Estimating the Degree of Expert's Agency Problem: The Case of Medical Malpractice Lawyers

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Very Preliminary and Incomplete - Comments Welcome!

Abstract

I empirically study the expert's agency problem in the context of lawyers and their clients. Incentives of lawyers and clients are misaligned in dispute resolution under contingency fee arrangement with which lawyers receive a fraction of recovered payment as compensation while bearing the legal cost. Lawyers prefer to pursue a case less than their clients prefer as they incur all the legal costs and receive smaller fraction of payment. In this paper, I measure the degree to which lawyers work in the interest of their clients. To do so, I construct a bargaining model of dispute resolution that nests two special cases as well as their convex combinations in which lawyers work in their clients' best interests and in which they work in their own interests, and estimate the model using data of medical malpractice disputes. The timing of dropped cases identifies the nesting parameter because cases are dropped more frequently and at earlier timings if lawyers work in their own interests. I find that lawyers work almost perfectly in their own interest. Then, I compute the cost of agency problem resulting from misaligned incentives by simulating the first-best outcome using the estimated model. Finally, I evaluate the impact of tort reform on contingency fee, and show that limitation of contingency fee lower the joint surplus further.

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1 Introduction

Expert agents can mislead their clients in their own interests due to lack of expertise on the side of their clients. Experts such as lawyers, physicians, auto repairers, and real estate agents are better informed of the services they provide than their clients. Due to this asymmetry of information, clients make decision based on advices of experts or even delegate their decision to the experts, and clients may not know or find it very costly to verify if the experts worked in their best interests. As a result, experts have incentive to work in their own interests instead of their clients' interests.

On the other hand, factors such as reputational concern, professional liability, capacity constraint, and/or professional ethics mitigates the experts' agency problem to some extent. For example, a dentist may suggest an expensive porcelain filling instead of a quick composite resin filling to treat a simple dental cavity, but she may refrain from doing so because of reputational concern or due to capacity constraints (lack of time for another appointment to place porcelain filling). The degree to which experts work in the interest of their clients depends on relative strength of these factors and is an open empirical question. Existing studies either confirms the existence of the experts' agency problem or countering effects of the mitigating factor, but have not measured the relative strength.

In this paper I estimate the degree to which experts work in their client's interest. Specifically, I consider the experts' agency problem for the case of lawyers and their clients in resolution of medical malpractice disputes. A plaintiff in medical malpractice dispute signs contingency fee contract with a lawyer. The incentives of the lawyer and the client are misaligned in dispute resolution under contingency fee arrangement with which the lawyer receives a fraction of recovered payment as compensation while bearing all the costs of legal services. Since the client incur no cost of the lawyer's services, the lawyer prefer to settle the case earlier than the client prefers, and the lawyer has stronger incentive to drop a case.[1] Using data on timing of settlements and dropping, I answer the primary question of this paper: What is the degree to which a lawyer work in the interest of a client?

Contingency fee is also an important policy issue in tort reform discussion, especially on medical malpractice. Regulation on contingency fees are adopted by 15 states as of 2005[2] and are currently under consideration at the federal level.[3] In spite of its policy importance,

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[1] In this paper, "drop" means that the side of the plaintiff stops pursuing the case, which includes voluntary dismissal, settlement with zero payment without filing of a lawsuit, and settlement with zero payment after filing of a lawsuit. .

[2] See the database of state tort law reforms constructed by Avraham (2006). These regulations typically impose a limit on the fraction lawyers can receive as contingency fee such as 40% and 33%.

[3] The House of Representatives passed the Help Efficient, Accessible, Low-Cost, Timely Healthcare (HEALTH) Act of 2003 in the 108th Congress, while the Senate voted against it. The bill has been reintroduced in 2004 and 2005 and is currently pending. The Medical Care Access Protection Act of 2006 stalled in the Senate also includes regulation on contingency fee for plaintiff's attorneys on medical malpractice

little is known empirically about how regulation on contingency fee affects the outcomes of medical malpractice disputes such as legal costs, settlement payments, and probability of lawsuits, as well as how it affects the agency problem of lawyers and their clients. This is another question I ask in this paper.

In order to answer these questions, I construct a bargaining model of dispute resolution that nests two special cases as well as their convex combinations; one in which lawyers work in the best interests of their clients, and one in which lawyers work for their own interests. I estimate the model using a unique micro-level data on medical malpractice disputes. The nesting parameter measures the degree to which incentives are misalignement. Using the estimated model, I simulate the first-best outcome and measure the cost of agency problem resulting from the misaligned incentive. Finally, I conduct a counterfactual policy experiment of limiting contingency fees and assess the impact of the policy on outcomes and welfare.

A plaintiff (i.e. a patient) in a medical malpractice dispute retain a lawyer and adopt contingency fee arrangement for vast majority of cases.[4] A claim by the side of plaintiff against a healthcare provider initiates a medical malpractice dispute. The plaintiff's lawyer[5] and the defendant engage in negotiations over the terms of settlement in the shadow of court judgment. If the side of plaintiff files a lawsuit and the parties do not reach an agreement or the side of the plaintiff do not drop the case, they will face a judgment by the court, which determines whether the defendant is liable and, if so, the award to the plaintiff. The side of the plaintiff can drop a case at any time during the process.

To study this process, I construct a dynamic bargaining model in which the plaintiff's lawyer and the defendant bargain over a settlement following Yildiz (2003, 2004) and Watanabe (2006). At any time during the negotiation, as long as the case has neither been settled nor dropped, the plaintiff's lawyer has the option of filing a lawsuit that would initiate the litigation phase. If the case is neither settle nor dropped during the litigation phase, the case is resolved in court, where a jury verdict determines whether the defendant is liable and, if so the award to the side of the plaintiff. In any period prior to the termination of a dispute, the plaintiff's lawyer and the defendant must pay the legal costs which I allow to differ across the sides of the plaintiff and the defendant and depending on whether or not a lawsuit is filed. In particular, the legal costs are typically higher during the litigation phase, which entails additional legal procedures with respect to the pre-litigation phase. I do not consider expert's agency problem for the side of the defendant because medical lia-

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cases.

[4]For example, Sloan et al (1993) reports that plaintiffs retained lawyers in 99.4 percent of the cases and that contingency fee arrangement was adopted in 99.4 percent of the cases in Florida.

[5]I assume throughout the paper that the plaintiff's lawyer is the decision maker for the side of the plaintiff. This is a common assumption in the literature that is supported by surveys for individual clients (see, e.g. Sloan et al (1993) and Kritzer (1998)).

bility insurance companies who are well-informed of the legal issues and procedures makes desicions for the defendant.

A parameter $\delta \in [0, 1]$ in the model reflects the degree to which the lawyer work in the client's interest. Depending on the value of this parameter the model nests two special cases and their convex combination; one in which the plaintiff's lawyer work in the best interest of the plaintiff ($\delta = 0$), and one in which the lawyer work in her own interest ($\delta = 1$). In the former case, the objective of the plaintiff's lawyer is to maxmize the payment from the defendant ignoring any legal cost incurred by the side of the plaintiff. In the latter case, the objective of the plaintiff's lawyer is to maximize a contingency fee fraction of payment from the defendant minus the sum of per-period legal cost incurred by the side of the plaintiff.

I characterize the unique subgame-perfect equilibrium of this dynamic bargaining game. Equilibrium outcomes specify (i) the lawyer's decision of whether to file a lawsuit and (ii) if so the time to filing, (iii) whether or not the case is dropped by the plaintiff's lawyer, (iv) whether or not the case is settled out of court, (v) the time to resolution by dropping or by settlement, (v) the legal costs incurred, and (vi) the terms of settlement. Delaying agreement is costly because of the per-period legal costs. However, the possibility of learning new information makes delay valuable for both players. This fundamental trade-off plays an important role in the equilibrium characterization and is a key determinant of the time to filing and the time to settlement. Furthermore, I find that the more misaligned the incentives of the plaintiff and his or her lawyer are, the shorter the time to settlement as well as to dropping and the higher the probability of dropping a case. This is because the plainiff's lawyer takes her per-period cost more fully if their incentives are misaligned. This property identifies the nesting parameter in estimation.

I estimate the model using a unique data set on individual medical malpractice disputes. The data set contains detailed information on the time, mode, cost, and terms of settlement as well as the time of filing lawsuit (if a lawsuit is filed) and the time of dropping (if a case is dropped) for all medical malpractice disputes in Florida over the period 1985-1999. The estimate for the nesting paramater δ is 0.8128, which implies that the lawyers do not work very much in the best interest of their clients.

I use the estimated structural model to compute the cost of agency problem resulting from the incentive misalignment. To do so, I simulate the first-best outcome which corresponds to the case that the plaintiff's lawyer maximize the payment from the defendant minus the legal cost incurred.[6]   I find that the joint surplus for the side of the plaintiff is

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[6]Socially optimal outcome cannot be achieved in the model we estimate. In case the plaintiff's lawyer work in his/her interest, the lawyer only considers a fraction of the payment from defendant minus the legal cost. In this case, the lawyer is giving too much weight for the legal cost. In case the plaintiff's lawyer work in the plaintiff's best interest, the lawyer ignores the legal cost she incurs. In this case, the legal cost is underweighted.

15% less compared to the firt-best outcome. Under the first-best outcome, more cases are litigated and the time to resolution increases. The legal costs of the both side increases, but the increase in payment to the side of the plaintiff from the side of the defendant is larger than the increase in cost.

Finally, I conduct couterfactural policy experiments and evaluate how regulation on contingency fee arrangement affects the outcomes of dispute resolution as well as the cost of the agency problem. Specifically, I consider a limit on contingency fee at 25%. I find that more cases are dropped, frequency of filing of lawsuits decrease, and mean time to resolution decreases. This is because the plaintiff's lawyer receive less fraction of the payment as compensation with such limit on fees while the per-period legal cost remains the same. The expected join-surplus decreases by about 13% reflecting a large decrease in expected payment.

1.1   Literature

A small but growing empirical literature studies agency problem in expert services.[7] Levitt and Syverson (2006) compares home sales in which real estate agents are the owner of the house and in which they are not, and found that houses are sold at higher price and stayed longer on market in the former case. Gruber and Owings (1996) analyzed physicians' likelihood of performing cesarean section delivery, and show a strong correlation between decline in fertility and increase in cesarean, which they interpret as physician's inducing demand for cesarean by exploiting agency relationship. Iizuka (2006) investigates Japanese prescrition market in which physician can sell drugs as well as prescribing it and find that their prescriptions are influenced by the markup of the drugs. All these papers presents evidence that agency problem exists in expert services. Hubbard (1998) studies auto repaireres's emission inspection decision, and shows that auto repairers help to pass by expecting customers to return rather than maximizing short run profits by selling repairs. This paper shows an evidence of factors that mitigates agency problem. None of the paper, however, directly estimates the degree of incentive misalignment and quantify the cost of the agency problem.

The paper also adds to the literature on empirical study of pre-trial bargaining.[8] Using data on the mode of resolution of civil disputes, Waldfogel (1995) estimates two-period bargaining model with heterogenous belief. Sieg (2000) estimates barganing model with

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[7]Theoretical models of expert sercises includes Dranove (1988), Wolinsky (1993), Emons (1997), and Fong (2005).

[8]See the surveys by Kessler and Rubinfeld (2005) and Spier (2007). Theoretical literature on agency problem regarding contingency fee contract includes Miller (1987), Rubinfeld and Scotchmer (1990), Dana and Spier (1993), Watts (1994), Hay (1996, 1997), Rickman (1999), Choi (2003), and Polinsky and Rubinfeld (2003). These papers employs two-period models which abstracts from learning during procedure. Hence, dropping during pre-trial bargaining is not considered.

asymmetric information to study the mode, cost, and terms of settlement in medical malpractice dispute using the same data set I use in this paper. Watanabe (2006) further investigate the dispute resolution process by constructing and estimating a multi-period dynamic barganing model to study the timing of settlement and litigation in addition to the mode, cost and terms of settlement. All of these papers, however, abstract from the dropping decision and potential agency problem bewteen plaintiff and plaintiff's lawyer, and do not utilize the data of dropped cases. Danzon and Lillard (1983) uses data of dropping in medical malpractice disputes and find that limits on contingency fees lowers likelihood of dropping significantly. Helland and Tabarrok (2003) also uses data on medical malpractice disputes and find that limit on contingency fees both lowers likelihood of dropping and increases time to settlement. These two papers, however, are not interested in agency problem and timing of dropping, which I address in this paper.

The remainder of the paper is organized as follows. In Section 2, I present the model and characterize the equilibrium. Section 3 describes the data and Section 4 presents the econometric specification. Section 5 will contains the results of the empirical analysis.

2   Model

I consider a sequential bargaining model of legal dispute resolution with perfect-information and stochastic learning. The players of the bargaining game are a plaintiff's lawyer (p) and a defendant (d).[9] The plaintiff's lawyer and the defendant bargain over the compensation payment $x \in \mathcal{R}^+$ from the defendant to the plaintiff to resolve the dispute. Each player $i \in \{d, p\}$ has linear von-Neumann-Morgenstern preferences over monetary transfer and legal costs. Both players know the amount of the potential jury award $V \in \mathcal{R}^+$, but the outcome of the judgement is uncertain, i.e. the players do not know who will win the case in the event of a trial.[10] Hence, defendant pays V to the side of the plaintiff if the plaintiff wins the judgmen, while the defendant does not pay any amount otherwise. I denote the plaintiff's probability of prevailing by π.

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[9]Throughout the paper, I assume the decision maker for the side of the plaintiff as plaintiff's lawyer. Sloan et al. (1993) finds that plaintiffs "almost always followed their lawyer's advice regarding settlement (p85)." They report that plaintiffs setted 100% of the cases when lawyer's advice favored accepting and 4.8% when lawyer's advice favored rejecting. Another reason for this assumption is due to the informational asymmetry between plaintiffs and his/her lawyers. Lawyers are experienced experts of the medical liability system, and the plaintiffs are less likely have better information than the lawyers. However, for the side of the defendant, I do not assume defendants' lawyers as decision makers because the defendants are primarily insurance companies and are well-informed and have expertise on dispute resolution.

