

The Evolution of the Common Law with Strategic Litigants*

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Abstract

The common law is shaped by the cases that are litigated in court. We study the incentives for litigants to influence legal evolution by strategically choosing which disputes to litigate. In our framework, clarifying the law typically benefits defendants. This creates a strict incentive for plaintiffs to settle cases, or to abandon legal claims even when litigation is costless. When plaintiffs are regulator, we associate this scenario with ‘regulator capture’. By contrast, defendants have an incentive to force litigation, even in instances where plaintiffs would ordinarily not litigate, by generating ‘test cases’. We predict that settlement and regulatory capture is most likely when regulators are sufficiently long-run oriented, whilst test cases arise when defendants are. We analyze the welfare consequences arising from these dynamic incentives.

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1 Introduction

Within the common law tradition, courts are largely reactive institutions. Typically, they do not “seek out specific interpretive occasions, but instead wait for others to bring matters to their attention” (Fiss, 1984). Accordingly, “judge made” law can be viewed as a function of the demand for judicial decisions by litigants. Thus, the trajectory of how a particular law evolves will depend on the “stream” of cases that are brought before the court by plaintiffs (Zywicki, 2012).

In the modern state, these plaintiffs are often regulatory agencies with strategic concerns regarding the types of cases that they choose to litigate. For example, the Securities and Exchange Commission’s (SEC) or the Federal Trade Commission (FTC) in the United States have, over decades, prosecuted various firms for violating regulations within their respective purviews. For a regulator taking a long-run view, the decision of whether to initiate litigation, and whether to offer a firm a settlement, will reflect the regulator’s concerns, not only about outcomes in the instant case, but of how future outcomes are affected. Thus, regulators may have an incentive to strategically manipulate current enforcement actions to affect the outcome of future enforcement actions.

In this paper, we explore on such avenue for strategic manipulation: the decision to settle out of court to avoid having legal precedent established. The argument that settlement prevents the common law from evolving has been made by other legal scholars. In a well-cited paper “Against Settlement”, Fiss (1984) notes that: “ *A settlement will thereby deprive a court of the occasion, and perhaps even the ability, to render an interpretation.*” Thus, legal actors do not merely passively respond to the law; rather *the decision to settle itself shapes the law.*

This contention stands in sharp contrast to the extant literature in law-enforcement or regulation, which generally assume that legal actors take the law as ‘given’ and respond accordingly. Indeed, Galanter (1974) notes that most analyses of the legal system “start at the

rules end... and then see what affect [these] have on the parties.” However, as in the case of the decision to settle, legal actors have incentive to shape the law to their own benefit.

This incentive will be especially strong for repeat players. As Galanter (1974) notes: “repeat players can play for rules as well as immediate gains”. That is, repeat players make decisions that not only affect their immediate outcomes but also try to shape the law to improve their future prospects and payoffs. In our context, this implies that a regulator’s decision to settle will not depend solely on the current payoff relative to going to trial, but also on how the court’s ruling (or lack thereof) may affect their future ability to regulate firms. Similarly, the firm’s decision to accept the settlement will depend on whether it benefits from going to trial and having the law clarified (which could affect its future payoffs), or not.

The goal of this paper is to understand how the concerns of long-lived plaintiffs and defendants, who can decide to settle pre-trial, affect the evolution of common law. We examine whether and when litigants have incentives to settle when doing so prevents the law from being clarified. Further, we explore how anticipation of these incentives by defendants affects their own decision-making, especially with respect to the intensity of conduct that may invite litigation.

To investigate these issues we build on previous models that capture the evolutionary process of the common law (see Baker and Mezzetti, 2012; Niblett, 2013; Parameswaran, 2018). A firm’s production generates a negative externality. The social cost of this externality (and thus the socially efficient output level) is uncertain, but its distribution is common knowledge. Given this uncertainty, the firm’s output will fall into one of three possible categories: it may either be definitely below the socially efficient level, definitely above the socially efficient level, or there may be ambiguity about whether it is above or below the efficient level. A welfare-maximizing court implements a negligence-type rule, in which the firm is definitely not held liable in the first case (*per se immunity*), and definitely held liable in the second (*strict liability*). The legal rule is silent in the region of ambiguity. If a case arises in this region, an

evidentiary trial may be held if a plaintiff brings the case to trial. For simplicity, we assume that, during the trial, the court perfectly learns whether the firm has over-produced or not.

Plaintiffs in our framework are regulators who act as agents of the victims and may seek legal action against the firm. Since cases in either the region of immunity or strict liability are automatically decided, the decision to seek legal action is critical only when confronted with a case in the ambiguous region. If so, the plaintiff can do one of three things: nothing, settle, or take the firm to court. Thus, it is only in this region, and then only if the plaintiff brings the case, that the court's role is salient.

The above framework introduces a critical, unique, feature of our model; namely, that enforcement is *jointly undertaken by both the court and the regulator*. If the size of the externality were known, then the regulator's decision would amount to imposing a "Pigovian tax" on firms that are liable, or implementing the optimal "Beckerian" (second-best) policy. However, because the cost is unknown, the regulator can sanction firms that produce in the ambiguous region *only if the court* finds them liable upon trial and investigation. Thus, the regulator depends on the court to determine whether the firm is liable. Conversely, the court is dependent on the regulator for its stream of cases. While the regulator cannot sanction a firm without the court, the court can only decide upon cases that are brought before it by the regulator. In this regard our paper departs from the extant literature (Baker and Mezzetti, 2012; Parameswaran, 2018) in that enforcement is conducted jointly by two strategic parties and the stream of cases brought before the court is not automatic but rather determined by the strategic interests of the litigants.

Whether a case goes to trial depends on the incentives for settlement. However, settlement occurs in the shadow of trial. In particular, going to trial must be individually rational for the plaintiff, otherwise it will have no leverage in negotiating a favorable settlement. To establish similarities and differences with previous models, we begin by establishing baseline outcomes in a static model where there is no learning motive, but there are explicit costs to

litigation. We show that the firm will either produce the largest output that is guaranteed to not attract litigation (the ‘safe output’), or the output in the ambiguous region that optimally trades-off higher profits against the penalty if held liable by the court. The ‘risky output’ is independent of litigation costs, and is unaffected by whether settlement is anticipated or not. By contrast, the ‘safe output’ is increasing in the plaintiff’s litigation costs; as litigation becomes costlier, the plaintiff will not find it optimal to litigate when the expected damages are positive but small. This implies that there are cases in the ambiguous region that are never brought to court, even though the plaintiff has a positive probability of prevailing, because doing so is too costly. The region of *per se* immunity is *de facto* broad. We show that the firm produces the ‘risky output’ unless the *de facto* permissive threshold is sufficiently broad, or equivalently, unless litigation costs are sufficiently high.

We then consider a two period (dynamic) game with a long lived plaintiff and firm. In this game we abstract from other motives to settle by assuming that litigation is costless. Instead, the utility differential from having the law clarified is the implicit opportunity cost of going to trial.

We find that, in general, clarifying the law makes the plaintiff strictly worse off. Intuitively, with more information, the firm can make choices that enable it to maximize profits at lower risk of being held liable. If sufficiently forward looking, the plaintiff will either be willing to accept settlements that are smaller than the settlement amount in the static game *even in the absence of any direct court costs*, or, may simply not prosecute the case at all. We associate the latter scenario with ‘regulatory capture’. Thus, despite there being no exogenous litigation costs, these ‘endogenous’ information costs again introduce a wedge between the *de facto* and the *de jure* permissive legal thresholds.

By contrast, clarifying the law makes the defendant strictly better off in the long run, and this creates an incentive for trials to proceed. We show that litigation will arise and the law will evolve whenever defendants are relatively more long-term oriented than plaintiffs. Moreover,

we identify conditions in which the dynamic incentives lead firms to strategically produce ‘test-cases’, distorting their production choices to guarantee that the case will proceed to trial.

We study the welfare consequences that stem from these strategic incentives. Efficiency in the dynamic game requires that the firm to produce the *ex ante* socially efficient output in each period (efficiency) and for the plaintiff to always litigate to allow for learning (*dynamic efficiency*). We show that the equilibrium will be dynamically efficient whenever the defendant is more forward-looking than the plaintiff, and will tend towards first period static efficiency (though not strictly achieve it) as the plaintiff becomes increasingly forward looking. Hence, we show the regime with test cases along the equilibrium path is ‘most efficient’, whilst the regime with settlements is ‘least efficient’.

These results are significant because an overwhelming percentage of regulatory enforcement actions result in settlements. For example, around 92 % of cases of Foreign Corrupt Practices Act (FCPA) violations are settled out of court (and without going to trial) with the SEC.¹ And, indeed from an efficiency perspective settlement is usually pareto superior to trial. However, our results suggest that it could prevent the law from being clarified, and further that strategic plaintiffs will not have incentive to clarify the law.² We discuss these legal implications in the conclusion in more detail.

This paper is organized as follows. In the immediately following subsection we discuss the relevant literature. Section 2 presents the basic legal framework. Section 3 studies the static game and Section 4 studies the dynamic (two-period) game with long lived litigants. The final section concludes.

¹Data is obtained from the Stanford Law School FCPA clearing house.

²Indeed, some legal scholars note that “FCPA enforcement is a legal desert, with guidance often drawn not from binding case law but from a whirl of enforcement patterns.”

1.1 Literature Review

This article contributes to a growing literature that studies the role of learning in judicial decision-making (see, in particular, Hadfield (1991), Baker and Mezzetti (2012), Fox and Vanberg (2014), Callander and Clark (2017) and Parameswaran (2018)). Indeed, our model setup is identical to Parameswaran (2018), except that that paper abstracts from the possibility of settlement. Separately, it contributes to the enforcement literature whose modern genesis begins with Becker (1968).

All of the above papers focus on dynamic decision making by an informationally constrained court that learns as it hears cases. Of particular interest is when and whether courts construe rules broadly versus narrowly, and the implications of these choices for efficiency of the common law. Baker and Mezzetti (2012) and Callander and Clark (2017) both present models in which the underlying behavior of agents is random and legal-rule invariant. In Baker and Mezzetti (2012), the court trades off the benefit of learning from cases against the explicit adjudication costs. When confronted with a case whose ideal disposition is unknown, the court summarily dispose of the case if it is ‘close enough’ to an existing case with known disposition, and investigate the case otherwise. The court, thus implements, ‘somewhat broad’ legal rules. Baker and Mezzetti (2012) show that, if adjudication costs are not too high, the law will evolve incrementally and eventually converge to the ideal legal rule.

Parameswaran (2018) builds on the Baker and Mezzetti (2012) framework by explicitly modelling the agent behavior that generates cases. Rather than facing a random exogenous stream of cases, the court’s docket will be endogenous to the rules it makes. Parameswaran (2018) shows that with legal uncertainty, the stream of outputs chosen by the firm will be biased away from the *ex ante* efficient level, which skews the court’s ability to learn. (Hadfield (1991) makes a similar argument in an informal model, although her argument depends crucially on agent heterogeneity. Parameswaran (2018) shows that the insight holds even in a world with a representative agent.) In effect, the adjudication costs in Baker and

Mezzetti are replaced with the implicit (bias) costs stemming from endogenous response to legal rules. Parameswaran (2018) shows that the size of this implicit (bias) cost is itself endogenous and increases as the law evolves, creating a dynamic where the law evolves for a finite period before settling. Moreover, legal evolution stops before the court can implement the ideal legal rule.

Our model differs from each of these in that, whereas they are particularly interested in optimal decision making by the court, we consider an essentially passive court. Instead, we focus on the incentives for agents to settle under the shadow of the law, and ask how this affects efficiency in the short run, and the long-run evolution of the common law.

