly convicted. A reduction in mistaken convictions – an increase in a_2 – reduces the last term. An increase in a_2 also increases the second term in the welfare equation because it increases the proportion of bad types going to trial according to Proposition 3. Together, these two effects imply that reducing mistaken convictions always increases welfare. And so, the optimal amount of mistaken convictions is zero.

Philosophers, politicians and legal scholars have long suggested that greater effort be devoted to preventing mistaken convictions than to preventing mistaken exonerations in criminal trials. Proposition 4 demonstrates that this principle applies not just to criminal law but to any area of law. The justification for asymmetric treatment need not rely on arguments about the "wrongfulness" of imposing an undeserved punishment. Instead, the justification can be that asymmetric treatment induces bad people to select trial. This self-selection in turn provides more information to third parties.

The aforementioned welfare results only apply when consumers take precaution after a liability. If consumers do not take precautions, then welfare is the same for perfect and imperfect courts. There is no way to salvage the value of products sold by bad types. Nor is any precaution wasted on good types. Thus, accuracy has no value.

The welfare analysis thus far suggests that inaccurate courts are superior to perfect courts. The next obvious question is whether inaccurate courts are the best we can do. No. The best policy couples perfect courts with a prohibition on settlement. When settlement is prohibited, both good and bad types go to trial. With perfect courts, trials perfectly signal types and thereby perfectly allocate precautions. Because firms appropriate all the surplus in our model, we can demonstrate the superiority of perfect courts with a settlement restriction by showing that firms would prefer to ban settlement before learning their type. The next proposition states that this is, in fact, the case.

Proposition 5 *Before learning their type, firms prefer a rule that prohibits settlement.*

If a ban on settlement improves firm welfare, why do some firms settle? The problem is the firms cannot commit to forgo settlement after they learn their type. The lack of commitment power is what creates the welfare loss from perfect courts. Of course, settlement has advantages; it reduces risk and saves on litigation costs. But this model suggests a reason for making settlement more difficult by, for example, requiring judicial approval of all settlement decisions, especially when consumer precautions are relatively important.

3 What if Bad Firms are Sued More Often?

Suppose the plaintiff can conduct an investigation about which firms are good and which firms are bad prior to suit. All else equal, plaintiffs prefer to sue bad firms. Such an investigation would thus lead to a higher rate of suits against bad types. Let the probability of suit against a bad firm be αs and the probability of suit against a good firm be $(1-\alpha)s$ where $\alpha \in (\frac{1}{2}, 1]$.

If courts are perfect, there continues to exist the separating equilibrium described in Proposition 1. Bad types always want to settle because they will always be found liable at trial. If courts are imperfect and the fraction of bad types sued is low enough, there exist a semiseparating equilibrium that is similar to that described in Proposition 2. However, if the fraction of bad types being sued get high enough, we find the surprising result that the quality inference conveyed to consumers by a no liability finding is weak. In fact, a firm's payoff from a finding of no liability might be worse than the payoff from no signal at all, whatever the firm's type. If that transpires, both types of firm will want to settle. To get there, both types make the same "pooling" settlement offer. Given the plaintiff's consistent beliefs, this pooling offer makes the plaintiff just indifferent between accepting the offer and not. This result is described in the next proposition.

Proposition 6 *Define*

$$\overline{\alpha} = \frac{\pi_g a_2 c}{\pi_g a_2 c + \pi_b (1-a_1)[V-c]}$$

If courts are imperfect, $\alpha > \bar{\alpha}$, and damages are sufficiently small, then there exists a pooling equilibrium where both bad and good type settle. Formally, for any $(a_1, a_2) \in \Theta = (1/2, 1) \times (1/2, 1)$, we have $\left(\gamma_g = 0, \gamma_b = 0\right)$ and

$$\tau = \frac{\pi_b \alpha (1-a_1)}{\pi_b \alpha (1-a_1) + \pi_g (1-\alpha) a_2} \qquad \lambda = \frac{\pi_b \alpha a_1}{\pi_b \alpha a_1 + \pi_g (1-\alpha)(1-a_2)}$$

$$\mu = \pi_b$$

For the pooling equilibrium, we must set $\underline{\alpha}$ so that, given the level of court errors, the consumer is pessimistic enough to take precautions following a finding of no liability. The more accurate the court is, the higher this threshold and the greater α must be to induce precautions even after a positive trial outcome. Furthermore, the good type will have to pay more to settle the case than what they anticipate paying the plaintiff at trial. The reason is that to get the plaintiff to accept the offer, the good type must pool with the bad type, paying an amount of money that reflects the average value of the case, not the value of a case against the good type.[11] The good type makes this sacrifice to preserve the large bump in future sales from hiding that a lawsuit had ever been filed.

In this equilibrium, the payoffs to the good and bad type are the same after being sued. That said, the chance of being sued differs. And with suit comes the required settlement payment to the plaintiff. So the payoffs for good and bad types do diverge, but not because they face different payouts in litigation but rather because the chance of having a suit filed differs. The normal way scholars think that accruacy benefits society is by changing the payoffs to good and bad types in litigation. Assuming the threshold on α is met, Proposition (4) suggests that additional expenditures on accuracy will not have this effect.

One final interesting feature of the pooling equilibrium is that the incentive for the plaintiff to find a bad type is self-limiting. Since all firms settle when α exceeds $\bar{\alpha}$, the plaintiff receives the same benefit whether he sues a good firm or a bad firm, meaning the returns on further investigation to raise α are low. That said, if bad firms trigger more accidents than good firms, it might be plausibly argued that a plaintiff suing randomly will find more bad types than good types, i.e., that α will exceed $\bar{\alpha}$ even without investigation.

[11] Given that the defendant makes the offer, there does not exist an equilibium where the bad type pays a higher settlement amount than the good type. To see this, suppose not. If the offers separate by types, the bad type will always want to deviate, mimic the good type's lower settlement offer and still settle the case.