[10]In the literature the uncertainty of the judgment is caused either (i) by the uncertainty of the winning party (see e.g., Pries and Klein(1984)) or (ii) by the uncertainty of the award amount (see e.g. Spier (1992)). Implications of the model do not differ between (i) and (ii) because the expected award is what matters. I take the former assumption because I can better explain the data in which a large proportion of cases concludes with no jury award at the court judgment.

Plaintiffs and his/her lawyers adopt contingency fee arrangement for vast majority of the medical malpractice cases in Florida[11], while defendants' legal councils charge an hourly legal fee. The contingency fee arrangement entitles the plaintiff's lawyers to a fraction of the money received from the defendant only if a positive payment is received. I denote the fraction by γ, hence a plaintiff's lawyer receives fraction γ of the defendant's payment to the side of the plaintiff as compensation for the legal services they provide, and the palintiff receives the remaining fraction $1 - \gamma$.

Timing and Phases The bargaining game has two multi-period phases depending on whether the plaintiff's lawyer has filed a lawsuit or not: the pre-litigation phase (Phase O) and the litigation phase (Phase L). The game starts with Phase O at period $t = 0$. Players bargain every period until they reach an agreement. Phase O has a finite number of periods $\overline{T} < \infty$, due to the statute of limitation at period $t = \overline{T} + 1 < \infty$, after which the plaintiff's claim to recover is barred by law. The plaintiff has an option of filing a lawsuit in Phase O as long as no agreement has been reached and the case has not been dropped. The filing of a lawsuit moves the game to Phase L. Thus, in Phase O, a case may be either filed (leading to Phase L), dropped (without filing a lawsuit), settled (without filing a lawsuit), or terminated by the statute of limitations.

The plaintiff's endogenous decision to file a lawsuit initiates Phase L. Let $t_L \in \{0, ..., \overline{T}\}$ denote the date of the filing of lawsuit. Once the plaintiff files a lawsuit, the case is processed in court towards the judgment scheduled $T + 1$ periods after the date of filing, that is date $t = t_L + T + 1 < \infty$. While the case is processed in court, it can always be dropped by the plaintiff or settled by both parties until $t = t_L + T$. Failure to reach a settlement agreement by $t = t_L + T$ results in the resolution by the court judgment at $t = t_L + T + 1$.

Information and Beliefs The model is a game of perfect information. As described above, the players can observe all the actions of the other player. The information revealed is also commonly observed by both players. Hence, there is no asymmetric information. The players, however, do not have a common prior over the probability that the plaintiff will win the case (π). This asymmetry in initial beliefs may be due for example to differences in each party's perception of the relative ability of his or her lawyer or to differences in opinion about the predisposition of potential juries.

I assume that the players' beliefs of the probability of the plaintiff's prevailing $\pi \in [0, 1]$ follow beta distributions, a flexible as well as tractable distribution with support $[0, 1]$ that is widely used in statistical learning models on Bernoulli trial process. Player i's initial

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[11]Sloan et al. (1993) reports that 99.4% of the cases adpoted contingency fee arrangement in their Survey of Medical Malpractice Claimants conducted in Florida during 1989-1990.
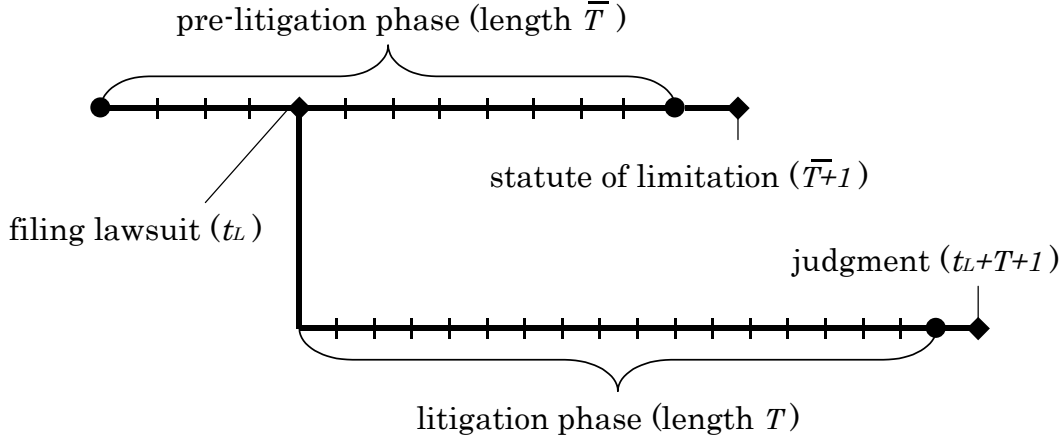
Figure 1: Diagram of Model Structure. The plaintiff and the defendant start bargaining over a settlement in pre-litigation stage. At any time in pre-litigatioin stage, as long as the plaintiff has not dropped the case or no agreement has been reached, the plaintiff has the option of filing a lawsuit that endogenously determine t_L and would initiate the litigation stage. If neither a lawsuit is filed, the case is dropped, nor a settlement is reached by $\overline{T}$ in pre-litigation phase, the case is no longer valid due to statute of limitation. If neither agreement is reached nor the case is dropped during the litigation stage, the case is resolved by court judgment at $t_L + T + 1$.

belief, denoted by b_0^i, are represented by $Beta(\theta_i, \rho - \theta_i)$, where $0 < \theta_d < \theta_p < \rho$.[12] A common parameter ρ represents the firmness of belief as explained later. Thus, at the initial date, the players have expected probability of plaintiff's prevailing as

$$
\begin{aligned}
E(b_0^p) &= \frac{\theta_p}{\rho} \text{ for the plaintiff, and} \\
E(b_0^d) &= \frac{\theta_d}{\rho} \text{ for the defendant.}
\end{aligned}
$$

At the beginning of each period t in Phase $J \in \{O, L\}$, information related to winning probability (such as the result of a third party medical examination or testimony by an expert witness) arrives with probability λ_J. I denote an arrival of information at t by $n^t \in \{0, 1\}$, where $n^t = 1$ means arrival of information while $n^t = 0$ represents no arrival.

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[12] See Yildiz (2003, 2004) for a similar learning mechanism. Arrival of information is deterministic in his model, while it is stochastic in my model.

The cumulated amount of information at period t is denoted by $n_t \in \{0, ..., t\}$, and therefore

$$n_t = n_{t-1} + n^t.$$

Information is either in favor of or against the plaintiff. I denote the content of the arrived information n^t by $m^t \in \{0, 1\}$. The content is for the plaintiff if $m^t = 1$, while $m^t = 0$ means the arrived information is against the plaintiff, and

$$m^t = \begin{cases} 0 & \text{with probability } 1 - \pi \\ 1 & \text{with probability } \pi, \end{cases}$$

where π is not known to the players. The cumulated information in favor of the plaintiff is denoted by $m_t \in \{0, ..., n_t\}$, leading to

$$m_t = m_{t-1} + n^t m^t$$

where m^t is multiplied by n^t since the content of information matters only if information arrives.

Players update their beliefs according to Bayesian updating as follows: The beliefs at period t, denoted by b_t^p and b_t^d, follow $Beta(\theta_p + m_t, \rho - \theta_p + n_t - m_t)$ and $Beta(\theta_d + m_t, \rho - \theta_d + n_t - m_t)$ respectively. Hence, at period t, the expectations on the probability π of plaintiff's prevailing on the judgement are

$$E(b_t^p) = \frac{\theta_p + m_t}{\rho + n_t}$$

and

$$E(b_t^d) = \frac{\theta_d + m_t}{\rho + n_t}.$$

The players use these expectations as their estimates of π. The firmer the beliefs (i.e., the higher the firmness of belief parameter ρ), the less is the impact of the information obtained in the legal process. By modelling beliefs this way, I can capture the relative impact of new learning on prior beliefs. The information environment I have described above is common knowledge to both players. For notational convenience, I let $k_t = (n_t, m_t) \in \{0, t\} \times \{0, t\}$ denote the information state.

Stage Games In Phase O, players play the following stage game in every period $t \in \{0, ..., \overline{T}\}$. At the beginning of each period, information arrives with probability λ_{Ot} and does not arrive with probability $1 - \lambda_{Ot}$. The information is such that it affects the outcome of the judgment (e.g., the result of third-party medical examination) and is commonly

observed by both players. Then, the plaintiff's lawyer chooses whether to drop the case or continue it. If she chooses to drop the case, the case is resolved with no payments being made from defendant to the side of the plaintiff. Otherwise, nature chooses the proposer, with probability ϕ for the plaintiff and $1 - \phi$ for the defendant. The chosen party proposes the amount of compensation payment x, which will be either accepted or rejected by the other party. If accepted, the game concludes with the proposed amount of money x being transferred from the defendant to the side of the plaintiff, and the dispute is resolved. In such a case, the plaintiff's lawyer receives γx and the plaintiff receives $(1 - \gamma)x$. If the proposal is rejected, the plaintiff chooses whether or not to file a lawsuit. The case moves to Phase L if the plaintiff files a lawsuit, while it remains in Phase O and the same stage game is repeated if the plaintiff chooses not to file. If the case is neither filed nor settled during the $\overline{T}$ periods, the statute of limitation renders the claim by the plaintiff to be ineffective.

After the side of the plaintiff files a lawsuit, the parties play the following stage game in every period $t \in \{t_L, ..., t_L + T\}$ until the court judges on the case at $t = t_L + T + 1$. At the beginning of each period, information that affects the outcome of the judgment arrives with probability λ_{Lt} and does not arrive with probability $1 - \lambda_{Lt}$. Then, the plaintiff's lawyer chooses whether to drop the case or continue it. If she chooses to drop the case, the case is resolved with no payments being made from defendant to the side of the plaintiff. Otherwise, nature again chooses the proposer, with probability ϕ for the plaintiff and $1 - \phi$ for the defendant. The chosen party proposes the amount of compensation payment x, which will be either accepted or rejected by the other party. If accepted, the game terminates with the proposed amount of money being transferred from the defendant to the side of the plaintiff, and the dispute is resolved. In such a case, , the plaintiff's lawyer receives γx and the plaintiff receives $(1 - \gamma)x$. If rejected, the case remains in Phase L and the same stage game is repeated until $t = t_L + T$.

I allow the rates of information arrival to differ across phases. One of the reasons for differing rates stems from the "discovery process." In this process, both parties can employ a variety of legal devices to acquire information on the case that follows the filing of a lawsuit.

I denote per-period legal costs at period t in Phases O and L for player $\iota \in \{d, p\}$ by $C_{Ot}^i \in R^+$ and $C_{Lt}^i \in R^+$ respectively. I assume that these legal costs are drawn independently in each period t from identical distributions. I allow the distribution of per-period costs to differ depending on whether or not the plaintiff has filed a lawsuit. In particular, the legal costs of both sides are typically higher in the litigation phase, which entails additional legal procedures with respect to the pre-litigation phase. The distributions from which per-period costs are drawn in Phases O and L are denoted by $G_{C_O}(\cdot)$ and $G_{C_L}(\cdot)$. The realizations of the per-period costs only affect the total legal costs,

and they do not affect the equilibrium stopping timing and settlement terms because players make desicions based on expeted legal cost of the subsqent periods.

I consider a common time-discount factor denoted by $\beta \in [0, 1]$.

A Parameter to Measure the Degree of Incentive Misalignment As discussed above, plaintiffs' lawyers use a contingency fee arrangement, while defendants' legal councils charge an hourly legal fee. The contingency fee arrangement entitles the plaintiff's lawyers to a fraction $\gamma \in [0, 0.5)^{13}$ of the money received from the defendant only if a positive payment is received. Because of this deferment, the plaintiff incurs no additional legal cost by delaying agreement because the plaintiff's lawyer incurs the legal cost. Hence, the plaintiff and his/her lawyer's incentive are not aligned. The plaintiff prefer to pursue a case much longer than her lawyer prefer. The plaintiffs's objective is to maximize the expected payment from the defendant, while the lawyer always considers the cost as well as the payment.

The main objective of this paper is to measure the degree to which lawyers and their clients' incentives are misaligned, and I will measure this with the following parameter $\delta \in [0, 1]$. If a lawyer behaves perfectly in the interst of her plaintiff, she maximizes the expected payment and does not consider per-period legal cost. If payment is x, such lawyer's payoff can be written as

$$u_0 = (1 - \gamma)x.$$

If a laywer behaves in her best interest, she considers the legal cost and only fraction γ of the payment. Hence, we can write it as

$$u_1 = \gamma x - C_j^p.$$

where $j \in \{O, L\}$. My interest is to measure what the true payoff system is for the plaintiff's lawyer, and these two cases are the special cases in which the lawyer are perfectly working in the interest of her client and in which she work in her own interest. Since these two cases are the extreme ones, I can consider a convex combination of these two cases with a parameter δ, which can be written as

$$
\begin{aligned}
u_\delta &= \delta \cdot u_1 + (1 - \delta) \cdot u_0 \qquad\qquad\qquad (1)\\
&= (1 - \delta - \gamma + 2\delta\gamma)x - \delta C_j^p
\end{aligned}
$$

Now, $\delta = 1$ implies that a lawyer behaves in her interest and $\delta = 0$ implies that a lawyer behaves in the plaintiff's interest. Hence, δ mesures the degree to which the incentive of

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[13]I impose this assumption because contingency fee are below 50% for vast majority of cases.

the lawyers and the plaintiff are misaligned. For notational convenience, I define function $A(\delta)$ as

$$A(\delta) \equiv 1 - \delta - \gamma + 2\delta\gamma.$$

2.1 Equilibrium Characterization

The model is a dynamic game with perfect information. Thus, I employ subgame-perfect equilibrium as the equilibrium concept. Because the model has a finite number of periods, backward induction provides us with a characterization of the unique subgame-perfect equilibrium. I start the analysis from the last stage in Phase L, and move to Phase O.