Other dynamic models of judicial decision-making investigate how the common law evolves, and the implications for efficiency, when judges (or courts) have heterogeneous preferences (see Gennaioli and Shleifer (2007), Ponzetto and Fernandez (2008), and Niblett (2013)). Gennaioli and Shleifer (2007), for example, provide foundations for the “Cardozo Theorem”, which states that the individual biases of judges tend to wash out as law is created piecemeal, and that legal evolution is, on average, efficiency enhancing. Ponzetto and Fernandez (2008) similarly show that the common law converges towards more efficient rules, making it more effective in the long-run than statutory rule making. These models typically do not involve any uncertainty about the ideal legal rule — although the game is dynamic, there is no role for learning.

This article contributes to the literature on the efficiency of common law more broadly. In a seminal article, Posner (1973) argued that the decisions of efficiency-minded judges would tend to cause the common law to produce efficient rules. Subsequent articles have examined why the common law may tend to efficiency, even if judges are imperfect in their motives, information or execution. Priest (1977) and Rubin (1977) provide a ‘demand-side’ argument, that inefficient legal rules are more likely to be litigated and subsequently overturned, than efficient ones. Cooter and Kornhauser (1980) provide a formalization of these arguments.

By contrast, Hylton (2006) shows that information asymmetries between litigants can cause biased rules, which favor the more informed party, to evolve. Zywicki (2002) stresses the importance of ‘supply-side’ factors, such as institutional rules and norms, in determining the efficiency of common law. Cooter, Kornhauser and Lane (1979) show that incremental rule-making by courts can converge upon efficient rules, even if individual courts are imperfectly informed about the ideal rule. Hadfield (2011) asks whether legal rules will dynamically adapt to new or local conditions. By and large, the primary force that drives the law, in these articles, is case selection (i.e. which cases are litigated). The opposite effect, of the law driving the sorts of cases that arise, is typically left unexplored (although, see Png (1987) and Parameswaran (2018)).

Finally, this paper contributes to the law and economics of enforcement in two ways. For the most part this literature assumes that agents passively respond to the rules and laws, that the law itself is static, and that regulators or courts enforce the law independently. Instead, here plaintiffs and dependants can make strategic choices which can shape the law, and furthermore, laws or regulations are jointly enforced by the courts and plaintiffs whose interests may not be aligned with each others.

2 Model

We adapt the model in Parameswaran (2018). Consider a two-period game with three players: a firm, a regulator and a court. In each period $t \in \{1, 2\}$, a risk neutral, profit-maximizing firm must choose a quantity of output, q_t , to produce. The firm’s gross (per-period) profit from production is $\pi_t = q_t - \frac{1}{2}q_t^2$, which is maximized at $q_{max} = 1$. Production creates a negative externality that harms a victim. The size of the harm is θq_t , where $\theta \in (0, 1)$ is the constant marginal harm. Accordingly, the socially efficient level of output is $q_{eff} = 1 - \theta < q_{max}$, which implies that unregulated firms will over-produce. Since firms will

not produce the socially efficient output, there is scope for welfare-improving regulation.

The regulator acts as an agent of the victims, on whose behalf it may seek compensatory damages. Thus, the regulator takes the role of the plaintiff, whilst the firm is the defendant. If θ were known, then the enforcement problem faced by a regulator is well-studied (see Becker, 1968). Instead, in this context, the regulator cannot always summarily sanction a firm because it does not always know for sure whether the firm's output is inefficiently large or not. This uncertainty introduces the need for legal institutions (courts and the common law) that clarify the law for all parties by determining whether actions of the firm should be permitted or sanctioned. Thus, because of the uncertainty regarding θ , the court and regulator jointly enforce this regulation.

We model this uncertainty by assuming that, when the game begins (at $t = 1$), all players commonly believe that $\theta \sim U[l_1, u_1]$, where $0 \leq l_1 < u_1 \leq 0.8$. The uniformity assumption is purely for simplicity. For similar technical reasons to Parameswaran (2018), we assume that $u_1 \leq 0.8$.

Suppose, at period t , the agents believe that $\theta \sim U[l_t, u_t]$. Then all players know that an output $q_t < 1 - u_t$ will definitely not exceed the socially efficient level and that an output $q_t > 1 - l_t$ definitely will. The players do not know whether quantities produced in the region $q_t \in (1 - u_t, 1 - l_t)$ are inefficiently large or not.

An efficiency-minded court seeks to implement a negligence-type rule that holds the firm liable only when it has produced more than the true socially efficient quantity q_{eff} . Given the uncertainty about θ , the court actually implements an incomplete negligence rule characterized by a pair of thresholds (λ_t, μ_t) (with $\lambda_t \leq \mu_t$). The rule holds firms producing $q_t \leq \lambda_t$ not liable, and firms producing $q_t \geq \mu_t$ liable. The rule is silent as to how cases in the region $q_t \in (\lambda_t, \mu_t)$ will be decided. We refer to λ_t and μ_t as *permissive* and *restrictive* thresholds, respectively. They divide the case space into regions of *per se immunity*, *ambiguity* and *strict liability*.

When a case in the ambiguous region comes before the court, an evidentiary trial is held to determine how it should be decided. For simplicity, we assume that the evidence presented at the trial perfectly reveals the true value of θ . (In section 4.3, we briefly discuss how our results might differ if information revelation at trial was incomplete.) Since there is learning at trial, in subsequent periods t' , all agents have correct beliefs $u_{t'} = l_{t'} = \theta$. Additionally, the firm becomes liable for compensatory damages θq_t if, upon learning θ , the court finds that the firm's output was inefficiently large (i.e. if $q_t > 1 - \theta = q_{eff}$).

An efficiency minded court would definitely not hold a firm liable for producing $q_t < 1 - u_t$, and it will definitely hold liable a firm producing $q_t > 1 - l_t$. Hence, it must be that $\lambda_t \geq 1 - u_t$ and $\mu_t \leq 1 - l_t$. We say the legal rule is *narrow* if the region of ambiguity coincides with the set of cases whose ideal disposition is unknown — i.e. if the court does not make commitments as to how it will decide cases whose correct dispositions are unknown. When rules are narrow, $\lambda_t = 1 - u_t$ and $\mu_t = 1 - l_t$. By contrast, the legal rule is *broad* if it dictates the liability status of a case whose ideal status is unknown (i.e. if $\lambda_t > 1 - u_t$ or $\mu_t < 1 - l_t$). In both Baker and Mezzetti (2012) and Parameswaran (2018), the question of interest was how courts should optimally choose the thresholds λ and μ , and whether or when the legal rule should be broad. Since our focus is different, we simplify the analysis by assuming that the court behaves mechanically by always writing narrow rules. Thus, we always have $\lambda_t = 1 - u_t$ and $\mu_t = 1 - l_t$, similar to the approach in Niblett (2013). However, we leave open the possibility that the equilibrium behavior of the regulator causes the law to be *de facto* broad, even though it is *de jure* narrow. Notice that, in any period t' after a trial, we must have $\lambda_{t'} = 1 - \theta = \mu_{t'}$, so that there ceases to be any ambiguity in the law after a trial is held.

Let $I(q_t, l_t, u_t)$ denote the damages that the firm expects to pay if it produces output q_t and the case goes to trial. If $q_t \leq \lambda_t$, then the court summarily dismisses the case and no damages are paid. If $q_t \geq \mu_t$, then the firm will pay full expectation damages $E[\theta]q_t = \frac{1}{2}(u_t + l_t)q_t$.

Finally, if $q_t \in (\lambda_t, \mu_t)$, the firm will pay damages provided that $q_t > 1 - \theta$. In expectation it pays: $\int_{l_t}^{u_t} \theta q_t \mathbf{1}[q_t > 1 - \theta] \frac{1}{u_t - l_t} d\theta$. We have:

$$I(q_t, l_t, u_t) = \begin{cases} 0 & \text{if } q_t \leq \lambda_t = 1 - u_t \\ \frac{u_t^2 - (1 - q_t)^2}{2(u_t - l_t)} \cdot q_t & \text{if } q_t \in (\lambda_t, \mu_t) \\ \frac{1}{2}(u_t + l_t)q_t & \text{if } q_t \geq \mu_t = 1 - l_t \end{cases}$$

We allow for the possibility that the plaintiff/regulator and defendant/firm face trial costs c_P and c_D . Our focus in this paper is on settlements arising for reasons other than cost avoidance. Accordingly, much of our analysis will assume that litigation costs, c_D and c_P , are zero. Nevertheless, to make clear how our mechanism relates to the cost-avoidance explanation, we allow for potentially costly litigation in the baseline analysis.

The timing of each stage game is as follows: First the firm produces output q_t . The regulator may initiate litigation. If so, the litigants engage in a bargaining process (described below) which may result in an out of court settlement s_t . In the case of settlement, the firm pays s_t to the regulator, and in doing so, both parties avoid trial costs and there is no learning. If there is no settlement, then the regulator must decide whether to proceed to trial or to drop the case. If the case proceeds to trial, then all parties perfectly learn θ , and the defendant becomes liable for compensatory damages if $q_t > q_{eff} = 1 - \theta$.

To ensure that our settlement results are not simply an artifact of some particular bargaining protocol, we use a fairly general bargaining framework that embeds several common special cases. We assume that the settlement offer s is determined by asymmetric Nash Bargaining between the plaintiff and defendant, where the disagreement payoff is the subgame perfect payoff when settlement fails. A parameter $\phi \in [0, 1]$ captures the bargaining strength of the plaintiff. The Nash bargaining approach includes, as special cases, the well studied scenarios where either the plaintiff ($\phi = 1$) or the defendant ($\phi = 0$) can make a take-it-or-leave-it offer.

When $\phi \in (0, 1)$, Imai and Salonen (2000) and Parameswaran, Cameron and Kornhauser (2021) show that the Nash Bargaining approach coincides with the limit case of bargaining between the players à la Baron and Ferejohn (1989) as players can make arbitrarily rapid counter-proposals, where ϕ is the plaintiff's recognition probability.

A strategy for the firm is a function $q_t(l, u; c_D, c_P, \phi) \in [0, 1]$ that determines a quantity to be produced in each period. A strategy for the plaintiff is a decision $a_t \in \{0, 1\}$ about whether to proceed to trial or to drop the case in the event that bargaining fails. A bargaining solution $s_t \in \mathbf{R}$ selects an optimal settlement offer to be paid by the defendant to the plaintiff. A triple $\{q_t, a_t, s_t\}$ is a Bayesian Perfect Equilibrium if, for each t :

1. q_t maximizes the firm's expected discounted stream of profits, taking as given the future behavior of the plaintiff, the anticipated bargaining outcome, and the evolution of the legal rule.
2. a_t minimizes the plaintiff's expected discounted stream of uncompensated harms from the externality.
3. s_t is consistent with asymmetric Nash Bargaining.

3 Static Game

We begin by studying the optimal behavior in the static game where there is no benefit to clarifying the law. Our analysis in this section allows for positive litigation costs, and thus gives the 'standard account' of settlement within our framework. In the following section, we analyze the dynamic model assuming no litigation costs, and compare the qualitative features of equilibrium behavior stemming from these distinct mechanisms. We omit time-subscripts whenever we can do so without confusion.

3.1 No Settlement

Our analysis proceeds by backward induction. Since settlement occurs in the shadow of the law, we first analyze outcomes in the subgame where the players fail to reach a settlement agreement. Of course, if the firm's output is in either the *per se* immunity or strict liability regimes, the legal consequences are immediate. Thus, we focus our analysis on the case when the firm produces in the ambiguous region.

Suppose q is in the ambiguous region. The regulator will go to trial only if (*ex ante*) expected damages exceed its litigation costs (i.e. $I(q, l, u) > c_P$). This is the regulator's individual rationality constraint. Clearly, if c_P is sufficiently large this constraint will be violated and the threat to go to trial is not credible. Define $\bar{c}_P(l, u) = (1 - l)\frac{u+l}{2}$. Individual rationality implies:

Lemma 1 *There exists $\hat{\lambda}(c_P, l, u) \geq 1 - u$ such that litigation is credible whenever the firm produces $q > \hat{\lambda}(c_P, l, u)$. Moreover:*

- $\hat{\lambda}(c_P, l, u)$ is monotonically increasing in c_P , and
- $\hat{\lambda}(0) = 1 - u$, and $\hat{\lambda}(\bar{c}_P) = 1 - l$.