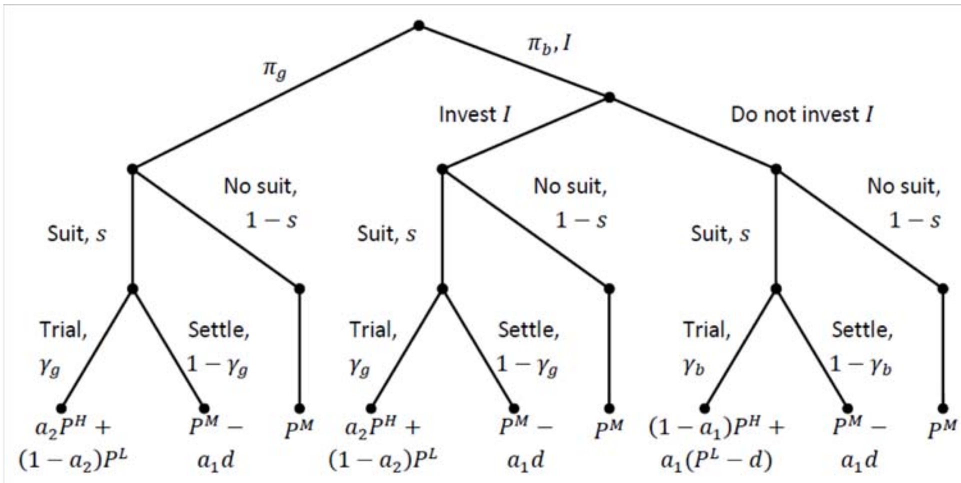

Figure 2: Settlement game with investment

4 Producer Investment

Until now we have assumed that firms are either good or bad and can do nothing to change that fact. This section allows bad firms to invest in quality and transform themselves into good types. To simplify matters, we revive the assumption that bad firms and good firms are sued with the same probability. Because accuracy affects welfare only if consumers take precautions, we focus on this in what follows.

Formally, suppose there still are π_g good types and π_b bad types. However, bad types can now invest I and become a good type. The cost of investment varies across bad firms, ranging from 0 to ∞. This cost is distributed according to $F(I)$. Intuitively, $F(I)$ is the fraction of bad firms that invest in a safer, higher quality product. Figure 2 illustrates the timing of the game with investment.

Our benchmark remains a perfect court. Proposition $1'$ in the appendix shows that there still exists a separating equilibrium in which only good types go to trial and the bad types settle. The payoff to a bad type that invests in quality and becomes a good type is

$$sV + (1-s)(1-\mu)V - I \tag{3}$$

where s is the probability of being sued and μ is the posterior following no signal. If the bad firm that transforms into a good firm is sued in a perfect court, it will be found not liable and obtain price V. If the transformed firm is not sued, they get the market price of $(1-\mu)V$. The third term is the cost of investment. The payoff to remaining a bad type is

$$s[(1-\mu)V-d]+(1-s)(1-\mu)V \tag{4}$$

Following suit in a perfect court, the bad type immediately settles for $-d$ and gets the market price for future sales. If the bad type is not sued, they also get the market price. The level of investment at which the bad firm is indifferent between investing and not is obtained by setting (3) equal to (4) and solving for I:

$$s[\mu V+d]=I \tag{5}$$

The left hand side of (5) is the benefit to a bad type of investing in quality with perfect courts; the right hand side is the cost. The benefit has two components: (1) if sued in a perfect court, the bad firm makes more money off future sales (V instead of $(1-\mu)V$); (2) if sued, the bad firm no longer pays damages, d.

Define $I^{*\text{Perfect}}$ as this solution to equation (5). If $F(I^{*\text{Perfect}})=1$, all bad firms invest and there are no bad firms left in the market. If $F(I^{*\text{Perfect}})=0$, none of the bad firms invest and we have the situation from before, with π_b bad firms and π_g good firms. Given this, define the fraction of good firms in the market as $\overline{\pi}_g=\pi_g+F(I^{*\text{Perfect}})\pi_b$. Note that, because a bad firm might draw a high investment cost, perfect courts do not induce every bad firm to invest in higher quality. The next lemma is a formal statement of this argument.

Lemma 7 *With perfect courts, not all bad firms invest to become good types. That is,* $0<I^{*Perfect}<\infty$.

Now consider imperfect courts. Proposition 2′ in the appendix demonstrates that, under assumption (A1), there continues to be a semi-separating equilibrium in which the good type always goes to trial and the bad type mixes. In this equilibrium, the bad type's payoff to becoming a good type is

$$s[a_2P^{NL}+(1-a_2)\left(P^L-d\right)]+(1-s)P^M-I \tag{6}$$

As before, the first term is the payoff when a bad firm invests in quality faces suit and goes to trial. The second term is the payoff from not being sued. The third term is the cost. The bad type's payoff from remaining a bad type is

$$s[a_1(P^{NL} - d) + (1 - a_1)P^{NL}] + (1 - s)P^M \tag{7}$$

The term in the square bracket is the payoff to the bad type from going to trial. The second term is the bad firm's payoff from not being sued. The level of investment at which the bad firm is indifferent between investing and not is obtained by setting (6) equal to (7)

$$s(a_1 + a_2 - 1)[P^{NL} - P^L + d] = I \tag{8}$$

The left hand side is the price premium associated with being a good type. The right hand side is the cost. Let I^* be the investment level for the indifferent firm. The fraction of good firms is $\overline{\pi}_g = \pi_g + F(I^*)\pi_b$, where $F(I^*)$ is the cumulative probability that investment cost is less than I^*.

Two equations jointly determine investment and the remaining bad types mixing probability in the semi-separating equilibrium. First, there is equation (8), which pins down the realization of investment cost that makes the bad firm indifferent between investing and not. Second, there is equation (1) which ensures that, given the prices associated with Bayes consistent updating by the consumers, the bad type is indifferent between trial and settlement. In equilibrium, both the indifference conditions for investment and bad type mixing must hold.

As noted, the main result from the law and economics literature is that, because accuracy increases the gap between the payoff to good and bad behavior, it deters undesirable actions (Kaplow 1994; Kaplow and Shavell 1994). Under certain stability conditions, our model yields the same result with respect to reductions in mistaken exonerations $(1 - a_1)$. The deterrence implications of reducing mistaken convictions $(1 - a_2)$, however, are uncertain.

Before formally stating these results, we present the two stability conditions:

(A2) $s[a_1 + a_2 - 1]\left(\frac{\partial \tau}{\partial I}\right) V < 1$

(A3) $|(1 - a_1)\frac{\partial \tau}{\partial I}| > |\frac{\partial \mu}{\partial I}|$

The first condition requires that an increase in investment not increase the net benefit to investment (that is, equation 6 is decreasing in I). The second condition requires that additional investment increases the net benefit to going to trial to bad firms. Together they ensure that imperfect courts yield less investment than perfect courts ($I^* < I^{*\text{Perfect}}$) and that the bad type mixes.