2.1.1 Phase L (Litigation Phase)

In order to characterize the unique subgame perfect equilibrium by backward induction, I start my analysis from the date of the judgment by the court at the end of Phase L. Recall that a Phase L subgame is reached only if the case is litigated at some period during Phase O. Let $t_L \in \{0, ..., \overline{T}\}$ denote the date of filing the lawsuit which is an endogenously determined. If the players cannot settle by date $t_L + T$, the judgement by the court at $t = t_L + T + 1$ determines the outcome of the last stage. Since two decisions are made in each period in Phase L, we define two continuation values for each player. Let $V_{t-t_L}^i(k_t)$ denote the continuation value for player $i \in \{p, d\}$ at the beginning of date t in Phase L with information state k_t, and $\overline{V}_{t-t_L}^i(k_t)$ the continuatoin value after dropping decision by plaintiff's lawyer and before settlement decision at the end of the period t. Note that the subscript is $t - t_L$, which is the number of periods in Phase L so that $V_1^i(k_{t_L})$ corresponds to the continuation value at the first period in Phase L that will be on the right hand side of the Bellman equation in Phase O. The continuation value of the judgment is

$$V_{T+1}^p(k_{t_L+T+1}) = \begin{cases} A(\delta)V & \text{if the plaintiff prevails} \\ 0 & \text{otherwise.} \end{cases}$$

$$V_{T+1}^d(k_{t_L+T+1}) = \begin{cases} -V & \text{if the plaintiff prevails} \\ 0 & \text{otherwise.} \end{cases}$$

where $A(\delta)V$ is the amount plaintiff's laywer obtains if she win the case and V is the amount paid the defendant to the side of the plaintiff. The plaintiff will have the difference $(1 - A(\delta))V$.

Having above $V_{T+1}^i(k_{t_L+T+1})$ as final values, I can obtain $V_{t-t_L}^i(k_t)$ and $\overline{V}_{t-t_L}^i(k_t)$ by applying backward induction. The equilibrium in Phase L subgame is characterized in the Proposition 1 below.

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Proposition 1 *In the unique subgame perfect equilibrium given k_t and t_L,*

1. *the payoff of the players at $t \in \{t_L + 1, ..., t_L + T\}$ in Phase L are expressed as*

$$V^p_{t-t_L}(k_t) = \max\left\{0, \overline{V}^p_{t-t_L}(k_t)\right\}$$

$$V^d_{t-t_L}(k_t) = \begin{cases} 0 & \text{if } 0 > \overline{V}^p_{t-t_L}(k_t) \\ \overline{V}^d_{t-t_L}(k_t) & \text{otherwise.} \end{cases}$$

where

$$\overline{V}^p_{t-t_L}(k_t) = \phi\beta \max\left\{-A(\delta)E^d_t\left[V^d_{t+1-t_L}(k_{t+1}) - C^d_L\right], E^p_t\left[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L\right]\right\}$$
$$+ (1-\phi)\beta E^p_t\left[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L\right],$$

$$\overline{V}^d_{t-t_L}(k_t) = \phi\beta E^d_t\left[V^d_{t+1-t_L}(k_{t+1}) - C^d_L\right]$$
$$+ (1-\phi)\beta \max\left\{-\frac{1}{A(\delta)}E^p_t\left[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L\right], E^d_t\left[V^d_{t+1-t_L}(k_{t+1}) - \delta C^p_L\right]\right\}.$$

2. *the plaintiff's lawyer drops the case at $t \in \{t_L + 1, ..., t_L + T\}$ in Phase L iff*

$$0 > \overline{V}^p_{t-t_L}(k_t)$$

3. *the players settle at $t \in \{t_L + 1, ..., t_L + T\}$ in Phase L iff*

$$0 \geq E^p_t[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L] + A(\delta)E^d_t[V^d_{t+1-t_L}(k_{t+1}) - C^d_L].$$

4. *given that players settle at $t \in \{t_L + 1, ..., t_L + T\}$ in Phase L, the payment is*

$$x_t = \begin{cases} -\beta E^d_t\left[V^d_{t+1-t_L}(k_{t_S+1}) - C^d_L\right] & \text{if the plaintiff is a proposer} \\ \beta\frac{1}{A(\delta)}E^p_t\left[V^p_{t+1-t_L}(k_{t_S+1}) - \delta C^p_L\right] & \text{if the defendant is a proposer,} \end{cases}$$

Proof. *See Appendix A* ∎

This proposition characterizes the subgame perfect equilibrium in Phase L. The expression for $V^p_{t-t_L}(k_t)$ in *1* is the continuation value at the beginning of the period when plaintiff's lawyer faces the dropping decsion. As described in *2*, plaintiff's lawyer drops a case if her interim continuation value $\overline{V}^p_{t-t_L}(k_t)$ is below 0. In such a situation, both sides have 0 as their continuation value. Interim continuation value after dropping decision and before settlment decision $\overline{V}^i_{t-t_L}(k_t)$ is obtained by solving for random-proposer barganing. Note that expectations are indexed by player because two players have different beliefs over the probability of winning at judgment.

The identify of the proposer do not affect the settlement decision as can be seen in *3*. The amount of payment depends on the identify of the proposer as in *4*. This arises because the players choose to settle if the joint surplus of settlement today is larger than the joint surplus of continuing the case. The compensation payment depends on the identity of the proposer because the recognized proposer obtains all of the surplus. This is true even in the extreme case that plaintiff's lawyer work in the interest of her client (i.e. $A(\delta) = 1 - \gamma$) and do not take per-period legal costs into consideration. Delaying agreement is still costly for her because she misses the benefits of the saving of the defendant's legal costs that indirectly increases compensation payment. Therefore, delaying agreement is costly for both players, and quick settlement is preferable. However, the possibility of learning new information makes delay valuable, since this information enhances the probability of a settlement, which in turn generates positive surplus for both players. This fundamental trade-off plays an important role in the equilibrium characterization and is a key determinant of the timing of settlement.

Dropping decision is simply an individual rationality constraint for the plaintiff's lawyer at each period. If there is no learning, the continuation values for the plaintiff's lawyer increases monotonically over time as can be seen from *1*. This monotonicity implies that if the value is negative at period t, the value is also negative for any period $t' < t$, i.e. if a case is to be dropped at t, it must be dropped at any earlier date t'. Hence, all dropping occurs only in the initial period if there is no learning. Therefore, dropping in periods other than the initial period only occurs with learning at arrival of new information against the plaintiff's side. In such case, continuation value stays positive for first several periods, and it become negative at the arrival of unfavorable information.

The proposition also shows that dropping and settlement decisions are directly affected by the degree of incentive misalignment δ. Increase in δ decreases the continuation value of the plaintiff's lawyer in two ways; through increase in per-period cost and through decrease in $A(\delta)$. Decrease of $A(\delta)$ lowers $\overline{V}^p_{t-t_L}(k_t)$ because the expected award at judgement $E^p_t[A(\delta)V]$ decreases corrspoding to change in $A(\delta)$. Thus, the larger δ is, the smaller $\overline{V}^p_{t-t_L}(k_t)$ is, and the more likely tha the case is dropped. In other words, plaintiff's lawyer prefer to drop a case at earlier date if her incentives is less aligned. In the extreme case that the lawyer works perfectly in her client's interest ($\delta = 0$), the case is never dropped.

Similar intuition works for the effect of incentive alignment and settlement decision. The expression in *3* can be rewritten as

$$E_t[\delta C^p_L + C^d_L] \geq E^p_t[V^p_{t+1-t_L}(k_{t+1})] + A(\delta)E^d_t[V^d_{t+1-t_L}(k_{t+1})],$$

where the left-hand side is expected per-period legal cost which is not indexed by player

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because players have common belief over the distribution of cost. The right-hand side is the expected surplus from continuation. Increase in δ increase the value of the left-hand side, and decreases the value of the right hand side[14]. Hence, the less aligned the incentives are (the larger δ is), the shorter it takes to reach a settlement on average. The plaintiff's lawyer who considers her own legal cost more seriously and focusing more on payments to herself, which is much smaller than the payment to the plaintiff, prefer to settle at earlier dates.

2.1.2 Phase O (Pre-Litigation Phase)

Let $W_t^i(k_t)$ denote the continuation value for player $i \in \{p, d\}$ at the beginning of date t in Phase O with information state k_t. Again, I start from the last stage of Phase O subgame. The maximum number of periods in Phase O is $\overline{T}$, after which the claim by the plaintiff loses its value due to the statute of limitation. Hence, each player has continuation payoff of 0 at date $\overline{T} + 1$, i.e.,

$$W_{\overline{T}+1}^p(k_{\overline{T}+1}) = W_{\overline{T}+1}^d(k_{\overline{T}+1}) = 0.$$

I compute $W_t^i(k_t)$ by applying backward induction and having the above as final values. In Phase O, the plaintiff has an option of litigating a case at any date $t \in \{0, ..., \overline{T}\}$. Solving the value function in Proposition 2 up to the first period in Phase L, I can obtain the continuation value of the Phase L subgame, $V_1^i(k_t)$. Note that this continuation value of litigation does not depend on the date of litigation t_L itself but does depend on the information state k_t at period t.

First, I will look at the filing decision by the plaintiff's lawyer because filing decision is the last decsion to be made in a period. The plaintiff's lawyer chooses to litigate at the end of date t if and only if

$$E_t \left[V_1^p(k_{t+1}) - \delta C_L^p \right] \geq E_t \left[W_{t+1}^p(k_{t+1}) - \delta C_O^p \right],$$

where the left-hand side is the payoff from filing a lawsuit and the right-hand side is the payoff from stay in pre-litigation phase. Hence, the continuation value for the plaintiff at the end of date t is written as

$$Y_t^p(k_t) = \beta \max \left\{ E_t \left[V_1^p(k_{t+1}) - \delta C_L^p \right], E_t \left[W_{t+1}^p(k_{t+1}) - \delta C_O^p \right] \right\},$$

where $Y_t^p(k_t)$ denotes an interim continuation value for the plaintiff's lawyer after the settlment decision and before the filing decision in period t in Phase O given state k_t. The

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[14]Though $A(\delta)$ increase in δ, $A(\delta)E_t^d[V_{t+1-t_L}^d(k_{t+1})]$ decrease in δ because $E_t^d[V_{t+1-t_L}^d(k_{t+1})]$ is always negative and decreases in δ.

defendant's continuation value depends on the filing decision of the plaintiff's lawyer described above, and is written as

$$Y_t^d(k_t) = \begin{cases} \beta E_t\left[V_1^d(k_{t+1}) - C_L^d\right] & \text{if } E_t\left[V_1^p(k_{t+1}) - \delta C_L^p\right] \geq E_t^p\left[W_{t+1}^p(k_{t+1}) - \delta C_O^p\right] \\ \beta E_t\left[W_{t+1}^d(k_{t+1}) - \delta C_O^p\right] & \text{otherwise,} \end{cases}$$

where $Y_t^d(k_t)$ denotes an interim continuation value for the plaintiff's lawyer after the settlment decision and before the filing decision in period t in Phase O given information state k_t. I can then conduct the exact same analysis for settlement and dropping decision as I did for Phase L, and the subgame-perfect equilibrium for Phase O is characterized in Proposition 2.

Proposition 2 *In any subgame perfect equilibrium given k_t,*

1. the payoffs of the players at $t \in \{0, ..., \overline{T}\}$ in Phase O are expressed as

$$\begin{aligned} W_t^p(k_t) &= \max\left\{0, \overline{W}_t^p(k_t)\right\} \\ W_t^d(k_t) &= \begin{cases} 0 & \text{if } 0 > \overline{W}_t^p(k_t) \\ \overline{W}_t^d(k_t) & \text{otherwise.} \end{cases} \end{aligned}$$

where

$$\begin{aligned} \overline{W}_t^p(k_t) &= \phi \max\left\{-A(\delta)Y_t^d(k_t), Y_t^p(k_t)\right\} + (1-\phi)Y_t^p(k_t), \\ \overline{W}_t^d(k_t) &= \phi Y_t^d(k_t) + (1-\phi)\max\left\{-\frac{1}{A(\delta)}Y_t^p(k_t), Y_t^d(k_t)\right\}. \end{aligned}$$

2. the players settle at $t \in \{0, ..., \overline{T}\}$ in Phase O iff

$$Y_t^p(k_t) + A(\delta)Y_t^d(k_t) \leq 0.$$

3. the plaintiff litigates at $t \in \{0, ..., \overline{T}\}$ in Phase O iff

$$E_t\left[V_1^p(k_{t_L+1})\right] \geq E_t\left[W_{t+1}^p(k_{t+1})\right].$$

4. given that players settle at $t \in \{0, ..., \overline{T}\}$ in Phase O, the payment is

$$x_t = \begin{cases} -Y_t^d(k_t) & \text{if the plaintiff is a proposer} \\ Y_t^p(k_t) & \text{if the defendant is a proposer,} \end{cases}$$

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Proof. *See Appendix B* ∎

This proposition characterizes the subgame perfect equilibrium in Phase O. The mechanics of the settlement and dropping decisions are exactly the same as for the characterization for Phase L. The only difference is that the cost of delay and the possibility of learning in the next period depend on the plaintiff's decision to file or not at the end of each period.

The decision to file a lawsuit by the plaintiff is also derived from a trade-off between the cost of delay and the possibility of learning. The cost of delaying filing has two components. One is the per-period legal cost of the pre-litigation phase, because the total length of the underlying game becomes one period longer if filing is delayed by one period. Even though the plaintiff incurs no legal cost per period, this delay still impacts him because minimizing the defendant's legal cost may result in a higher compensation payment to the plaintiff. The second component is the cost of delay due to discounting. The plaintiff prefers to obtain the continuation value of the Phase L subgame earlier, since a one-period delay in filing costs him $(1 - \beta)V_1^p(\cdot)$ when no information arrives. The benefit of delaying filing by one period is that the parties have one more period to obtain new information and hence reach an agreement. Thus, the plaintiff prefers to stay in Phase O longer if C_O^i are small and β is large, while low λ_{Ot} provides an incentive for the plaintiff to file early.