$\hat{\lambda}(c_P, l, u)$ denotes the minimum output that the firm would need to produce to make it worthwhile for the plaintiff to take the case to court. Note that $\hat{\lambda}(c_P, l, u) > 1 - u = \lambda$, whenever $c_P > 0$. There are a set of cases that court could potentially decide in the plaintiff's favor, but which will be summarily dismissed by the regulator because litigation is costly. This implies that the effective region of *per se* immunity is larger from the firm's perspective than is implied by the legal rule. The firm operates under a *de facto* broad permissive rule ($\hat{\lambda}(c_P, l, u) > 1 - u$), even though the *de jure* rule ($\lambda = 1 - u$) is narrow. Of course, if $c_P = 0$, then $\hat{\lambda}(0, l, u) = 1 - u = \lambda$, and the *de facto* and *de jure* rules coincide. Additionally, when

c_P becomes sufficiently large (i.e. $c_P \geq \bar{c}_P$), the *de facto* rule becomes sufficiently broad as to cause the effective region of ambiguity to disappear entirely. The regulator will only attempt to sanction the firm when it has unambiguously over-produced.

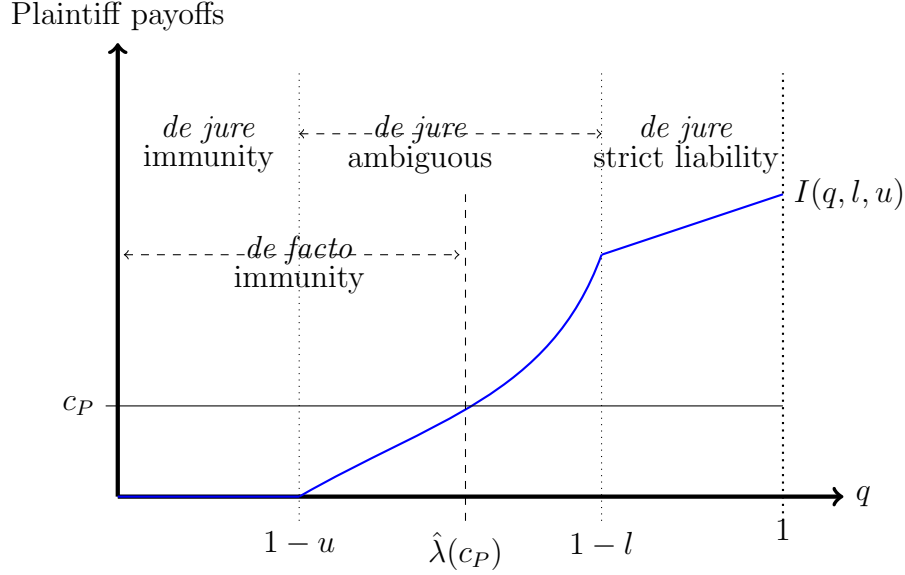


Figure 1: The relationship between the firm’s output, the expected penalty schedule, and the regulator’s incentives to litigate.

We formalize this result concerning the distinction between the *de facto* and *de jure* legal rule in the following proposition:

Proposition 1 Let $\hat{c}_P(l, u) = \frac{u+l}{2}(1-l)$. The *de facto* permissive rule is:

- narrow, if $c_P = 0$. i.e. $\hat{\lambda}(0) = 1 - u = \lambda$.
- somewhat broad, if $c_P \in (0, \bar{c}_P)$. i.e. $\lambda = 1 - u < \hat{\lambda}(c_P) < 1 - l = \mu$.
- maximally broad, such that there is no effective region of ambiguity, if $c_P \geq \bar{c}_P$. i.e. $\hat{\lambda}(c_P) = 1 - l = \mu$.

We briefly note an analogy to Baker and Mezzetti (2012). In that paper, the *court* faces explicit adjudication costs (whilst the incentives for litigants are left unmodeled). Baker

and Mezzetti (2012) show that it is optimal for the court to write broad legal rules when adjudication is costly, and that the breadth of rules increases as adjudication costs increase. Moreover, beyond some threshold cost, rules will be maximally broad and there will be no ambiguity in the law. Our model shows that similar qualitative features can arise when the burden of costs fall upon litigants rather than the court.

3.2 Settlement

The previous subsection characterized the subset of cases where the threat of litigation was credible. We now analyze optimal settlements arising from the threat of litigation. Obviously, if litigation is not credible, the firm will reject any positive settlement offer, and the regulator will drop the case. We focus on the more interesting case, where litigation is credible.

Suppose q is in the ambiguous region. The disagreement payoffs in the bargaining game are the expected payoffs from going to trial. These are $I(q, l, u) - c_P$ for the plaintiff and $-I(q, l, u) - c_D$ for the defendant. Since going to trial represents a negative-sum game, the litigants will definitely agree to a settlement. The equilibrium settlement offer is characterized by:

$$S = \arg \max_{s \geq 0} [s - (I(q, l, u) - c_P)]^\phi [-s + (I(q, l, u) + c_D)]^{1-\phi} \quad (1)$$

Lemma 2 *The equilibrium settlement is given by:*

$$S = \begin{cases} 0 & \text{if } q \leq \hat{\lambda}(c_P, l, u) \\ I(q, l, u) - c_P + \phi(c_D + c_P) & \text{if } q > \hat{\lambda}(c_P, l, u) \end{cases}$$

where $\hat{\lambda}(c_P, l, u)$ is characterized in Lemma 1

We highlight two features of this equilibrium offer. First, under Nash Bargaining, the settlement offer always gives the plaintiff her expected payoff from going to trial, $I(q, l, u) - c_P$,

which is the expected penalty less the plaintiff's legal costs. Additionally, the plaintiff receives a fraction ϕ of the total litigation costs that are avoided by settling out of court. Intuitively, settlement generates a surplus of $(c_D + c_P)$, and the parameter ϕ simply determines what fraction of this surplus is received by the plaintiff. Hence, we see that, varying ϕ as appropriate, we can achieve any desired distribution of the surplus between the parties.

Second, under Nash Bargaining, the firm's marginal profit from increasing q (inclusive of anticipated settlement payments) is independent of $\phi \in [0, 1]$. Hence, the firm's optimal output choice is invariant to the choice of bargaining weights. Moreover, this marginal profit is the same whether pre-trial settlement is permitted or not.³ Hence, at the margin, neither the possibility of settlement, nor the details of the bargaining protocol, affect the firm's choice about how much to produce.

3.3 Profit maximizing quantity

We now study the firm's profit maximizing output choice. A firm can choose its quantity in one of three regions: $q \leq \hat{\lambda}(c_P, l, u)$ (*de facto* immunity), $q \geq 1 - l$ (strict liability), or $q \in (\hat{\lambda}(c_P, l, u), 1 - l)$ (*de facto* ambiguity). Since the sanctions vary across regions, the profits from production will vary across the regions, as well. The firm's problem is:

$$\max_q \Pi(q) = \begin{cases} q - \frac{1}{2}q^2 & \text{if } q \leq \hat{\lambda}(c_P, l, u) \\ q - \frac{1}{2}q^2 - I(q, l, u) + c_P - \phi(c_P + c_D) & \text{if } q \in (\hat{\lambda}(c_P, l, u), 1 - l) \\ q - \frac{1}{2}q^2 - q\frac{u+l}{2} & \text{if } q \geq 1 - l \end{cases}$$

where we assume that $c_P < \bar{c}_P$ which ensures that the *de facto* region of ambiguity is non-empty (i.e. $\hat{\lambda}(c_P, l, u) < 1 - l$). We also make the (conservative) assumption that, if the firm

³To see this, note that when $\phi = 1$, the firm is always indifferent between settling and going to court. So its decision making when settlements are disallowed will be identical to the case when settlements are permitted and $\phi = 1$.

produces in the strict liability region, the parties will not incur legal costs, since the case is decided summarily. This assumption is entirely benign. As we will see, even under our no-cost assumption, the firm would never find it optimal to produce in the strict liability region; introducing positive legal costs will merely make an already undesirable choice even more so.

Notice, importantly, that litigation costs do not affect the firm's profits at the margin. The size of the plaintiff's costs, however, does affect the boundary between the *de facto* regions of *immunity* and *ambiguity*, and this may affect the firm's decision about how much to produce.

Let $q_A(l, u) = 1 - \frac{1-(u-l) + \sqrt{(1-(u-l))^2 + 3u^2}}{3}$ be the solution to the first order condition implied by the firm's incentives in the ambiguous region. It is easily verified that $q_A(l, u) < 1 - E[\theta] = q_E(l, u)$, where $q_E(l, u)$ is the *ex ante* socially efficient output. Uncertainty about the law over-deters the firm, causing it to produce below the expected socially efficient level (see Calfee and Craswell, 1984).

The firm's equilibrium output choice is characterized as follows:

Proposition 2 *There exists a threshold $\lambda^*(l, u, c_P, c_D, \phi) \geq 1-u = \lambda$ with $\lambda^*(l, u, c_P, c_D, \phi) < q_A(l, u)$, such that:*

$$q(l, u, c_P) = \begin{cases} q_A(l, u) & \text{if } \hat{\lambda}(l, u, c_P) < \lambda^*(l, u, c_P, c_D, \phi) \\ \hat{\lambda}(l, u, c_P) & \text{if } \hat{\lambda}(l, u, c_P) \geq \lambda^*(l, u, c_P, c_D, \phi) \end{cases}$$

Proposition 2 is a special case of Proposition 1 in Parameswaran (2018), except that the threshold characterized here is the *de facto* (rather than *de jure*) one. For a detailed explanation of the properties of the proposition, we refer the interested reader to that paper. Here we simply describe the main feature salient to this paper.

The firm's decision amounts to choosing between two output levels which we refer to as the 'safe' and 'risky' options. The safe option is the highest output that will definitely not attract litigation. This is the *de facto permissive* threshold $q = \hat{\lambda}(c_P, l, u)$. The risky option is the output that maximizes profit (including expected penalties) within the ambiguous region (i.e. $q = q_A$). It is never optimal to choose an output for which the firm will definitely be penalized. Proposition 2 states that the firm will choose the 'safe option' when the *de facto* legal rule is sufficiently broad, and the 'risky option' otherwise. Choosing the risky option benefits the firm by earning larger pre-penalty profits, but comes with the risk of incurring a penalty. If the safe quantity is too low, then the pre-penalty profits forgone from choosing the safe option will be large, and this incentivizes the firm to choose the risky option. By contrast, if the safe quantity is sufficiently large, the pre-penalty profits forgone will be low relative to the expected penalty from the risky option, and so the safe option will be preferred.

The threshold λ^* determines how large the safe output $\hat{\lambda}$ needs to be to make this the optimal choice. Naturally, it depends on beliefs, as well as litigation costs and the bargaining powers of both parties. Intuitively, as the plaintiff's bargaining power becomes larger, the defendant will have to pay a larger fraction of the settlement surplus (i.e. the sum of litigation costs) to the plaintiff. This makes settlement less attractive for the defendant, and equivalently, makes the safe output (where there is no threat of litigation and settlement) more attractive.

Since, in the following section, we will be particularly concerned about decision-making when litigation is costless, we note the following:

Corollary 1 *If $c_P = 0 = c_D$, then the firm's optimal output satisfies:*

$$q^*(l, u) = \begin{cases} q_A(l, u) & \text{if } u - l > 1 - u \\ \lambda = 1 - u & \text{if } u - l \leq 1 - u \end{cases}$$

When litigation is costless, there is no distinction between the *de facto* and the *de jure* thresholds, and so $\hat{\lambda} = \lambda = 1 - u$. The firm chooses $q = \lambda = 1 - u$ when the extent of uncertainty about θ is sufficiently small; otherwise, it chooses q_A .

