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An Integrated Theory of Litigation and Legal Standards

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Abstract

I propose an integrated understanding of litigation and legal standards that allows us to answer key questions in the functioning of common law legal systems: When do *substantive trials* occur?; does society face too many or too few of *these* trials?; and can legal standards be used to correct a potentially inefficient frequency of litigation? I characterize the dynamics of substantive trials and predict their occurrence on an infinite horizon. I show, for three reasons, that private and socially optimal litigation frequencies are not equal, identifying corrections. I also derive state contingent and non-contingent optimal standards, and discuss policy implications.

Key words: Standard of effort, substantive trials, frequency of litigation, dynamic litigation, common law courts, negligence

JEL: K10, K40, K41

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1. INTRODUCTION

Few institutions are more important for preserving American constitutional order and for impacting the life of common citizens than the U.S. Supreme Court. Court decisions such as *Brown* (1954), *Miranda* (1966), *Roe* (1973) and *Obergefell* (2015) are among the many examples of how this bicentenary Court has constantly been called to clarify, update and create laws that regulate significant matters of daily life.[1] However, the Court is only able to shape the evolution of the law when called upon to resolve substantive legal disputes. In other words, the Supreme Court cannot initiate the process of improving the law until a trial solicits its ruling. Given this limitation, it seems relevant to ask: How often do trials that allow superior courts to update the law take place? Does society face too many or too few of *these* trials? And if the frequency of *this type* of trial is not efficient, what can we do to correct this inefficiency?

Here I address the previous questions in the context of the evolution of common law legal standards. Common law legal standards play the fundamental role of incentivizing individuals to choose optimal levels of effort in their ordinary and professional lives. Standards such as the prudent physician, corporate fiduciary duties or the reasonable person are key to improving the quality of professional services and preventing accidents in daily life. Society, however, faces a double challenge in its endeavor to set efficient legal standards. First, as the socioeconomic and technological conditions faced by society are constantly evolving, optimal standards are unlikely to be constant over time. Second, common law judges, who have the unique opportunity to update the standards through their judicial decisions, have to wait until a trial takes place to actively participate in this process.[2] Central questions follow: When does a legal dispute result in a trial on the merits that may update legal standards? When does society face too many or too few of such trials? Can standards be used to correct a potentially inefficient trial frequency?

To address these questions I study the interaction between litigating parties and the courts, before and during disputes. To this end, I analyze the impact of the legal standards on the litigation

[1] In *Brown* (1954) the Court decided that it is unconstitutional to separate black and white students in public schools. In *Miranda* (1966) it decided that prisoners must be advised by the police of their rights before being questioned by the police. In *Roe* (1973) it decided that women have a constitutional right to an abortion during the first two trimesters of pregnancy. And in *Obergefell* (2015) the Court legalized same-sex marriage across all 50 states.

[2] The updating of standards may refer to changes in the legal statement (*e.g.*, medical malpractice standards move from a local to a national level) as well as to changes in their meaning or interpretation (*e.g.*, meaning and implications of the corporate fiduciary duties in the case of the sale of a corporation).

decisions (to sue, settle or litigate on merits) made by the parties in dispute. Yet, given the impact of legal standards on the incentives and wellbeing of parties, I also analyze Court decisions to confirm or update legal standards. To my knowledge, these bilateral interactions have not been studied within a dynamic setting as I do here.

While trials are ongoing, most fall within the category of 'fact trials,' for which their legal agents (judge, jury and advocates) seek to clarify facts to establish the liability of the disputing parties.[3] There is, however, a separate and rare set of trials in which legal agents debate substantive legal issues. When such 'substantive trials' reach a supreme court they allow justices to confirm, revise, or update common law.[4] In the present study I introduce a dynamic tort model under the rule of simple negligence that examines the occurrence of substantive trials.[5] I model the sequence of events, beginning with the potential defendant's choice to invest in effort to prevent an accident which might lead the injured party to sue, and continue with the decision by the parties to either reach an agreement or defer to a Court decision (trial). At trial, the Court determines whether a defendant's effort met threshold standards for the current socioeconomic and technological reality, and in the process may update these standards. In analyzing this process, I consider scenarios in which the court is either myopic or forward-looking in its sentencing.

As a first main outcome, the model determines the periodicity with which substantive trials occur. In other words, given the occurrence of a substantive trail, the model predicts when the next trial will happen. The period between trials shortens when one or more of the following alterations occurs: reduced cost of litigation, greater harm associated with a tort, or increased evolution of the regulated socio-economic and technological context. The cyclical nature of substantive trials determines a period of time during which legal standards are fixed. The logic of this dynamic is as follows. First, when new legal standards are set at a substantive trial, potential defendants optimally choose to update their effort, matching it to that legal standard. Second, if few periods have passed since the last substantive trial, then potential plaintiffs will not sue, as the probability

[3] According to the Bureau of Justice Statistics in 2006 non-traffic cases per full-time general jurisdiction court judge ranged from a low of 360 cases in Massachusetts to a high of 4,374 in South Carolina. Hence the assumption that trials take place every period, used in frameworks such as Miceli (2010) or Baker and Mezzetti (2012) seems reasonable.

[4] For example, trials that challenge the state of doctrines such as *fair use* in Intellectual Property Law or *minimum resale price* in Antitrust Law or *antitakeover defenses* in Corporate Law have not taken place every month, not even every year but have happened with low periodicity.

[5] Unintentional harm (accidental injuries) under the requirement of a standard of simple negligence. As defined in *Parrot vs Wells Fargo* (1872) simple negligence is the omission to do something which a reasonable man, guided by those considerations which a prudent and reasonable man would not do. Much of our analysis is valid if other rules of liability such as contributory, comparative negligence or even shared as in Friedman (2017) are considered.

that the regulated context has evolved in a way that the effort made by the potential defendant makes him liable will not be large enough. Finally, applying the logic of information decay, when enough time has passed since the last trial, the probability that the potential defendant has indeed acted negligently will justify plaintiffs´ initiation of a trial. Unlike the traditional reasons why trials occur — asymmetries of information, different expectations for the outcome, or irrationality — substantive trials take place because of incomplete information.

Having characterized the dynamics of substantive trials, I continue by calculating the optimal periodicity of these type of trials — we consider injuries, as well as precaution and litigation costs associated with present and future parties in dispute.[6] I find that the optimal periodicity is not constant, but instead depends upon the socio-economic and technological conditions revealed at the previous substantive trial. In a demanding context in which effort must increase over time to meet legal standards, society benefits when substantive trials take place less frequently because the social cost of an erroneous standard tends to decrease with time. Unlike the periodicity of trials initiated by litigants (I call it private periodicity), optimal periodicity depends upon the discount rate and not upon the distribution of litigation expenses between the parties in dispute.

I identify three reasons why private and optimal periodicities are not equal. First, while a plaintiff only considers the litigation costs in his own legal actions, a central planner considers the total cost of the same litigation (this is a negative externality which implies an excess of trials). Second, while a plaintiff only considers the harm she individually suffers, a central planner considers the costs and benefits for society if the current standard is updated (this can be a positive or a negative externality). Third, while litigants only care about the present,[7] a central planner considers the comprehensive impact of adjusted standards on future expected harm, as well as effort and litigation costs of a trial (again, this can be a positive or negative externality).[8]

Having found private and optimal periodicities of substantive trials, I suggest specific remedies to ameliorate or eliminate the difference between the private and social periodicities. For example, I identify the optimal distribution of litigation expense and the optimal tax/subsidy per dispute. I

[6] In other versions of the paper I simultaneously studied the dynamics of fact and substantive trials. As the exposition became so cumbersome and the main results did not change I decided to eliminate fact trials from the model. That said, it is important to consider that an update of a legal standard will not only benefit PDs and PPs that could be involved in future substantive disputes, but it will also benefit the PDs and PPs involved in fact disputes. Indeed because of the number of disputes, the standard update will be more relevant for the last type of disputes.

[7] Unless we are dealing with projected scenarios of repeated litigation as in Che (1993) or Hua and Spier (2006).

[8] Notice that the decision to hold a trial at time t instead of $t + 1$ modifies the timing of all future trials.

note that a tax/subsidy always exists that will induce parties to litigate with an optimal frequency. Yet, in the case of the distribution of litigation expenses, a complete correction of the private-social divergence might not be feasible if trials are too infrequent. A key question here is whether courts can use the standards to reduce or eliminate the private-social frequency gap, and the answer depends upon the compensation system. I find that when legal compensations take the form of full damages then the private periodicity of substantive trials does not depend upon legal standards. But if compensation takes the form of expectation damages then the periodicity will depend upon them, and in this scenario courts can set standards that reduce the private-social gap.

In the third and final part of this paper, I identify dynamically efficient legal standards in several situations. I identify standards that are not contingent upon the state of the regulated context (the standard is the same during the period of time that takes place between two substantive trials) and I also identify standards that are state contingent (standards that can change each period of time). Both contingent and non-contingent standards are a weighted combination of the optimal standards for each state of the regulated context. Furthermore, because non-contingent standards tend to over-emphasize the relevance of the new expected state of the regulated context they demand larger efforts than contingent standards. In addition, I find that when the compensation system is based upon full damages then courts cannot use legal standards to affect the frequency of substantive trials. But if the compensation system is based upon expectation damages courts can actively affect the frequency of litigation by reshaping the standards. However, as the parties are the ones that decide when to go to trial, the optimal frequency of litigation cannot be achieved.[9]

The paper connects with three strands of the literature. First, it connects with an extensive literature that has studied the central question on when trials take place. From the seminal models of Posner (1973), Rubin (1977) and Priest (1977) that consider the costs and benefits faced by the parties deciding lawsuits, passing through more detailed descriptions of the dynamics of pre-trial and on-trial processes faced by the parties such as in Spier (1992) or Bebchuck (1996) and arriving to more recent structural models such as Dranove, Ramanarayanan and Watanabe (2013) the

[9] A key consideration in the discussion is whether agents can learn the state of nature outside Court (you may vinculate this to conventions, trainings, etc.). As expected, results centrally depend on the cost that agents pay to learn. If the cost is very small then defendants will always pay to make better decisions. Instead if the cost is large then the analysis holds unchanged. The most interesting case happens when the cost has an intermediate value. In that situation, the results are changed quantitatively but not qualitatively. Essentially, substantive trials still take place in cycles but those cycles are longer. An important consideration is that the parties´ investments in information generate private benefits unlike trials which generate social benefits.

literature has emphasized that trials take place either because there exist asymmetries of information, the parties have different expectations on the outcome of the dispute or one of the litigants is irrational. To my knowledge the literature does not distinguish between fact-uncertainty related or legal-uncertainty related trials in the way I do here.

The paper also draws upon a series of articles that study the differences between the private and social incentives to initiate lawsuits that may end in trials. Seminally Shavell (1982), Menell (1983) and Kaplow (1986) suggest that the existence of two externalities would explain why it is very likely that the frequency with which trials take place is not optimal. These two externalities, which are further studied by Shavell (1997, 1999), consist in: 1) the parties in dispute do not internalize that the total costs of litigation are larger than the litigation costs they face individually and 2) the parties in dispute do not internalize that their decisions to resolve their disputes through litigation will motivate other parties to choose higher levels of precautionary effort. Here, in the context of a long-lived Court that faces an infinite horizon problem I find that only the externality based on differences in litigation costs exist, the externality on different incentives to make effort does not appear. I find the two other externalities (harm and litigation costs; and intertemporal considerations) and not only explicitly identify expressions for them but also derive specific remedies.

As a third connection, this paper also intersects with more recent literature that studies efficiency in the evolution of common law. Building upon classic work by Ehrlich and Posner (1974), Rubin (1977) and Priest (1977), which argues that common law evolves efficiently ― although for different reasons ― Fon and Parisi (2003, 2005, 2006) identify the conditions under which a path dependent law, both under *stare decisis and jurisprudence constant*, will evolve towards the consolidation of legal rules. These papers focus in the role played by the parties and their stakes in dispute to determine whether efficient rules tend to replace inefficient rules with time. Papers such as Genniaoli and Shleifer (2007a) or Niblett, Posner and Shleifer (2010) shift the focus of the discussion on the evolution of the law from the decisions made by the parties to the decisions made by the Courts. Although the first paper finds theoretical support to the claim of efficient evolution,[10] the second one finds empirical evidence that supports a claim of no

[10] In the words of the authors: “Even when judges are motivated by personal agendas, legal evolution is, on average, beneficial because it washes out judicial biases and renders the law more precise.

convergence for certain legal rules.[11] Miceli (2010) also contributes to this literature at identifying the steady state legal rules and argues in favor of a tendency of the law to evolve efficiently.

Closest to my framework is Baker and Mezzetti (2012) who develop a dynamic model to study the rational evolution of jurisprudence, including whether it is efficient, and derive an economic explanation of why judges sometimes follow precedents. The authors model the evolution of the legal doctrine as an interval that converges to a steady state. Although Baker and Mezzetti solve a full blown dynamic problem they do not model the litigation decisions of the parties and ergo the central questions on the realization and frequency of trials as well as the link between standards and trials cannot be answered over there. In this paper I do not support or reject the claim that common law evolves efficiently — in large part because within my model this discussion is tied to assumptions about the evolution of the regulated context. Instead I predict the expected evolution of legal standards when courts are myopic and characterize the standards that a long-lived and benevolent Court (central planner) would like to set.