Proposition 8 *If consumers take precautions after a liability finding and assumptions (A1)-(A3) hold, then (i) an increase in a_1 increases deterrence (that is, $\frac{\partial I^*}{\partial a_1} > 0$) and (ii) an increase in a_2 has an ambiguous effect on deterrence (that is, $\frac{\partial I^*}{\partial a_1} > 0$ or $\frac{\partial I^*}{\partial a_2} < 0$).*

If one reduces mistaken exonerations, fewer bad types submit to trial because they are less likely to receive a favorable verdict. This causes a decrease in the price when consumers observe no signal. After all, this price is based on the pool of firms who do not receive a trial outcome, whether they were not sued or settled. To maintain the bad type's indifference between the settling and going to trial when the payoff to settling falls, the expected payoff from going to trial must also fall. Thus, reducing mistaken exonerations reduces the payoff to being a bad type whether they settle or go to trial. As a result, the gap between the payoff to the good and bad types increases. Since this gap determines the return on investing in quality, investment rises.

Eliminating mistaken convictions does not necessarily have a similar, salutary effect. Under the same logic as Proposition 3, reducing mistaken convictions increases the proportion of bad types going to trial. As there are fewer bad types in the pool of firms who do not obtain a trial verdict, the market price increases. As a result, the payoff to being a bad type increases. At the same time, the payoff to being a good type also increases because – by reducing mistaken convictions – good types are more likely to receive a positive verdict. Since the payoffs to both types increase, the impact of a change in mistaken convictions on the gap between the two is uncertain.

With these comparative statics in hand, our attention turns to welfare. Welfare now depends on (1) whether consumers invest in precautions when purchasing from a bad type and (2) how many firms invest in quality. Perfect courts yield a higher amount of investment by firms but no precautions by consumers. Some

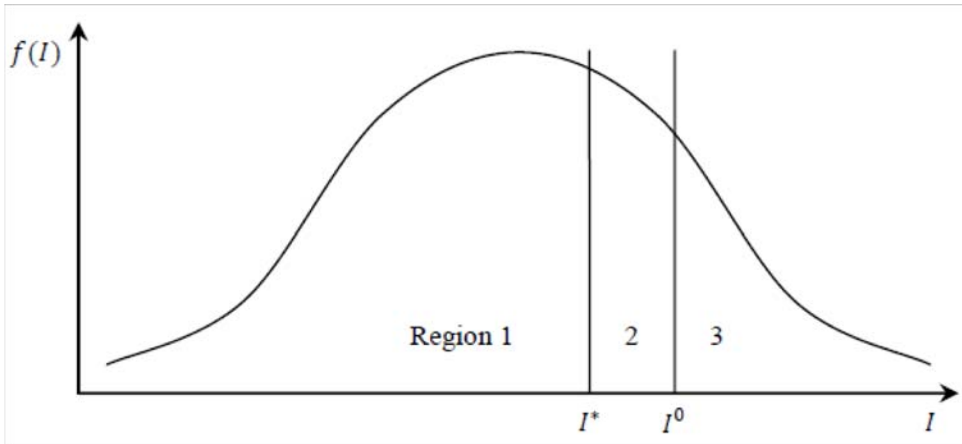

Figure 3: Distribution of Investment Costs Among Firms

degree of inaccuracy diminishes the amount of investment by firms but facilitates greater consumer precaution. Which is better? It turns out that whether court inaccuracy improves welfare depends on two factors: (1) the effectiveness of consumer precautions compared to producer investment and (2) the fraction of firms that fail to invest in quality with perfect courts. The next proposition lays out the formal statement of this result.

Proposition 9 *Consider a court with errors $a_1 < 1, a_2 = 1$, and a semi-separating equilibrium where bad types invest if $I < I^*$ and non-investing bad types mix with probability γ^*. When consumers take precautions, the welfare associated with this equilibrium exceeds the welfare associated with perfect courts whenever*

$$\left[\left(1 - F\left(I^0\right)\right)\pi_b\right] s\gamma^* a_1 (V - c) >$$

$$\int_{I^*}^{I^{*\ Perfect}} (\pi_b V - t) f(t)\, dt - [F\left(I^{*\ Perfect}\right) - F(I^*)] s\gamma^* a_1 \pi_b (V - c)$$

To understand the condition under which imperfect courts improve welfare, look at Figure 3, which plots the distribution of investment costs I. We split the possible values of I into three regions. The first region is investment costs less than I^*, which is the investment level associated with the imperfect court . If the firm draws a cost in this region, it invests in quality whether the court is perfect or not. The welfare implications of perfect and imperfect courts are the same over this region.

The second region is between I^* and $I^{*\text{Perfect}}$, which is the investment level associated with perfect courts. Here accuracy matters. With perfectly accurate courts, the firm makes the investment. The expected value of this investment is $\int_{I^*}^{I^{*\text{Perfect}}} (\pi_b V - t) f(t)\, dt$. With imperfect courts, the firm does not make the investment, and remains a bad type. Yet all is not lost. Given imperfect courts, some fraction of these bad types are sued and go to trial, which facilitates the deployment of consumer precautions. The expected value of consumer precautions over this range is $[F(I^{*\text{Perfect}}) - F(I^*)] s\gamma^* a_1 \pi_b (V - c)$. The "net" benefit of perfect courts over this range is the difference between the expected value of producer investment and the expected value of consumer precautions, discounting this latter value by the probability they are deployed.

Finally, there is the range of investments above $I^{*\text{Perfect}}$. If a firm draws an investment cost in this region, it never makes the investment. Welfare is thus zero with perfect courts. But imperfect courts can still trigger consumer precautions, with welfare benefits equal to $(1 - F(I^{*\text{Perfect}}))\pi_b s\gamma^* a_1 (V - c)$ when bad types are sued and go to trial. If the welfare gains over region 3 exceed the welfare gains from perfect courts over region 2, imperfect courts increase welfare.