Corollary 1 characterized the static equilibrium for a specific pair of costs. We conclude this section by generalizing the result to any pair of costs (c_P, c_D) . For concreteness, suppose $u - l > 1 - u$. Let $\underline{c}_P(l, u)$ be defined implicitly by $\hat{\lambda}(\underline{c}_P(l, u)) = q_A(l, u)$, and define $\bar{c}_D(l, u, \phi) = \frac{\Pi(l, u) - [(1-u) - \frac{1}{2}(1-u)^2]}{\phi}$, where $\Pi(l, u) = q^*(l, u) - \frac{1}{2}q^*(l, u)^2 - I(q^*(l, u), l, u)$.

Lemma 3 *There exists a function $c_P(c_D, l, u, \phi)$, with $c_P(0) \leq \underline{c}_P$, $c_P(c_D) = 0$ for all $c_D \geq \bar{c}_D$ and $c'_P(c_D) < 0$ for all $c_D \in (0, \bar{c}_D)$ s.t.*

$$q^*(l, u, c_P, c_D, \phi) = \begin{cases} q_A(l, u) & \text{if } c_P < c_P(c_D, l, u, \phi) \\ \hat{\lambda}(c_P) & \text{if } c_P \geq c_P(c_D, l, u, \phi) \end{cases}$$

The ideas in Lemma 3 are illustrated in Figure 2. When joint litigation costs are low, the firm will produce the risky output and the parties will settle out of court. Low costs mean both that the plaintiff can credibly litigate, and that the terms of settlement are not unduly expensive for the defendant. (Recall, as part of the settlement, the defendant pays a fraction of the total litigation costs saved, to the plaintiff.) By contrast, when total litigation costs are high, the firm will produce the safe output and there will be no litigation.

In summary, we have shown that costly litigation creates an incentive for pre-trial settlement. However, the settlement negotiations merely divide the total litigation costs saved by the parties, and do not skew the firm's choice about how much to produce at the margin. The fact of costly litigation affects the firm's pre-trial output choice only insofar as it makes litigation by the plaintiff uncredible in some instances. If so, the firm can afford to raise its output up to the point where litigation becomes credible. There are never trials along the

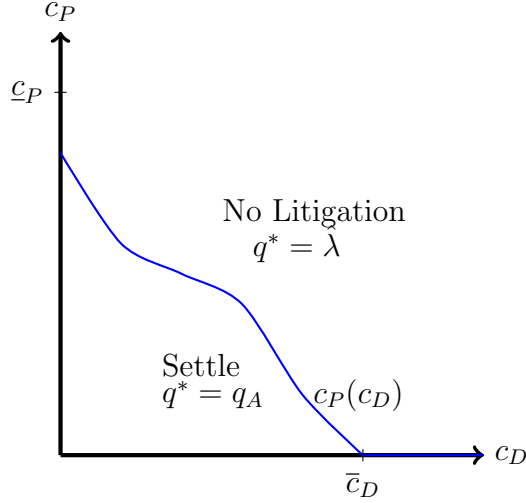


Figure 2: Firm's choice over the cost-parameter space.

equilibrium path. Either the litigants settle out of court (if the firm chooses the risky output) or the plaintiff does not even initiate litigation (if the firm chooses the safe output). Which of these outcomes obtains depends on the breadth of the *de facto* permissive threshold, which in turn depends on the plaintiff's cost of litigation.

In the next section, we explore a different mechanism that generates settlement. We show that this mechanism potentially generates trials along the equilibrium path, and creates incentives that skew the firm's output choice.

4 Dynamic Model

We now proceed to the dynamic (2 period) model. We assume that both the plaintiff and defendant are long-lived, and discount the second period at rates $\delta_P, \delta_D \in [0, 1]$ respectively. This formulation includes, as special cases, a short-lived defendant ($\delta_D = 0$) and a short-lived plaintiff ($\delta_P = 0$). The stage game is identical to the one analyzed in the previous section.

Our focus in this section is on the dynamic incentives to litigate or settle that arise from the law being clarified (or not), and the implications for the firm's first period quantity choice.

To this end, we assume that $c_P = c_D = 0$, so that the incentive to settle (or not) is not driven by explicit litigation costs. An implication is that, in the second period, the plaintiff can always credibly ‘threaten’ to take the firm to court. Furthermore, in the second period, settlement is always a weakly dominant strategy if the firm’s quantity lies in the ambiguous region.

Before proceeding with our analysis, it is useful to make some observations concerning the equilibrium behavior in this dynamic game. First, once the second period arrives, the game is essentially one shot, and so Propositions 1 and 2 fully characterize the equilibrium behavior given the players’ beliefs $[l_2, u_2]$ at the beginning of the second period. In particular, if the second period incentives cause the firm to produce the risky output, the regulator will threaten litigation, but the parties will agree to a settlement out of court.

Second, the incentives to settle in the first period differ in so far as going to trial, by revealing the true θ , causes the law to be clarified in the second period. With this clarity, the firm will produce the true efficient quantity $q_{eff} = 1 - \theta$ in the second period, and do so without risk of penalty. The defendant obviously benefits from clarity, since it is able to produce a larger quantity in expectation (since $E[q_{eff}] = q_E(l, u) > q^*(l, u)$)⁴ whilst avoiding damages. Conversely, clarity in the law harms the plaintiff since she now faces a larger harm in expectation (due to the larger quantity) without any possibility of compensation.

4.1 Credible Trials

As in the static model, we begin by characterizing the plaintiff’s decision about whether to go to trial or not, in the event that settlement bargaining fails. If the plaintiff goes to trial, then, in the first period, she will receive expected damages of $I(q_1, l, u)$. However, going to trial results in the law being clarified, which enables the firm to produce the true

⁴Since $c_P = 0 = c_D$, we suppress the cost arguments, and write $q^*(l, u)$ to mean $q^*(0, 0, l, u, \phi)$. (With costless litigation, the second period choice is unaffected by the bargaining weight ϕ .)

socially efficient quantity $q_{eff} = 1 - \theta$ with impunity in the future. Thus, in the second period, the plaintiff suffers the full expected harm from the firm's production $E[\theta(1 - \theta)]$. By contrast, if the plaintiff drops the case, then she receives no damages in the first period, but prevents learning. The firm produces $q^*(l, u)$ in the second period, and the plaintiff suffers the expected harm $q^*(l, u) \cdot E[\theta]$ less expected damages $I(q^*(l, u), l, u)$. Hence, the plaintiff can credibly go to trial provided that:

$$I(q_1, l, u) - \delta_P E[\theta(1 - \theta)] \geq -\delta_P(q^*(l, u) \cdot E[\theta] - I(q^*(l, u), l, u))$$

Notice that the plaintiff's benefit from going to trial is increasing in the expected first period damages, which are in turn increasing in the firm's first period quantity. Let $A(l, u) = E[\theta(1 - \theta)] - q^*(l, u) \cdot E[\theta] + I(q^*(l, u), l, u) > 0$. We have the following result:

Lemma 4 *There exists a threshold quantity (the de facto permissive threshold) $\tilde{\lambda}(\delta_P, l, u)$ ⁵, characterized by:*

$$I(\tilde{\lambda}(\delta_P, l, u), l, u) = \delta_P A(l, u)$$

such that the plaintiff will credibly take the defendant to trial iff $q_1 > \tilde{\lambda}(\delta_P, l, u)$. Moreover, $\tilde{\lambda}(\delta_P, l, u)$ is increasing in δ_P , $\tilde{\lambda}(0, l, u) = 1 - u$ and $\tilde{\lambda}(1, l, u) > q^(l, u)$.*

Lemma 4 characterizes the *de facto* first period permissive threshold. The plaintiff can credibly take the firm to court provided that the firm produces an output larger than this threshold quantity. The lemma additionally shows that this threshold increases as the plaintiff becomes more patient. If the plaintiff is perfectly impatient ($\delta_P = 0$), it can credibly go to trial whenever the firm produces in the ambiguous region; the permissive threshold is narrow. As the plaintiff becomes more patient, the second period cost of having the law

⁵We distinguish the *de facto* threshold in the static game $\hat{\lambda}(c_P, l, u)$ from the *de facto* threshold in the first period of the dynamic game $\tilde{\lambda}(\delta_P, l, u)$.

clarified deters her from going to trial unless the anticipated first period damages are sufficiently large. Indeed, as the plaintiff becomes sufficiently patient (i.e. $\delta_P \rightarrow 1$), the plaintiff will not be able to credibly take the firm to trial when the firm produces the static optimal output $q^*(l, u)$.

We note an analogy between the plaintiff's litigation cost c_P in the baseline model, and the plaintiff's discount factor δ_P in the dynamic model. In the latter, going to trial is costly for the plaintiff insofar as it produces worse second period outcomes. The discount factor δ_P , thus, parameterizes the cost of going to trial in terms of the first period salience to the regulator of second period losses. As δ_P increases, going to trial implicitly becomes more costly, and this deters the plaintiff from bringing cases unless expected first period damages are sufficiently large. Hence, as in the static model with positive litigation costs, dynamic considerations cause legal rules to be *de facto* broad, even if they are *de jure* narrow.

4.2 Settlement Bargaining

Next, we characterize the anticipated outcomes in the settlement phase. Recall that, if $q_1 \leq \tilde{\lambda}(\delta_P, l, u)$, then the plaintiff cannot credibly go to trial, and so, in the event that bargaining fails, the plaintiff will drop the case. Hence, there will be no learning, whether the parties settle or not, and as such, there are no dynamic considerations in the decision to settle. Settlement purely generates a zero sum first period transfer. The only possible agreement, then, is a settlement with $s_1 = 0$, and this produces the same outcome as if bargaining had failed entirely.

Next, suppose $q_1 > \tilde{\lambda}(\delta_P, l, u)$, so that the plaintiff can credibly go to trial. Now, there are dynamic consequences from settlement, since there will be learning (only) if settlement fails. Let us consider the incentives for the plaintiff and defendant to settle, in turn. Start with the defendant. In the first period, she pays s_1 if she settles and pays expected damages

of $I(q_1, l, u)$ if she does not. In the second period, if she settles and thus does not learn, she optimally produces $q^*(l, u)$ (see Proposition 2), and earns expected profits of $\Pi(l, u) = q^*(l, u) - \frac{1}{2}q^*(l, u)^2 - I(q^*(l, u), l, u)$. By contrast, if settlement fails, she perfectly learns θ , and will optimally produce the true socially efficient quantity $q_{eff} = 1 - \theta$ without fear of being assessed damages. Her expected second period profits will be: $E[(1 - \theta) - \frac{1}{2}(1 - \theta)^2] = \frac{1}{2}(1 - E[\theta^2])$. Hence, it is in the interest of the defendant to settle provided that:

$$-s_1 + \delta_D \Pi(l, u) \geq -I(q_1, l, u) + \delta_D \frac{1}{2}(1 - E[\theta^2])$$

$$I(q_1, l, u) - s_1 \geq \delta_D B(l, u)$$

where $B(l, u) = \frac{1}{2}(1 - E[\theta^2]) - \Pi(l, u) > 0$.

Next, consider the plaintiff. Her first period payoff is the opposite of the defendant's (since there is a pure transfer in the first period). In the second period, with settlement, she suffers the expected uncompensated harms from the firm producing $q^*(l, u)$, which amount to $q^*(l, u) \cdot \frac{u+l}{2} - I(q^*(l, u), l, u)$. By contrast, if settlement fails, she experiences the full harm of having the true socially efficient quantity $q_{eff} = 1 - \theta$ produced. In expectation, she faces uncompensated harms of $E[\theta(1 - \theta)]$. Hence, it is in the interest of the plaintiff to settle provided that:

$$s_1 + \delta_P(-q^*(l, u)E[\theta] + I(q^*(l, u), l, u)) \geq I(q_1, l, u) - \delta_P E[\theta(1 - \theta)]$$

$$I(q_1, l, u) - s_1 \leq \delta_P A(l, u)$$

Hence, there is scope for settlement provided that:

$$\delta_D B(l, u) \leq I(q_1, l, u) - s_1 \leq \delta_P A(l, u)$$

Lemma 5 *Suppose $q_1 > \hat{\lambda}(\delta_P, l, u)$ so that going to trial is individually rational for the*

plaintiff. Then, the agents will agree to a settlement provided that the plaintiff is sufficiently more patient than the defendant. Formally:

$$\frac{\delta_P}{\delta_D} \geq \frac{B(l, u)}{A(l, u)} = \kappa(l, u)$$

The equilibrium settlement is: $s^* = I(q_1, l, u) - (1 - \phi)\delta_P A(l, u) - \phi\delta_D B(l, u)$.