As a final consideration, this paper has both positive and normative messages. On the positive side I make testable predictions on the dynamics of trials and the standards set by judges, distinguishing present-looking from forward-looking judges. On the normative side I find the optimal frequency of litigation and the optimal legal standards. It is a prerogative of the reader to decide which of these messages are potentially more relevant.

The rest of the article is organized as follows. Section 2 discusses the link between the evolution of the regulated context and legal standards. Section 3 introduces the model. Section 4 derives the main results and Section 5 discusses them. Section 6 studies robustness of the results and discusses extensions. Finally, Section 7 concludes.

2. EVOLUTION OF THE REGULATED CONTEXT AND EVOLUTION OF THE COMMON LAW LEGAL STANDARDS

Our socioeconomic and technological realities are constantly evolving. Not only do technological and financial innovations change our professional and ordinary lives but so too do cultural and socioeconomic fads. Through some examples I want to show how changes in the

[11] The authors work with a dataset relating construction disputes that took place from 1970 to 2005. Genniaoli and Shleifer (2007b) suggest that the common law appeal courts´ practice of overruling past precedents will make it difficult for rules to converge to efficient levels.

technological and socio-economic context have been behind a large number of the substantial legal cases that have called courts to revise and/or update legal standards. Following this, I note recent scholarly evidence emphasizing the impact of legal standards (mainly their changes) on the behavior of the agents involved in the economic activities associated with the dispute in question. Using these two sources (legal cases and academic research) I emphasize the relevance of bilateral interaction between the relevant agents and the courts in any attempt to describe the dynamics of substantive litigation and the evolution of legal standards.

Technological and Procedural Innovation in Medicine: When innovative transvaginal mesh was commercially introduced early in the 2000s, this new technology promised to relieve the urinary incontinence-related problems suffered by millions of women around the world. Unfortunately, while it delivered on some promised benefits, the mesh (temporary or permanent) also brought many problems. In the words of Maher et al (2016) "While transvaginal permanent mesh is associated with lower rates of awareness of prolapse, reoperation for prolapse, and prolapse on examination than native tissue repair, it is also associated with higher rates of reoperation for prolapse, stress urinary incontinence, or mesh exposure and higher rates of bladder injury at surgery and de novo stress urinary incontinence." Not surprisingly, the use of the mesh generated a large number of legal disputes challenging the standards of care in the design and use of the device. For example *Gross v. Ethicon, Inc., and Johnson & Johnson et al.,* (2013), *Huskey, et al., v. Ethicon, Inc., and Johnson & Johnson, et al. (2014), Salazar v. Boston Scientific, Inc., et al. (2014),* are all disputes in which the jury decided in favor of the plaintiff claims against a manufacturer that had failed to warn the plaintiff and his doctor about the potential risks of using the mesh. Although in these cases the claim was made against the producer of the device, Supreme Court decisions such as in *Riegel vs Medtronic (2008)* have tended to shift the potential liability in the use of the device in medical procedures/treatments from the manufacturing company to the doctor. The central issue has been the definition of the standards required from doctors to inform patients and obtain their consent in the application of treatments or use of new medical devices.[12]
Directors´ Actions and Decisions in the Face of M&As:[13] Few corporate transactions bring

[12] The concern in the medical profession to identify the standard of care that will free doctors from potential liabilities associated to the use of new medical devices is considerable. Mucowski et al (2010) discuss more generally the use of the transvaginal mesh and doctors´ requirement to get patients informed consent.
[13] Although here I am dealing with corporations and not torts law, fiduciary duties are a quintessential example of a negligence standard. Both the board of directors and managers owe the owners of the company a duty to act in a

conflicts between managers and shareholders to the surface more evidently than Mergers and Acquisitions. Like any other major corporate transaction, in the case of M&As, corporate directors and managers are required to make decisions with the care and loyalty necessary to protect shareholders´ interests. The common belief is that while acquisitions tend to benefit shareholders (because of the large premiums associated with an acquisition) they might simultaneously hurt managers, monetarily and/or non-monetarily, because of the change in management that follows a change of ownership. In this line, the creation of poison pills[14] in the early 1980s was a financial innovation that gave managers more power to oppose the attempted acquisition of their companies. Shortly after the innovation of poison pills, in *Moran vs Household International (1985)* the trial and supreme courts of Delaware were called to determine if the board of directors of Household had acted according to their fiduciary duties by adopting the poison pill. The court supported the legality of the adoption of the antitakeover defense. Interestingly, rejections of close variations of the basic version of poison pills, such as no-hand or dead-hand poison pills[15] (which made acquisitions even more challenging) followed shortly after *Moran* in cases such as *Bank of New York vs Irvine Bank Corp* (1988).

The previous legal cases are aligned with the link — which this paper aims to study — between changes in the technological and socioeconomic reality and the generation of legal cases in which reinforcement or reinterpretation of legal standards take place (substantive trials). However, these changes would not be so relevant for future welfare and litigation if legal standards did not significantly affect agents´ behaviors. Two recent studies suggest that this is the case. First, Frakes (2013) provides convincing evidence of medical doctors' responses to changes in medical malpractice legal standards. The author studies changes in doctors' treatments and diagnoses (obstetric and cardiac) when they are required to follow national instead of local (state) standards of care.[16] Frakes (2013) estimates that the change in standards reduced the gap between the national and state specific medical treatments and diagnoses procedures by between 30% and 50%.

Second, in the context of corporate finance, Cremers and Ferrell (2014) document *Moran's*

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certain way (maximize shareholders value) such that if a breach of that duty caused a harm to the shareholders, directors and/or managers are acting negligently.

[14] A poison pill is a shareholder rights plan that makes the acquisition of the company considerably more expensive. Typically, shareholders are given the right to buy (sell) shares at a discount (premium) if a third party purchases more than a certain threshold (typically 15%) of the property of the company in open transactions.

[15] Under this variations, poison pills can be removed only by the same directors or managers who added them to the bylaws or corporate charters.

[16] According to Frakes (2013) both informational and incentive mechanisms are behind the doctors´ responses.

statistically and economically significant effect on the extension and intensity with which directing boards implement antitakeover defenses (measured by their G-Index).[17] The authors find that on average 60% of studied firms increased their antitakeover defense annually between 1985 and 1989. In the case of Poison Pills the number of firms adopting them increased from close to 5% in 1985 to over 50% in 1989 (figure 2 in Cremers and Ferrell [2014]). These results suggest that *Moran* significantly impacted the behavior of firms and their managers.

3. THE MODEL

I present a simple model to derive the main results (see Section 4). There are no pre-trial negotiations, no settlements, no heterogeneity in the parties in dispute, the regulated context has only two possible states, there are no fact trials and the parties cannot learn the state of the context outside Court. In Section 6 I relax many of these assumptions and show that the main results hold.

Litigating Parties, Precautionary Effort and Accidents

Suppose that every period $t \geq 0$ there are $N \gg 1$ pairs of one-period lived "potential plaintiffs" (PP) and one period-lived "potential defendants" (PD).[18] Every period PDs choose the level of precautionary effort $e \in [0,1]$ at cost $c(e)$, $c'(e) \geq 0$, $c''(e) \geq 0$ and $c(0) = c'(0) = 0$ such that an accident happens with probability $\theta(t)p(e)$. Parameter $\theta(t) \in \{\theta_0, \theta_1\}$, with $\theta(0) = \theta_0 \in [0,1]$, captures the notion of an evolving regulated context in which $\theta_1 = \theta_0 + \Delta$ and $\Delta, \theta_1 \in [0,1]$. Function $p(e) \in [0,1]$ with $p'(e) \leq 0, p''(e) \geq 0$ and $p(1) = 1 - p(0) = 1$ implies that the probability of an accident decreases with e.[19] In the case of an accident we call the PP a Plaintiff (P) and the PD a Defendant (D). Each D inflicts the corresponding P a harm $h > 0$.

Liability Rule, Litigation and the Evolution of the Regulated Context

PDs choose effort in the context of a liability rule of simple negligence in which the legal standard is initially given by $e_0 \in [0,1]$.[20] If a tort takes place then Ps have to decide whether to initiate legal actions which always end in a trial.[21] At a trial P pays a fraction $f \in [0,1]$ of the trial

[17] In words of the authors: "This decision therefore arguably represents a major shift in the power toward corporate boards and away from the market for corporate control". That said, the main interest of the authors is to study the impact of the adoption of the rights plans in the value of corporations.

[18] Note that I am imposing that N is very large, it might easily be in the order of millions (e.g. if t referres to years).

[19] Unlike the traditional tort model, here the maximum probability of an accident is $\theta(t)$ and not 1.

[20] Under a rule of simple negligence, Ds are found liable if their efforts fall below the required legal standard.

[21] Although not required for conclusions, I consider that all Ps initiate legal actions simultaneously.

which costs $k > 0$ with $h > k$, while D pays the other fraction $1 - f$ of the same costs. Compensations take the form of full damages, that is, D has to pay h to P if found liable. In Section 4 I show that relevant implications follow if compensations take the form of expectation damages.

Each period $t \geq t_l$ the parameter $\theta(t)$ takes the value θ_0 with probability $z(t) = \frac{1+e^{-\lambda(t-t_l)}}{2}$ or takes the value θ_1 with probability $1 - z(t)$ in which t_l is when the last trial took place. Parameter λ measures the speed of evolution of the regulated context, the larger is λ then the more likely is that $\theta(t) = \theta_1$. Note that $z(t)$ is decreasing in t.[22] The exponential function generates a process of information decay. That is, the probability that the state of the context coincides with the one discovered at the last trial is smaller at time $t + dt$ than at time t.[23]

Here I assume that a trial is the only instance when $\theta(t)$ is fully revealed to all the agents, but relax this assumption in Section 6. If a trial reveals that $\theta(t) = \theta_0$ then a new cycle (a period between two trials) begins and $z(t) = 0$. If the trial reveals that $\theta(t) = \theta_1$ then that state never changes again and no further trial occurs.[24] We define: $\theta_i(t) = z(t)\theta_i + \big(1 - z(t)\big)\theta_{i+1}$.

Substantive Trials, Legal Standards, the Court and Timeline of Actions

In the event of a trial, P will argue that the accident took place because D did not make the effort required by the current state of the regulated context $\theta(t)$. The essence of the dispute is legal uncertainty, the Court is called to preserve or update the standard given the state of the regulated context revealed at the trial. As noted in our introduction we call this type of trial 'substantive'.

To end with the description of the model, we treat the Court as unique, benevolent and myopic.[25] The Court sets legal standards e_i with $i \in \{0,1\}$ equal to the level of effort that minimizes total harm and precaution costs given by

$$c_T(e) = \theta_i p(e)h + c(e)$$

Hence e_0 and e_1 are implicitly defined by $\theta_i hp'(e_i) = -c'(e_i)$. In order to have regularity in the solution we impose that $\theta_0 p(e_1)N \gg 1$, a condition that assures that the probability that every

[22] Results can be derived with a general function $z(t)$ that decreases with time. However, as I want to emphasize the role played by the speed in the evolution of the regulated context I immediately define function $z(t)$.

[23] Harris and Holmstrom (1987) reveal the implications of this Markovian process property in a model in which an infinitely lived lender has to decide every period whether to pay a cost to collect information about the quality of an infinitely lived borrower to whom is deciding to finance.

[24] In the general model of Section 6 I consider that there are as many states as required for $\theta(t)$ to converge to 1 when it starts at value θ_0 and sequentially increases in step Δ.

[25] The Court only cares about the interests of the current parties. Many would argue that this is a better description of Court behavior than the assumption that courts are forward-looking.

period there is at least one accident is practically 1.[26] In Section 4 we also consider the case in which the Court is long-lived and sets dynamically efficient standards. Table 1 summarizes the game played by PDs, PPs, Ds and Ps *each time period.*

<< Insert Table 1 about here>>

4. MAIN RESULTS

Here I present the main results, first characterizing the litigation dynamics of substantive trials, later identifying the optimal frequency of the same type of trials and finally characterizing dynamically efficient standards.[27] We find that, aside from extreme solutions in which substantive trials never occur (because the cost of effort is very small) or occur every time period (because the cost of litigation is very small), trials take place with a frequency that is reduced when litigation costs rise, the speed of evolution of the regulated context goes down or when harm goes down.

In the most true-to-life scenario in which trials take place with a given frequency, PDs choose to make effort equal to the legal standard at all times.[28] This result is far from trivial because PDs are always tempted by a higher level of effort that would relieve them from liability in case of an accident or by a lower and less costly effort level. Knowing that PDs have made effort equal to the current standard, PPs will prefer not to sue PDs if they suffer an accident few periods after the last substantive trial took place. This is because it is unlikely that the regulated context has changed since the last trial. However, after sufficient time has passed since the previous trial, PPs will be willing to pay for a trial because the probability that PDs made an effort that is not optimal for the current state of nature will be large enough to generate a positive expected payoff.

As a second main result I explicitly identify the reasons (externalities) why the frequency with which the parties initiate substantive trials (I call it private frequency) is not equal to the optimal frequency of substantive trials (the frequency that maximizes social welfare). Although others (Shavell [1982], Menell [1983] and Kaplow [1986]) have noted this private-social frequency gap, I uncover new externalities in closed-form mathematical expressions.