The two factors discussed above determine whether this inequality holds. Region 3 is the fraction of firms that fail to invest with perfect courts. The lower is optimal investment with perfect courts, the higher the gains from imperfect courts because this region is larger. Moreover, the gains from imperfect courts over this region hinge on $(V - c)$: the bigger the gains from consumer precautions, the greater the value of imperfect courts. Finally, the "net" benefit over region 2 depends on the relative efficiency of producer investments in quality and consumers investments in quality: the more efficient consumers are relative to producers, the smaller is the net benefit from perfect courts in this range.

5 Conclusion

This paper contributes to the literature on trial accuracy, focusing on the information benefits to outsiders to the litigation. To improve welfare, we want bad firms to go to trial, and, conditional on trial, the result to be accurate. This paper shows these two objectives necessarily conflict. And this conflict implies that judicial errors do not necessarily reduce welfare, especially when it is more important to identify which firms are bad than which firms are good. The results do not imply that wholly uninformative courts are ideal. Rather, they suggest that some degree of imperfection should be tolerated in order to induce some bad firms to go to trial. This recommendation holds true even if there is no cost to making courts more accurate. Moreover the imperfection should be of a particular type: mistaken exonerations induce firms to go to trial but mistaken convictions do not. In other words, if the null hypothesis is that a firm is a bad type, then welfare is maximized by tolerating some Type I error but no Type II error. When consumer precautions are relatively cheap compared to producer precautions, this is true, even when firms have the ability to make investments to change their type and improve their quality.

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6 Appendix

Proof of Proposition 1. Given perfect courts and the equilibrium strategies, consumers' consistent beliefs are

$$\tau = 0 \quad \lambda = 1 \quad \mu = \frac{\pi_b}{\pi_b + (1 - \pi_b)(1 - s)}$$

For a good type, the expected payoff from going to trial is V. The payoff from deviating is $V - \min\{c, \mu V\} - d$, which is less. For a bad type the payoff from settling is $V - \min\{c, \mu V\} - d$. The payoff from going to trial is $V - c - d$, since $\lambda = 1$ and $c < V$ by assumption. The payoff from trial is strictly lower if $c > \mu V$, which follows since A1 implies that $c > \pi_b V$ and $\mu < \pi_b$. ■

Proof of Proposition 2. We will use the following facts and derivatives in this proof.

Fact 1. *(A1) implies $c > \mu V$ for all values of γ_b in Proposition 2.* **Proof**. *If $\gamma_b = 1$, then $\mu = \pi_b$. Moreover, $\frac{d\mu}{d\gamma_b} = -\mu(1 - \mu)\frac{s}{1 - s\gamma_b} < 0$, so μ takes on its* *largest value at $\gamma_b = 1$.Finally, as noted in the proof of proposition 1, (A1) which states that $c > (2\pi_b - \pi_b^2)\,V$ implies that $c > \pi_b$.*

Fact 2. *$\mu > \tau$ in the candidate equilibrium for Proposition 2, in which the bad types mix and the good types go to trial.* **Proof**. *If this were not true, then the bad type's payoff to settling would exceed its payoff to even a finding of non-liability. And so, the bad type would strictly prefer settlement, a contradiction.*

Fact 3. *$\lambda > \tau$ for all $(a_1, a_2) \in \Theta$.* **Proof**. *If a court is informative, consumers must believe that a liability finding indicates a higher probability that the firm is a bad type. Using the the consistent beliefs in the candidate equilibrium for Proposition 2, this can be easily confirmed.*

Fact 4. *(A1) implies $\pi_b/[\pi_b + 2(1-\pi_b)a_2] > \pi_b^2$* for $a_2 \in [1/2, 1]$. **Proof**. *The inequality can be written $1 > \pi_b^2 + 2a_2\pi_b - 2a_2\pi_b^2$* or

$$w(a_2) = (2a_2 - 1)\pi_b^2 - 2a_2\pi_b + 1$$

At $a_2 = 1$, this value is $w(1) = (\pi_b - 1)^2 > 0$. At $a_2 = \frac{1}{2}$, we have $-\pi_b + 1 > 0$. Finally, $w'(a_2) = 2\pi_b^2 - 2\pi_b < 0$. So $w(a_2) > 0$ in the relevant range of a_2.

Useful derivatives.

$$\frac{\partial\tau}{\partial\gamma} = \frac{\tau\,(1-\tau)}{\gamma_b} > 0 \quad \frac{\partial\tau}{\partial a_1} = -\frac{\tau(1-\tau)}{1-a_1} < 0 \quad \frac{\partial\tau}{\partial a_2} = -\frac{\tau(1-\tau)}{a_2} < 0$$

$$\frac{d\lambda}{d\gamma} = \frac{\lambda\,(1-\lambda)}{\gamma_b} > 0 \quad \frac{d\lambda}{da_1} = \frac{\lambda\,(1-\lambda)}{a_1} > 0 \quad \frac{d\lambda}{da_2} = \frac{\lambda\,(1-\lambda)}{1-a_2} > 0$$

$$\frac{d\mu}{d\gamma} = -\mu\,(1-\mu)\,\frac{s}{1-s\gamma_b} < 0$$

Turning to *Proposition 2,* consider the candidate equilibrium where good types always goes to trial and the bad type mixes with probability γ_b. To prove this is an equilibrium requires: (1) Bayes consistent beliefs by the consumers and (2) bad type indifference at the prices associated with those beliefs; and (3) that the good type prefers trial at the prices associated with those beliefs. Because bad types are more likely to be found liable than good types, if the bad type is indifferent between trial and settlement, the good type will prefer trial. Thus, we can prove the proposition simply by showing that, for every a_1 and a_2, there exists a value of $\gamma_b \in (0,1)$ which induces – via Bayes consistent beliefs – prices such that the bad type is indifferent.