3 Data

The Florida Department of Financial Services, an insurance regulator of the Florida state government, collects a detailed micro-level data set on medical malpractice disputes in Florida. A statute on professional liability claims requires medical malpractice insurers to file a report to the Department on *all* of their closed claims once the claim is resolved. The report contains detailed information on the dispute resolution process, as well as individual case characteristics. The information on the dispute resolution process includes important dates (calender date of occurrence, initial claim, filing of lawsuit, resolution either by dropping, settlement, or by court judgement), settlement payments (or award by the court in case of resolution by court judgment), and total legal costs incurred by the defendants. The information on case characteristics includes patient characteristics (e.g. age and sex), defendant characteristics (e.g. defendant type, specialty, and insurance policy), and the characteristics of injury (e.g. severity and place of occurrence). Hence, this data set contains detailed information on all the variables of interest, i.e., if and when a lawsuit is filed, whether or not the case is settled out of court or dropped, the time to resolution, the legal costs incurred and the terms of settlement.

My sample of observations consists of 5,379 claims against physicians[15] which were

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[15]Claims against hospitals, HMOs, dentists, ambulance surgical centers, and crisis stabilization units are

	Number of Observations	Resolution Probability	Mean Compensation	Mean Defense Legal Cost
Dropped without Lawsuit	783	0.146	0 (0)	7,330 (23,023)
Dropped after Lawsuit	751	0.140	0 (0)	40,370 (44,978)
Settled without Lawsuit	472	0.088	314,266 (303,917)	9,047 (15,014)
Settled after Lawsuit	2,887	0.537	303,402 (379,909)	53,989 (88,887)
Resolved by Judgment with Positive Award	127	0.024	541,832 (620,722)	127,966 (113,147)
Resolved by Judgment with No Award	359	0.067	0 (0)	83,182 (87,268)
Total	5,379	1.000	203,210 (343,922)	45,047 (77,794)

Compensation payments and legal costs are measured in 2000 dollars. Numbers in parentheses provides standard deviations.

Table 1: Descriptive Statistics I - Resolution Probability, Payments and Legal Costs

resolved between October 1985 and July 1999.[16] Following Sieg (2000), I restrict attention to cases with the defendant's legal cost exceeding $1,000 and which were not dropped during the litigation process.[17] Because the timing and disposition of cases differ greatly depending on the severity of the injury, I restrict attention to the cases in which injuries resulted in permanent major damage to or death of the patient.

Tables 1 and 2 show the descriptive statistics of all the variables I use for estimation. In my data, 28.6% of the cases are dropped or settled with zero payment, 62.5% of the cases were settled by parties, and the remaining 9.1% of the cases were resolved by judgement by the court. Regarding dropped and settled cases, only one senveth of settled cases settled without filing a lawsuit and majority of settled cases are settled after filing a lawsuit, while the proportion of cases dropped without filing a lawsuit and after filing a lawsuit are about the same around 14%. For the judged cases, the defendants were three times more likely to win the judgment (i.e., award was zero). Mean compensation payments were similar for

	Time to Filing	Time to Resolution after Filing	Total Time to Resolution
Dropped without Filing	–	–	4.81 (3.22)
Dropped after Filing	2.30 (2.31)	7.36 (4.51)	9.66 (5.09)
Settled without Filing	–	–	3.23 (2.41)
Settled after Filing	2.48 (2.26)	7.45 (4.55)	9.93 (5.16)
Resolved by Judgment with Positive Award	2.69 (2.67)	11.41 (6.61)	14.10 (7.17)
Resolved by Judgment with No Award	2.50 (3.21)	9.69 (5.17)	12.19 (6.24)
Total	2.45 (2.38)	7.75 (4.76)	8.81 (5.57)

Numbers are in quarters of a year.   The numbers in parentheses provide standard deviations.

Table 2: Descriptive Statistics II - Timings

the cases that were settled after filing a lawsuit and those that were settled without filing a lawsuit (around $300,000).

Legal costs for defendants substantially differed across modes of resolution. Defense lawyers usually charge based on the amount of time they spent. It is not surprising to find that the mean of the defense legal costs correlates strongly with the mean time to resolution as displayed in Table 2. Mean of defence legal costs for cases settled without a lawsuit is about one-fifth of the cases settled after a lawsuit. This difference correlates with the shorter mean time to resolution as in Table 2. The cases settled after filing a lawsuit have a significantly higher mean cost ($53,989) compared to the settled cases without a lawsuit ($9,047). Similarly, the cases dropped after filing a lawsuit have a significantly higher mean cost ($40,370) compared to the cases dropped without a lawsuit ($7,330). Among the cases resolved by court judgement, mean defense costs are more than 50% higher for the cases won by the plaintiffs than the cases won by the defendants, which again corresponds to the longer time to resolution.

Mean time to filing a lawsuit, which corresponds to the periods spent in the pre-litigation phase, is similar across the dropped cases, the settled cases, and the cases resolved by court
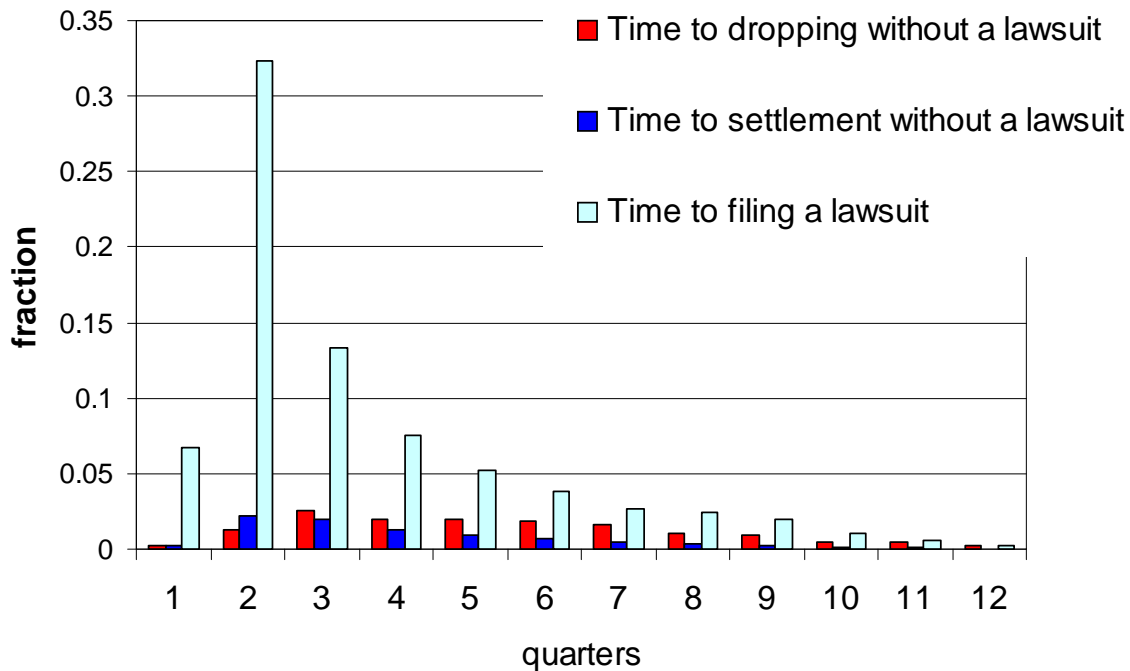
Figure 2: Histogram of Time to Dropping, Settlement and Filing. Fractions of time to dropping without a lawsuit, settlement without a lawsuit, and filing a lawsuit add up to one. This isbecause cases are either 1) dropped without a lawsuit, 2) settled without a lawsuit, or 3) resolved after a lawsuit is filed.

judgment. The time to resolution differ between the cases settled after filing and the cases resolved by the judgment. This difference results from the difference in time to resolution after filing lawsuit. The cases settled without a lawsuit, which correspond to settlement in pre-litigation phase, spend longer periods in the pre-litigation phase than the filed cases on average, and the cases dropped without a lawsuit spends even longer time on average about 4.81 quarters.

Figure 2 provides the histogram of filing, dropping, and settlement in pre-litigation phase. Note that the sum of the fractions for filing, dropping, and settlement add up to one because each case is either filed, dropped without a lawsuit, or settled without a lawsuit. In Florida, the statute of limitation regarding a medical malpractice cases is two years. Hence, more than 95% of the cases are filed or settled without filing a lawsuit before the ninth quarter.[18]

A fraction of cases filing lawsuits in pre-litigation phase and a fraction of cases settling

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[18]The remaining cases may be due, for example, to invervening medical complications that entail an automatic extension of the statute of limitations.
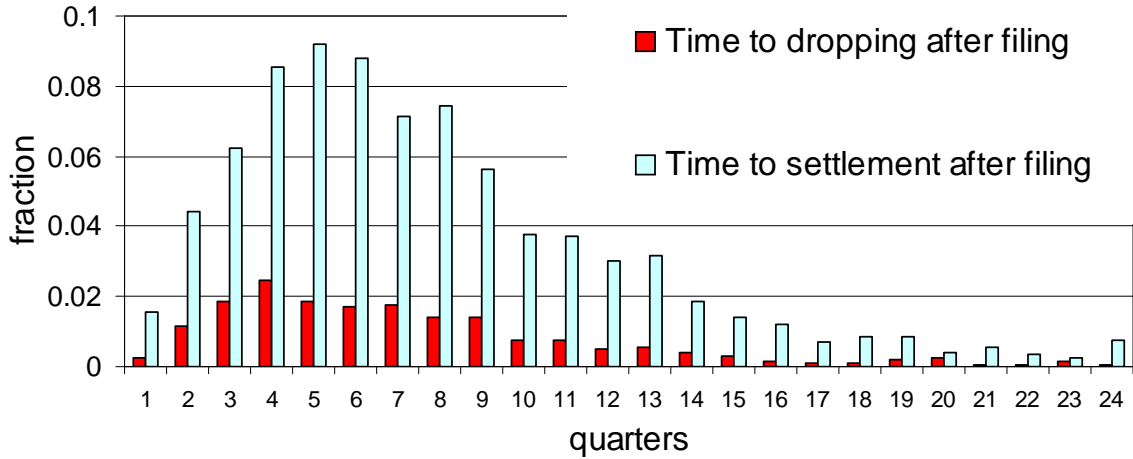
Figure 3: Histogram of Time to Dropping and Settlement after Filing. Fraction of dropped and settled Cases will add up to one. Time is counted from the date of filing a lawsuit in quarters. Cases exceeding 6 years are counted in the bin of the 24th quarter.

without lawsuits have a common pattern. In both the hazard rate increases significantly at the second quarter and gradually increases over time. Corresponding to a high hazard rate after the second quarter, the histogram reflects that more than 30% of cases are filed in the second quarter before the fraction declines rapidly over time. Regarding the time to settlement without a lawsuit, the decline after the second quarter is much slower as a result of the lower hazard rate. Compared to the filed and settled cases, hazard rate for dropping is lower and dropped cases spends longer time in pre-litigaiton phase.

Figures 3 presents more details on the time to settlement and dropping after filing lawsuits. The hazard rates for settlement and dropping are almost the same and they increase over time until 9th quarter as can be seen from the very similar patterns in the fiture. Ninety percent of settled cases are settled in 13 quarters, and less than 5% of cases are settled after 16 quarters. Similary, ninety percent of dropped cases are dropped in 13 quarters, and less than 5% of cases are settled after 17 quarters.

Compensation payments have very high variance. Figure 4 presents the histogram of (log) compensation payments from the defendant to the plaintiff. Of the total cases, about 6.7% of them concluded with judgment in favor of the defendant and 28.6% of them are dropped, thus, have zero payments. The amount of positive payments have very high variance, and the shape of the distribution is close to log-normal distribution. The distributions of settled cases without filing and of settled cases after filing are similar. More than 40% of the cases are with payments between $98,700 and $729,400. The distribution
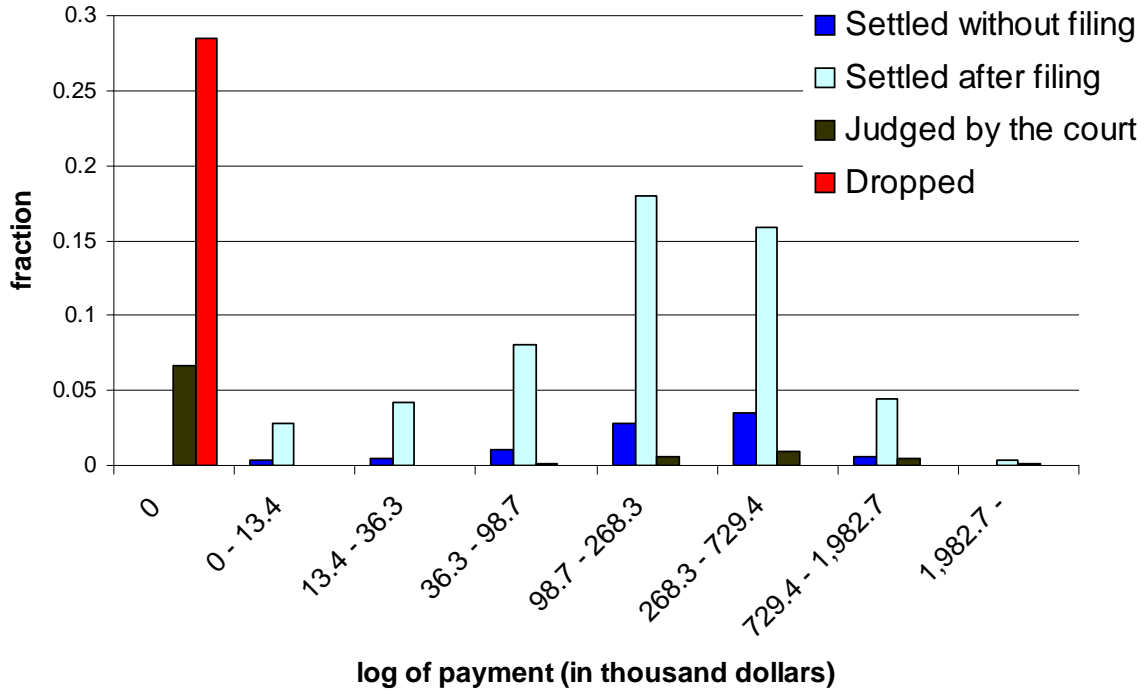
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Figure 4: Histogram of Payments. Fractions of four alternative ways of resolution add up to one.

for the cases judged with positive award is also similar to the log-normal distribution, while the mean and variance are much larger.