The intuition is as follows: All else equal, in the dynamic game, litigation hurts the plaintiff and helps the defendant. When $\delta_P = 0 = \delta_D$, the dynamic incentives are absent, and so, by the Section 3 analysis, we know that the litigants will agree to a settlement $s_1 = I(q_1, l, u)$. As the litigants become more patient, the benefit to settling goes up for the plaintiff and goes down for the defendant. Thus the maximum willingness to pay by the defendant falls below $I(q_1, l, u)$, but so does the minimum willingness to accept by the plaintiff. A settlement is possible only if the defendant's willingness to pay falls by less than the plaintiff's willingness to accept. But the amount by which both of these fall is increasing in each agent's degree of patience. Hence, settlement will succeed provided that the plaintiff is sufficiently more patient than the defendant. The ratio $\kappa(l, u)$ determines how much more patient the plaintiff must be to guarantee settlement.

Two special cases are worth noting: First, if the defendant is short lived ($\delta_D = 0$), then the litigants will always successfully settle (provided that litigation is rational for the plaintiff). By contrast, if the plaintiff is short-lived ($\delta_P = 0$, and assuming $\delta_D > 0$) then the litigants will never successfully settle.

4.3 Defendant's Optimal Output Choice

We now turn to characterizing the firm's optimal first period output. Let us begin with the case where settlement is not equilibrium consistent (i.e. $\delta_P < \kappa(l, u)\delta_D$). As we have shown,

this situation arises when the defendant's benefit exceeds the plaintiff's cost from having the law clarified. The defendant will ideally choose an output q_1 that induces learning. Notice that, so long as q_1 induces the case to go to trial, the exact choice of q_1 does not affect second period utility at the margin. Thus, conditional upon inducing learning, the firm will simply choose the output that maximizes expected first period profits. If $q_A(l, u) > \tilde{\lambda}(\delta_P, l, u)$, then it is clearly optimal to choose q_A since this maximizes expected first period profits and induces learning. However, if $q_A(l, u) \leq \tilde{\lambda}(\delta_P, l, u)$, then producing this output is not consistent with the case going to trial. The firm will instead produce $\tilde{\lambda} + \varepsilon$ — the smallest output for which the plaintiff can credibly take the defendant to trial.⁶ We can think of this action as the firm generating a 'test case' to bring before the court. Although doing so (relative to producing the safe output $\tilde{\lambda}$) exposes the defendant to first period liability, we can verify that the benefit from learning outweighs this cost. The above discussion implies:

Lemma 6 *Suppose $\delta_P < \kappa(l, u)\delta_D$. The firm will always choose an output that results in a trial. Furthermore:*

$$q^{**} = \begin{cases} q_A(l, u) & \text{if } \tilde{\lambda}(\delta_P, l, u) < q_A(l, u) \\ \tilde{\lambda} + \varepsilon & \text{if } \tilde{\lambda}(\delta_P, l, u) \geq q_A(l, u) \end{cases}$$

Notice that the qualitative features of the firm's first period choice — whether it produces q_A or $\tilde{\lambda} + \varepsilon$ — depend on a comparison between $\tilde{\lambda}(\delta_P, l, u)$ and $q_A(l, u)$. Define $\underline{\delta}_P(l, u) = I(q_A(l, u), l, u)$. By construction $\tilde{\lambda}(\underline{\delta}_P(l, u), l, u) = q_A(l, u)$. We can re-write Lemma 6 in the following way:

Corollary 2 *Suppose $\delta_P < \kappa(l, u)\delta_D$. Then:*

$$q^{**} = \begin{cases} q_A(l, u) & \text{if } \delta_P < \underline{\delta}_P(l, u) \\ \tilde{\lambda} + \varepsilon & \text{if } \delta_P \geq \underline{\delta}_P(l, u) \end{cases}$$

⁶We recognize that the firm is maximizing on an open set, and that a maximizer therefore does not exist. $\tilde{\lambda} + \varepsilon$ should be interpreted as the smallest q that would be available if we discretized our model. We can think of this as the smallest quantity consistent with going to trial that is detectable by the plaintiff.

The intuition is straightforward. When δ_P is low, the *de facto* permissive threshold will not be very broad, which makes the risky output q_A more attractive to the firm. As δ_P becomes larger, the *de facto* permissive threshold becomes broader, eventually making this choice more attractive.

Next, consider the case where settlement is equilibrium consistent (i.e. $\delta_P \geq \kappa(l, u)\delta_D$). Notice that the possibility of settlement is independent of the defendant's chosen first period quantity. (This is because the surplus from settlement stems entirely from the second period utility gain/loss from having the law clarified or not.) Hence, in this regime, learning is precluded no matter the size of the firm's period 1 quantity. The first period quantity merely affects whether the plaintiff can credibly extract a settlement from the defendant or not. Thus, the firm chooses q_1 purely to maximize its first period expected profit. As in the static game, it can either choose the safe output $\tilde{\lambda}(\delta_P)$ which avoids liability entirely, or the static optimal risky output $q_A(l, u)$. In the latter case, the firm anticipates a settlement with the plaintiff as characterized in the previous section. Similar, to the insight in Proposition 2, the firm will produce the risky output unless the *de facto* permissive threshold is sufficiently broad. We have:

Lemma 7 *Suppose $\delta_P < \kappa(l, u)\delta_D$ so that cases never go to trial. There exists a threshold $\lambda^{**}(\delta_P, \delta_D, l, u, \phi)$ such that:*

$$q^{**} = \begin{cases} q_A(l, u) & \text{if } \tilde{\lambda}(\delta_P, l, u) < \lambda^{**} \\ \tilde{\lambda}(\delta_P, l, u) & \text{if } \tilde{\lambda}(\delta_P, l, u) \geq \lambda^{**} \end{cases}$$

We again notice that the qualitative features of the firm's first period choice — whether it produces q_A or $\tilde{\lambda}$ — depend on a comparison between $\tilde{\lambda}(\delta_P, l, u)$ and $\lambda^{**}(\delta_P, \delta_D, l, u, \phi)$. Let $\underline{\delta}_D(l, u) = \frac{\delta_P(l, u)}{\kappa(l, u)}$. We can show the following result:

Corollary 3 *Suppose $\delta_P \geq \kappa(l, u)\delta_D$. There exists a function $\tilde{\delta}_P(\delta_D, l, u)$ such that:*

$$q^{**} = \begin{cases} q_A(l, u) & \text{if } \delta_P < \tilde{\delta}_P(\delta_D, l, u) \\ \tilde{\lambda}(\delta_P, l, u) & \text{if } \delta_P \geq \tilde{\delta}_P(\delta_D, l, u) \end{cases}$$

Moreover, $\tilde{\delta}_P(\underline{\delta}_D) = \underline{\delta}_P$, and $\tilde{\delta}_P$ is strictly increasing in δ_D whenever $\delta_D < \underline{\delta}_D$.

Corollary 3 is analogous to Lemma 3. For each δ_D , there is a threshold $\delta_P(\delta_D)$, such that the firm produces the risky output whenever δ_P is below this threshold, and the safe output otherwise. To understand the dependence of δ_P on δ_D , note that, as δ_D increases, the firm's expected profit from producing the risky output increases as well (because the settlement amount itself is decreasing in δ_D). To keep the firm indifferent between choosing the safe and risky outputs, the safe output must be made more attractive. But this requires δ_P to be larger. Hence $\tilde{\delta}_P$ is an increasing function of δ_D .

Lemmas 6 and 7 together with their associated corollaries imply the following: there are qualitatively four different types of behavior that can arise in the first period of the dynamic game. Depending on the values taken by (δ_P, δ_D) , the firm may either choose the risky output q_A or the 'safe output' $\tilde{\lambda}$ (or $\tilde{\lambda} + \varepsilon$). And this choice may either result in a settlement (possibly with $s = 0$, which is tantamount to the plaintiff not litigating in the first place), or in a trial with learning. We formalize this insight, and its dependence on the underlying parameter values, in Proposition 3 below.

Before stating the Proposition, a small technical point. The function $\tilde{\delta}_P(\delta_D)$ defined in Corollary 3 was only formally pinned down for $\delta_D \leq \underline{\delta}_D$ (see the proof of Corollary 3). For $\delta_D > \underline{\delta}_D$, define $\tilde{\delta}_P(\delta_D) = \underline{\delta}_P$. Notice by construction that $\underline{\delta}_P < \kappa(l, u)\delta_D$ for all $\delta_D > \underline{\delta}_D$.

We are now ready to present the main result:

Proposition 3 *The properties of the dynamic equilibrium are characterized by two loci. The first locus $\delta_P \geq \kappa(l, u)\delta_D$ determines whether the firm produces the risky output $q_A(l, u)$ or the ‘safe output’ ($\hat{\lambda}(\delta_P)$ or $\hat{\lambda}(\delta_P) + \varepsilon$). The second locus $\delta_P \geq \tilde{\delta}_P(\delta_D, l, u)$ determines whether the agents settle or go to trial. This produces four possible regimes:*

1. *If $\delta_P > \kappa(l, u)\delta_D$ and $\delta_P < \tilde{\delta}_P(\delta_D, l, u)$, there is ‘standard settlement’ —the firm produces the risky output making litigation credible, but the agents settle out of court.*
2. *If $\delta_P > \kappa(l, u)\delta_D$ and $\delta_P > \tilde{\delta}_P(\delta_D, l, u)$, there is ‘regulatory capture’ —the firm produces the highest level of output for which litigation is not credible.*
3. *If $\delta_P < \kappa(l, u)\delta_D$ and $\delta_P < \tilde{\delta}_P(\delta_D, l, u) = \underline{\delta}_P$, there is ‘genuine litigation’ —the firm produces the risky output, and the case proceeds to trial.*
4. *If $\delta_P < \kappa(l, u)\delta_D$ and $\delta_P > \tilde{\delta}_P(\delta_D, l, u) = \underline{\delta}_P$, there are ‘test cases’ —the firm produces an output larger than is statically optimal in order to entice litigation.*

Figure 3 illustrates the key features of Proposition 3, and the partition of the parameter space into the four qualitative regimes.

Several features of the equilibrium are worth noting. First, unlike in the static model with explicit litigation costs, the dynamic model predicts that, under certain conditions, trials will arise along the equilibrium path. Indeed, trials will arise whenever the defendant is sufficiently more long-run oriented than the plaintiff (i.e. $\delta_P < \kappa(l, u)\delta_D$). As noted in the Introduction, the vast majority of cases are settled out of court (or not even litigated in the first place), though cases do proceed to trial from time to time. This is suggestive — we think quite plausibly — that plaintiff-regulators are typically more future oriented than their defendant counterparts. Moreover, it predicts that cases that proceed to trial will tend to involve entrenched defendants who can afford to take a long run view.