Plugging prices into equation (1) and rearranging, we can write the indifference condition as a function of the posteriors, which are themselves functions of a_1, a_2 and γ_b:

$$t(\gamma_b, a_1, a_2) = \min\{c, \mu V\} - a_1 \min\{c, \lambda V\} - (1 - a_1)\min\{c, \tau V\} = 0$$

Note that in equation (1) damages for the bad type after a liability finding equal the settlement offer, so those damages and the settlement offer cancel out. Facts 1 and 2 mean that we can replace $\min\{c, \mu V\}$ with μV and $\min\{c, \tau V\}$ with τV, respectively. Thus

$$t(\gamma_b, a_1, a_2) = \mu V - a_1 \min\{c, \lambda V\} - (1 - a_1)\tau V = 0$$

We complete the proof by showing that, for all $(a_1, a_2) \in \Theta$, there is some $\gamma_b \in (0,1)$ for which $t(\gamma_b, a_1, a_2) = 0$. We achieve this in three steps. First, we'll show that $t(0, a_1, a_2) > 0$ for all $(a_1, a_2) \in \Theta$. Second, we'll show that $t(1, a_1, a_2) < 0$ for all $(a_1, a_2) \in \Theta$. Finally, we show that $dt/d\gamma < 0$ at any $(a_1, a_2) \in \Theta$, and hence a fixed point with a unique value of $\gamma_b \in (0,1)$ must exist for all $(a_1, a_2) \in \Theta$.

Step 1. The result follows from

$$t(0, a_1, a_2) = \mu V = \frac{\pi_b}{\pi_b + \pi_g(1 - s)} V > 0$$

Step 2. The derivative of $t(1, a_1, a_2)$ with respect to a_1 is

$$\begin{aligned} \tfrac{dt(1,a_1,a_2)}{da_1} &= -c + (2\tau(1) - \tau(1)^2)\, V < 0 \quad \text{if } \tau(1)V \leq c < \lambda(1)V \\ \tfrac{dt(1,a_1,a_2)}{da_1} &= (2\tau - \tau^2) - (2\lambda - \lambda^2) < 0 \qquad \text{if } c > \lambda(1)V \end{aligned}$$

We can sign these derivatives by observing that $d\,(2x - x^2)\,/dx > 0$ for $x < 1$. Since $\pi_b > \tau$, (A1) implies that $\frac{dt(1,a_1,a_2)}{da_1} < 0$ if $\tau(1)V \leq c < \lambda(1)V$. Since $\lambda > \tau$, the $\frac{dt(1,a_1,a_2)}{da_1} < 0$ when $c > \lambda(1)V$. It follows that, for any value of a_2, $t(1, a_1, a_2)$ takes on its largest value at $a_1 = \frac{1}{2}$.

Denote as a_2^* the value of a_2 that maximizes $t(1, 1/2, a_2)$. We shall consider two cases: (A) $c > \lambda V$ and (B) $c < \lambda V$. In case (A), the indifference condition may be written

$$t\left(1, \frac{1}{2}, a_2^*\right) = \pi_b V - \frac{1}{2}\left(\frac{\pi_b}{\pi_b + 2\pi_g(1 - a_2^*)}\right)V - \frac{1}{2}\left(\frac{\pi_b}{\pi_b + 2\pi_g a_2^*}\right)V$$

This is strictly greater than zero since both right hand side terms in parentheses are less than π_b. In case (B), the indifference equation is

$$t\left(1, \frac{1}{2}, a_2^*\right) = \pi_b V - \frac{1}{2}c - \frac{1}{2}\left(\frac{\pi_b}{\pi_b + 2\pi_g a_2^*}\right)V$$

This is negative if

$$c > \left(2\pi_b - \frac{\pi_b}{(\pi_b + 2a_2^*(1 - \pi_b))}\right)V$$

Fact 4 implies the right hand side is smaller than $2\pi_b - \pi_b^2$. Thus (A1), which says $c > 2\pi_b - \pi_b^2$, ensures the inequality above holds and $t\left(1, \frac{1}{2}, a_2^*\right) < 0$.

To summarize this step, (A1) ensures that $t(1, a_1, a_2) < 0$ no matter where it takes on its maximum. And so, for any other configurations of errors $t(1, a_1, a_2)$ must also be less than zero.

Step 3. Using the derivatives stated at the start of our proof, we see that

$$\begin{array}{ll} \frac{dt(\gamma_b,a_1,a_2)}{d\gamma} = \frac{d\mu(\gamma)}{d\gamma} - [1 - a_1]\frac{d\tau(\gamma)}{d\gamma} < 0 & \text{if } \mu(\gamma)V \leq c < \lambda(\gamma)V \\ \frac{dt(\gamma_b,a_1,a_2)}{d\gamma} = \frac{d\mu(\gamma)}{d\gamma} - (1 - a_1)\frac{d\tau(\gamma)}{d\gamma} - a_1\frac{d\lambda(\gamma)}{d\gamma} < 0 & \text{if } \lambda(\gamma)V < c \end{array}$$

Thus, for every value of c compatible with assumption (A1), $dt/d\gamma_b < 0$. ■

Proof of Proposition 3. Denote the bad firm's mixing probability simply by γ. Consistent beliefs are

$$\tau = \frac{\pi_b\gamma(1 - a_1)}{\pi_b\gamma(1 - a_1) + \pi_g a_2} \qquad \lambda = \frac{\pi_b\gamma a_1}{\pi_b\gamma a_1 + \pi_g(1 - a_2)}$$

$$\mu = \frac{\pi_b(1-s\gamma)}{\pi_b(1-s\gamma)+\pi_g(1-s)}$$

Part (A) Consumers take precautions. (i) The bad type's indifference equation is

$$\mu V - a_1 c - (1-a_1)\tau V = 0$$

Taking the derivative with respect to a_1 yields

$$\frac{\partial \mu}{\partial \gamma}\frac{\partial \gamma}{\partial a_1}V - (1-a_1)\frac{\partial \tau}{\partial \gamma}\frac{\partial \gamma}{\partial a_1}V - (1-a_1)\frac{\partial \tau}{\partial a_1}V - c + \tau V = 0$$

Plugging in for $\partial\tau/\partial a_1$and solving for $d\gamma/da_1$ we get

$$\frac{\partial \gamma}{\partial a_1} = \frac{c - \tau V - \tau(1-\tau)V}{\frac{\partial \mu}{\partial \gamma}V - (1-a_1)\frac{\partial \tau}{\partial \gamma}V}$$

The denominator is negative since $\partial\mu/\partial\gamma < 0$ and $\partial\tau/\partial\gamma > 0$ (see the derivatives given at the start of the proof to Proposition 2). Because $d\left(2x - x^2\right)/dx > 0$ for $x < 1$ and $\pi_b > \tau$, (A1) implies that the numerator is positive. It follows that $d\gamma/da_1 < 0$.