Similar to that of compensation payments, the distribution of legal costs is close to a log-normal distribution. As clearly seen from Figure 5, the distribution of costs shifts in the order of dropped cases withou filing, settled cases without filing, dropped cases after filing, settled cases after filing, and the cases jugdeg by the court, and cases dropped without filing tends to have much lower costs compared to other cases, and the cases resolved by court judgments tend to have much higher costs.

4   Econometric Specification

Model Solution   Given that the model does not admit analytical solution, I solve the model numerically. As shown in Propositions 1 and 2 in the model section, the subgame perfect equilibrium of the model is obtained by backward induction. Given a parameter value, I first compute $V^p_{t-t_L}(k_t)$ and $V^d_{t-t_L}(k_t)$ recursively beginning from $t = t_L + T + 1$ (the date of the court judgment given filing at period t_L) to $t = t_L$ (the date of filing a lawsuit)
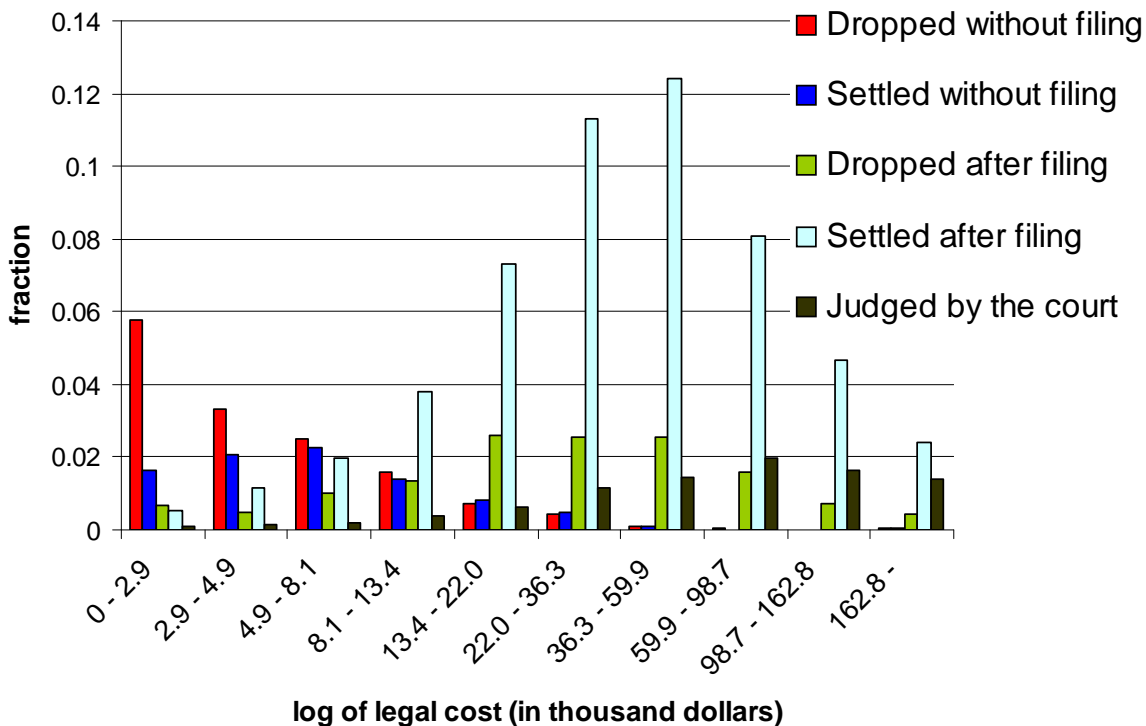
Figure 5: Histogram of Defense Legal Costs. Fractions of five alternative ways of resolution add up to one.

for each $t_L \in \{0, 1, ..., \overline{T}\}$. Using obtained values for $V_1^p(k_{t+1})$ and $V_1^d(k_{t+1})$ to compute continuation value in the case that plaintiff's lawyer files a lawsuit at the end of the period t, I compute $W_t^p(k_t)$ and $W_t^d(k_t)$ recursively from $t = \overline{T}$ to $t = 0$. Due to relatively small size of the state space, continuation values at each state are computed exactly.

Unobserved Heterogeneity I allow for unobserved heterogeneity in several dimensions. First, I consider unobserved heterogeneity in the time to judgment after filing, T. Given two cases that are resolved by court judgment, the time to judgment T can significantly differ across cases. For example, congestion in the legal system in a particular jurisdiction affects the time to judgement T. Hence, I need to assume an unobserved heterogeneity on the exogenous parameter T. Because there is no reason to belive that settled cases would have systematically different distribution of time to judgment compared with judged case, I estimate the distribution of the time to judgment nonparapmetrically using the data of the cases that are judged by the court. This estimation is outside of the model, and it is simply a histogram of time to judgment. I denote the cumulative distribution function (CDF) of

T by $F_T(\cdot)$.

The statute of limitation period $\overline{T}$, which is also exogenous in the model, also differs across cases though the statute of limitation date for medical malpractice litigation in Florida is set at 2 years. The legally determined statute of limitation period is not the actual length of time player can bargain without filing a lawsuit. The statute of limitation is legally counted from the date of the occurrence of incident, but the bargaining does not necessarily begin on the date of occurrence. For example, a plaintiff may begin bargaining 8 months after the occurrence of the incident, which leaves him 16 months before filing if the legal length of the statute of limitation is 24 months. I assume $\overline{T}$ to follow a negative binomial distribution which is a flexible distribution with discrete support. I denote their CDFs by $F_{\overline{T}}(\cdot)$ with parameters ψ_{0T} and ψ_{1T}.

Another dimension of unobserved heterogeneity is on jury awards. Cases that are resolved by court judgment may have very different potential jury awards V depending on the unobserved characteristics of the case, composition of the juries, and other factors. Hence, I consider unobserved heterogeneity in V. I assume that V follows a log-normal distribution $F_V(\cdot)$ with mean and variance denoted by μ_V and σ_V^2.

I also consider unobserved heterogeneity in the distribution of per-period legal costs $G_{C_O}(\cdot)$ and $G_{C_L}(\cdot)$. I assume these cost distributions as Gamma distributions with scale parameters ω_O and ω_L, and common shape parameter ω for computational tractability, and model unobserved heterogeneity as parameters ω_O and ω_L to follow parametric distributions as following. These distributions differs across cases due to factors such as the law firm the plaintiff and defendant employ or some other unobserved characteristics. I assume the mean of distributions $G_{C_O}(\cdot)$ (or expected per-period legal cost), $\omega_O\omega$ to follow log-normal distributions whose cumulative distribution functions are denoted by $F_C(\cdot)$ with parameters μ_C and σ_C^2. Thus, given a realization of mean of the distribution $G_{C_O}(\cdot)$, we only need to estimate ω because a draw from F_C determines one parameter. Given a case, the per-period legal cost after filing a lawsuit is most likely to increase due to the increase in the hours worked by the lawyers to prepare more documentations. Hence, I reparametrize ω_L by a new parameter α so that $E[C_L^i] = (1 + \alpha)E[C_O^i]$, or $\omega_L\,\omega = (1 + \alpha)\omega_O\omega$. Since the degree of the increase of the per-period legal cost depends on the characteristics of the case, as well as the law firm employed for the case, I assume α to have unobserved heterogeneity. Therefore, I consider unobserved heterogeneity in α, and assume it to follow log-normal distributions whose cumulative distribution function is denoted by $F_\alpha(\cdot)$ with parameters μ_α and σ_α^2. Similar to the argument for $G_{C_O}(\cdot)$, we only need to estimate ω due to a draw from F_α determining one parameter. For the side of the plaintiff and the defendant, I draw parameters of cost distributions independently from the above distribtuion $F_C(\cdot)$ and $F_\alpha(\cdot)$ as discussed later as an identification assumption. For notational convenience, I denote the

realization of unobserved heterogeneity by $Z = \{C_O, \alpha, V, T, \overline{T}\}$.

Estimation   I use the equilibrium characterization derived by Propositions 1 and 2 to compute the likelihood contribution of each observation. Because I can compute the conditional probabilities of equilibrium decisions (as above), I can now construct the likelihood function. The contribution to the likelihood function of each observation in the sample is equal to the probability of observing the vector of endogenous events (x, t_S, t_L, s, l) given the vector of the parameters $\Theta = \{\delta, \theta_d, \theta_p, \rho, \lambda_{O0}, \lambda_{O1}, \lambda_{L0}, \lambda_{L1}, \pi, \phi, F_T, F_{\overline{T}}, F_C, F_\alpha, F_V\}$. Because I consider unobserved heterogeneity in $Z = \{C_O, \alpha, \pi, V, T, \overline{T}\}$, I need to conduct a Monte Carlo integration over these variables Z in order to obtain the likelihood which can be written as

$$L(\Theta|x, t_S, s, t_L, l) = \int \int \int \int \int \int \Pr(x, t_S, s, t_L, l | Z; \Theta) dF_C dF_\alpha dF_T dF_{\overline{T}} dF_V,$$

where $\Pr(x, t_S, s, t_L, l | Z; \Theta, i)$ is computed using the conditional probabilities computed above as follows. (i) For the cases dropped without filing a lawsuit, $\Pr(x, t_S, s, t_L, l | Z; \Theta)$ isI take the log of above probability and sum them over all the elements in the sample to obtain the log-likelihood.

For parameters γ (contingency fee), I used $\gamma = 0.33$ following Sieg (2000). I used $\beta = 0.995$ for time discount factor for a quarter.

Identification   I need an indentification assumption for the legal cost of the plaintiff's lawyer because data of the plaintiff's legal cost is not available. I assume that the parameters for cost distribution for the side of the plaintiff is drawn from the same distribution as the defendant's legal costs, i.e. C_{jt}^p and C_{jt}^d are iid draw from different cost distributions whose parameters are iid draw from the same distribution F_C and F_α. This is a natural assumption considering that market for legal service is comepetitive. These distributions are identified from the variation of data of the defendants's total legal costs and time a case spent in Phase O and Phase L.

Data of settlement payments conditional on filing and settlement date (or awards if a case is resolved by court judgment) along with legal cost identifies the distribution of awards F_V. Parameter for relative bargaining power ϕ is identified from the settlement payment conditional on filing and settlement date because fling and settlement timing determines surplus whose allocation between a proposer and the other party is determined by ϕ.

The distribution of time to judgement from filing F_T is non-parametrically identified by the data of the time to judgment of the cases judged by the court with a natural assumption that time to jusgement are not systematically different among judged, settled, and dropped cases. Similarly, the winning rate of the plaintiff at court judgement identifies π, which

is estimated outside of the model. The distribution of time to statute of limitation $F_{\overline{T}}$ is identified by the data of time to filing with the distributional assumption. Parameters for information arrival rates and initial pirors are identified from the variation of data of the settlement timings in Phase O and Phase L, and fractions of cases judged by the court, and farctions of cases settled in Phase O and in Phase L.

Finally, as I have discussed in the model section, the parameter of incentive misalignment δ affects the fraction of cases dropped and the timing of dropping and settlement. The more misaligned the incentives are (the higher δ is), the shorter the time to settlement and dropping are as well as the more cases to be dropped. Hence, δ is identified from the fraction of cases dropped and the timing of dropping given the identificaiton of the rest of the parameter as discussed above.

5 Results

5.1 Parameter Estimates

Parameter estimates are presented in Table 3. The estimates of the weighting parameter $\delta \in [0, 1]$ is 0.8128. This implies that the plaintiff's lawyers works more in their short-run interest than in the best interest of their clients. This result can be interpreted in several ways because there are several factors that provides inceintive for a plaintiff's lawyer not to work only in their short-run interest such as reputational concern, professional liability, capacity constraint, or altruism. The result shows that these factors do not work very strongly in this context though I cannot distinguish between which of these factors are contributing.

Difference in beliefs is very large at the initial stage, but their beliefs are very weak. Plaintiff's belief on probability of his winning is $\theta_p/\rho = 0.9554$, while mean of defendant's belief on probability of plaintiff's winning is $\theta_d/\rho = 0.0315$. These beliefs are very weak because the firmness parameter ρ is very small at 0.0021. For example, if an information against the plaintiff would arrive in period 1, i.e. $n^t = 1$ and $m^t = 0$, the plaintiff's belief would change from 0.9554 to $\frac{0.0001+0}{0.0021+1} = 0.0001$. This implies that the learning plays an important role. Also, an assumption that only "one piece" of information can arrive in a period might be the reason for this result.

Arrival rate of information at t in pre-litigation stage is $\lambda_{Ot} = 0.0066 + 0.0073 \times t$, and that of litigation stage at t'-th period from litigation is $\lambda_{Lt'} = 0.0064 + 0.0231 \times t'$. Thus, information are more likely to arrive as procedure advances. Also, the arrival rate is much higher once lawsuit is filed. This is very natural result because filing of lawsuit institutionally influences the arrival of new information affecting the outcome of judgment.