I show that the private periodicity is likely to be inefficient for three reasons. First, while litigants only care about their portion of litigation costs, society cares about the expenses paid by

[26] That is assured if indeed N is very large as we have imposed.
[27] I speak of number of accidents even when this is stochastic. The large value of N makes that prerogative harmless.
[28] This is true for all $t < \overline{\tau}$ and is also true for $t = \overline{\tau}$ if certain conditions hold (see Proposition 1).

both parties (there are too many trials). Second, while parties in dispute only care about the harm they suffered, a social planner considers that *a change in legal standard* will affect the harm and precautionary costs faced by *N* potential accidents (there might be too many or too few trials, this is new to the literature). Third, while parties only consider their costs and benefits, a central planner considers the net present benefits and costs associated to a given timing of trials in an infinite horizon (there might be too many or too few trials, this is new to the literature).

As a third and final result I identify dynamically efficient legal standards and determine conditions under which these standards reduce the litigation frequency gap (encourage or discourage litigation). I find both state and non-state contingent optimal standards to be a weighted combination of the optimal standards for the specific states of the regulated context in a trial cycle. Because non-contingent standards are fixed during a cycle they over-emphasize the relevance of a new and more effort demanding reality, it follows that state contingent standards tend to be less demanding than non-contingent standards.[29]

An unexpected finding is that the capacity of legal standards to correct litigation frequency depends upon the compensation system. Specifically, I find that the frequency of substantive trials does not depend on the legal standards when compensation takes the form of full damages. But that frequency depends on the standards when compensation takes the form of expectation damages. Not only does compensation depend explicitly on the current and future legal standards, but in addition the frequency of private litigation will be inversely related to $p(e_0) - p(e_1)$. Then, a central planner who wants to increase litigation should set legal standards that are further apart from each other, the opposite holds true to decrease litigation.

Next, Lemma 1 states a useful technical detail, then Propositions 1 to 3 summarize results.

Lemma 1: If we define $c_T(e;x) \equiv p(e)x + c(e)$ such that $-\frac{c'(e^*(x))}{p'(e^*(x))} \equiv x$ then it is true that: $c_T(e^*(x);x) = \int_0^x p(e^*(y))dy$ and $\frac{de^*(x)}{dx} > 0$.

Proof: See the Appendix.

4.1 When do substantive trials take place?

Aside from the extreme solutions in which substantive trials either take place each time period or they never take place, substantive trials take place with a periodicity $\overline{\tau}$ (or equivalently

[29] We notice that both standards are more demanding the higher is the expected harm associated to a potential accident and the faster the regulated context evolves.

frequency $1/\overline{\tau}$) given by

$$z(\overline{\tau}) = 1 - \frac{fk}{h} \rightarrow \ \overline{\tau} = \frac{-ln\left(1 - \frac{2fk}{h}\right)}{\lambda} \quad (1)$$

I discuss the sensitivity of $\overline{\tau}$ with respect to the parameters of the model after Proposition 1, but first I explain the derivation of (1). A direct application of backward induction allows us to solve the game played by litigating parties every time period (see table 1). Because myopic Courts decide mechanically at the game´s third stage, we only solve the second and first stages. Table 2 summarizes PPs´ decisions to demand conditional upon effort made by PDs in the first stage.[30]

<< Insert Table 2 about here>>

Evidently, PPs do not sue PDs if they know that PDs made an effort ($e = e_1$) that liberates them from liability in all scenarios (regardless whether $\theta(t)$ is θ_0 or θ_1), and PPs always demand PDs if they know that PDs are always liable ($e < e_0$) in the case of an accident. Because $h > fk$ then lawsuits are always rational. But what happens when $e \in [e_0, e_1[$? The answer is that PPs only sue if the expected benefit in a trial is larger than the litigation cost fk they pay. That is

$$\underbrace{z(t)0}_{At\ trial\ is\ revealed\ \theta(t)=\theta_0} + \underbrace{\big(1 - z(t)\big)h}_{At\ trial\ is\ revealed\ \ \theta(t)=\theta_1} > fk$$

Ds will only be found liable if the regulated context has evolved to a state that demands more effort than e_0. Note that because $z(0) = 0$ the expected utility for a PP is negative when a new trial cycle begins.[31] However, with time $\big(1 - z(t)\big)$ will increase such that at $\overline{\tau}$ PPs will see a positive expected value and initiate a trial in the case of an accident.[32]

Knowing what happens at the second stage, I now determine PDs´ optimal effort decision $e^*(t)$ in the first stage of the game. I provide details of the calculation in the Appendix, but here I emphasize the two key features of the result. First, when $t < \overline{\tau}$ then PDs always choose $e^*(t) = e_0$. This implies that except for some extreme conditions, a trial does not take place before $t = \overline{\tau}$.[33]

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[30] Depending on the parameters of the model, PDs might optimally choose almost any level of effort as long as $e^* \leq e_1$ (an effort $e > e_1$ is always dominated by e_1 because as in both cases no lawsuit takes place then PDs only compare $c(e_1)$ with $c(e)$ in which the first cost is smaller).

[31] As the process is stationary when I write t then I implicitly refer to $t_l + t$. That is t periods within a new cycle.

[32] Strictly speaking, PPs are indifferent between suing or not suing at $\overline{\tau}$ but an epsilon later they will make that decision.

[33] PDs choose $e^*(t) = e_0$ when $t < \overline{\tau}$. First, e_0 is preferred to any effort $e > e_0$ because $c(e) > c(e_0)$. The cost of effort is the only cost faced by PDs when $t < \overline{\tau}$ because lawsuits never take place (see table 2 when $e > e_0$). And second, PDs also prefer effort e_0 to any effort $e < e_0$ when $t < \overline{\tau}$ because $\theta_0(t)(h + (1 - f)k) > \theta_0 h$ which implies that the minimum total cost at $e < e_0$ is larger than the total cost at e_0 (this follows directly from $\frac{dc_T(e^*(x),x)}{dx} > 0$ in Lemma 1). Hence, unless $fk = 0$ or $\lambda = \infty$ (a trial happens at $t = 0$) a trial does not take place before $\overline{\tau}$.

Second, at $t = \overline{\tau}$, PDs might choose any $e^*(t) \in [e_0, e_1]$ depending on the parameters of the model, and this implies that a trial will take place at time $\overline{\tau}$ or a trial never takes place.[34] To be more specific, the next condition determines PDs´ decision at $t = \overline{\tau}$

$$c(e_1) > \begin{cases} p(e_0)(\theta_0 + \frac{fk\Delta}{h})k + c(e_0) \text{ if } \theta_0 \geq \frac{fk^2\Delta}{h(h-k)} \\ p(e^*)(\theta_0 + \frac{fk\Delta}{h})k + c(e^*) \text{ if } \theta_0 < \frac{fk^2\Delta}{h(h-k)} \end{cases} \qquad \text{(C1)}$$

If (C1) holds, then at $t = \overline{\tau}$ all PDs make effort $e^* \in [e_0, e_1[$ which generates a lawsuit. On the other hand, if (C1) does not hold then $e^* = e_1$ and a substantive trial never takes place.[35] The right side of (C1) distinguishes two scenarios, one in which PDs chose effort e_0 and the other in which they choose $e^* \in]e_0, e_1[$. The first occurs only when θ_0 is sufficiently large. I find in Section 6 that this first condition is always true within a more general model.[36]

In what follows I focus on the interesting scenario in which substantive trials take place every $\overline{\tau}$ periods. Yet, remember that trials may not occur or may do so on an ongoing basis. Proposition 1 summarizes dynamics for substantive trials including PDs´ optimal effort choices.

Proposition 1 (The Dynamics of Substantive Trials):

i. *A substantive trial either takes place every period, never takes place or takes place every $\overline{\tau}$ periods. More specifically: If $\frac{fk}{h} = 0$ or $\lambda = \infty$ then a trial takes place every period. If $\frac{fk}{h} \geq \frac{1}{2}$ or $\lambda = 0$ or (C1) does not hold then a trial never takes place. In all the other scenarios a substantive trial takes place every $\overline{\tau}$ periods.*

ii. *PDs make effort $e^*(t) = e_0$ for all $t < \overline{\tau}$. At $t = \overline{\tau}$ PDs make effort $e^*(t) \in [e_0, e_1[$ if (C1) holds but make effort $e^*(t) = e_1$ if (C1) does not hold.*

Proof: See the Appendix.

The Proposition conveys that the frequency of substantive trials increases when PPs pay a smaller fraction of litigation costs (f goes down) and when total litigation costs are smaller (k goes

[34] Once more at $t = \overline{\tau}$ PDs always prefer e_0 to any effort $e < e_0$. This time because $\theta_0(\overline{\tau})(h + (1-f)k) > \theta_0 h$ (again this follows from Lemma 1). Hence at $t = \overline{\tau}$ PDs either choose $e^* \in [e_0, e_1[$ in which case there is a trial (see table 2) or they choose e_1 and in this case a trial never takes place (see table 2).

[35] Although the comparison of costs in (C1) is made at time $t = \overline{\tau}$, because the costs faced by PDs when they make effort $e^* \in [e_0, e_1[$ are increasing with time, if PDs prefer e_1 at $t = \overline{\tau}$, they will do it for good.

[36] After we note that PDs face cost $\left(\theta_0 + \frac{fk\Delta}{h}\right)p(e^*)k + c(e^*)$ if $e^* \in]e_0, e_1[$ at $t = \overline{\tau}$ but they face cost $\theta_0 p(e_0)h + c(e_0)$ if they choose e_0 we conclude (Lemma 1) that PDs prefer effort e_0 if and only if $\left(\theta_0 + \frac{fk\Delta}{h}\right)k \leq \theta_0 h$ or equivalently $\theta_0 \geq \frac{fk^2\Delta}{h(h-k)}$. The last inequality is more likely to hold the smaller is Δ which happens if the regulated context evolves among several states. In Section 6 I find additional reasons why e_0 is optimal for PDs at $t = \overline{\tau}$.

down). To add to this, trial frequency increases when injury cost rises (h goes up) and when the regulated context evolves more rapidly (λ goes up). Because legal standards are optimally set for a given regulated context, when this context changes so too should the standards. Because the only way to change standards is by litigation, potential litigants are more likely to initiate trials when the standards are inadequate for the current context. In what follows, I calculate the optimal periodicity of litigation and then compare it with $\bar{\tau}$.

4.2 Optimal Frequency of Litigation

I determine the optimal periodicity of substantive trials τ^* that minimizes the present and future costs of accidents, effort, and litigation incurred across an infinite horizon.[37] If we denote V_i as the total expected cost when the legal standard equals e_i, then

$$V_0 = A_0(\tau) + e^{-r\tau}\big[z(\tau)V_0 + \big(1 - z(\tau)\big)V_1\big]$$

$$\rightarrow V_0 = \frac{A_0(\tau) + e^{-r\tau}\big(1 - z(\tau)\big)V_1}{1 - e^{-r\tau}z(\tau)} = \frac{A_0(\tau) - (1 - e^{-r\tau})V_1}{1 - e^{-r\tau}z(\tau)} + V_1$$

In which

$$A_0(\tau) \equiv \int_0^{\tau} \big[\big(z(t)\theta_0 + \big(1 - z(t)\big)\theta_1\big)p(e_0)h + c(e_0)\big]Ne^{-rt}\,dt + ke^{-r\tau},$$

is the addition at every time period of the harm generated by the $\theta_0(t)p(e_0)N$ accidents that take place plus the cost of the precautionary effort $c(e_0)N$ made by all PDs and the litigation cost k of the substantive trial that marks the end of the cycle. Parameter r is the discount rate. Also,

$$V_1 \equiv A_1(\infty) \equiv N\,\frac{[p(e_1)\theta_1 h + c(e_1)]}{r},$$

is the total cost of accidents, effort and litigation once the regulated context reaches its steady state θ_1 *ad infinitum*. Then a central planner sets the trial periodicity that minimizes V_0

$$\min_{\tau}\left\{V_0 = \frac{A_0(\tau) - (1 - e^{-r\tau})V_1}{1 - e^{-r\tau}z(\tau)}\right\} \qquad (2)$$

Before writing the FOC associated with this problem, note that V_0 can be re-written as

$$V_0 = \frac{\int_0^{\tau}[c_T(e_0;\theta_0(t)h) - c_T(e_1;\theta_1 h)]Ne^{-rt}\,dt + ke^{-r\tau}}{1 - e^{-r\tau}z(\tau)}$$

The numerator reveals the trade-off faced by a central planner when choosing the optimal timing of substantive trials. On one hand, the difference in harm and precautionary costs because

[37] Having in mind Proposition 1, we assume that (C1) holds and $\theta_0 \geq \frac{fk^2\Delta}{h(h-k)}$, hence PDs make effort e_0 every period.