(ii) Taking the derivative of the indifference equation with respect to a_2 and solving for $\partial\gamma/\partial a_2$ yields

$$\frac{\partial \gamma}{\partial a_2} = \frac{-(1-a_1)\frac{\tau(1-\tau)}{a_2}V}{\frac{\partial \mu}{\partial \gamma}V - (1-a_1)\frac{\partial \tau}{\partial \gamma}V}$$

The denominator is once again negative. Because the numerator is also negative, $\partial\gamma/\partial a_2 > 0$.

Part (B) Consumers do not take precautions. (i) The bad type's indifference equation is

$$\mu V - a_1 \lambda V - (1-a_1)\tau V = 0$$

Take the derivative with respect to a_1 yields

$$\frac{\partial \mu}{\partial \gamma}\frac{\partial \gamma}{\partial a_1}V - (1-a_1)\frac{\partial \tau}{\partial \gamma}\frac{\partial \gamma}{\partial a_1}V - (1-a_1)\frac{\partial \tau}{\partial a_1}V$$

$$-a_1 \frac{\partial \lambda}{\partial \gamma} \frac{\partial \gamma}{\partial a_1} V - a_1 \frac{\partial \lambda}{\partial a_1} V - \lambda V + \tau V = 0$$

Solving for $d\gamma/da_1$ we get

$$\frac{\partial \gamma}{\partial a_1} = \frac{(2\lambda - \lambda^2)V - (2\tau - \tau^2)V}{\frac{\partial \mu}{\partial \gamma} V - (1 - a_1)\frac{\partial \tau}{\partial \gamma} V - a_1 \frac{\partial \lambda}{\partial \gamma} V}$$

The denominator is negative since $\partial\mu/\partial\gamma < 0$, $\partial\tau/\partial\gamma > 0$, and $\partial\lambda/\partial\gamma > 0$. Because $d\left(2x - x^2\right)/dx > 0$ for $x < 1$ and $\lambda > \tau$, the numerator is positive. It follows that $d\gamma/da_1 < 0$

(ii) Taking the derivative of the indifference equation with respect to a_2 and solving for $\partial\gamma/\partial a_2$ yields

$$\frac{\partial \gamma}{\partial a_2} = \frac{a_1 \frac{\lambda(1-\lambda)}{a_2} V - (1 - a_1)\frac{\tau(1-\tau)}{a_2} V}{\frac{\partial \mu}{\partial \gamma} V - (1 - a_1)\frac{\partial \tau}{\partial \gamma} V - a_1 \frac{\partial \lambda}{\partial \gamma} V}$$

The sign of the numerator is ambiguous. ■

Proof of Proposition 4. Denote the bad firm's mixing probability in Proposition 2 simply by γ. With perfect courts good types go to trial and bad types do not. Expected welfare is

$$W^{\text{Perfect}} = \pi_g V$$

With imperfect courts we consider two cases.

The first is with consumer precautions following a finding of liability ($c < \lambda V$). Here expected welfare from imperfect courts is

$$W = \pi_g \left[(1 - s) + s a_2\right] V + \pi_g s (1 - a_2)\left(V - c\right) + \pi_b s \gamma\left(a_1, a_2\right) a_1 (V - c)$$

$$\Leftrightarrow W = W^{Perfect} + \pi_b s \gamma\left(a_1, a_2\right) a_1 \left(V - c\right) - \pi_g s (1 - a_2) c \qquad (9)$$

The derivative of W with respect to a_2 is positive. Formally, we see that

$$\frac{\partial W}{\partial a_2} = \pi_b s a_1 \left(V - c\right) \frac{\partial \gamma}{\partial a_2} + \pi_g s c > 0$$

So reducing mistaken convictions always improves welfare from imperfect courts.

Moreover, if we plug consistent beliefs for λ defined in proposition (2) into the condition $c < \lambda V$ and rearrange results in

$$a_1 s\gamma_b \pi_b V > a_1 s\gamma_b \pi_b c + \pi_g s(1 - a_2)c$$

This inequality implies the sum of the last three terms in equation (9) must be positive. So, $W > W^{\text{Perfect}}$.

The second case considered is where consumers do not take precautions at all. Here expected welfare from imperfect courts is the same the expected welfare from perfect courts. Because no precautions are taken, the second and third terms in (9) are zero. Thus, changes in accuracy have no effect on welfare. ■

Proof of Proposition 5. Denote the bad firm's mixing probability in Proposition 2 simply by γ. Allowing settlement, the expected payoff to a firm is prior to knowing its type is

$$[\pi_g s a_2 + \pi_b s\gamma(1-a_1)]P^{NL} + [\pi_g s(1-a_2) + \pi_b s\gamma a_1]P^L + [(1-s\gamma)\pi_b + (1-s)\pi_b]P^M$$

As usual we caonsider two cases, with and without consumer precautions. First, plugging in prices when consumers take precautions gives

$$V - [\pi_b s\gamma(1-a_1) + \pi_b(1-s\gamma)]V - [\pi_g s(1-a_2) + \pi_b s\gamma a_1]c$$

Prohibiting settlement is akin to setting $\gamma = 1$, without changing a_1 or a_2 (i.e., mandating that the settlement decision be independent of the court errors). Take the derivative of the expected payoff with respect to γ,yields

$$-[\pi_b s - \pi_b s e_1 - \pi_b s]V - [\pi_b s e_1]c$$

which reduces to $\pi_b s a_1[V - c] > 0$.And so, the expected payoff is maximized where $\gamma = 1$. Second, plugging in prices into the ex ante expected payoff for firms when consumers do not take preacutions is

$$V - [\pi_b s\gamma(1-a_1) + \pi_b(1-s\gamma) + \pi_b s\gamma a_1]V = \pi_g V$$

Banning settlement has no effect on this payoff. In sum, banning settlement improves expected firm payoffs when consumers take precaution and has no effect on expected payoffs when consumers do not take precautions. ■

Proof of Proposition 6.

The firms engage in two pooling activities in this equilibrium. First, both firms make the same settlement offer. Second, both firms decide to settle rather than go to trial. Denote the pooling settlement offer o. The plaintiff's belief that the firm is a bad type following this offer is

$$\omega = \frac{\alpha \pi_b}{\alpha \pi_b + \pi_g (1 - \alpha)}$$

The offer that makes the plaintiff just indifferent between accepting and rejecting is

$$o = \omega a_1 d + (1 - \omega)(1 - a_2) d$$

Suppose that plaintiff beliefs off the equilibrium path are the same as the pooling beliefs. Under this assumption, the plaintiff will reject any offer less than o. And so, if both types wish to settle, o is the best possible offer.