Other parameter I allow to differ across stage is the per period legal cost. Mean of

Parameter	Estimates
δ	0.8128 (0.0377)
θ_d	0.0001 (0.0001)
θ_p	0.0021 (0.0001)
λ_{O0}	0.0066 (0.1075)
λ_{O1}	0.0073 (0.0101)
λ_{L0}	0.0064 (0.0451)
λ_{L1}	0.0231 (0.0023)
π	0.2613 (0.1930)
ϕ	0.6053 (0.3549)
ρ	0.0022 (0.0001)
μ_C	6.7278 (0.4909)
ω	0.7966 (5.1032)
σ_C^2	0.4219 (0.1475)
μ_α	-0.9013 (0.2372)
σ_α^2	3.4108 (0.4460)
μ_V	13.2785 (0.4797)
σ_V^2	0.9360 (0.2209)
cf1	15.4099 (1.4625)
cf2	3.7688 (2.8544)
cf3	9.8190 (0.5432)
$\psi_{0\overline{T}}$	7.5491 (0.3328)
$\psi_{1\overline{T}}$	0.6488 (0.0012)
Log-likelihood	40504.5961

Table 3: Maximum Likelihood Estimates

defence legal cost per period in pre-litigation phase is \$2,762 with estimated variance of \$4,252. On average, legal cost per period increases 2.115 times after filing of lawsuit and mean legal cost per period in litigation phase is \$5,842. Mean of damage V[19] is \$905,738, which is much larger than the mean settlement and mean judgement in the data. I need to work further so that these number will be closer to the one in the data. Finally, the relative bargaining power between plaintiff and defendant is caputred by ϕ.[20] The estimate of ϕ being 0.6053 implies that plaintiff have relatively stronger bargaining power though the standard error is relatively large.

5.2 Model Fit

As a result of estimation, I find that the model fits all aspect of the data well. I provide the fit of the model regarding the time to settlement and filing, as well as the compensation payments for different modes of resolution. In Figures 6 and 7, I present the fit of the model to the data on the time to dropping and filing. The model replicates the dynamic patterns of filing and dropping in pre-litigation very well as shown in Figure 6. In particular, the model fits the data on the time to filing, which increase sharply in period 2 and decreases gradually, very well. Regarding settlement in the pre-litigation phase, the magnitude of the fraction is captured correctly. Though I do not report the fit of the settlement in pre-litigaton phase in Figure 6, the degree of the fit is similar to those of the dropping and filing.

Figure 7 shows the fit of the model on the time to settlement and dropping after filing a lawsuit. The model captures the shape of the data, which increases for the first several period and then declines gradually. The difference between the predicted fractions of cases settling and the data in the first three periods and the last several periods may result from the linearity assumption on the rate of arrival. This assumption may have prevented the model from capturing some factors in the data.

6   Comparison to the First-Best Outcome

In this section, I compare the estimated model with the first-best outcome for the side of the plaintiff. I define the first-best outcome as the outcome under which the expected joint surplus for the side of the plaintiff is maximized. The join surplus for the side of the plaintiff is the expected payment from the side of the defendant to the side of the plaintiff minus the legal cost incurred by the plaintiff's lawyer.

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[19]This is the amount plaintiff will (potentially) receive if he won the judgment at trial.

[20]In the model, ϕ is a probability that the plaintiff will be recognized as a proposer. This is a measure of bargaining power in the model because proposer always benefits from proposer advantage, while the other party is only offered the amount equal to his continuation payoff.
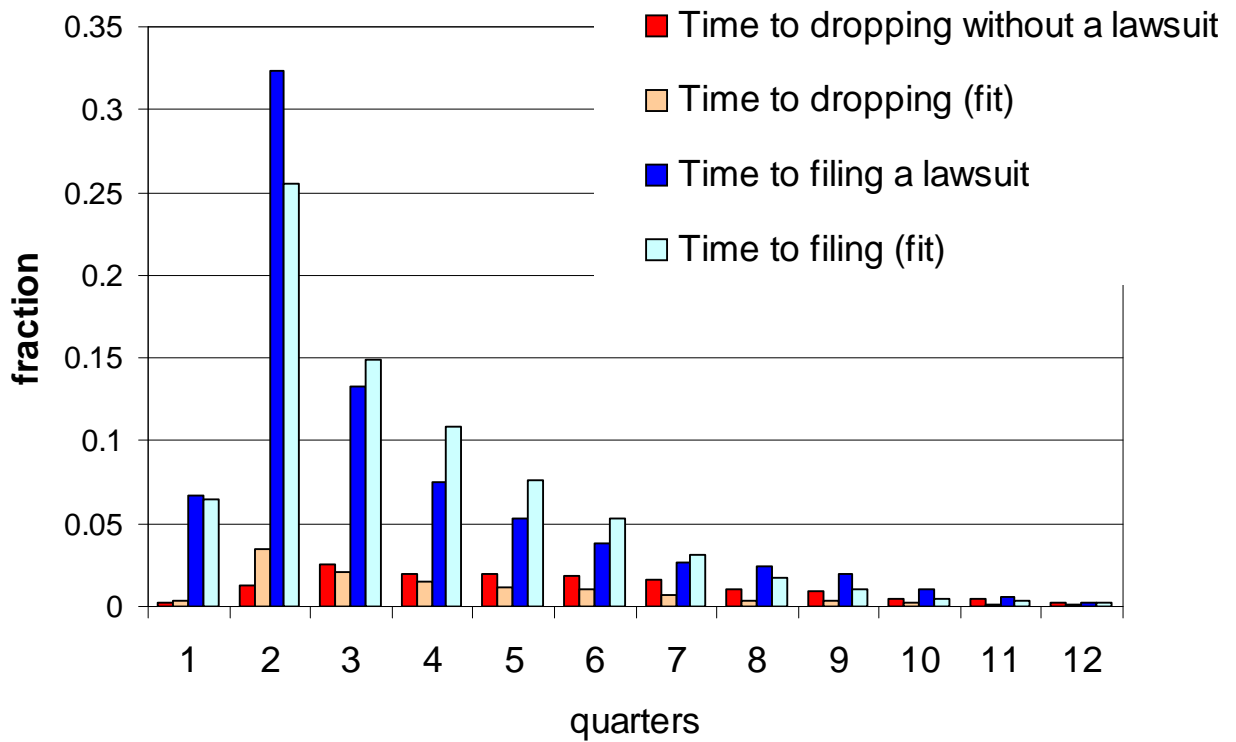
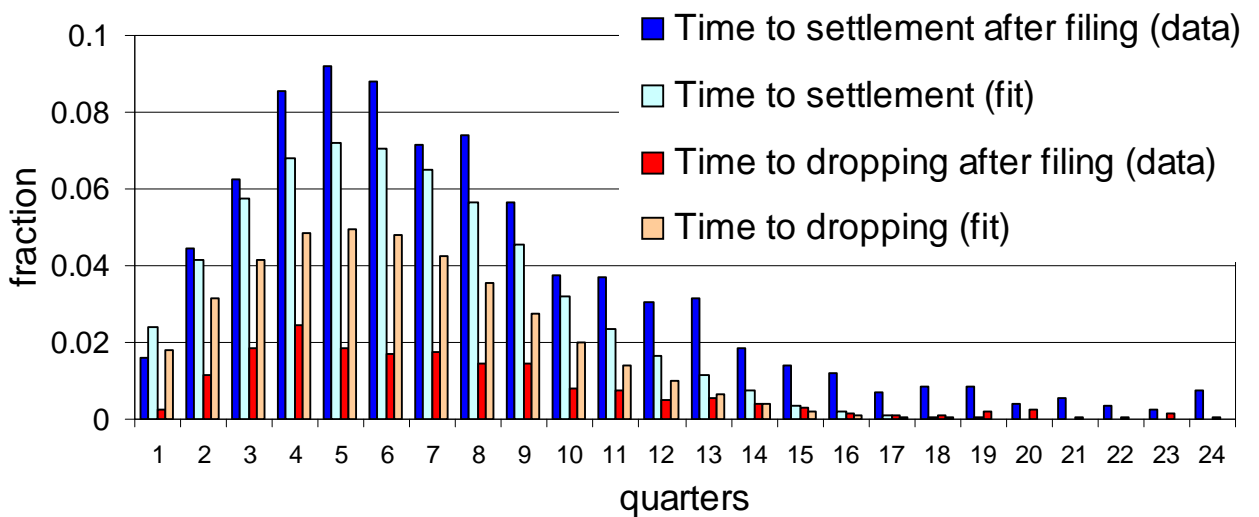Figure 6: Histogram of Timing in Pre-Litigation Phase

Figure 7: Histogram of Timing after Filing

	Fitted Model	First Best
Fraction of Dropped Cases in Phase O	11.3%	7.4%
Fraction of Filed Cases	77.5%	80.8%
Mean Time to Resolution (quarters)	7.77	8.10
Mean of Legal Cost (dollars)	29,885	31,557
Mean Payment (dollars)	1,180,982	1,448,523
Joint Surplus (dollars)	1,151,098	1,416,937

Table 4: First-best outcome

The outcome is computed by simulating the model setting parameter values to $\gamma = 1$ and $\delta = 1$. This corresponds to a situation in which a plaintiff's lawyer can buy out a case. Under these parameter values, the side of the plaintiff is internalizing the full legal cost that was incurred the plaintiff's lawyer and 100% of the payment rather than fraction γ under contingency fee arrangement.

Table 4 summarizes the comparison of fitted model with the simulated first-best outcome. Under the first-best outcome, about 4% less fraction of cases are dropped before filing a lawsuit, and 3% more lawsuits are filed. The mean time to resolution increases by 0.3 quarters. Reflecting higher fraction of lawsuits, less dropped cases, and longer time to resolution, the mean legal cost increases by 5.8%. However, the increase of the legal cost is very small compared to the increase in payment of 22.7% from 1,180,982 dollars to 1,416,937 dollars. Hence, the expected joint-surplus under firt-best outcome is 23.1% larger at 1,416,937 dollars.

7 Policy Experiments

Finally, I conduct a counter-factual policy experiment to limit the contingency fee. Regulation on contingency fees are adopted by 15 states as of 2005[21] and are currently under consideration at the federal level.[22] In spite of its policy importance, little is known empirically about how regulation on contingency fee affects the outcomes of medical malpractice disputes such as legal costs, settlement payments, and probability of lawsuits, as well as how it affects the agency problem of lawyers and their clients.

For the couter-factual experiment, I set the limit of the contingency fee to 25% ($\gamma = 0.25$), and simulate the distribution of equilibrium outcome using the estimated parameters.

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[21]See the database of state tort law reforms constructed by Avraham (2006). These regulations typically impose a limit on the fraction lawyers can receive as contingency fee such as 40% and 33%.

[22]The House of Representatives passed the Help Efficient, Accessible, Low-Cost, Timely Healthcare (HEALTH) Act of 2003 in the 108th Congress, while the Senate voted against it. The bill has been reintroduced in 2004 and 2005 and is currently pending. The Medical Care Access Protection Act of 2006 stalled in the Senate also includes regulation on contingency fee for plaintiff's attorneys on medical malpractice cases.

	Fitted Model	Limit of Fee at 25%
Fraction of Dropped Cases in Phase O	11.3%	12.1%
Fraction of Filed Cases	77.5%	76.7%
Mean Time to Resolution (quarters)	7.77	7.70
Mean of Legal Cost (dollars)	29,885	29,372
Mean Payment (dollars)	1,180,982	1,032,369
Joint Surplus (dollars)	1,151,098	1,002,997

Table 5: Policy experiment on limit on contingency fee

With the limit at 25%, the fraction of payment to plaintiff's lawyer decreses from 33% to 25%, while the per-period legal costs incurred by her remains the same. This implies that the plaintiff's lawyer have less incentive to maximize the join-surplus because she can receive even smaller fraction of the payment.

Table 5 summarizes the comparison of the fitted model with the outcome of the counterfactual experiment. The policy of limiting the contingency fee would increase the number of case to be dropped in pre-litigation phase from 12.1% to 11.3% and reduces the filing of lawsuits from 77.5% to 76.7%. The mean time to resolution also decreaes from 7.77 quarters to 7.70 quarters. These changes are consisten with the change in the lawyer's incentive due to the limit of contingency fee. Reflecting shorter time to resolution, more frequent dropping, and less filing of lawsuit, legal cost also decreases from 29,885 dollars to 29,372 dollars. However, the decrease in mean payment by 12.6% is much larger than the saving of legal cost. This results in the decrease of join surplus by 12.9% from 1,151098 to 1,002997.

8 Appendix

Appendix A   Proof of Proposition 1

Consider two separate cases depending on whether the players will settle or continue.