PDs make effort e_0 and not e_1, which is: $\int_0^\tau Dc_T(t)Ne^{-rt}$ (with $Dc_T(t) \equiv [c_T(e_0;\theta_0(t)h) - c_T(e_1;\theta_1 h)]$) increases with τ if τ is large enough.[38] On the other hand, litigation costs, which are given by $ke^{-r\tau}$ decreases with τ. This implies that the value of τ^* is found when these two marginal effects (this time considering the denominator in (2)) are equal.[39] Formally, the FOC of (2) is

$$\frac{e^{-r\tau}}{\left(1-e^{-r\tau}z(\tau)\right)^2}\left(\begin{array}{c} N\underbrace{\left(\left(1-e^{-r\tau}z(\tau)\right)Dc_T(\tau)-\left(rz(\tau)-z'(\tau)\right)\int_0^\tau Dc_T(t)e^{-rt}dt\right)}_{\text{Increment in Harm-Precautionary Costs}} \\ -\underbrace{rk\left(1-\frac{e^{-r\tau}}{r}z'(\tau)\right)}_{\text{Decrement in Trial Costs}}\end{array}\right)=0$$

While the first expression inside the large parenthesis represents the marginal increment in the costs of harm and precaution, the second expression represents the marginal decrement in litigation costs.[40] In the appendix (proof of Proposition 2) I show that τ^* is implicitly given as

$$\tau^* = \frac{-ln\left[\frac{r}{(r+\lambda)-\lambda e^{-\tau^* r}}\left(1-\frac{\frac{rk(r+\lambda)\lambda e^{-r\tau^*}}{(r+\lambda)-\lambda e^{-r\tau^*}}+2k(r+\lambda)}{\frac{rk(r+\lambda)\lambda e^{-r\tau^*}}{(r+\lambda)-\lambda e^{-r\tau^*}}+\left(A_0(r+\lambda)-rB_0\right)}\right)\right]}{\lambda} \qquad (3)$$

In which $A_0 \equiv \left[\frac{\theta_0+\theta_1}{2}p(e_0)h + c(e_0) - \left(\theta_1 p(e_1)h + c(e_1)\right)\right]N; B_0 \equiv -\frac{\Delta}{2}p(e_0)hN$. Figure 1 provides a graphical representation of the implicit unique solution in (3).

<<Insert Figure 1>>

The expression for τ^* indicates that society benefits from more trials (τ^*goes down) when the difference of the total costs generated by a change in effort (from e_0 to e_1) goes up. This difference in total costs is $A_0(r+\lambda) - rB_0$. In addition, τ^* increases when the cost of a trial k goes up or when the regulated context evolves less rapidly (smaller λ).[41] Although intuition says that τ^* should also go up with r (because the more society cares about the future the more frequently trials

[38] The marginal effect is $Dc_T(\tau)Ne^{-r\tau}$. Because $[c_T(e_0;\theta_0(0)h) - c_T(e_1;\theta_1 h)] < 0$ society prefers $\theta(t) = \theta_0$ and standard e_0 to $\theta(t) = \theta_1$ and standard e_1. Hence, in the initial periods of a cycle, society will not see large benefits from initiating a trial. But with time $c_T(e_0;\theta_0(t)h)$ will increase such that eventually $[c_T(e_0;\theta_0(t)h) - c_T(e_1;\theta_1 h)]$ will be positive. Optimally, a trial takes place when the benefits from correcting the standard compensate the cost k.

[39] Extreme solutions: $\tau^* = 0$ (*e.g.* when $k = 0$) or $\tau^* = \infty$ (*e.g.* when $h = 0$).

[40] The first expression is positive because it is 0 when $\tau = 0$ and its derivative with respect to τ is equal to $\left(1-e^{-r\tau}z(\tau)\right)\frac{\partial c_T(\tau)}{\partial t} - z'(\tau)\left(Dc_T(\tau)e^{-rt} + r\int_0^\tau Dc_T(t)e^{-rt}dt\right) + z''(\tau)\left(Dc_T(\tau)e^{-rt} + \int_0^\tau Dc_T(t)e^{-rt}dt\right)$ which is positive because $z'(\tau) < 0$ and $z''(\tau) > 0$.

[41] This is true because $\frac{k(r+\lambda)\lambda}{A_0(r+\lambda)-rB_0}$ increases with k, λ and $\frac{k(r+\lambda)r}{A_0(r+\lambda)-rB_0}$ decreases with λ (see figure 1).

should take place) I find that the effect of r is ambiguous. Later I discuss this finding.

The comparison of τ^* with $\bar{\tau}$ identifies three reasons why the private frequency of substantive trials is not optimal. Each reason is rooted in an externality that we denominate: costs of litigation, harm, and intertemporal effects. I identify the two first externalities by imposing $r = \infty$ (a central planner only cares about the present) such that then τ^* becomes[42]

$$\tau^* = \frac{-ln\left[1 - \frac{2k}{A_0 - B_0}\right]}{\lambda} \qquad (4)$$

<u>Costs of litigation</u>: While $\bar{\tau}$ depends on the fraction of costs paid by PPs (fk), (4) tells us that τ^* depends on the total costs faced by the parties (k). Hence, because Ps do not internalize the litigation costs paid by Ds there will be an excess of substantive trials (a negative externality).

<u>Harm:</u> While $\bar{\tau}$ depends on h, (4) shows that τ^* depends on $A_0 - B_0$, which is the difference in the expected costs (harm and precaution) that society saves if the standard changes from e_0 to e_1. Because I do not know whether h is larger or smaller than

$$A_0 - B_0 = \left\{\left[\frac{\theta_0 + \theta_1}{2} p(e_0)h + c(e_0) - \big(\theta_1 p(e_1)h + c(e_1)\big)\right] + \left[\frac{(\theta_1 - \theta_0)}{2} p(e_0)h\right]\right\} N$$
$$= \left\{\big(p(e_0) - p(e_1)\big)\theta_1 h + \big(c(e_0) - c(e_1)\big)\right\} N > 0$$

a priori I cannot say if the externality is positive (too few trials) or negative (too many trials).[43]

<u>Intertemporal:</u> Now I consider the most general case in which $r < \infty$. While $\bar{\tau}$ does not depend on r the optimal frequency $\tau^*$is affected by the discount rate in three ways. First, $\frac{(r+\lambda)-\lambda e^{-r\tau}}{r} > 1$ acts as an adjustment to the perceived speed of the evolution of the regulated context such that I can implicitly convey the optimum frequency of litigation as follows

$$\frac{1 - \frac{(r+\lambda) - \lambda e^{-r\tau}}{r} e^{-\lambda\tau}}{2} = \frac{\left(A_0 - \frac{r}{r+\lambda} B_0\right) + 2k}{2\left(\left(A_0 - \frac{r}{r+\lambda} B_0\right) + \frac{rk\lambda e^{-r\tau}}{(r+\lambda)\big((r+\lambda) - \lambda e^{-r\tau}\big)}\right)}$$

And compare it with the equivalent expression that identifies the private frequency of litigation

$$\frac{1 - e^{-\lambda\tau}}{2} = \frac{fk}{h}$$

Hence, for the same expressions on the right, society prefers more trials because it perceives a

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[42] Applying L´Hôpital when $r \to \infty$.

[43] For example if $c(e) = \frac{\beta e^2}{2}$ and $p(e) = 1 - e$ then $A_0 - B_0 = \frac{(h\Delta)^2}{2\beta} N$ which is larger than h if and only if $\Delta > \sqrt{\frac{2\beta}{hN}}$.

faster evolution of the regulated context. Second, the discount rate is also relevant because a central planner cares about the present value of the expected litigation costs which is proportional to $\frac{rk\lambda e^{-r\tau}}{(r+\lambda)\left((r+\lambda)-\lambda e^{-r\tau}\right)}$. This present value decreases with r unless λ is very large.[44] In words, the less we care about future litigation costs (r is large) the more trials should take place. Third, the discount rate also affects the difference in harm and precautionary costs if the standard of effort changes. That is, expression $A_0 - \frac{r}{r+\lambda}B_0$ decreases with r, which implies that society obtains less utility if the frequency of trials goes up and ergo the optimal τ should be larger.

Because it is unclear which of these three effects of r on litigation dominates, we do not know whether this externality is positive or negative. Proposition 2 summarizes the findings on optimal periodicity of trials and how this periodicity compares to the private frequency of trials.

Proposition 2 (Optimal periodicity of substantive trials): *If $\theta(t) \in \{\theta_0, \theta_1\}$ then society would like substantive trials to take place every τ^*periods of time. Also, $\overline{\tau}$ and $\tau^*$are not equal because:*

i. *While Ps face a litigation cost of fk, society faces a total cost k (negative externality)*

ii. *While Ps consider that they can recover h, society considers that expected harm can be reduced in $A_0 - B_0$ if the legal standard is updated (negative or positive externality)*

iii. *While Ps only care about their case, society considers the future expected effects on harm, precautionary and litigation costs (negative or positive externality)*

Proof: See the Appendix.

4.3 How to eliminate or reduce the private-social gap in litigation frequency

The simplest tool that authorities (regulators or legislators) can use to partially or completely eliminate the difference between $\tau^*$and $\overline{\tau}$ is to adjust the distribution of litigating expenses between the involved Ps and Ds. While the private-social gap can be eliminated when privates generate too few trials, this gap might only be partially corrected when privates generate too many trials. To see this, note that the distribution of litigating expense f^* that eliminates the gap is given as

$$\frac{-ln\left[1-\frac{2f^*k}{h}\right]}{\lambda} = \frac{-ln\left[\frac{r}{(r+\lambda)-\lambda e^{-\tau^* r}}\left(1-\frac{\frac{rk(r+\lambda)\lambda e^{-r\tau^*}}{(r+\lambda)-\lambda e^{-r\tau^*}}+2k(r+\lambda)}{\frac{rk(r+\lambda)\lambda e^{-r\tau^*}}{(r+\lambda)-\lambda e^{-r\tau^*}}+(A_0(r+\lambda)-rB_0)}\right)\right]}{\lambda}$$

or

[44] This expression appears only because the duration of a trial cycle depends on the standard. In Bustos (2006) this expression does not appear because all the cycles have the same duration.

$$f^* = \frac{h}{2k}\left(1 - \frac{r}{(r+\lambda) - \lambda e^{-\tau^* r}}\left(1 - \frac{\frac{rk(r+\lambda)\lambda e^{-r\tau^*}}{(r+\lambda) - \lambda e^{-r\tau^*}} + 2k(r+\lambda)}{\frac{rk(r+\lambda)\lambda e^{-r\tau^*}}{(r+\lambda) - \lambda e^{-r\tau^*}} + (A_0(r+\lambda) - rB_0)}\right)\right)$$

Because we know that both arguments in the logarithms are within $[0,1]$, in the case that $\tau^* < \overline{\tau}$ then $0 < f^* < f < 1$. But in the case that $\tau^* > \overline{\tau}$ then we do not know whether $f^* < 1$. Note that because we discourage litigation by increasing the costs faced by Ds, the larger τ^* is then the larger the value of f^* will be. Similarly, if the reduction in total costs due to a change in standards increases, or the regulated context evolves more rapidly, then the value of f^* will reduce.

Tax or Subsidy

Regulators can also appeal to a traditional tax or subsidy mechanisms to address an inefficient trial frequency. This has been suggested (Shavell [1982], Kaplan [1986] among others), but to our knowledge the exact expressions for the taxes/subsidies have not been explicitly identified. If we apply a t/s tax or subsidy *per trial* such that

$$\overline{\tau} = \frac{-ln\left[1 - \frac{2f(k + t/s)}{h}\right]}{\lambda}$$

and then we equalize $\tau^*$and $\overline{\tau}$ we find that

$$t/s^* = \left(1 - \frac{r}{(r+\lambda) - \lambda e^{-\tau^* r}}\left(1 - \frac{\frac{rk(r+\lambda)\lambda e^{-r\tau^*}}{(r+\lambda) - \lambda e^{-r\tau^*}} + 2k(r+\lambda)}{\frac{rk(r+\lambda)\lambda e^{-r\tau^*}}{(r+\lambda) - \lambda e^{-r\tau^*}} + (A_0(r+\lambda) - rB_0)}\right)\right)\frac{h}{2f} - k$$

This expression is a tax if the right side is positive (corrects a situation in which $\tau^* > \overline{\tau}$) but is a subsidy if it is negative (corrects a situation in which $\tau^* < \overline{\tau}$). Unlike the redistribution of litigation expenses, here the optimal frequency of trials can always be achieved.

4.4 Dynamically efficient Legal Standards

The periodicity of substantive trials does not directly depend on legal standards. However, the standards do affect PDs´ effort decisions. Keeping this in mind, I calculate the standards that a long-lived Court would impose. First I consider when standards remain fixed during a cycle (non-contingent standards) and then consider when standards are allowed to vary each period of time (contingent standards).[45] I find that optimal non-contingent standards are more demanding than optimal contingent standards. This is because non-contingent standards give the future state of the context the same weight every period of time even when likely that the context has not changed.[46]

In order to calculate optimal non-contingent standards, a long-lived Court solves

$$\min_{e_0,e_1}\left\{\frac{A_0(e_0,\overline{\tau})-V_1(e_1)e^{-r\overline{\tau}}(1-z(\overline{\tau}))}{1-e^{-r\overline{\tau}}z(\overline{\tau})}\right\}$$

It follows that e_1^{nc} ("nc" for non-contingent) is determined by

$$\theta_1 p'(e_1^{nc})h+c'(e_1^{nc})=0\leftrightarrow-\frac{c'(e_1^{nc})}{p'(e_1^{nc})}=\theta_1 h$$

and e_0^{nc} is determined by

$$-\frac{c'(e_0^{nc})}{p'(e_0^{nc})}=\frac{\left[\frac{\theta_0+\theta_1}{2}\frac{1-e^{-r\overline{\tau}}}{r}+\frac{\theta_0-\theta_1}{2}\frac{1-e^{-(r+\lambda)\overline{\tau}}}{r+\lambda}\right]}{\frac{1-e^{-r\overline{\tau}}}{r}}h$$

That is, the steady state optimal non-contingent standard (e_1^{nc}) is the same as that in the basic model, but the initial optimal non-contingent standard (e_0^{nc}) is a weighted combination of the possible states of the regulated context du ring this cycle. Evidently society ends better off under contingent than non-contingent standards because we are maximizing the same function with fewer restrictions.[47] More specifically, $e_1^{nc}=e_1^c$ ("c" for contingent) and

$$-\frac{c'(e_0^c(t))}{p'(e_0^c(t))}=\left(\theta_0\frac{1+e^{-\lambda t}}{2}+\theta_1\left(1-\frac{1+e^{-\lambda t}}{2}\right)\right)h$$

A direct application of Lemma 1 allows us to compare e_0^{nc} with e_0^c as follows

$$e_0^{nc}>e_0^c\leftrightarrow\frac{1-e^{-(r+\lambda)\overline{\tau}}}{r+\lambda}\frac{r}{1-e^{-r\overline{\tau}}}<e^{-\lambda t}:t\leq\overline{\tau}$$

This inequality is always true because $e^{-\lambda t}\geq e^{-\lambda\overline{\tau}}$ and $\frac{1-e^{-(r+\lambda)\overline{\tau}}}{r+\lambda}\frac{r}{1-e^{-r\overline{\tau}}}\leq e^{-\lambda\overline{\tau}}$.[48] Hence non-contingent standards are greater than contingent standards. As the first standards are fixed during

[45] Although mathematically it is clear which state-contingent standards are, in practice, it could be argued that standards are always contingent. A critical distinction happens if I consider that defendants are required to make optimal effort for the "available information" because in that case substantive trials never take place.