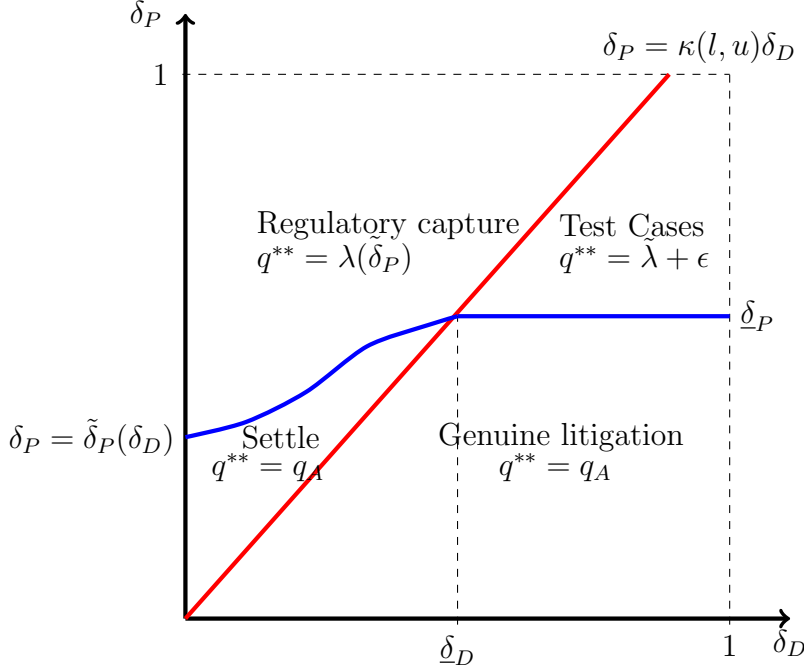


Figure 3: Firm’s choice and litigation outcomes over the discount-parameter space.

Second, our model makes the counter-intuitive point that regulators who are most concerned about long-run outcomes are most susceptible to ‘regulatory capture’. When learning has potentially harmful long run consequences for future plaintiffs, regulators will be more cautious about bringing cases, and this attenuates the incentive for firms to internalize the harms they impose on third parties.

Third, unlike in the static model, there are dynamic incentives for the firm to distort its production decision (relative to what it would choose if it were purely concerned with maximizing static profits). This is most evident in the region of the parameter space where the firm makes a production choice that generates a test-case. Such an incentive never arose in the static model; it was never optimal for the firm to distort its output to affect the terms of settlement. By contrast, in the dynamic game, the learning motive creates incentives for the firm to distort its choice to guarantee that cases will go to trial.

The incentive to distort is stark in our model, because, for simplicity, we considered a framework where learning was all-or-nothing. The firm’s choice either begets perfect information

revelation or none at all. But we can also imagine partial information revelation schemes. For example, in Parameswaran (2018), learning at trial is incomplete; the agents only learn whether the chosen output q was above or below the true efficient level $q_{eff} = 1 - \theta$, not the value of θ itself. Thus, if prior beliefs are $\theta \sim U[l_t, u_t]$, posterior beliefs will either be $\theta \sim U[l_t, 1 - q_t]$ or $\theta \sim U[1 - q_t, u_t]$. In this environment, the defendant not only has a concern for whether learning occurs, but how the learning affects future beliefs. In particular, the defendant does better to learn that their chosen q was not inefficiently large (which enables higher future production). At the margin, this will distort the firm's choice towards producing lower quantities.

4.4 Efficiency

We conclude our analysis by considering the efficiency implications of the behavior that we have studied. We take, as a benchmark, the choices that a benevolent social planner would make. Since settlement results in a zero-sum transfer between agents (assuming no litigation costs), the social planner assigns no particular value to settlement. Straightforwardly, the social planner will produce the *ex ante* socially efficient output $q_E(l_t, u_t)$ in each period, given the period-beliefs (l_t, u_t) . Furthermore, the social planner will litigate whenever there is ambiguity about the law, since clarity improves total social welfare. Hence, there are two components to social welfare. *Static efficiency* requires that the firm produce the *ex ante* socially efficient output in each period, whilst *dynamic efficiency* obtains when there is learning.

A few observations are in order. Firstly, if the equilibrium is dynamically efficient (i.e. if the case goes to trial), then it will be statically efficient in the second period (since, after learning, the firm produces the true socially efficient output q_{eff}). By contrast, if the equilibrium is dynamically inefficient (i.e. if the case is settled or there is regulatory capture), then the firm produces $q^*(l, u) < q_E(l, u)$ in the second period, which is statically

inefficient. Hence, dynamic efficiency directly bears upon second period static efficiency. By proposition 3, it is clear that the equilibrium will be dynamically efficient (and thus also statically efficient in the second period) whenever the defendant is sufficiently patient relative to the plaintiff/regulator.

Second, the question of first period static efficiency is independent of dynamic efficiency. Recall that $q_A(l, u) < q_E(l, u)$, so that if the firm is choosing the risky output (and by Proposition 3, this occurs when $\delta_P < \tilde{\delta}_P(\delta_D)$) it will be inefficiently under-producing relative to the static benchmark. (Recall, the uncertainty in legal outcomes has the effect of over-detering the firm (see Calfee and Craswell, 1984; Parameswaran, 2018).) However, as δ_P increases above $\tilde{\delta}_P(\delta_D)$, the firm switches to producing the safe output (or generates a test case), and this output is increasing in δ_P . Hence, as the plaintiff becomes more patient, the firm's first period quantity choice moves closer to the statically efficient output.

The above discussion implies the following:

Lemma 8 *The equilibrium behavior of the litigants is:*

1. *Dynamically efficient, and therefore statically efficient in the second period, if $\delta_P < \kappa(l, u)\delta_D$. Else, it is dynamically inefficient.*
2. *Statically inefficient in the first period. Moreover, the firm's first period choice moves closer to the statically efficient choice as δ_P increases.*

An immediate implication of Lemma 8 is that the equilibrium will be 'most efficient' (in the sense of being dynamically efficient and implementing an output that is closer to the statically efficient first period output) in the regime where the firm offers test cases, and it will be 'least efficient' when the regime is characterized by settlements.

5 Conclusion

The extant literature on the economics of enforcement typically takes laws as given and then analyzes their effect on the affected parties; both enforcers (regulators) and firms. By contrast, in this paper, we allow the affected parties to influence or shape the law itself. Since common law courts are largely reactive institutions that only adjudicate those cases which are brought before them, litigants can affect the law's evolution through their decisions about settlement and (even) whether to litigate at all.

Our analytical framework identifies two distinct ways in which this could occur. First, to avoid clarifying the law plaintiffs can prevent disputes from going to trial, either by settling pre-trial or by abandoning (or not initiating) litigation altogether. By contrast, defendants (especially sufficiently forward-looking ones) benefit from having the law clarified. Thus, even in situations where the plaintiff would ordinarily not pursue litigation (i.e. if the firm produced its statically optimal output) they can 'force the plaintiff's hand' by distorting their output choice and generating test cases. Each of these effects are especially salient when when the plaintiff or defendant is sufficiently forward-looking.

The result that a long-lived plaintiff does not have incentive to clarify the law to some extent formalizes intuition offered previously by legal scholars. One such argument (Galanter, 1974) notes that "repeat players to 'settle' cases where they expect unfavorable rule outcomes." While Galanter does identify that repeat will players will find reason to shape the law, he does not specify exactly how this will occur between plaintiffs and defendants. Our formalization, however, finds that strategies and incentives for long-lived plaintiffs are very different from those of defendants.

All told, our analysis shows that strategic concerns of long lived plaintiffs can affect the stream of cases that arise in court. Specifically, it predicts that cases that proceed to trial will tend to involve entrenched defendants who can afford to take a long run view, whereas

long-lived plaintiffs, such as regulators, will typically look to resolve disputes out of court, to prevent the law from evolving. Importantly, forward-looking enough plaintiffs may ‘allow’ the firm to choose a higher quantity (than in the static game) without liability; i.e. firms receive a rent from the regulator who wishes to avoid learning. This generates the counter-intuitive point that regulators who are most concerned about long-run outcomes are most susceptible to ‘regulatory capture.’ These effects influence the law’s evolution and its efficacy.

Inter alia, these results raise questions about the overall value of settlement. Settlements are often encouraged because they avoid costly litigation in court. Indeed, from an economic standpoint settlement is often shown to be efficient, and pre-trial settlements have been encouraged by the courts. Accordingly, a vast proportion of enforcement actions by regulators often involve pre-trial settlements with malfeasors (see footnote 1 for examples).

Instead, we find that in a dynamic game, there are two sources of *inefficiencies*. First, is the intra-period externality that arises because the firm produces a higher-than efficient level of output. Second, the dynamic efficiency which arises because the plaintiff settles out of court and prevents the law from evolving. In general there is no guarantee that the law will evolve toward a more efficient outcome or that settlement ensures efficient outcomes. Thus our paper cautions against too quickly concluding that the common law usually yields efficient outcomes (Rubin (1977)). Instead, they provide formal support to arguments made by Fiss (1984) who questioned the value of settlement.

Finally, our paper contributes to the broader literature on regulatory enforcement by offering two, relatively novel, ideas. First, instead of studying how systems and institutions affect actors, we study how actors affect the rules and the institutions such as the courts, while also being affected by those very institutions. As we have shown here, long-lived actors (plaintiffs and defendants) have incentive to try to shape institutions (the courts) to their advantage, but possibly to the detriment of overall social welfare. Second, much of the extant literature either focuses on the role of courts or those of the regulator. Instead, our

framework proposes the ideas that, at least in some cases, the regulator and the court jointly enforce the regulations. As our formal analysis shows, acknowledging these effects alters the impact of regulations. However, both of these two ideas have received very little attention in law and economics. Thus, future work should consider these issues more deeply in other contexts.

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Appendices

Proof of Lemma 1. Recall that the plaintiff's IR constraint is $I(q, l, u) > c_P$. Notice that $I(q, l, u)$ is continuous and strictly increasing in q whenever $q > 1 - u$. Moreover, $I = 0$ when $q = 1 - u$. Hence, for any $c_P > 0$, there exists a $\hat{\lambda} > 1 - u$ s.t. $I(\hat{\lambda}, l, u) = c_P$. Moreover, $\hat{\lambda}$ is strictly increasing in c_P . Since I is strictly increasing in q , it following that $I(q, l, u) > c_P$ whenever $q > \hat{\lambda}(c_P, l, u)$. ■

Proof of Proposition 1. From the proof of Lemma 1 we know that $\hat{\lambda} = 1 - u$ at $c_P = 0$, and $\hat{\lambda} = 1 - l$ when $c_P = \bar{c}_P(l, u)$, and further that $\hat{\lambda}$ is strictly increasing and continuous in c_P for any $c_P \in (0, \bar{c}_P)$. The result then follows immediately, recognizing that the *de jure* permissive threshold is $\lambda = 1 - u$ and the restrictive threshold is $\mu = 1 - l$. ■

Proof of Lemma 2. If $q \leq \hat{\lambda}(c_P, l, u)$, then the plaintiff cannot credibly threaten to take the case to trial. Both agents have disagreement payoffs equal to 0. The firm will not accept any settlement $s > 0$ whilst the regulator will not accept any settlement $s < 0$. The only possible settlement is $s = 0$, which produces the same outcome as if there were no litigation.

Next, suppose $q > \hat{\lambda}(c_P, l, u)$. Then the trial threat is credible. The disagreement payoffs are $I(q, l, u) - c_P$ for the plaintiff, and $-I(q, l, u) - c_D$ for the defendant. The optimal settlement offer is the one that solves (1). The result follows directly from the first order conditions. ■

Proof of Proposition 2. First, notice that the firm will never produce $q < \hat{\lambda}(c_P, l, u)$, since the firm's profit is strictly increasing in the region of *de facto immunity*. Similarly, the firm will never produce $q > 1 - l$, since profits are strictly decreasing in the region of *strict liability*. Hence $q \in [\hat{\lambda}(c_P, l, u), 1 - l]$.

Now, suppose $\hat{\lambda}(l, u, c_P) < 1 - l$. There are two possibilities: either the firm produces $q = \hat{\lambda}$ or it produces some optimally chosen output in the ambiguous region $q \in (\hat{\lambda}, 1 - l)$.