First, consider the case of $E_t^p[V_{t+1-t_L}^p(k_{t+1}) - \delta C_L^p] + A(\delta)E_t^d[V_{t+1-t_L}^d(k_{t+1}) - C_L^d] > 0$, in which players do not settle. I will show that they will not settle under this condition using proof by contradiction. Suppose that the players settle in period t with monetary transfer x_t. The plaintiff agrees only if $A(\delta)x_t \geq \beta E_t^p \left[V_{t+1-t_L}^p(k_{t+1}) - \delta C_L^p \right]$, while the defendant agrees only if $-x_t \geq \beta E_t^d \left[V_{t+1-t_L}^d(k_{t+1}) - C_L^d \right]$. This requires $0 = \beta^{-1}(x_t - x_t) \geq \frac{1}{A(\delta)} E_t^p \left[V_{t+1-t_L}^p(k_{t+1}) - \delta C_L^p \right] + E_t^d \left[V_{t+1-t_L}^d(k_{t+1}) - C_L^d \right]$. This contradicts with $E_t^p[V_{t+1-t_L}^p(k_{t+1}) - \delta C_L^p] + A(\delta)E_t^d[V_{t+1-t_L}^d(k_{t+1}) - C_L^d] > 0$, which proves that the players will not settle at t. Hence, the continuation value of each player before the nature chooses

proposr at date t denoted as $\overline{V}^i_{t-t_L}(k_t)$ can be written as

$$\begin{aligned}
\overline{V}^p_{t-t_L}(k_t) &= \beta E^p_t\left[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L\right], \\
\overline{V}^d_{t-t_L}(k_t) &= \beta E^d_t\left[V^d_{t+1-t_L}(k_{t+1}) - C^d_L\right].
\end{aligned}$$

Second, consider the case of $E^p_t[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L] \leq -A(\delta)E^d_t[V^d_{t+1-t_L}(k_{t+1}) - C^d_L]$, in which players settle. Both players accept an offer if it gives them at least their continuation value. If the plaintiff is recognized as a proposer, she chooses to offer $x_t = \beta E^d_t\left[V^d_{t+1-t_L}(k_{t+1}) - C^d_L\right]$, the defendant's continuation value, which is the lowest offer the defendant accepts. In such case, the plaintiff's lawyer's payoff is $-A(\delta)x_t$, which is larger than her continuation value, i.e., $-A(\delta)x_t = -A(\delta)\beta E^d_t\left[V^d_{t+1-t_L}(k_{t+1}) - C^d_L\right] \geq \beta E^p_t[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L]$. In the case that the defendant is a proposer, he chooses to offer $x_t = \frac{1}{A(\delta)}\beta E^p_t\left[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L\right]$, which is the lowest offer the plaintiff's lawyer accepts. In such case, the defendant's payoff is $-x_t$, which is larger than his continuation value, i.e. $-\frac{1}{A(\delta)}\beta E^p_t\left[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L\right] \geq \beta E^d_t\left[V^d_{t+1-t_L}(k_{t+1}) - C^d_L\right]$. Thus, in equilibrium, the proposer offers the continuation value of the opponent, and the opponent accepts. The continuation value of each players before the nature chooses proposer at date t will be

$$\begin{aligned}
\overline{V}^p_{t-t_L}(k_t) &= \phi\beta(-A(\delta)E^d_t\left[V^d_{t+1-t_L}(k_{t+1}) - C^d_L\right]) + (1-\phi)\beta E^p_t\left[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L\right], \\
\overline{V}^d_{t-t_L}(k_t) &= \phi\beta E^d_t\left[V^d_{t+1-t_L}(k_{t+1}) - C^d_L\right] + (1-\phi)\frac{1}{A(\delta)}\beta(-E^p_t\left[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L\right]).
\end{aligned}$$

Combining both cases, the continuation value is written as

$$\begin{aligned}
\overline{V}^p_{t-t_L}(k_t) &= \phi\beta\max\left\{A(\delta)(-E^d_t\left[V^d_{t+1-t_L}(k_{t+1}) - C^d_L\right]), E^p_t\left[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L\right]\right\} \\
&\quad + (1-\phi)\beta(E^p_t\left[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L\right], \\
\overline{V}^d_{t-t_L}(k_t) &= \phi\beta E^d_t\left[V^d_{t+1-t_L}(k_{t+1}) - C^d_L\right] \\
&\quad + (1-\phi)\beta\max\left\{-\frac{1}{A(\delta)}E^p_t\left[V^p_{t+1-t_L}(k_{t+1}) - \delta C^p_L\right], E^d_t\left[V^d_{t+1-t_L}(k_{t+1}) - C^d_L\right]\right\}.
\end{aligned}$$

At the beginning of the period t, the plaintiff's lawyer chooses whether to drop the case or not. She drops the case if her continuation payoff is lower than 0 because she can always have outside option of 0 by dropping the case Hence, the continuation values at the beginning of period t are written as

$$V^p_{t-t_L}(k_t) = \max\left\{0, \overline{V}^p_{t-t_L}(k_t)\right\}$$

The continuation value for the defendant depends on the decision of the plaintiff's lawyer.

If she drops the case, the defendant has no obligation to pay, while his continuation value is $\overline{V}^d_{t-t_L}(k_t)$ if plaintiff's lawyer do not drop the case. Thus, the defendant's continuation value is written as

$$V^d_{t-t_L}(k_t) = \begin{cases} 0 & \text{if } 0 > \overline{V}^p_{t-t_L}(k_t) \\ \overline{V}^d_{t-t_L}(k_t) & \text{otherwise.} \end{cases}$$

∎

Appendix B   Proof of Proposition 2

I consider two separate cases depending on whether the players will settle or continue the case.

First, consider the case of $Y^p_t(k_t) > -A(\delta)Y^d_t(k_t)$, in which players do not settle. Suppose that the players settle in period t with monetary transfer x. The plaintiff's lawyer agrees only if $A(\delta)x \geq Y^p_t(k_t)$, while the defendant agrees only if $x \geq -Y^d_t(k_t)$. This requires $0 = x - x \geq \frac{1}{A(\delta)}Y^p_t(k_t) + Y^d_t(k_t)$. This contradicts with $Y^p_t(k_t) > -Y^d_t(k_t)$, which proves that the players will not settle at t. Hence, the continuation value of each players before settlement decision at date t will be

$$\overline{W}^i_t(k_t) = Y^i_t(k_t).$$

Now, consider the case of $Y^p_t(k_t) \leq -A(\delta)Y^d_t(k_t)$, in which players settle. Each player accepts an offer if and only if it gives him/her at least his/her continuation value, and a party recognized by nature to propose chooses to offer this continuation value because it is least costly offer to be accepted by the other party. If the plaintiff's side is recognized as the proposer, she offers $Y^d_t(k_t)$ to the defendant, which is defendant's continuation value and defendant accepts. In this case, the plaintiff's lawyer receives $-A(\delta)Y^d_t(k_t)$. If the defendant is recognized as the proposer, he offers $x = \frac{1}{A(\delta)}Y^p_t(k_t)$ with which the plaintiff's lawyer receives her continuation value of $Y^p_t(k_t)$. Thus, I can write the continuation value of each player beforeat the settlement decision at date t as

$$\overline{W}^p_t(k_t) = \phi \left[-A(\delta)Y^d_t(k_t) \right] + (1-\phi)Y^p_t(k_t),$$
$$\overline{W}^d_t(k_t) = \phi Y^d_t(k_t) + (1-\phi)\left[-\frac{1}{A(\delta)}Y^p_t(k_t) \right].$$

Combining the above two cases, I can rewrite the continuation value as

$$\overline{W}^p_t(k_t) = \phi \max \left\{ -A(\delta)Y^d_t(k_t), Y^p_t(k_t) \right\} + (1-\phi)Y^p_t(k_t),$$
$$\overline{W}^d_t(k_t) = \phi Y^d_t(k_t) + (1-\phi)\max \left\{ -\frac{1}{A(\delta)}Y^p_t(k_t), Y^d_t(k_t) \right\}.$$

At the beginning of the period t, the plaintiff's lawyer chooses whether to drop the case or not. Same as in Phase O, she drops the case if her continuation payoff is lower than 0 because she can always have outside option of 0 by dropping the case Hence, the continuation value for the plaintiff's lawyer at the beginning of period t is written as

$$W_t^p(k_t) = \max\left\{0, \overline{W}_t^p(k_t)\right\}$$

The continuation value for the defendant depends on the decision of the plaintiff's lawyer. If she drops the case, the defendant has no obligation to pay, while his continuation value is $\overline{W}_t^d(k_t)$ if plaintiff's lawyer do not drop the case. Thus, the defendant's continuation value is written as

$$W_t^d(k_t) = \begin{cases} 0 & \text{if } 0 > \overline{W}_t^p(k_t) \\ \overline{W}_t^d(k_t) & \text{otherwise.} \end{cases}$$

∎

Appendix C   Computation of Conditional Choice Probablities

In Chapter 2, I characterized the equilibrium outcome on the time, mode, cost, and terms of settlement, as well as the time of filing a lawsuit (if a lawsuit is filed). However, the outcomes are contingent on the realization of the state of information $k_t = (n_t, m_t) \in \{0, ..., t\} \times \{0, ..., t\}$ which is not observable to the econometrician. Thus, from the perspective of the econometrician, the litigation timing t_L, the resolution timing t_S, the compensation payment x, and the total legal cost are all random variables because they depend on the (unobservable) realization of k_t. Hence, I first compute the conditional probability of observing the realization of such random variables in order to compute the likelihood contribution of each observation.

Let $d_t^{DO}(n_t, m_t)$, $d_t^{SO}(n_t, m_t)$, $d_t^{DL}(n_t, m_t, t_L)$, $d_t^{SL}(n_t, m_t, t_L)$, and $d_t^{FI}(n_t, m_t)$ denote the indicator function respectively for dropping in Phase O, settlement in Phase O, dropping in Phase L, settlement in Phase L, and filing of a lawsuit at period t. Using the results of Propositions 1 and 2, these indicator functions are written as

$$
\begin{aligned}
d^{DO}{}_t(n_t, m_t) &= I\left\{\overline{W}_t^p(n_t, m_t) < 0\right\}, \\
d^{SO}{}_t(n_t, m_t) &= I\left\{Y_t^p(n_t, m_t) + A(\delta)Y_t^d(n_t, m_t) < 0\right\}, \\
d^{FI}{}_t(n_t, m_t) &= I\left\{E_t V_1^p(n_{t+1}, m_{t+1}) > E_t W_{t+1}^p(n_{t+1}, m_{t+1})\right\}, \\
d^{DL}{}_t(n_t, m_t, t_L) &= I\left\{\overline{V}_{t-t_L}^p(n_{t+1}, m_{t+1}) < 0\right\}, \\
d^{SL}{}_t(n_t, m_t, t_L) &= I\left\{E_t \overline{V}_{t+1-t_L}^p(n_{t+1}, m_{t+1}) + A(\delta)E_t \overline{V}_{t+1-t_L}^d(n_{t+1}, m_{t+1}) - \delta C_L^p - A(\delta)C_L^d < 0\right\},
\end{aligned}
$$

where $d_t^{DO}(n_t, m_t) = 1$, $d_t^{SO}(n_t, m_t) = 1$, $d_t^{DL}(n_t, m_t, t_L) = 1$, $d_t^{SL}(n_t, m_t, t_L) = 1$,

$d_t^{FI}(n_t, m_t) = 1$ indicate dropping in Phase O, settlement in Phase O, dropping in Phase L, settlement in Phase L, and litigation at period t given (n_t, m_t) and (n_t, m_t, t_L), while 0 indicate otherwise. In computing equilibrium, we assume the rates of information arrival as $\lambda_{Ot} = \lambda_{O0} + \lambda_{O1}t$ and $\lambda_{Lt} = \lambda_{L0} + \lambda_{L1}t$. Let $q_t^O(n_t, m_t)$ denote the probability of being in state $k_t = (n_t, m_t) \in \{0, ..., t\} \times \{0, ..., t\}$ in Phase O, and let $q_t^L(n_t, m_t, t_L)$ denote the probability of being in state k_t in Phase L given the litigation date of $t_L < t$. I can compute q_t^O recursively as follows:

$$
\begin{aligned}
q_0^O(0,0) &= 1, \\
q_t^O(n, m) &= \lambda_{Ot}\pi q_{t-1}^O(n-1, m-1) \\
&\quad \times \left[1 - d_t^{SO}(n-1, m-1) - d_t^{DO}(n-1, m-1)\right]\left[1 - d_t^{FI}(n-1, m-1)\right] \\
&\quad + \lambda_{Ot}(1-\pi)q_{t-1}^O(n-1, m)\left[1 - d_t^{SO}(n-1, m) - d_t^{DO}(n-1, m)\right]\left[1 - d_t^{FI}(n-1, m)\right] \\
&\quad + (1 - \lambda_{Ot})q_{t-1}^O(n, m)\left[1 - d_t^{SO}(n, m)1 - d_t^{DO}(n, m)\right]\left[1 - d_t^{FI}(n, m)\right].
\end{aligned}
$$

The initial condition for q_t^L is $q_{t_L}^L$, which can be written as

$$
q_{t_L}^L(n, m, t_L) = \sum_{n_{t_L}=0}^{t_L} \sum_{m_{t_L}=0}^{t_L} q_{t_L}^O(n_{t_L}, m_{t_L})d_t^{FI}(n_{t_L}, m_{t_L}).
$$

I can compute q_t^L recursively for $t > t_L$ as follows:

$$
\begin{aligned}
q_t^L(n, m, t_L) &= \lambda_{Lt}\pi q_{t-1}^L(n-1, m-1, t_L)\left[1 - d_t^{SL}(n-1, m-1, t_L) - d_t^{DL}(n-1, m-1, t_L)\right] \\
&\quad + \lambda_{Lt}(1-\pi)q_{t-1}^L(n-1, m, t_L)\left[1 - d_t^{SL}(n-1, m, t_L) - d_t^{DL}(n-1, m, t_L)\right] \\
&\quad + (1 - \lambda_{Lt})q_{t-1}^L(n, m, t_L)\left[1 - d_t^{SL}(n, m, t_L) - d_t^{DL}(n, m, t_L)\right].
\end{aligned}
$$