[46] Instead, contingent standards are a weighted average that tracks the evolution of nature more closely.

[47] Note that substantive trials take place even when standards are contingent on the state of nature because a long-lived rational Court will demand $e_1^c\neq e_0^c$ if a trial reveals that $\theta(t)=\theta_1$.

[48] Note that that inequality can be re-written as $\overline{\tau}\geq-ln\left[\frac{r}{(r+\lambda)-\lambda e^{-r\overline{\tau}}}\right]/\lambda$ which is true because the RHS is 0 when $\overline{\tau}=0$, converges to $-ln\left[\frac{r}{r+\lambda}\right]/\lambda$ when $\overline{\tau}=\infty$ and the slope is $\frac{re^{-r\overline{\tau}}}{(r+\lambda)-\lambda e^{-r\overline{\tau}}}<1$ for all values of $\overline{\tau}>0$.

a cycle, they give state θ_1 an excessive weight.[49] Proposition 3 summarizes the results.

Proposition 3 (Optimal non-contingent and contingent legal standards): *If* $\theta(t) \in \{\theta_0, \theta_1\}$ *then the optimal non-contingent legal standards are implicitly defined by*

$$-\frac{c'(e_i^{nc})}{p'(e_i^{nc})} = \begin{cases} \dfrac{\left[\dfrac{\theta_0+\theta_1}{2}\dfrac{1-e^{-r\bar{\tau}}}{r} + \dfrac{\theta_0-\theta_1}{2}\dfrac{1-e^{-(r+\lambda)\bar{\tau}}}{r+\lambda}\right]h}{\dfrac{1-e^{-r\bar{\tau}}}{r}} \text{ if } i=0 \\ \theta_1 h \text{ if } i=1 \end{cases}$$

and the optimal contingent legal standards are implicitly defined by

$$-\frac{c'(e_i^c(t))}{p'(e_i^c(t))} = \begin{cases} \left(\theta_0 \dfrac{1+e^{-\lambda t}}{2} + \theta_1\left(1-\dfrac{1+e^{-\lambda t}}{2}\right)\right)h \text{ if } i=0 \\ \theta_1 h \text{ if } i=1 \end{cases}$$

Proof: See the main text.

4.5 The role of Legal Standards when Compensations take the form of Expectation Damages

An element of discussion that readers may have missed is the potential of legal standards to reduce the private-social frequency gap. Although I find that the frequency of substantive trials does not directly depend on legal standards, I show here that if the compensation system takes the form of expectation damages (and not full damages) then $\bar{\tau}$ depends on the standards. To see this, note that Ps are compensated under expectation damages in the amount that leaves them indifferent to the scenario in which Ds made the required effort. That is, Ps recover $\theta_1\big(p(e_0)-p(e_1)\big)h$ if Ds make effort e_0 and the true state of nature is revealed to be θ_1. It follows that the frequency of substantive trials explicitly depends on present and future standards

$$\bar{\tau}(e_0, e_1) = \frac{-ln\left[1-\dfrac{2fk}{h\theta_1\big(p(e_0)-p(e_1)\big)}\right]}{\lambda}$$

Hence, a central planner interested in setting dynamically efficient standards solves

$$\min_{e_0,e_1}\left\{V_0(e_0,e_1) = \frac{A_0(e_0,\bar{\tau}) - V_1(e_1)e^{-r\bar{\tau}}(1-z(\bar{\tau}))}{1-e^{-r\bar{\tau}}z(\bar{\tau})}\right\}$$

Keeping in mind that $\bar{\tau}$ is a function of e_0 and e_1, it follows that now the FOC are

$$\theta_1 p'(e_1^*)h + c'(e_1^*) = \frac{\partial V_0(e_0^*, e_1^*)}{\partial \bar{\tau}}\frac{\partial \bar{\tau}}{\partial e_1}\frac{(1-e^{-r\bar{\tau}}z(\bar{\tau}))r}{(1-e^{-r\bar{\tau}})N} \qquad (5)$$

[49] Note that the inequality $e_i^{nc} > e_i^c$ reverts at a certain time but that happens after $\bar{\tau}$.

$$\left[\frac{\theta_0+\theta_1}{2}p'(e_0^*)h+c'(e_0^*)\right]\frac{1-e^{-r\bar{\tau}}}{r}+\left[\frac{\theta_0-\theta_1}{2}p'(e_0^*)h\right]\frac{1-e^{-(r+\lambda)\bar{\tau}}}{r+\lambda}$$
$$=-\frac{\partial V_0(e_0^*,e_1^*)}{\partial\bar{\tau}}\frac{\partial\bar{\tau}}{\partial e_0}\frac{(1-e^{-r\bar{\tau}}z(\bar{\tau}))}{N} \qquad (6)$$
$$\big(1-z(\bar{\tau}\,)\big)\big(p(e_0^*)-p(e_1^*)\big)\theta_1 h=fk \qquad (7)$$

If we use the super-index ED for expectation damages and the super-index FD for full damages then the comparison of (1) and (7) tells us that $\bar{\tau}^{ED}>\bar{\tau}^{FD}$. Ergo, under expectation damages privates generate fewer trials than under full damages. This is because Ps expect to recover less under the first than under the last system. The difference in litigation frequency implies that the adjustment in optimal standards (increment in effort) under expectation damages is larger than under full damages. To see that, note that (5) divided by (6) generates

$$\frac{\theta_1-\theta_0}{2}h(1-\frac{1-e^{-(r+\lambda)\bar{\tau}}}{1-e^{-r\bar{\tau}}}\frac{r}{r+\lambda})=\left(\frac{c'(e_0^*)}{p'(e_0^*)}-\frac{c'(e_1^*)}{p'(e_1^*)}\right)$$

Exactly the same expression can be obtained from Proposition 3 (non-contingent standards). The difference is that $\bar{\tau}^{ED}>\bar{\tau}^{FD}$ which implies that $e_1^{*,ED}-e_0^{*,ED}>e_1^{*,FD}-e_0^{*,FD}$.[50]

Although a compensation system of expectations damages allows the Court to modify the frequency of litigation, the first best frequency (defined by Proposition 2) cannot be achieved — the first best frequency is achieved only if $\frac{\partial V_0(e_0,e_1)}{\partial\tau}=0$ — . The intuition behind this result is that the Court cannot freely choose when to initiate trials because plaintiffs do this according to (7).

5. DISCUSSION OF THE RESULTS

5.*1 Frequency of Litigation*

The paper makes clear-cut predictions of what will happen to the frequency of substantive litigation when parameters, such as the cost of litigation or harm, vary. Others provide empirical evidence that litigation goes down when: trial costs go up (e.g. Kessler and Rubinfeld [2007]), Ps´ costs rise (e.g. Hughes and Snyder [1995]) or compensation goes down (e.g. Priest and Klein [1985], Hans and Reyna [2011], Viscusi [2013]). Of more novelty, here I predict that the frequency

[50] Note that $\frac{1-e^{-(r+\lambda)\bar{\tau}}}{1-e^{-r\bar{\tau}}}$ decreases with $\bar{\tau}$.

of litigation increases if the regulated context evolves more rapidly. Although anecdotal, next I describe two examples that point in that direction.

On one hand, the active development of jurisprudence by Delaware courts associated with the use of Poison Pills seems to have been triggered by the constant financial and strategic innovations ideated by lawyers, managers and directors to block changes in corporate control.[51] In 18 of the 25 years spanning from *Moran* (1985) to *Selectica* (2010), the Delaware Supreme Court decided at least one substantive case per year related to *Moran* (Westlaw).[52]

On the other hand, substantive litigation (Supreme Court decisions) associated with 'slip and fall' cases in the state of Georgia has been rare in the last 37 years.[53] After the landmark decision of *Alterman Foods, Inc* (1980), in which the Court established a standard in which Ps were forced to prove that Ds had superior knowledge of the hazard involved, the Supreme Court did not address the issue again until 1997 in *Robinson vs Kroger*. After *Robinson* the Court decided on the issue in only three additional cases, two in 2007 and one in 2009 (Westlaw).[54] The lack of substantive litigation seems to have gone hand in hand with the lack of events or innovations (technological, commercial, climatological or cultural) that could have required a revision in the allocation of liabilities associated with a slip and fall over 37 years.

5.2 Optimal Frequency of Litigation and Optimal Legal Standards

The American legal system receives millions of new cases annually. According to the US Bureau of Justice Statistics (BJS), in 2006 the number of newly filed, reopened, and reactivated cases from the nation's state courts reached 102.4 million.[55] However, a small percentage of cases ended in a trial. According to BJS reports, in 2005 there were more than 30 million cases in the areas of tort, contract and real property from which only 26,950 went to trial.

Although the previous statistics may lead us to conclude that the country faces too many trials, many trial cases refer to disputes of uncertainties and/or asymmetries between litigants. Yet, cases that challenge the current state of common law — either because the issue in dispute is new (moot),

[51] The nature of the legal doctrine might be such that it could be better described with standards that favor one of two parties in conflict such as in Baker and Mezzetti (2012). That said, with the correct interpretation, the evolution of many legal standards can also be described as a single bounded process. For example, the appearance of variations of the Pill (such as flip-over, back-end, NOL and others) implies higher standards of effort for managers and directors.

[52] Edelman and Thomas (2010) describe the most important judicial sentences during this period of time.

[53] In a typical 'slip and fall' case a plaintiff who suffered injuries from a fall seeks to obtain compensations from the owner or controller (potential defendant) of the premises in which the fall took place.

[54] *Fowler Properties, Inc vs Dowland* (2007), *Dickerson vs Guest Services Co. of Virginia* (2007) and *American Multi-Cinema, Inc. vs Brown* (2009).

[55] 54% of those cases are related to non-criminal traffic and local ordinance violations.

the doctrine requires clarification, or the jurisprudence requires revision — are much less common. The small percentage of cases that are appealed to superior courts is evidence that the fraction of substantive disputes is small. According to Eisenberg (2004) only 10.9% of all cases are ever appealed, and according to the BJS less than 0.1% of all cases reach a supreme court (state or national).[56] Given these numbers, it may be that there are too few trials in some areas of the law.

Although our results on optimal litigation (and also optimal standards) are normative, regulators could apply the model developed here to numerically estimate the optimal expressions. For example, suppose that $p(e) = 1 - e$ and $c(e) = \beta e^2/2$ with $\beta \geq 0$ such that $e_i = \theta_i h/\beta$. In addition, suppose that the main parameters of the model equal those in Table 3.

<<Insert Table 3 about here>>

Then in Table 4, I show predictions for optimal trial frequencies, as well as the optimal distribution of litigation expenses, optimal taxes/subsidies and optimal legal standards.

<<Insert Table 4 about here>>

Results tell us that private parties generate too few substantive trials (one every 10 years). In order to correct this, authorities could reduce Ps´ litigation expenses (in our simulations f^* fluctuates between 0.2 and 0.39) or subsidize both parties. In percentages, the subsidy falls over time from 60% to 22% (the private and social frequency gap falls with time). Even more, differences between static and dynamic standards are negligent because parameter λ is small. As predicted, dynamically efficient standards demand more effort than statically efficient ones.

6. ROBUSTNESS AND EXTENSIONS

I show that Propositions 1 to 3 hold beyond the basic model introduced in Section 3. That is, I relax many of the previously imposed assumptions and show that our main results are general.

6.1 Multi-state Regulated Context

Suppose that we add the possibility that the regulated context evolves several times, such that $\theta(t) \in \{\theta_0 + i\Delta / i \in \mathbb{N} \cup \{0\}\}$. As before, $z(t)$ follows an exponential process. While parameter

[56] Focusing only on medical malpractice, Saks (1992) notes that even when close to 1% of all medical patients have been victims of medical malpractice (iatrogenic injuries) only 10% of them initiate legal actions (a common explanation is that PPs never learn of the medical negligence). Furthermore, fewer than 10% of the claims go to trial, the majority of which are settled (Spier [2007] reports that in state and federal courts less than 4% and 2% of the civil cases go to trial respectively. Studdert et al [2006] also report low percentages of claims by injured patients).