Next we consider whether settlement is indeed optimal. Off the equilibrium path, assume that good and bad firms proceed to trial in the same proportion as they exist in the population. This belief survives the intuitive criterion because going to trial is not strictly dominated for either type. If, for example, consumers believe off the equilibrium path that all firms in trial are good, the bad type would want to deviate and go to trial. The consumer belief following a finding of no liability is

$$\tau = \frac{\pi_b \alpha (1 - a_1)}{\pi_b \alpha (1 - a_1) + \pi_g (1 - \alpha) a_2}$$

which is an increasing function of α. For any given range of errors and level of c set $\overline{\alpha}$ so that $\tau V = c$. In so doing, we see that

$$\overline{\alpha} = \frac{\pi_g a_2 c}{\pi_g a_2 c + \pi_b (1 - a_1)[V - c]}$$

which must be less than one. For any values of a_2 and a_1 if $\alpha > \overline{\alpha}$, the consumer takes precautions following a finding of no liability. Consequently, the consumer also takes precautions following a liability finding. The payoff to the good type from trial is thus

$$V - c - (1 - a_2)d$$

The payoff to the good type from settlement – to hiding that a suit has been filed – is

$$(1 - \pi_b)V - o$$

A deviation by the good type from settlement to trial is unprofitable if

$$V - c - (1 - a_2)d < V - \pi_b V - o$$

which reduces to

$$o - (1 - a_2)d < c - \pi_b V$$

or

$$d[\omega a_1 d + (1 - \omega)(1 - a_2) - (1 - a_2)] < c - \pi_b V$$

which clearly holds as $d \to 0$ since $c > \pi_b V$. The bad type will not want to deviate either because the bad type's payoff to trial with minimally informative courts must be less than the good type's payoff to trial. ■

Proof of Proposition 1′. The proof mirrors the proof of proposition 1 for firms that are good without investing and firms that are bad and do not invest. For bad firms that invest, the payoff to going to trial is $V - I$. The payoff from deviating and settling is $P^M - d - I$, which is strictly less since $P^M = (1 - \mu)V$. ■

Proof of Proposition 2′. The proof builds off the proof of proposition 2. The only difference is that for all potential values of investment by the bad firms, we have $\overline{\pi}_g = \pi_g + F(I)\pi_b > \pi_g$. It follows that $\overline{\pi}_b < \pi_b$. And so, if $c > (2\pi_b - \pi_b^2)V$, it must be true that $c > (2\overline{\pi}_b - \overline{\pi}_b^2)$ because $\partial(2x - x^2)/\partial x > 0$ for $x < 1$. To complete the proof replace π_b with $\overline{\pi}_b$ throughout the proof of proposition 2 above. Doing so demonstrates that there is a semi-separating equilibrium for every value of $\overline{\pi}_g$, including the $\overline{\pi}_g$ associated with the equilibrium level of investment, I^*. ■

Proof of Lemma 7. When there are perfect courts, the posterior in the no signal state is

$$\mu = \frac{1 - \pi_g - F(I)\pi_b}{(1 - \pi_g - F(I)\pi_b) + [\pi_g + F(I)\pi_b](1 - s)}$$

or

$$\mu = \frac{1 - \pi_g - F(I)\pi_b}{1 - s\pi_g - sF(I)\pi_b}$$

Plugging this into equation (5) we have

$$s\left[\frac{1 - \pi_g - F(I)\pi_b}{(1 - s\pi_g - sF(I)\pi_b}\right]V + sd - I = 0$$

Write the RHS as

$$g(I) = sV\left[\frac{1 - \pi_g - F(I)\pi_b}{(1 - s\pi_g - sF(I))\pi_b}\right] + sd - I$$

Notice that $g(\infty) = -\infty$ because the first term in $g(\infty)$ is finite and the third term is $-\infty$. Next consider $g(0)$ which must be positive since

$$g(0) = \frac{1 - \pi_g}{(1 - s\pi_g)}V + sd > 0$$

Finally, note that

$$g'(I) = -\frac{f\pi_b}{(1 - s\pi_g - sF(I)\pi_b)}sV + \frac{[1 - \pi_g - F(I)\pi_B]\, sf\pi_b}{(1 - s\pi_g - sF(I)\pi_b)^2}sV - 1$$

which reduces to

$$sV\left(\frac{(s-1)f\pi_b}{(1 - s\pi_g - sF(I)\pi_b)^2}\right) - 1$$

This is less than zero because $s < 1$. Since $g\left(\infty\right) < 0$, $g\left(0\right) > 0$, and $g'(I) < 0$, there must be a $0 < I^{*\text{Perfect}} < \infty$ such that $g(I^{*\text{Perfect}}) = 0$. ■

Proof of Proposition 8. We will use the following facts later in this proof. Denote the bad firm's mixing probability in the semiseparating equilibrium of

Proposition $2'$ simply by γ. Consistent beliefs for consumers are

$$\begin{aligned}
\tau &= \frac{\pi_b \left(1 - F\left(I^*\right)\right) \gamma (1 - a_1)}{\pi_b \left(1 - F\left(I^*\right)\right) \gamma (1 - a_1) + \left(\pi_g + \pi_b F\left(I^*\right)\right) a_2} \\
\lambda &= \frac{\pi_b \left(1 - F\left(I^*\right)\right) \gamma a_1}{\pi_b \left(1 - F\left(I^*\right)\right) \gamma_b^* a_1 + \left(\pi_g + \pi_b F\left(I^*\right)\right) (1 - a_2)} \\
\mu &= \frac{\pi_b \left(1 - F\left(I^*\right)\right) (1 - s\gamma)}{\pi_b \left(1 - F\left(I^*\right)\right) (1 - s\gamma) + \left(\pi_g + \pi_b F\left(I^*\right)\right) (1 - s)}
\end{aligned}$$