The first order conditions in the ambiguous region imply a local optimum at $q_A(l, u) = 1 - \frac{1-(u-l)+\sqrt{(1-(u-l))^2+3u^2}}{3}$. We can show that $q_A < q_E = 1 - \frac{u+l}{2} < 1-l$, though there is no guarantee that $q_A > \hat{\lambda}$.

If $q_A \leq \hat{\lambda}$, then $q = \hat{\lambda}$ is evidently optimal, since it earns larger profits without the threat of penalty. Suppose $q_A > \hat{\lambda}$. Let $\Pi_A(l, u, c_P, c_D, \phi) = q_A - \frac{1}{2}q_A^2 - I(q_A, l, u) + (1-\phi)c_P - \phi c_D$ be the firm's profit from choosing q_A anticipating the litigation and settlement that may follow. Since $q_A > \hat{\lambda}$, we know that $I(q_A, l, u) > c_P$ and so $I(q_A, l, u) - (1-\phi)c_P + \phi c_D > 0$. Hence $\Pi_A < q_A - \frac{1}{2}q_A^2$.

Let $\Pi_\lambda(\hat{\lambda}) = \hat{\lambda} - \frac{1}{2}\hat{\lambda}^2$ be the firm's profit from choosing $q = \hat{\lambda}$. Since $\hat{\lambda} < 1-l$, $\Pi_\lambda(\hat{\lambda})$ is strictly increasing in $\hat{\lambda}$. Hence, there exists some $\lambda^*(l, u, c_P, c_D, \phi) \geq 1-u$ s.t. $\Pi_\lambda(\lambda^*(l, u, c_P, c_D, \phi)) = \Pi_A(l, u, c_P, c_D, \phi)$. Moreover, since $\Pi_A < q_A - \frac{1}{2}q_A^2$, it follows that $\lambda^*(l, u, c_P, c_D, \phi) < q_A(l, u)$. Hence $q^* = \hat{\lambda}$ if $\hat{\lambda} \geq \lambda^*(l, u, c_P, c_D, \phi)$ and $q^* = q_A(l, u)$ otherwise. ■

Proof of Corollary 1. If $c_P = 0$, then by Lemma 1, $\hat{\lambda}(c_P) = 1-u$. Moreover, if $c_D = 0$, then $\Pi_A > \Pi_\lambda$ whenever $q_A > 1-u$. With some algebra, we can show that this occurs when $u-l > 1-u$. ■

Proof of Lemma 3. By construction $I(\hat{\lambda}(c_P), l, u) = c_P$. If the firm produces the safe output $\hat{\lambda}(c_P)$, its profit is $\Pi_\lambda = \hat{\lambda} - \frac{1}{2}\hat{\lambda}^2$. Denote by $\Pi_A(l, u) = q_A(l, u) - \frac{1}{2}q_A(l, u)^2 - I(q_A(l, u), l, u)$ the firm's expected profit's from the risky output absent litigation costs. With settlements, its expected profit is: $\Pi_A(l, u) + (1-\phi)c_P - \phi c_D$.

The firm will optimal choose the safe output if:

$$\hat{\lambda}(c_P) - \frac{1}{2}\hat{\lambda}(c_P)^2 > \Pi_A(l, u) + (1-\phi)c_P - \phi c_D$$

Let $c_P(c_D)$ denote the locus of cost pairs for which the firm is indifferent between these choices. Then the firm will choose the risky output if $c_P < c_P(c_D)$ given c_D , and vice versa.

Clearly $c_P(c_D)$ is defined implicitly by:

$$\hat{\lambda}(c_P(c_D)) - \frac{1}{2}\hat{\lambda}(c_P(c_D))^2 = \Pi(l, u) + (1 - \phi)c_P(c_D) - \phi c_D \quad (2)$$

First, note that if $c_D = 0$, then the condition becomes:

$$\hat{\lambda}(c_P(0)) - \frac{1}{2}\hat{\lambda}(c_P(0))^2 - I(\hat{\lambda}(c_P(0)), l, u) + \phi c_P = \Pi(l, u)$$

Clearly the RHS is constant in c_P . The LHS is increasing in c_P whenever $\hat{\lambda}(c_P) < q_A$ (since $q - \frac{1}{2}q^2 - I(q, l, u)$ is increasing in q for $q < q_A$). Since $\hat{\lambda}(\underline{c}_P) = q_A$, the LHS reduces to $\Pi(l, u) + \phi \underline{c}_P \geq RHS$ when $c_P = \underline{c}_P$. Hence, if $\phi = 0$, then $c_P(0) = \underline{c}_P$, and if $\phi > 0$, then $c_P(0) < \underline{c}_P$.

Next, return to (2) and note that if $c_D \geq \bar{c}_D$, then the LHS will be larger than the RHS even if $\hat{\lambda}(c_P) = 1 - u$. Hence, the firm will always choose $\hat{\lambda}$, which implies that $c_P(c_D) = 0$.

Finally, suppose $c_D \in (0, \bar{c}_D)$. Totally differentiate (2) w.r.t c_D . We have:

$$\begin{aligned} [1 - \hat{\lambda}(c_P(c_D))] \frac{\partial \hat{\lambda}(c_P)}{\partial c_P} \frac{\partial c_P}{\partial c_D} &= -\phi + (1 - \phi) \frac{\partial c_P}{\partial c_D} \\ \frac{\partial c_P}{\partial c_D} &= -\frac{\phi}{[1 - \hat{\lambda}(c_P(c_D))] \frac{\partial \hat{\lambda}(c_P)}{\partial c_P} - (1 - \phi)} \\ &= -\frac{\phi}{\frac{1 - \hat{\lambda}(c_P(c_D))}{I'(\hat{\lambda}(c_P(c_D)))} - (1 - \phi)} \\ &\in (-1, 0) \end{aligned}$$

where the third line uses the fact that $\frac{\partial \hat{\lambda}(c_P)}{\partial c_P} = \frac{1}{I'(\hat{\lambda}(c_P))}$, where $I'(q, l, u) = \frac{\partial I(q, l, u)}{\partial q}$. (This can be shown by totally differentiating the credibility constraint w.r.t. c_P .) The fourth line uses the fact that $1 - \hat{\lambda} - I'(\hat{\lambda}, l, u) > 0$ whenever $\hat{\lambda} < q_A$, which is an immediate consequence of the first order conditions. Hence, we have shown that $c_P(c_D)$ is strictly decreasing in the relevant region. ■

Proof of Lemma 4. The plaintiff's IR constraint can be written:

$$I(q_1, l, u) > \delta_P(E[\theta(1 - \theta)] + I(q^*(l, u), l, u) - q^*(l, u) \cdot E[\theta])$$

The left-hand side is continuous and strictly increasing in q_1 , whilst the right-hand side is constant in q_1 . Hence, there exists some $\tilde{\lambda}$ such that the IR condition is satisfied whenever $q_1 > \tilde{\lambda}(\delta_P, l, u)$. Since $I(1 - u, l, u) = 0$, $\tilde{\lambda}(0, l, u) = 1 - u$.

Next, we show that $\tilde{\lambda}(1, l, u) > q^*(l, u)$. Define $\mathcal{A}(q, l, u) = E[\theta(1 - \theta)] + I(q, l, u) - q \cdot E[\theta]$. Then the *de facto* threshold is defined by $I(\tilde{\lambda}(\delta_P, l, u), l, u) = \delta_P \mathcal{A}(q^*(l, u), l, u)$. If $\mathcal{A}(q^*(l, u), l, u) > 0$, then the right-hand side is strictly increasing in δ_P and so it must be that $\tilde{\lambda}$ is strictly increasing in δ_P as well. Moreover, if $I(q^*(l, u), l, u) < \mathcal{A}(q^*(l, u), l, u)$, then it must be that $\tilde{\lambda}(1, l, u) > q^*(l, u)$.

Thus it suffices to show that $\mathcal{A}(q^*(l, u), l, u) > I(q^*(l, u), l, u)$. Notice that this will be true whenever $q^*(l, u)E[\theta] < E[\theta(1 - \theta)]$, since $I(q, l, u) \geq 0$. There are two possibilities to consider: either $q^*(l, u) = 1 - u$ or $q^*(l, u) = q_A(l, u)$. If $q^*(l, u) = 1 - u$ (which occurs when $u - l \leq 1 - u$), then:

$$\begin{aligned} E[\theta(1 - \theta)] &= \int_l^u \theta(1 - \theta) \cdot \frac{1}{u - l} d\theta \\ &> \int_l^u \theta(1 - u) \cdot \frac{1}{u - l} \\ &= q^*(l, u)E[\theta] \end{aligned}$$

as required.

Suppose instead $u - l > 1 - u$ so that $q^*(l, u) = q_A(l, u)$. Let $x(l, u) = E[\theta(1 - \theta)] - q_A(l, u)E[\theta]$. It suffices to show that $x > 0$. First, consider the special case of $l = 0$. Then $x(0, u) = \frac{u}{6}(1 - 3u + \sqrt{(1 - u)^2 + 3u^2})$. With a little algebra, we can verify that $x(0, u) > 0$ whenever $u < 0.8$. (Recall, we restricted the parameter space so that $u < 0.8$.) Next, for any u , note

that:

$$\frac{\partial x}{\partial l} = \frac{[1 + 3l + 2l^2 - u - 2lu + 3u^2]}{6\sqrt{(1 + l - u)^2 + 3u^2}} + 1 - \frac{l + u}{3}.$$

Clearly, the last two terms of the previous expression are positive (together). Now consider the first term. Again, the denominator is positive. The numerator,

$$[1 + 3l + 2l^2 - u - 2lu + 3u^2]$$

is increasing in l (its derivative with respect to l is $3 + 6l - 2u > 0$) and it is strictly positive at $l = 0$ ($= 1 - u + 3u^2$). Thus, for any value of l , $\frac{\partial x}{\partial l} > 0$. Hence, if $u < .8$ then $x > 0$ for any $l < u$. This completes the proof. ■

Proof of Lemma 5. We have already shown that there is scope for settlement provided that:

$$\delta_D B(l, u) \leq I(q_1, l, u) - S \leq \delta_P A(l, u)$$

Ignoring the middle term, the result follows immediately, provided that $\delta_D > 0$ and $B(l, u) > 0$.

To show the latter, first note the total expected second period social welfare if there is learning is given by: $W_L(l, u) = E[1 - \theta] - \frac{1}{2}E[(1 - \theta)^2] - E[\theta(1 - \theta)] = \frac{1}{2}E[(1 - \theta)^2]$. By contrast, if there is no learning, expected second period social welfare is:

$$\begin{aligned} W_{NL}(l, u) &= q^*(l, u) - \frac{1}{2}q^*(l, u)^2 - E[\theta]q^*(l, u) \\ &\leq (1 - E[\theta]) - \frac{1}{2}(1 - E[\theta])^2 - E[\theta](1 - E[\theta]) \\ &= \frac{1}{2}(1 - E[\theta])^2 \\ &< \frac{1}{2}E[(1 - \theta)^2] = W_L(l, u) \end{aligned}$$

where the second line uses the fact that *ex ante* social welfare is maximized at $q = 1 - E[\theta]$,

and the last line uses Jensen's inequality. Hence, learning increases social welfare. But we have also shown that learning harms the plaintiff. Thus, learning must benefit the defendant in the second period. $B(l, u) = \frac{1}{2}(1 - E[\theta^2]) - \Pi(l, u)$ is the second period benefit to the plaintiff from learning. Clearly $B(l, u) > 0$. ■

Proof of Lemma 6 and Corollary 2. Suppose $\delta_P < \kappa(l, u)\delta_D$. The firm has 3 possible choices: (i) the risky output $q_A(l, u)$, which results in learning; (ii) the safe output $\tilde{\lambda}$, which does not induce learning; and (iii) a test case $\tilde{\lambda} + \varepsilon$, which does induce learning.