τ_i denotes the number of time periods between substantive trials when the legal standard is e_i — I call it a cycle type i —, parameter T is the total number of cycle types that might take place.[57]

Parameter Δ determines the value of $T \in \aleph$. If $\Delta > 1 - \theta_0$ then $T = 1$, but if $\Delta \in \left[\frac{1-\theta_0}{2}, 1 - \theta_0\right]$ then $T = 2$ and so on such that if $\Delta \in \left[\frac{1-\theta_0}{i+1}, \frac{1-\theta_0}{i}\right]$ then $T = i + 1$. Next I solve the case in which $T = 2$. To do that, I define

$$V_i \equiv \frac{A_i(\tau_{i+1}^*) + V_{i+1} e^{-r\tau_{i+1}^*}\left(1 - z(\tau_{i+1}^*)\right)}{1 - e^{-r\tau_{i+1}^*} z(\tau_{i+1}^*)} \text{ with } i \in \aleph, i < T \text{ and } V_T \equiv N \frac{[p(e_T)h + c(e_T)]}{r}$$

with

$$A_i \equiv \left[\frac{\theta_i + \theta_{i+1}}{2} p(e_i)h + c(e_i)\right] - rV_{i+1}; B_i \equiv \frac{(\theta_i - \theta_{i+1})}{2} p(e_i)h$$

Then a social planner solves:

$$\min_{\tau_1,\tau_2} \left\{ \frac{1}{1 - e^{-r\tau_1} z(\tau_1)} \left[A_0(\tau_1) + \left(\frac{A_1(\tau_2) + V_2 e^{-r\tau_2}\left(1 - z(\tau_2)\right)}{1 - e^{-r\tau_2} z(\tau_2)} \right) e^{-r\tau_1}(1 - z(\tau_1)) \right] \right\}$$

which implies for $i \in \{1,2\}$

$$\tau_i^*(\Delta) = \frac{-ln\left[\frac{r}{(r+\lambda) - \lambda e^{-\tau_i^* r}}\left(1 - \frac{\frac{rk\lambda e^{-r\tau_i^*}}{(r+\lambda) - \lambda e^{-r\tau_i^*}} + 2k(r+\lambda)}{\frac{rk\lambda e^{-r\tau_i^*}}{(r+\lambda) - \lambda e^{-r\tau_i^*}} + (A_{i-1}(r+\lambda) - rB_i)}\right)\right]}{\lambda}$$

The expressions for $\tau_1^*(\Delta)$ and $\tau_2^*(\Delta)$ are identical except for the expected reduction in the costs of injury and precaution, which occurs because Ds´ effort changed. Furthermore $\tau_1^*(\Delta)$ is smaller than $\tau_2^*(\Delta)$ when $(A_1(r+\lambda) - rB_1)$ is smaller than $(A_0(r+\lambda) - rB_0)$. As we will formalize in Proposition 2G, it is a regularity of the solution that $\tau_i^*(\Delta)$ increases in i. *A decreasing frequency of substantive trials is optimal because the expected costs also decrease over time.*

Proposition 2G (Optimal periodicity of substantive trials): *If $\Delta \in \left[\frac{1-\theta_0}{T}, \frac{1-\theta_0}{T-1}\right]$ such that in an infinite horizon there will be $T \in \mathbb{N}$ types of cycles then the optimal frequency of trials is $\tau_i^*(\Delta)$ which is increasing with $i \in \{1,2, \ldots T\}$.* **Proof:** See the Appendix.

Proposition 3 can also be generalized. In Proposition 3G I find that the optimal contingent and

[57] Note that while there is a finite number of cycle types, there could be an infinite number of cycles and ergo an infinite number of trials. As we will show later, parameter T is determined by θ_0 and Δ.

non-contingent standards are weighted combinations of the optimal standards for the current and future expected states of the regulated context.

Proposition 3G (Optimal non-contingent and contingent legal standards): *If Δ is the step of adjustment in the evolution of the regulated context $\theta_i = \theta_0 + i\Delta$ with $i \in \aleph$ and T is the number of cycle types of trials then the optimal non-contingent legal standards are implicitly defined by*

$$-\frac{c'(e_i^{nc})}{p'(e_i^{nc})} = \begin{cases} \dfrac{\left[\dfrac{\theta_i + \theta_{i+1}}{2}\dfrac{1 - e^{-r\bar{\tau}}}{r} + \dfrac{\theta_i - \theta_{i+1}}{2}\dfrac{1 - e^{-(r+\lambda)\bar{\tau}}}{r+\lambda}\right]h}{\dfrac{1 - e^{-r\bar{\tau}}}{r}} \text{ if } i < T \\ h \text{ if } i = T \end{cases}$$

with $\left(1 - z(\tau)\right)h = fk$. And the optimal contingent legal standards are implicitly defined by

$$-\frac{c'(e_i^{c})}{p'(e_i^{c})} = \begin{cases} \left(\theta_i \dfrac{1 + e^{-\lambda t}}{2} + \theta_{i+1}\left(1 - \dfrac{1 + e^{-\lambda t}}{2}\right)\right)h \text{ if } i < T \\ h \text{ if } i = T \end{cases}$$

Proof: It follows deductively after we consider the scenarios in which $T \in \mathbb{N}$.

6.2 Heterogeneous parties, pre-trial negotiation and settlements

Here I consider that not all Ps are identical, as a fraction $\pi \in [0,1]$ of them suffer a low harm h_L while a fraction $1 - \pi$ of them suffer a high harm h_H with $h_H > h_L$. Although Ps know the harm they have suffered, Ds only know that it is h_L with probability π. Hence before a trial Ds only know that the representative P has suffered expected harm equal to $\bar{h} = \pi h_L + (1 - \pi)h_H$.[58]

If a legal action takes place then the parties enter into a negotiation process which costs $c > 0$ with $k > c$ such that Ps pay a fraction $f \in [0,1]$ of those costs and Ds pay the other fraction $1 - f$. At the negotiation process, Ds make a take-it-or-leave-it (TIOLI) settlement offer $S \geq 0$ to the corresponding P. If Ps accept the settlement offer then the dispute ends, and P receives a net payoff of $S - h - fc$ while D faces a cost of $S + (1 - f)c$. In the case that P rejects the offer, the dispute goes to trial *where the generated harm h and state of the regulated context $\theta(t)$ are fully revealed*. At trial, D has to pay $h + (1 - f)k$ while P receives a net payoff of $h - fk$. In order to eliminate the option of frivolous litigation we assume that $h_L > (k + c)$.

Once more I find that aside from extreme (corner) solutions in which substantive trials either

[58] The analysis can be replicated if we work with a distribution of harm, say in the interval $[\underline{h}, \bar{h}]$ *a la* Spier (1992) or Miceli (2010) in which each PD has a belief on the harm suffered by the respective PP. Results will be written in function of that distribution instead of parameter π.

take place each time period or never take place,[59] trials take place with a periodicity given as

$$\bar{\tau} = \frac{-ln\left[1 - \dfrac{2f(k+c)}{h_H}\right]}{\lambda} \quad \text{or} \quad \bar{\tau}' = \frac{-ln\left[1 - \dfrac{2\left(\dfrac{(1-\pi)}{\pi} + f\right)k}{h_H}\right]}{\lambda} \qquad (8)$$

Figure 2 summarizes the possible trial dynamics conditional on the value of π and proposition 1G states the details of the solution.

<<Insert Figure 2 about here>>

Proposition 1G (The Dynamics of Substantive Trials): *A substantive trial either takes place every period, never takes place or takes place every $\bar{\tau}$ or every $\bar{\tau}'$periods. Specifically:*

i. *If $\pi < \pi_2\left(\bar{\bar{\tau}}\right) = \frac{k}{\frac{f(k+c)}{h_L}h_H + (1-f)k}$ then trials never take place; if $\pi \in \left[\pi_2\left(\bar{\bar{\tau}}\right), \pi_2(\bar{\tau})\right]$ then trials never take place; take place each time period; or take place with frequency $\bar{\tau}'$. And if $\pi > \pi_2(\bar{\tau}) = \frac{k}{k+fc}$ then trials never take place; take place each time period; or take place with frequency $\bar{\tau}$.*

ii. *If trials take place with frequency $\bar{\tau}$ or $\bar{\tau}'$ then: PDs make effort e_i for all $t \leq \bar{\tau}$. In addition, if $\bar{h} > \frac{3}{2}\left(c + \frac{f(k+c)}{h_L}(h_H - h_L)\right)$ then PDs make effort e_i for all $t \in [\bar{\tau}, \bar{\tau}']$.*

Proof: See the Appendix.

The dynamics of litigation centrally depends on parameter π because π determines whether Ds, conditional on Ps having sued Ds, make a high or low settlement offer.[60] Ds´ TIOLI offer is the minimum amount that convinces Ps not to go ahead with their litigation endeavors.[61] Ds choose between offering $S_L = max\{0, w(e,t)h_L - fk\}$ or $S_H = max\{0, w(e,t)h_H - fk\}$. If Ds make a

[59] This time because settlement offers are high, litigation costs are too high or the cost of effort is too low.

[60] Ps only accept if the offer is larger than what they expect to get at trial which is $w(e,t)h_L - fk$ in the case of P_L and $w(e,t)h_H - fk$ if P_H in which $w(e,t)$ is the expected probability that the Court will rule D liable and is equal to

$$w(e,t) = \begin{cases} 1 \text{ if } e < e_i \\ 1 - z(t) \text{ if } e \in [e_i, e_{i+1}[\\ 0 \text{ if } e \geq e_{i+1} \end{cases}$$

[61] Strictly speaking these offers make Ps indifferent between settlement or trial which opens the space for a mixed strategy solution. However, Ds never mix as they prefer to offer an epsilon more to convince Ps not to move to Court because in Court Ds pay more $(w(e,t)h + (1-f)k$ instead of $w(e,t)h - fk)$. To avoid excessive technicalities we follow the literature (Spier [1992], Hua and Spier [2005], Avraham and Bustos [2010]) and consider that Ds offer the supreme value in the relevant interval which is $w(e,t)h - fk$. Note that a mixed solution is not possible if Ds only have partial bargaining power because then the settlement offer is strictly larger than what Ps expect to get in Court.

low offer then all P_L accept it but all P_H reject it, and go to trial with the corresponding expected expense for D of $(1-\pi)k$. Instead, if Ds make a high offer they convince all Ps to end the dispute. That is, while a high settlement offer implies paying more to the low-type plaintiffs, a low settlement offer induces the high-type plaintiffs to go to trial. Hence Ds offer S_L only when

$$S_L\pi + (1-\pi)[h_H + (1-f)k] < S_H \leftrightarrow \pi > \frac{h_H + (1-f)k - S_H}{h_H + (1-f)k - S_L}$$

It follows that a necessary condition for substantive trials to take place is that π has to be sufficiently large. A condition equivalent to (C1), evaluated at $t=\bar{\tau}$, sets a litigation in motion.

More relevant to this study, Proposition 1G reveals the existence of two trial dynamics. The first, in which periodicity is $\bar{\tau}$, takes place when π is large, while the second, in which periodicity is $\bar{\tau}'$, takes place when the value of π is intermediate. In the second dynamics a trial happens when $\pi((1-z(\bar{\tau}'))h_H - fk) = (1-\pi)k$. That is, when PDs are indifferent between making high and low settlement offers. While in the case of making the high offer PDs pay an additional $1-z(\bar{\tau}')h_H - fk$ to each P_L, they save the litigation costs k they would pay to each P_H if they make the low offer. Hence substantive trials take place more frequently when the fraction of low claims is large (more incentives to make the low offer) and negotiation costs are irrelevant.[62]

As an important final remark, we note that *ii.* in Proposition 1G implies that if trials take place with frequency $\bar{\tau}$ then PDs always choose to make effort equal to the current legal standard.

6.3 When PDs can invest to learn the state of the regulated context

So far I have assumed that agents cannot learn about the regulated context outside Court. But, professionals can attend conferences, conventions or training programs in order to update their knowledge. However, the assumption is more defensible if we realize that changes in the regulated context often imply changes in the interpretation of legal doctrines that only legal experts can clarify. To put it plainly, what matters here is not whether the innovations of the intrauterine mesh or Poison Pills are effective for the purposes for which they were created, but what matters is the way in which these innovations modify the legal duties of doctors and directors.

In what follows I assume that PDs are able to learn the state of the regulated context if they invest $Ie^{\vartheta(t-t_l)} \geq 0$, with ϑ and I positive constants, at the beginning of every period t.[63] I show

[62] Note that $\bar{\tau} = \bar{\tau}'$ when $c = 1-\pi = 0$.

[63] The cost of investment is increasing in time since the last substantive trial took place because the interpretation of the relevant legal doctrine becomes more challenging as more events take place. More effort will be required by PDs to clarify which decisions liberate them from legal responsibilities.

that unless I is very small then the main results -substantive trials take place after a given number of periods and a private-social gap in trial frequency exists- hold.

First, note that the decisions of PDs (and ergo PPs) do not change when $t < \overline{\tau}$. Because an investment in information costs $Ie^{\vartheta(t-t_l)} + z(t)c(e_i) + \big(1 - z(t)\big)c(e_{i+1})$, which is larger than $c(e_i)$, PDs maintain their decision to make effort e_i without spending $Ie^{\vartheta(t-t_l)}$ for all $t < \overline{\tau}$.[64] But what happens when $t \geq \overline{\tau}$? The answer is that PDs invest in information only if

$$Ie^{\vartheta\overline{\tau}} < \left(1 - \frac{f(k+c)}{h_H}\right)\left[\frac{(1-\pi)\theta(\overline{\tau})c}{\left(1 - \frac{f(k+c)}{h_H}\right)}\left(1 + \frac{k}{\left(1 - \frac{f(k+c)}{h_H}\right)h_H - fk}\right) - \big(c(e_{i+1}) - c(e_i)\big)\right] \quad (9)$$

If (9) does not hold at $t = \overline{\tau}$ then the results are identical to those in the basic model because PDs do not invest in information, instead they make effort e_i and a substantive trial takes place at that period. Instead if (9) holds at $t = \overline{\tau}$ then PDs invest in information, which avoids a lawsuit.[65] However, as the LHS of (9) is an increasing function in t while the RHS is a decreasing function in t, it follows that at a certain moment (when LHS and RHS intersect) PDs will not invest in information; they will make effort e_i and a trial will take place at that period. The rest of the analysis is as in the basic model, in which agents only learn in Court.