Some useful derivatives of these beliefs are

$$\frac{\partial \tau}{\partial \gamma} = \frac{\tau (1 - \tau)}{\gamma} > 0 \qquad \frac{\partial \mu}{\partial \gamma} = -\frac{\mu (1 - \mu) s}{1 - s\gamma} > 0$$

$$\frac{\partial \tau}{\partial I} = -\frac{f\left(I^*\right) \tau (1 - \tau)}{F\left(I^*\right) \left(1 - F\left(I^*\right)\right)} < 0 \qquad \frac{\partial \mu}{\partial I} - \frac{f\left(I^*\right) \mu (1 - \mu)}{F\left(I^*\right) \left(1 - F\left(I^*\right)\right)} < 0$$

In equilibrium, two equations jointly determine the investment level and the bad type's mixing probability:

$$s(a_1 + a_2 - 1)[P^{NL} - P^L + d] - I$$

$$(1 - a_1)P^{NL} + a_1 P^L = P^M$$

Plugging in for prices, these two equations can be written as

$$s(a_1 + a_2 - 1)[c + d - \tau V] - I = 0$$

$$\mu V - a_1 c - (1 - a_1)\tau V = 0$$

Totally differentiating the two equations with respect to a_1 gives

$$H \begin{bmatrix} \frac{\partial I}{\partial a_1} \\ \frac{\partial \gamma}{\partial a_1} \end{bmatrix} = \begin{bmatrix} s[\tau V - c - d] - s(a_2 + a_1 - 1)\frac{\tau(1-\tau)V}{1-a_1}] \\ c - \tau V - \tau(1 - \tau)V \end{bmatrix}$$

where $H = [r_1, r_2; r_3, r_4]$ and

$$\begin{aligned} r_1 &= -s[a_1 + a_2 - 1]\left(\frac{\partial \tau}{\partial I}\right)V - 1 \\ r_2 &= -s(a_1 + a_2 - 1)\frac{\partial \tau}{\partial \gamma}V \\ r_3 &= \frac{\partial \mu}{\partial I}V - (1 - a_1)\frac{\partial \tau}{\partial I}V \\ r_4 &= \frac{\partial \mu}{\partial \gamma}V - (1 - a_1)\frac{\partial \tau}{\partial \gamma}V \end{aligned}$$

(A2) implies that $r_1 < 0$. The fact that $\partial\tau/\partial\gamma > 0$ implies $r_2 < 0$. (A3) ensures that $r_3 > 0$. And $\partial\mu/\partial\gamma$ implies $r_4 < 0$. As a result, the $\det(H) = r_1 r_4 - r_2 r_4$ is positive.

Applying Cramer's rule, we know that $\partial I/\partial a_1 = |A| / |H|$ where

$$A = \begin{bmatrix} s[\tau V - c - d] - s(a_2 + a_1 - 1)\frac{\tau(1-\tau)V}{1-a_1} & r_2 \\ c - \tau V - \tau(1-\tau)V & r_4 \end{bmatrix}$$

Since $|H| > 0$, $sign\,(\partial I/\partial a_1) = sign\,(|A|)$. We know that $s[c - \tau V - d] - s(a_2 + a_1 - 1)\frac{\tau(1-\tau)V}{1-a_1}$ is equivalent to $s[(P^L - d) - P^{NL}] - s(a_2 + a_1 - 1)\frac{\tau(1-\tau)}{1-a_1}V$ – an expression which is negative since the payoff to a liability finding is lower than the payoff to a non-liability finding. In the proof of Proposition 2 we demonstrated that assumption (A1) implies $c - \tau V - \tau(1-\tau)V > 0$. The determinant of A is thus

$$r_4\left(s[\tau V - c - h] - s(a_2 + a_1 - 1)\frac{\tau(1-\tau)V}{1-a_1}\right) - r_2\left(c - \tau V - \tau(1-\tau)V\right)$$

which is positive. So, $\partial I/\partial a_1 > 0$.

(ii) Totally differentiating with respect to a_2 gives

$$H\begin{bmatrix} \frac{\partial I}{\partial a_2} \\ \frac{\partial \gamma}{\partial a_2} \end{bmatrix} = \begin{bmatrix} s[\tau V - c - d] + s(a_1 + a_2 - 1)[\frac{\partial \tau}{\partial a_2}V] \\ -(1 - a_1))\frac{\tau(1-\tau)}{a_2}V \end{bmatrix}$$

Applying Cramer's rule, we have $sign\,(\partial I/\partial a_2) = sign(|A|)$, where

$$A = \begin{bmatrix} s[\tau V - c - d] - s(a_1 + a_2 - 1)\frac{\tau(1-\tau)}{a_2}V] & r_2 \\ -(1 - a_1)\frac{\tau(1-\tau)}{a_2}V & r_4 \end{bmatrix}$$

The determinant of A is

$$\left(s[\tau V - c - d] - s(a_2 + a_2 - 1)\frac{\tau(1-\tau)}{a_2}V\right) r_4 + \left((1 - a_1)\frac{\tau(1-\tau)}{a_2}V\right) r_2$$

which has an ambiguous sign. ■

Proof of Proposition 9. Imperfect courts generate more welfare than perfect courts if:

$$\int_{I^*}^{I^{*\text{Perfect}}} (\pi_b V - t)\, f\,(t)\, dt < (1 - F\,(I^*))\, s\pi_b\gamma^* a_1\,(V - c)$$

Perfect courts generate additional investment with probability $F(I^{*\text{Perfect}}) - F(I^*)$. Imperfect courts generate additional consumer precaution with probability $(1 - F\,(I^*))$, which is larger than $F(I^{*\text{Perfect}}) - F(I^*)$. Thus, we get the benefit of the consumer precautions from imperfect courts over a larger range of the distribution of I. If we add and subtract $F(I^{*\text{Perfect}})s\gamma^*\pi_b a_1\,(V - c)$ on the RHS, we get

$$\int_{I^*}^{I^{*\text{Perfect}}} (\pi_b V - t)\, f\,(t)\, dt <$$

$$(1 - F(I^{*\text{Perfect}}))s\gamma^*\pi_b a_1\,(V - c) + [F(I^{*\text{Perfect}}) - F(I^*)]s\pi_b\gamma_b^* a_1\,(V - c)$$

Rearrange and we have

$$(1 - F(I^{*\text{Perfect}}))\pi_b s\gamma^* a_1\,(V - c) >$$

$$\int_{I^*}^{I^{*\text{Perfect}}} (\pi_b V - t)\, f\,(t)\, dt - [F(I^{*\text{Perfect}}) - F(I^*)]s\pi_b\gamma^* a_1\,(V - c)$$

■