First, we show that the safe option is never chosen. The safe option is preferred to the test case provided that:

$$\begin{aligned} \tilde{\lambda} - \frac{1}{2}\tilde{\lambda}^2 + \delta_D\Pi(l, u) &\geq \tilde{\lambda} - \frac{1}{2}\tilde{\lambda}^2 - I(\tilde{\lambda}, l, u) + \delta_D\frac{1}{2}(1 - E[\theta^2]) \\ I(\tilde{\lambda}, l, u) &\geq \delta_D B(l, u) \\ \delta_P A(l, u) &\geq \delta_D B(l, u) \\ \frac{\delta_P}{\delta_D} &\geq \frac{B(l, u)}{A(l, u)} = \kappa(l, u) \end{aligned}$$

where we use the fact that $I(\tilde{\lambda}) = \delta_P A(l, u)$. But this contradicts the assumption that $\delta_P < \kappa(l, u)\delta_D$. Hence the safe option is dominated by the test case.

Now, if $q_A(l, u) \leq \tilde{\lambda}(\delta_P)$, the safe option must dominate the risky one (since it generates larger period 1 profits, and generates the same second period behavior). If so, the test case is preferred to the risky option. By contrast, if $q_A(l, u) > \tilde{\lambda}(\delta_P)$, then the risky option and test case both generate the same second period outcome (since both induce learning), and so to choose between them it suffices to compare the first period profits from each. But we know that $q_A(l, u)$ maximizes first period profits when litigation is credible. Hence $q_A(l, u)$ is preferable. Hence, the firm chooses $q_A(l, u)$ whenever $\tilde{\lambda}(\delta_P) < q_A(l, u)$ and the test case otherwise.

Finally, to prove the Corollary, note that $\tilde{\lambda}(\underline{\delta}_P(l, u), l, u) = q_A(l, u)$ by construction, since $I(q_A(l, u), l, u) = \underline{\delta}_P(l, u)$. Then, since $\tilde{\lambda}$ is strictly increasing in δ_P , $\tilde{\lambda}(\delta_P) \geq q_A(l, u)$ implies that $\delta_P \geq \underline{\delta}_P(l, u)$. This completes the proof. ■

Proof of Lemma 7 and Corollary 3. Suppose $\delta_P > \kappa(l, u)\delta_D$. Then since disputes will always be settled, the firm's period 1 output q_1 will have no dynamic consequence; it should simply be chosen to maximize first period expected profit.

Suppose the firm produces in the region where trials are credible. Then, noting that any ensuing litigation will be settled, its stage game utility is:

$$q_1 - \frac{1}{2}q_1^2 - I(q_1, l, u) + (1 - \phi)\delta_P A(l, u) + \phi\delta_D B(l, u)$$

The q_1 that maximizes this is also the maximizer of $q_1 - \frac{1}{2}q_1^2 - I(q_1, l, u)$, which we know is $q_A(l, u)$. If instead the firm produces in the region where trials are not credible, it will produce $\tilde{\lambda}(\delta_P, l, u)$, since profits are strictly increasing in this region. Hence, the firm's choice is between $q_A(l, u)$ and $\tilde{\lambda}(\delta_P)$, as usual.

Recall, $\underline{\delta}_P(l, u)$ is defined so that $\tilde{\lambda}(\underline{\delta}_P) = q_A(l, u)$. If $\delta_P > \underline{\delta}_P$ (i.e. if $\tilde{\lambda}(\delta_P) > q_A(l, u)$), then the safe output is definitely preferred. To see this, let Π_λ and Π_A denote the firm's first period profits from producing $\tilde{\lambda}$ and q_A respectively. We have:

$$\begin{aligned} \Pi_\lambda &= \tilde{\lambda}(\delta_P) - \frac{1}{2}\tilde{\lambda}(\delta_P)^2 \\ &> q_A(l, u) - \frac{1}{2}q_A(l, u)^2 \\ &\geq q_A(l, u) - \frac{1}{2}q_A(l, u)^2 - S \\ &= \Pi_A \end{aligned}$$

Now, suppose $\delta_P \leq \underline{\delta}_P(l, u)$. Notice that since, by assumption, $\delta_P > \kappa(l, u)\delta_D$, then $\delta_D <$

$\frac{\delta_P}{\kappa(l,u)} \leq \frac{\delta_P(l,u)}{\kappa(l,u)} = \underline{\delta}_D(l,u)$. If the firm produces the safe output, its lifetime utility will be: $\tilde{\lambda}(\delta_P) - \frac{1}{2}\tilde{\lambda}(\delta_P)^2 + \delta_D\Pi(l,u)$. If instead it produces the risky output, anticipating the likely settlement, its lifetime utility will be: $\Pi(l,u) + \delta_D \cdot \frac{1}{2}(1 - E[\theta^2]) + (1 - \phi)[\delta_P A(l,u) - \delta_D B(l,u)]$, which is simply its lifetime utility if settlement fails plus its share of the surplus from settlement. Hence, the firm will produce the safe output $\tilde{\lambda}$ provided that:

$$\begin{aligned} \tilde{\lambda}(\delta_P) - \frac{1}{2}\tilde{\lambda}(\delta_P)^2 + \delta_D\Pi(l,u) &> \Pi(l,u) + \delta_D \cdot \frac{1}{2}(1 - E[\theta^2]) + (1 - \phi)[\delta_P A(l,u) - \delta_D B(l,u)] \\ \tilde{\lambda}(\delta_P) - \frac{1}{2}\tilde{\lambda}(\delta_P)^2 &> \Pi(l,u) + (1 - \phi)\delta_P A(l,u) + \phi\delta_D B(l,u) \\ \tilde{\lambda}(\delta_P) - \frac{1}{2}\tilde{\lambda}(\delta_P)^2 - I(\tilde{\lambda}(\delta_P), l, u) &> \Pi(l,u) - \phi[\delta_P A(l,u) - \delta_D B(l,u)] \end{aligned}$$

where we used the fact that $I(\tilde{\lambda}(\delta_P), l, u) = \delta_P A(l, u)$.

Define the function:

$$\chi(\delta_P, \delta_D) = \left\{ \tilde{\lambda}(\delta_P) - \frac{1}{2}\tilde{\lambda}(\delta_P)^2 - I(\tilde{\lambda}(\delta_P), l, u) \right\} - \Pi(l, u) + \phi[\delta_P A(l, u) - \delta_D B(l, u)]$$

Note that whenever $\delta_P \geq \kappa(l, u)\delta_D$ (as is assumed), $\delta_P A(l, u) - \delta_D B(l, u) \geq 0$. Also, by the definition of $\underline{\delta}_P$, the terms in braces simplify to $\Pi(l, u)$ when $\delta_P = \underline{\delta}_P$.

Fix some $\delta_D < \underline{\delta}_D$. Since $\underline{\delta}_P > \kappa(l, u)\delta_D$ for $\delta_D < \underline{\delta}_D$, then $\underline{\delta}_P A(l, u) - \delta_D B(l, u) > 0$. We then have: $\chi(\underline{\delta}_P, \delta_D) > 0$ (assuming $\phi > 0$) and $\chi(\kappa(l, u)\delta_D, \delta_D) < 0$. (The latter is true because the term in braces must be strictly less than $\Pi(l, u)$ and the third term will be zero.) Hence, by the intermediate value theorem, for each δ_D there must be some $\delta_P(\delta_D)$ s.t. $\chi(\delta_P(\delta_D), \delta_D) = 0$. In fact, this δ_P must be unique since χ is strictly increasing in δ_P over the relevant range. (To see this, note that when $\delta_P < \underline{\delta}_P$, $\tilde{\lambda}(\delta_P) < q_A(l, u)$, so $1 - \tilde{\lambda}(\delta_P) - \frac{\partial I(\tilde{\lambda}(\delta_P), l, u)}{\partial q} > 0$.)

The function $\delta_P(\delta_D)$ defines the boundary between the regions where $q_A(l, u)$ and $\tilde{\lambda}$, respectively, are chosen. Since $\frac{\partial \chi}{\partial \delta_P} > 0$ and $\frac{\partial \chi}{\partial \delta_D} = -\phi B(l, u) < 0$, then by the implicit function

theorem, $\frac{\partial \delta_P(\delta_D)}{\partial \delta_D} = -\frac{\frac{\partial \chi}{\partial \delta_D}}{\frac{\partial \chi}{\partial \delta_P}} > 0$.

Finally, if $\delta_P = \underline{\delta}_P$, then $\chi(\underline{\delta}_P, \delta_D) = 0$ only if $\underline{\delta}_P A(l, u) - \delta_D B(l, u) = 0$, i.e. if $\underline{\delta}_P = \kappa(l, u) \delta_D$, which implies that $\delta_D = \underline{\delta}_D$. ■

Proof of Proposition 3. The Proposition is an immediate consequence of Corollaries 2 and 3. The only thing that we haven't done is fully characterize the locus $\tilde{\delta}_P(\delta_D, l, u)$. The proof of Corollary 3 pins down this function for $\delta_D < \underline{\delta}_D$. For $\delta_D > \underline{\delta}_D$, we know that the firm induces a test case whenever $\delta_P > \underline{\delta}_P(l, u)$, so define $\tilde{\delta}_P(\delta_D, l, u) = \underline{\delta}_P(l, u)$ in this range. Furthermore, it should be clear that the function so defined is continuous at $\underline{\delta}_D$, since $\lim_{\delta_D \uparrow \underline{\delta}_D} \delta_P(\delta_D) = \underline{\delta}_P$. ■

Proof of Corollary 8. The lemma follows directly from Proposition 3. The only thing left to show is that $\tilde{\lambda}(1, l, u) < q_E(l, u)$. It suffices to show that $\tilde{\lambda}(1, l, u) < q_E(l, u)$. First, note that $\mathcal{A}(q, l, u)$ is quasi-convex in q . To see this, it suffices to show that any critical point in the region $q \in (0, 1)$ is a local minimum. Note that:

$$\mathcal{A}(q; l, u) = - \int_l^{1-q} q \frac{\theta}{u-l} d\theta + E[\theta(1-\theta)]$$

and so:

$$\begin{aligned} \mathcal{A}'(q) &= - \int_l^{1-q} \frac{\theta}{u-l} d\theta + \frac{q(1-q)}{u-l} = \frac{4q - 3q^2 - 1 + l^2}{2(u-l)} \\ \mathcal{A}''(q) &= \frac{2 - 3q}{u-l} \end{aligned}$$

Within the feasible set ($q \in [0, 1]$), $\mathcal{A}(q)$ admits a single critical point: $q = \frac{2 - \sqrt{1 + 3l^2}}{3}$, and this root lies in the interval $[0, \frac{1}{3}]$. But for any $q \in [0, \frac{1}{3}]$, $\mathcal{A}''(q) > 0$. Hence, any admissible critical point is a local minimum, and so R is quasi-convex in q over the relevant region. Now, since $q(l, u) \in [1 - u, q_E(l, u)]$ and since \mathcal{A} is quasi-convex in q , it follows that $\mathcal{A}(q(l, u)) \leq \max\{\mathcal{A}(1 - u), \mathcal{A}(q_E(l, u))\}$

Recall that $\hat{\lambda}(\delta_P, l, u)$ is defined implicitly by $I(\hat{\lambda}(\delta_P, l, u), l, u) = \mathcal{A}(q^*(l, u), l, u)$. To show that $\hat{\lambda} < q_E$, we establish that $I(q_E, l, u) > \mathcal{A}(q^*(l, u))$. By the quasi-convexity of \mathcal{A} , it suffices to show that $I(q_E, l, u) > \max\{\mathcal{A}(1 - u), \mathcal{A}(q_E)\}$. To see that $I(q_E, l, u) > \mathcal{A}(q_E)$, notice by Jensen's inequality that: $(1 - E[\theta])E[\theta] > E[\theta(1 - \theta)]$. Then:

$$I(q_E, l, u) > I(q_E, l, u) - (1 - E[\theta])E[\theta] + E[\theta(1 - \theta)] = \mathcal{A}(q_E, l, u)$$

as required. ■