7. CONCLUSIONS

I have introduced a dynamic torts model that distinguishes between fact and substantive trials. I have used the model to improve our understanding of three questions that are central for a common law legal system: When do substantive trials take place? When does society generate an efficient number of them? And what policy instruments, including legal standards, can be used to correct inefficient litigation frequencies?

The avenues for future research are many. On theoretical grounds, investigation is required to understand the dynamic forces behind areas of the law in which legal doctrine cannot be understood as a unilateral boundary, but rather as a range of permitted behaviors (see Bustos (2006), Baker and Mezzetti (2012) or Niblett (2013)). In addition, the literature has not given civil law systems the same attention as common law systems, and ergo questions on the optimal

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[64] We assume that PPs know when PDs invest in information either because PDs reveal it or PPs get to know that if an accident takes place.

[65] Note that (9) never holds when c is small because $c(e_{i+1}) - c(e_i) > 0$.

frequency of trials, the evolution of legal standards or the optimal interventions by legislators are pendent. On empirical grounds, future research could test a number of predictions derived from our model such as the impact of legal expense distribution and the impact of changes in the regulated context on trial frequency. Future empirical research could also analyze the impact that compensation systems have had on the evolution of legal standards, and could compare them with the predictions we make here. Overall, the study of the interaction between litigations and legal standards within a dynamic context seems to be a necessary element to improve our understanding of legal institutions worldwide.

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APPENDIX: MATHEMATICAL PROOFS

Proof of Lemma 1: The FOC of $\min_e c_T(e;y)$ is $p'(e^*(y))y + c'(e^*(y)) = 0$. If we integrate with respect to parameter y such that $-\int_0^x c'\big(e^*(y)\big)dy = \int_0^x yp'\big(e^*(y)\big)\frac{de^*(y)}{dy}dy$ then $-c\big(e^*(x)\big) = \int_0^x d\big(p\big(e^*(y)\big)y\big) - \int_0^x p\big(e^*(y)\big)dy = p\big(e^*(x)\big)x - \int_0^x p\big(e^*(y)\big)dy$. In which we have used that $c\big(e^*(0)\big) = 0$ and we have integrated by parts. It follows that $c_T(e^*(x),x) = p\big(e^*(x)\big)x + c\big(e^*(x)\big) = \int_0^x p\big(e^*(y)\big)dy$ and $\frac{dc_T(e^*(x),x)}{dx} = p\big(e^*(x)\big) > 0$. If we write the FOC with x instead of y and then differentiate it with respect to x we get $\frac{de^*(x)}{dx} = -\frac{p'(e^*(x))}{p''(e^*(x))+c''(e^*(x))} > 0$ which allows us to conclude that $\frac{d^2c_T(e^*(x),x)}{dx^2} = p'\big(e^*(x)\big)\frac{de^*(x)}{dx} < 0$. **End of Proof.**

Proof of Proposition 1: Given table 2 (decisions at the second stage), we characterize the decisions made by PDs during the first stage and from there follows the timing of trials. We distinguish whether $t < \overline{\tau}$ or $t \geq \overline{\tau}$. If $t < \overline{\tau}$ then PDs always choose $e^*(t) = e_0$. The reason is twofold. First, e_0 is preferred to any effort $e > e_0$ because we know that a lawsuit never takes place when $t < \overline{\tau}$ and $e \geq e_0$. Hence in that range of efforts, PDs chose e that minimizes $c(e)$ which is e_0. Second, PDs prefer effort e_0 to any effort $e < e_0$ if it is true that

$$p(e^*)\theta(t)(h + (1-f)k) + c(e^*) > c(e_0) \text{ with } e^* < e_0 \qquad \text{(A1)}$$

The left hand side of (A1) is the result of the addition of the cost of effort with the expected cost that PDs will pay in a trial $(h + (1-f)k)$ if an accident happens $(p(e^*)\theta(t))$. We verify that (A1) indeed holds. The left hand side is increasing in *t* ergo if $p(e^*)\theta_0(h + (1-f)k) + c(e^*) > c(e_0)$ then (2) holds for any $e < e_0$. And the last inequality is true because given that $\theta_0(h + (1-f)k) > \theta_0 h$ then $e^*\big(\theta_0(h + (1-f)k)\big) > e^*(\theta_0 h) = e_0$ (from Lemma 1) which implies that the effort that minimizes $p(e)\theta(t)(h + (1-f)k) + c(e)$ when $e \leq e_0$ is the corner solution e_0.[66] Then for all $e < e_0$ it is true that

$$p(e)\theta_0(h + (1-f)k) + c(e) > p(e_0)\theta_0(h + (1-f)k) + c(e_0) > c(e_0)$$

We conclude that unless $fk = 0$ (which means that a trial takes place immediately at $t = 0$) a substantive trial does not take place before $\overline{\tau}$. We finish the characterization by showing that either a trial takes place at $t = \overline{\tau}$ or a trial never takes place. After we notice that $\theta_0(\overline{\tau})(h + (1-f)k) > \theta_0 h$ then we know (again from Lemma 1) that when $t = \overline{\tau}$ for all $e < e_0$ it is true that

$$\underbrace{p(e)\theta_0(\overline{\tau})(h + (1-f)k) + c(e)}_{Expected\ Cost\ for\ e<e_0} > p(e_0)\theta_0(\overline{\tau})(h + (1-f)k) + c(e_0)$$

In addition, just from comparison of the two expressions, it is also true that

$$p(e_0)\theta_0(\overline{\tau})(h + (1-f)k) + c(e_0) > \underbrace{p(e_0)\theta_0(\overline{\tau})((1 - z(\overline{\tau}))h + (1-f)k) + c(e_0)}_{Expected\ Cost\ if\ e=e_0}$$

In which the right hand side are the total costs that PDs expect to pay if they choose effort e_0 at $t = \overline{\tau}$. Ergo, PDs never choose $e < e_0$ at $t = \overline{\tau}$. Instead PDs either choose $e^* \in [e_0, e_1[$ in which case there is a trial at $t = \overline{\tau}$ (see table 2) or they choose e_1 and in this case a trial never takes place (again see table 2). The decision on what effort is chosen by PDs at $t = \overline{\tau}$ is determined by the next condition

$$c(e_1) > \begin{cases} p(e_0)(\theta_0 + \frac{fk\Delta}{h})k + c(e_0) \text{ if } \theta_0 \geq \frac{fk^2\Delta}{h(h-k)} \\ p(e^*)(\theta_0 + \frac{fk\Delta}{h})k + c(e^*) \text{ if } \theta_0 < \frac{fk^2\Delta}{h(h-k)} \end{cases} \qquad \text{(C1)}$$

If (C1) holds then at $t = \overline{\tau}$ all PDs make a level of effort that generates a lawsuit and trial with certainty. If (C1) does not hold then a substantive trial never takes place. From the identification of the optimal efforts we derive the possible trial dynamics

i. If (C1) does not hold then a trial never takes place ($\overline{\tau} = \infty$). If (C1) does hold then a trial takes place at $t = \overline{\tau}$ given by (1). We note that $0 < \overline{\tau} < \infty$ when $fk \in]0, h[$. If (C1) does hold but $fk = 0$ then $\overline{\tau} = 0$ and if $fk = h$ then $\overline{\tau} = \infty$.
ii. Follows directly from the previous characterization.

End of Proof.

Proof of Proposition 1G: See separate file (Proof of Proposition 1G).

[66] Because the unconstrained minimum of $p(e)\theta(t)(h + (1-f)k) + c(e)$ is to the right of e_0 we know that $p(e)\theta(t)(h + (1-f)k) + c(e)$ is decreasing in *e* when $e \leq e_0$. Hence the minimum is at the corner point.

Proof of Propositions 2 and 2G

We derive the expression for τ^*. First we solve the simplest case corersponding to T = 1 and then we solve the general case for any T. In the case of only one cycle type welfare W is given by

$$\begin{aligned} W &= A(\tau) + e^{-r\tau}\big(1 - z(\tau)\big)V_1 + e^{-r\tau} z(\tau) A(\tau) + z(\tau) e^{-2r\tau}\big[\big(1 - z(\tau)\big)V_1 + z(\tau)A(\tau)\big] \\ &\quad + \big(z(\tau)\big)^2 e^{-3r\tau}\big[\big(1 - z(\tau)\big)V_1 + z(\tau)A(\tau)\big] \ldots \\ &= A(\tau)\sum_{i=0}^{\infty}\big(e^{-r\tau}z(\tau)\big)^i + V_1\big(1 - z(\tau)\big)e^{-r\tau}\sum_{i=0}^{\infty}\big(e^{-r\tau}z(\tau)\big)^i \\ &= \frac{A(\tau) + V_1 e^{-r\tau}\big(1 - z(\tau)\big)}{1 - e^{-r\tau}z(\tau)} = \frac{A(\tau) - V_1(1 - e^{-r\tau})}{1 - e^{-r\tau}z(\tau)} + V_1 \end{aligned}$$

In which

$$A(\tau) = \int_0^{\tau}\big[\big(z(t)\theta_0 + \big(1 - z(t)\big)\theta_1\big)hp(e_0) + c(e_0)\big]Ne^{-rt}\,dt + ke^{-r\tau}$$

$$\begin{aligned} \rightarrow A(\tau) &= \left(\frac{\theta_0 + \theta_1}{2}hp(e_0) + c(e_0)\right)\int_0^{\tau} e^{-rt}\,dt + \left(\frac{(\theta_0 - \theta_1)}{2}hp(e_0)\right)\int_0^{\tau} e^{-(r+\lambda)t}\,dt + ke^{-r\tau} \\ &= \underbrace{\left(\frac{\theta_0 + \theta_1}{2}p(e_0)h + c(e_0)\right)}_{A_0 + rV_1}\frac{1 - e^{-r\tau}}{r} + \underbrace{\left(\frac{(\theta_0 - \theta_1)}{2}p(e_0)h\right)}_{B_0}\frac{1 - e^{-(r+\lambda)\tau}}{r + \lambda} + ke^{-r\tau} \end{aligned}$$

And

$$V_1 = \frac{p(e_1)\theta_1 h + c(e_1)}{r}$$

Then we have to solve

$$\min_{\tau}\left\{\frac{A(\tau) - V_1(1 - e^{-r\tau})}{1 - e^{-r\tau}z(\tau)}\right\} = \min_{\tau}\left\{\frac{A_0\dfrac{1 - e^{-r\tau}}{r} + B_0\dfrac{1 - e^{-(r+\lambda)\tau}}{r + \lambda} + ke^{-r\tau}}{1 - \dfrac{e^{-r\tau}}{2} - \dfrac{e^{-(r+\lambda)\tau}}{2}}\right\}$$

which defines the following FOC

$$\begin{aligned} &\frac{A_0 e^{-r\tau} + B_0 e^{-(r+\lambda)\tau} - rke^{-r\tau}}{1 - \dfrac{e^{-r\tau}}{2} - \dfrac{e^{-(r+\lambda)\tau}}{2}} \\ &\qquad - \frac{A_0\dfrac{1 - e^{-r\tau}}{r} + B_0\dfrac{1 - e^{-(r+\lambda)\tau}}{r + \lambda} + ke^{-r\tau}}{\left(1 - \dfrac{e^{-r\tau}}{2} - \dfrac{e^{-(r+\lambda)\tau}}{2}\right)^2}\left(r\frac{e^{-r\tau}}{2} + (r + \lambda)\frac{e^{-(r+\lambda)\tau}}{2}\right) = 0 \\ \rightarrow &\left(1 - \frac{e^{-r\tau}}{2} - \frac{e^{-(r+\lambda)\tau}}{2}\right)\left(A_0 e^{-r\tau} + B_0 e^{-(r+\lambda)\tau} - rke^{-r\tau}\right) \\ &\qquad - \left(r\frac{e^{-r\tau}}{2} + (r + \lambda)\frac{e^{-(r+\lambda)\tau}}{2}\right)\left(A_0\frac{1 - e^{-r\tau}}{r} + B_0\frac{1 - e^{-(r+\lambda)\tau}}{r + \lambda} + ke^{-r\tau}\right) = 0 \\ \leftrightarrow &\; e^{-\lambda\tau}\left(-\lambda e^{-r\tau}kr + A_0\big(\lambda e^{-r\tau} - (r + \lambda)\big) + B_0 r\left(1 - \frac{\lambda}{r + \lambda}e^{-r\tau}\right)\right) = r\left(2kr - A_0 + \frac{B_1 r}{r + \lambda}\right) \end{aligned}$$

$$\leftrightarrow e^{-\lambda\tau} = \frac{r\left(2kr - A_0 + \frac{B_0 r}{r+\lambda}\right)}{-\lambda e^{-r\tau}kr + (r+\lambda)A_0\left(\frac{\lambda}{r+\lambda}e^{-r\tau} - 1\right) + B_0\left(1 - \frac{\lambda}{r+\lambda}e^{-r\tau}\right)}$$
$$= \frac{r\big(B_0 r - A_0(r+\lambda) + 2kr(r+\lambda)\big)}{\big(B_0 r - A_0(r+\lambda)\big)(r + \lambda(1-e^{-r\tau})) - \lambda(r+\lambda)e^{-r\tau}kr}$$
$$\rightarrow \tau^* = \frac{-ln\left[\frac{r\big((A_0(r+\lambda) - B_0 r) - 2kr(r+\lambda)\big)}{(A_0(r+\lambda) - B_0 r)(r+\lambda(1-e^{-r\tau})) + \lambda r(r+\lambda)e^{-r\tau}k}\right]}{\lambda}$$