Let $l = \{FILE, NOFILE\}$ denote if a case is litigated ($l = FILE$) or not ($l = NOFILE$), and $s \in \{DROP, SETTLE, JUDGE\}$ denote if the case is dropped ($s = DROP$), settled ($s = SETTLE$) or reaches judgment by the court ($s = JUDGE$). A case can be resolved in one of the five way; i) dropped without filing a lawsuit ($(l, s) = (NOFILE, DROP)$), ii) settlement without a lawsuit ($(l, s) = ((NOFILE, SETTLE))$, iii) dropped after a lawsuit ($(l, s) = (FILE, DROP)$), iv) settlement after lawsuit ($(l, s) = (FILE, SETTLE)$), and judgement of the court ($(l, s) = (FILE, JUDGE)$) on equilibrium path. With this notation, the probability that the econometrician observes litigation at date t_L can be written as

$$
\Pr(FILE) \times \Pr(t_L|FILE) = \sum_{n_{t_L}=0}^{t_L} \sum_{m_{t_L}=0}^{t_L} q_{t_L}^O(n_{t_L}, m_{t_L})d_t^{FI}(n_{t_L}, m_{t_L}),
$$

where $q_{t_L}^O(n_{t_L}, m_{t_L})$ is the probability of reaching state $k_{t_L} = (n_{t_L}, m_{t_L})$ in period t_L and $d_t^{FI}(n_{t_L}, m_{t_L})$ is the indicator of filing a lawsuit at t_L given the state k_{t_L}. Dropping and settlement in Phase L occurs only after litigation in Phase O. Thus, the probability of dropping and settlement at period t_S in Phase L conditional on litigation at Phase L is written as

$$\Pr(t_S, DROP | t_L, FILE) = \sum_{n_{t_S}=0}^{t_S} \sum_{m_{t_S}=0}^{t_S} q_{t_S}^L(n_{t_S}, m_{t_S}, t_L) d_t^{DL}(n_{t_S}, m_{t_S}, t_L),$$

$$\Pr(t_S, SETTLE | t_L, FILE) = \sum_{n_{t_S}=0}^{t_S} \sum_{m_{t_S}=0}^{t_S} q_{t_S}^L(n_{t_S}, m_{t_S}, t_L) \left[1 - d_t^{DL}(n_{t_S}, m_{t_S}, t_L)\right] d_t^{SL}(n_{t_S}, m_{t_S}, t_L),$$

where $q_{t_S}^L(n_{t_S}, m_{t_S}, t_L)$ is the probability of reaching state $k_{t_L} = (n_{t_L}, m_{t_L})$ in period t_S given the case is litigated at t_L and $d_t^{DL}(n_{t_S}, m_{t_S}, t_L)$ and $d_t^{SL}(n_{t_S}, m_{t_S}, t_L)$ are the indicators of dropping and settlement in period t_S at state (n_{t_S}, m_{t_S}) given the case is litigated at t_L. The probability of reaching judgment can be calculated similarly. If players do not settle for the whole period in Phase L between $t_L + 1$ and $t_L + T$, the case reaches judgment ($s = JUDGE$) by the court. Hence, I can write the probability of reaching judgement as

$$\Pr(JUDGE | t_L, FILE) = \sum_{n_T=0}^{T} \sum_{m_T=0}^{T} q_T^L(n_T, m_T, t_L)[1 - d_t^{DL}(n_T, m_T, t_L) - d_t^{SL}(n_T, m_T, t_L)].$$

In some cases, players may drop or settle in Phase O and there will be no litigation. Thus, the probability of observing dropping and settlement at date t_S without litigation ($l = NOFILE$) are

$$\Pr(t_S, DROP | \emptyset, NOFILE) = \sum_{n_{t_S}=0}^{t_S} \sum_{m_{t_S}=0}^{t_S} q_{t_S}^O(n_{t_S}, m_{t_S}) d_t^{DO}(n_{t_S}, m_{t_S}),$$

$$\Pr(t_S, SETTLE | \emptyset, NOFILE) = \sum_{n_{t_S}=0}^{t_S} \sum_{m_{t_S}=0}^{t_S} q_{t_S}^O(n_{t_S}, m_{t_S}) \left[1 - d_t^{DO}(n_{t_S}, m_{t_S})\right] d_t^{SO}(n_{t_S}, m_{t_S}),$$

where $q_{t_S}^O(n_{t_S}, m_{t_S})$ is the probability of reaching state $k_{t_S} = (n_{t_S}, m_{t_S})$ in period t_S, and $d_t^{DO}(n_{t_S}, m_{t_S})$ and $d_t^{SO}(n_{t_S}, m_{t_S})$ are the indicators of dropping and settlement at t_S given the state k_{t_S}.

Regarding payment and cost, I compute conditional probabilities for payment and cost to fall into bins x_k and c_k since supports of payments and costs are continuous. A piece of information that affects payment but that is unobservable to the econometrician is the identity of the proposer. The identity of the proposer at the time of the settlement affects

the payment as shown by both Propositions 1 and 2. Thus, we will consider this in computing the probability. Let d^p and d^d be the indicator function such that

$$
\begin{aligned}
d^p(n_t, m_t, x_k, t_S, t_L, FILE) &= I\{-\beta\left[E_t V_{t_S-t_L+1}^d(n_{t_S+1}, m_{t_S+1}) - \delta C_L^d\right] = x \in x_k\}, \\
d^d(n_t, m_t, x_k, t_S, t_L, FILE) &= I\{\beta E_t\left[V_{t_S-t_L+1}^p(n_{t_S+1}, m_{t_S+1}) - C_L^p\right] = x \in x_k\}, \\
d^p(n_t, m_t, x_k, t_S, \emptyset, NOFILE) &= I\{-Y_t^d(n_{t_S}, m_{t_S}) = x \in x_k\}, \\
d^d(n_t, m_t, x_k, t_S, \emptyset, NOFILE) &= I\{Y_t^p(n_{t_S}, m_{t_S}) = x \in x_k\}.
\end{aligned}
$$

Because the nature chooses the plaintiff as a proposer with probability ϕ and the defendant with probability $1 - \phi$, the probability of observing payment x falling into bin x_k given the settlement date t_S and the litigation date t_L, is

$$
\begin{aligned}
&\Pr(x \in x_k | t_S, SETTLE, t_L, FILE) \\
&= \sum_{n_{t_S}=0}^{t_S} \sum_{m_{t_S}=0}^{t_S} \phi q_{t_S}^L(n_{t_S}, m_{t_S}, t_L) d^p(n_{t_S}, m_{t_S}, x_k, t_S, t_L, FILE) \\
&+ \sum_{n_{t_S}=0}^{t_S} \sum_{m_{t_S}=0}^{t_S} (1 - \phi) q_{t_S}^L(n_{t_S}, m_{t_S}, t_L) d^d(n_{t_S}, m_{t_S}, x_k, t_S, t_L, FILE).
\end{aligned}
$$

Similarly, I can express the probability of payment to be in bin x_k with settlements without lawsuit in Phase O as

$$
\begin{aligned}
&\Pr(x \in x_k | t_S, SETTLE, \emptyset, NOFILE) \\
&= \sum_{n_{t_S}=0}^{t_S} \sum_{m_{t_S}=0}^{t_S} \phi q_{t_S}^O(n_{t_S}, m_{t_S}) d^p(n_{t_S}, m_{t_S}, x_k, t_S, \emptyset, NOFILE) \\
&+ \sum_{n_{t_S}=0}^{t_S} \sum_{m_{t_S}=0}^{t_S} (1 - \phi) q_{t_S}^O(n_{t_S}, m_{t_S}) d^d(n_{t_S}, m_{t_S}, x_k, t_S, \emptyset, NOFILE).
\end{aligned}
$$

In the case of dropping, there is no monetary transfer between the side of plaintiff and defendant. Hence, the payment is 0 with probability one given that the case is dropped, i.e.

$$
\begin{aligned}
\Pr(x &= 0 | t_S, DROP, \emptyset, NOFILE) = 0 \\
\Pr(x &= 0 | t_S, DROP, \emptyset, FILE) = 0
\end{aligned}
$$

If a case reaches judgement, the identity of the proposer does not matter because there is no bargaining taking place. The defendant pays the amount the jury awards if he loses,

and makes no payments otherwise. Hence, I can express the density of the payment in judgment as

$$\Pr(x \in x_k | t_S, JUDGE, t_L, FILE) = \begin{cases} 1 - \pi & if \ x = 0 \\ \pi \Pr(\beta^{-t} V = x \in x_k) & if \ x > 0. \end{cases}$$

Probabilities that the total defense cost C will fall into a bin C_k can be computed similarly. For cases settled after filing lawsuit, the probability of total defense cost falling into a bin C_k is calculated as

$$\Pr(C \in C_k | t_S, SETTLE, t_L, FILE)$$
$$= \begin{cases} 1 & if \ C = t_L C_O^d + (t_S - t_L) C_L^d \in C_k \\ 0 & if \ C = t_L C_O^d + (t_S - t_L) C_L^d \notin C_k, \end{cases}$$

while those for the cases settled without filing can be written as

$$\Pr(C \in C_k | t_S, SETTLE, \emptyset, NOFILE)$$
$$= \begin{cases} 1 & if \ C = t_S C_O^d \in C_k \\ 0 & if \ C = t_S C_O^d \notin C_k. \end{cases}$$

The total defense cost for dropped cases are written in the same way as settled case as

$$\Pr(C \in C_k | t_S, DROP, t_L, FILE)$$
$$= \begin{cases} 1 & if \ C = t_L C_O^d + (t_S - t_L) C_L^d \in C_k \\ 0 & if \ C = t_L C_O^d + (t_S - t_L) C_L^d \notin C_k, \end{cases}$$

and

$$\Pr(C \in C_k | t_S, DROP, \emptyset, NOFILE)$$
$$= \begin{cases} 1 & if \ C = t_S C_O^d \in C_k \\ 0 & if \ C = t_S C_O^d \notin C_k. \end{cases}$$

Regarding the cases concluded by a court judgement, we can calculate it similarly as

$$\Pr(C \in C_k | t_S, JUDGE, t_L, FILE)$$
$$= \begin{cases} 1 & if \ C = t_L C_O^d + (t_S - t_L) C_L^d \in C_k \\ 0 & if \ C = t_L C_O^d + (t_S - t_L) C_L^d \notin C_k, \end{cases}$$

This completes the computation of conditional probabilities.

Appendix D   Likelihood Function

The likelihood function is written as

$$L(\Theta|x, t_S, s, t, i) = \int \int \int \int \int \Pr(x, t_S, s, t_L, l|Z; \Theta, i) dF_C dF_\alpha dF_T dF_{\overline{T}} dF_V,$$

where $\Pr(x, t_S, s, t_L, l|Z; \Theta, i)$ is computed using the conditional probabilities computed above as follows. As I cannot compute the integration exactly, I use Monte Carlo integration by generating 10,000 draws from the distribution of unobserved heterogeneity. For each draw, I compute $\Pr(x, t_S, s, t_L, l|Z; \Theta)$ as follows, and sum the logarithm of the probablity over all the elements in the sample to obatin the lo-likelihood.   (i) For the cases dropped without filing a lawsuit, $\Pr(x, t_S, s, t_L, l|Z; \Theta)$ is

$$\begin{aligned}
&\Pr(x, t_S, s, t_L, l|Z; \Theta, i) \\
=\ &\Pr(NOFILE|Z, \Theta, i)) \times \Pr(t_S|DROP, \emptyset, NOFILE, Z, \Theta, i) \\
&\quad \times \Pr(x \in x_k|t_S, DROP, \emptyset, NOFILE, Z, \Theta, i) \\
&\quad \times \Pr(C \in C_k|t_S, DROP, \emptyset, NOFILE, Z, \Theta, i).
\end{aligned}$$

(ii) For the cases settled without filing a lawsuit, $\Pr(x, t_S, s, t_L, l|Z; \Theta)$ is

$$\begin{aligned}
&\Pr(x, t_S, s, t_L, l|Z; \Theta) \\
=\ &\Pr(NOFILE|Z, \Theta)) \times \Pr(t_S|SETTLE, \emptyset, NOFILE, Z, \Theta) \\
&\quad \times \Pr(x \in x_k|t_S, SETTLE, \emptyset, NOFILE, Z, \Theta) \\
&\quad \times \Pr(C \in C_k|t_S, SETTLE, \emptyset, NOFILE, Z, \Theta).
\end{aligned}$$

(iii) For the cases dropped after filing a lawsuit, $\Pr(x, t_S, s, t_L, l|Z; \Theta, i)$ is computed by

$$\begin{aligned}
&\Pr(x, t_S, s, t_L, l|Z; \Theta) \\
=\ &\Pr(FILE|Z, \Theta)) \times \Pr(t_L|FILE, Z, \Theta) \times \Pr(DROP|t_L, FILE, Z, \Theta) \\
&\quad \times \Pr(t_S|DROP, t_L, FILE, Z, \Theta) \\
&\qquad \times \Pr(x \in x_k|t_S, DROP, t_L, FILE, Z, \Theta) \\
&\qquad \times \Pr(C \in C_k|t_S, DROP, t_L, FILE, Z, \Theta).
\end{aligned}$$

(iv) For the cases settled after filing a lawsuit, $\Pr(x, t_S, s, t_L, l | Z; \Theta, i)$ is computed by

$$
\begin{aligned}
&\Pr(x, t_S, s, t_L, l | Z; \Theta) \\
=~ &\Pr(FILE | Z, \Theta)) \times \Pr(t_L | FILE, Z, \Theta) \times \Pr(SETTLE | t_L, FILE, Z, \Theta) \\
&\times \Pr(t_S | SETTLE, t_L, FILE, Z, \Theta) \\
&\qquad \times \Pr(x \in x_k | t_S, SETTLE, t_L, FILE, Z, \Theta) \\
&\qquad \times \Pr(C \in C_k | t_S, SETTLE, t_L, FILE, Z, \Theta).
\end{aligned}
$$

while (v) for the cases resolved in court judgment, I have

$$
\begin{aligned}
&\Pr(x, t_S, s, t_L, l | Z; \Theta) \\
=~ &\Pr(FILE | Z, \Theta) \times \Pr(t_L | FILE, Z, \Theta) \times \Pr(JUDGE | t_L, FILE, Z, \Theta) \\
&\times \Pr(t_S | JUDGE, t_L, FILE, Z, \Theta) \\
&\qquad \times \Pr(x \in x_k | t_S, JUDGE, t_L, FILE, Z, \Theta) \\
&\qquad \times \Pr(C \in C_k | t_S, JUDGE, t_L, FILE, Z, \Theta).
\end{aligned}
$$

Given a vector of parameter Θ, conditional choice probabilities are computed as in Appendix C.

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