Note that this is well defined because $(A_0(r+\lambda) - B_0 r) > 0$ and the expression in the argument of $\ln(\cdot)$ is smaller than 1 as $r\big((A_0(r+\lambda) - B_0 r) - 2kr(r+\lambda)\big) < (A_0(r+\lambda) - B_0 r)(r + \lambda(1-e^{-r\tau})) + \lambda(r+\lambda)e^{-r\tau}k$. For the general case, any value of T, we recursevily define V_i as

$$V_i \equiv \frac{A_i(\tau_{i+1}) + V_{i+1}e^{-r\tau_{i+1}}\big(1 - z(\tau_{i+1})\big)}{1 - e^{-r\tau_{i+1}}z(\tau_{i+1})} \text{ with } i \in [0, T-1] \text{ and}$$
$$V_T \equiv \frac{[p(e_T)\theta_1 h + c(e_T)]}{r}$$

Then, replacing recursively we get

$$V_{T-i} \equiv \left\{ \begin{aligned} &\sum_{j=0}^{i-1}\left(A_{T-(j+1)}\big(\tau_{T-j}\big)\frac{e^{-r\sum_{s=0}^{i-(j+1)}\tau_{T-s}}}{e^{-r\tau_T}\big(1 - z(\tau_T)\big)}\prod\nolimits_{s=0}^{i-(j+1)}\frac{1 - z(\tau_{T-s})}{1 - e^{-r\tau_{T-s}}z(\tau_{T-s})}\right) \\ &\qquad + \frac{V_T e^{-r\sum_{j=0}^{i-1}\tau_{T-j}}\prod_{j=0}^{i-1}\Big(1 - z\big(\tau_{T-j}\big)\Big)}{\prod_{j=0}^{i-1}\Big(1 - e^{-r\tau_{T-j}}z\big(\tau_{T-j}\big)\Big)} \end{aligned} \right\} \text{ with } i \in [1, T]$$

which implies that V_0 is a function of $\{\tau_1, \dots, \tau_T\}$ such that

$$\min_{\{\tau_1,\dots,\tau_T\}} V_0\,(\tau_1, \dots, \tau_T)$$

defines the next set of FOC:

$$\frac{\partial}{\partial\tau_i}\left(\frac{A_i(\tau_i) + V_{i+1}(\tau_{i+1},\dots,\tau_T)e^{-r\tau_i}\big(1 - z(\tau_i)\big)}{1 - e^{-r\tau_i}z(\tau_i)}\right) = 0 \text{ for all } i \in [1, T]$$

which translates into

$$\frac{A_{i-1}e^{-r\tau} + B_{i-1}e^{-(r+\lambda)\tau} - rke^{-r\tau}}{1 - \frac{e^{-r\tau}}{2} - \frac{e^{-(r+\lambda)\tau}}{2}} - \frac{A_{i-1}\frac{1 - e^{-r\tau}}{r} + B_{i-1}\frac{1 - e^{-(r+\lambda)\tau}}{r+\lambda} + ke^{-r\tau}}{\left(1 - \frac{e^{-r\tau}}{2} - \frac{e^{-(r+\lambda)\tau}}{2}\right)^2}\left(r\frac{e^{-r\tau}}{2} + (r+\lambda)\frac{e^{-(r+\lambda)\tau}}{2}\right) = 0$$

Or

$$\tau_i^* = \frac{-ln\left[\frac{r}{(r+\lambda) - \lambda e^{-\tau_i^* r}}\left(1 - \frac{\frac{rk\lambda e^{-r\tau_i^*}}{(r+\lambda) - \lambda e^{-r\tau_i^*}} + 2k(r+\lambda)}{\frac{rk\lambda e^{-r\tau_i^*}}{(r+\lambda) - \lambda e^{-r\tau_i^*}} + (A_{i-1}(r+\lambda) - rB_{i-1})}\right)\right]}{\lambda}$$

In order to prove that τ_i^* is increasing in i (Proposition 2G), we to prove that $(A_i(r+\lambda) - rB_i)$ decreases with i. In other words we want to prove that

$$(A_{i+1}(r+\lambda)-rB_{i+1})-(A_i(r+\lambda)-rB_i)\leq 0$$

Which is equivalent to

$$\left[\frac{\theta_{i+1}+\theta_{i+2}}{2}p(e_{i+1})h+c(e_{i+1})-V_{i+2}r\right](r+\lambda)-\left[\frac{(\theta_{i+1}-\theta_{i+2})}{2}p(e_{i+1})h\right]r$$
$$-\left\{\left[\frac{\theta_i+\theta_{i+1}}{2}p(e_i)h+c(e_i)-V_{i+1}r\right](r+\lambda)-\left[\frac{(\theta_i-\theta_{i+1})}{2}p(e_i)h\right]r\right\}\leq 0$$

And because $V_{i+1}<V_i$ for all *i* together with $V_i<\frac{[\theta_i p(e_i)h+c(e_i)]}{r}$ then we prove what we want if

$$\left[\frac{\theta_{i+1}+\theta_{i+2}}{2}p(e_{i+1})h+c(e_{i+1})-[\theta_T p(e_T)h+c(e_T)]\right](r+\lambda)-\left[\frac{(\theta_{i+1}-\theta_{i+2})}{2}p(e_{i+1})h\right]r$$
$$-\left\{\left[\frac{\theta_i+\theta_{i+1}}{2}p(e_i)h+c(e_i)-[\theta_i p(e_i)h+c(e_i)]\right](r+\lambda)-\left[\frac{(\theta_i-\theta_{i+1})}{2}p(e_i)h\right]r\right\}$$
$$\leq 0$$

which by itself is true if

$$\left[\theta_{i+2}p(e_{i+1})h+c(e_{i+1})-\left(\theta_T p(e_T)h+c(e_T)\right)\right]r\leq 0 \qquad \text{(A2)}$$

and

$$\left\{\left[\frac{\theta_{i+1}+\theta_{i+2}}{2}p(e_{i+1})h+c(e_{i+1})-[\theta_T p(e_T)h+c(e_T)]\right]-\left[\frac{\theta_{i+1}-\theta_i}{2}p(e_i)h\right]\right\}(r+\lambda)\leq 0 \qquad \text{(A3)}$$

First we prove (A2). From Lemma 1 we know that $\left(\theta_T p(e_T)h+c(e_T)\right)>\left(\theta_{i+2}p(e_{i+2})h+c(e_{i+2})\right)$ which implies

$$\left[\theta_{i+2}p(e_{i+1})h+c(e_{i+1})-\left(\theta_T p(e_T)h+c(e_T)\right)\right]$$
$$\leq\left[\theta_{i+2}p(e_{i+1})h+c(e_{i+1})-\left(\theta_{i+2}p(e_{i+2})h+c(e_{i+2})\right)\right]$$

And the RHS can be rewritten as

$$\underbrace{\frac{\left[\left(\theta_{i+2}p(e_{i+2})h+c(e_{i+2})\right)-\left(\theta_{i+1}p(e_{i+1})h+c(e_{i+1})\right)\right]}{\theta_{i+2}h-\theta_{i+1}h}}_{p(e_{i+1})}(\theta_{i+1}-\theta_{i+2})h$$
$$+(\theta_{i+2}-\theta_{i+1})p(e_{i+1})\overline{h}=0$$

Now we prove (A3). Once more from Lemma 1 we know that

$$\left\{\left[\frac{\theta_{i+1}+\theta_{i+2}}{2}p(e_{i+1})h+c(e_{i+1})-[\theta_T p(e_T)h+c(e_T)]\right]-\left[\frac{\theta_{i+1}-\theta_i}{2}p(e_i)h\right]\right\}$$
$$\leq\left\{\left[\frac{\theta_{i+1}+\theta_{i+2}}{2}p(e_{i+1})h+c(e_{i+1})-[\theta_{i+2}p(e_{i+2})h+c(e_{i+2})]\right]-\left[\frac{\theta_{i+1}-\theta_i}{2}p(e_i)h\right]\right\}$$

And the RHS is equal to

$$\leftrightarrow\left[\underbrace{\frac{\theta_{i+2}p(e_{i+2})h+c(e_{i+2})-\left(\theta_{i+1}p(e_{i+1})h+c(e_{i+1})\right)}{(\theta_{i+2}-\theta_{i+1})\overline{h}}}_{p(e_{i+1})}(\theta_{i+1}-\theta_{i+2})h-\frac{\theta_{i+1}-\theta_i}{2}p(e_i)h\right]$$
$$=-\Delta\left(\frac{p(e_i)+p(e_{i+1})}{2}h\right)\leq 0$$

The proofs for *i.* to *iii.* in Proposition 2, follow directly from the discussion in the main text in which first we consider $r=\infty$ (for *i.* and *ii.*) and the consider that $r<\infty$ (for *iii.*). **End of Proof.**

TABLES AND FIGURES

Table 1. Timing of events at every period of time: Substantive Trials	
Stage	Substantive-Trial
First	PDs choose effort e. PPs do observe it
Second	State of nature realizes but no agent observes it. If an accident happens then PPs decide whether to demand
Third	If a trial takes place then $\theta(t)$ is revealed. The Court verifies if D at least made effort e_i when $\theta(t) = \theta_i$. If D is found liable then he pays h to P. In addition P pays fk and D pays $(1 - f)k$
We interexchangeably use the words: demand, lawsuit or legal action. In the same way we interexchangeably use the words trial, decision on the merits or Court decision	

Table 2: PPs decisions to sue at stage 2 conditional on stage 1			
Stage			
PPs sue	$Always$	$Only\ if$ $t \geq \bar{\tau}$	$Never$
PDs choose optimal effort	$e < e_0$	$e \in [e_0, e_1[$	$e = e_1$

Table 3 Numerical values								
N	h	k	f	θ_i	Δ	β	λ	r
10^5	10^6	$5*10^4$	0.5	0.2	0.05	$1.2*10^4$	0.005	0.1

Table 4 Simulation: Frequencies, corrections and legal standards ($\bar{\tau} = 10.3$)						
	Timing	Corrections			Standards	
T	$\tau^* = \Delta t$	f^*	t/s^*	% [t/s^* over k]	Static	Dynamic (non-contingent)
1	4	0,20	-30199	60%	0,2458	0,2461
2	4	0,20	-30199	60%	0,2950	0,2953
3	5	0,25	-25310	51%	0,3442	0,3444
4	5	0,25	-25310	51%	0,3933	0,3936
5	5	0,25	-25310	51%	0,4425	0,4428
6	5	0,25	-25310	51%	0,4917	0,4919
7	5	0,25	-25310	51%	0,5408	0,5411
8	5	0,25	-25310	51%	0,5900	0,5903
9	6	0,30	-20446	41%	0,6392	0,6395
10	6	0,30	-20446	41%	0,6883	0,6887
11	6	0,30	-20446	41%	0,7375	0,7378
12	6	0,30	-20446	41%	0,7867	0,7870
13	7	0,34	-15605	31%	0,8358	0,8362
14	7	0,34	-15605	31%	0,8850	0,8854
15	8	0,39	-10789	22%	0,9342	0,9353
16	73	3,06	255803	-512%	0,98	1

Figure 1. Optimal frequency of substantive Trials

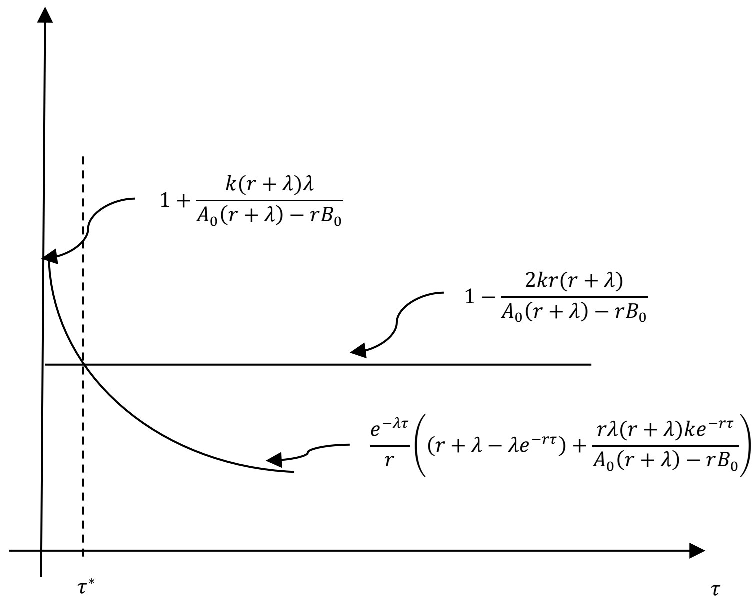

Figure 2. When Substantive Trials take place (conditional on π).