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Abstract

All substantive areas of law with no exception have a common concern for the processes by which legal disputes get resolved. Naturally, the success of any particular litigation strategy in a legal dispute depends on a number of factors. Examples of influential factors are procedural costs, the judge's accuracy and, most importantly, the litigation strategy followed by the counterpart in dispute. Previous work has focused on analysing legal disputes individually, thus providing an answer to the question: What litigation strategy may be most appropriate when confronted with a particular counterpart's strategy? The problem, of course, is that the counterpart's strategy is rarely known in advance.

In contrast, in this paper we adopt a *dynamic* view of the *legal system as a whole*. To do this, we assume that the most successful litigation strategies at a certain time are more likely to be followed in the future, so the prevalence of different strategies in the system will generally change in time. Importantly, this change in the frequency of litigation strategies in the legal system will in turn affect the relative success of each litigation strategy, thus creating a double feedback loop between prevalence and success of litigation strategies, which we aim to explore in this paper.

Thus, the subject main purpose of this paper is to offer a novel approach to study legal disputes, looking at the whole litigation system as a single entity that evolves through time. In particular, we focus on cases of medical liability, and use agent-based simulation to provide a dynamic view of how various factors, such as the magnitude of legal expenses and the accuracy of the judicial system, affect the type of litigation strategies that are successful and prevail in a certain judicial context.

Keywords

Agent-Based Simulation, Litigation Strategies, Medical Liability, Legal Expenses, Judicial Framework.

1. Introduction

In a society like ours, conflict is inevitable, both in disputes and in deals. Therefore, understanding the litigation process is becoming increasingly important, as not only the number of trials in courts, but also the size of awards have augmented drastically in the last decades[1]. Traditional hard-bargaining tactics are widespread within legal practice and, as a result, too often relationships fall apart, cases don't settle, deals break, justice is delayed and its enforcement confronts persistent obstacles. Hence, it seems that we are currently facing a crisis of confidence in the legal system. According to Goldberg et al. (1985, p.3), we can trace the origins of the problem back to the 1960s,

> '(which) were characterised by considerable strife and conflict. An apparent legacy of those times was a lessened tolerance for grievances and a greater tendency to turn them into lawsuits. (…) One factor was the waning role of some of society's traditional mediating institutions – the family, the church and the community. (…) The net result was an increased volume of legal claims, many of which had not been previously recognised. Courts began to find themselves inundated with new filings, triggering cries of alarm from the judicial administration establishment. At the same time, judicial congestion, with its concomitant delay, led to claims of denial of access to justice'.

Solutions were necessarily to be found. Thus, we can root the analysis of legal disputes, not merely descriptive but through formal modelling, two decades ago. A core article in that line of research is Cooter and Rubinfield's (1989) "*Economic Analysis of Legal Disputes and Their Resolution*". Cooter and Rubinfield mention (p.1068) how '*the inability of legal theory to provide sufficient guidance for American courts that were increasingly involved with policy questions*' provided a vacant niche that the economic analysis of law filled rapidly. This new perspective was thought to provide policy-makers with '*a behavioural theory to predict responses to changes in law and to evaluate these responses systematically according to a normative standard*'. Economic theory was, by nature, considered a branch of Science that could meet both the requirements of such formal and normative standards and enrich them with behavioural theory concepts. Mainly, two possible responses were proposed at the time. One was a '*demand for more judges and more courtrooms, another was a search for alternatives to the courts*'[2].

Furthermore, within Economics, game theory soon became the instinctive tool to analyse and model bargaining in legal disputes. However, mostly due to game theory assumptions –such as common knowledge of rationality– the limitations of this analytical device promptly became manifest. The predictions of models constructed under traditional game theory hypotheses are certainly insightful for the analysis of the strategic behaviour of the litigants, but are nevertheless insufficient to address issues regarding the dynamics of the process, or the changes that result from an actively changing environment.

The subject of this paper is precisely to offer a fresh and dynamic look at legal litigation. This novel approach to study legal disputes, looking at the whole litigation system as a single entity that evolves through time, would be characterized because it takes into account those litigant strategies that tend to prevail among legal practitioners. Such insights could be used to: first, prevent cases that have no legitimate basis from reaching the courtroom; second, to promote settlement in those cases where parties can achieve a satisfactory solution by means of (alternative) mediation; and third, to design a judicial process as effective as possible for those conflicts where none of the previous is possible and or desirable.

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[1] An illustration of this fact is given by Cooter and Rubinfeld (1989, p.1068), who point out that, between 1975 and 1985, civil cases tried in federal courts tripled, and an $11 billion judgment against Texaco forced one of America's largest corporations to file for reorganization through bankruptcy, where the related costs of litigation were known to be large, although difficult to quantify.

[2] Goldberg et al. (1985), p. 4

In particular, by means of agent-based simulation, we propose to focus on the mechanisms governing legal litigations in different judicial contexts. Our analysis aims to show how contextual variables may affect lawyers' adoption of different argumentation strategies. This approach has, in our view, both explanatory and normative value: understanding how various factors affect the success and prevalence of different argumentation strategies in a judicial system can help to anticipate the impact of introducing different policies regarding the structure of the judicial process, both on legal operators' attitudes and on the general efficiency of the legal system.

The rest of the paper is structured as follows: in *section 2*, we give a closer view of our framework of analysis and we state our research question in relation to it. In *section 3* we present an agent-based model designed to investigate the question explained above. In *section 4* we present and discuss several simulation results, which are complemented with some mathematical insights derived from the fact that our agent-based model can be usefully seen as a time-homogeneous Markov chain. Finally, *section 5* summarises our conclusions and gives an outline for future work.

2. Our Analytical Framework

We shall start from the very beginning. For simplicity's shake, in our model we assume that, when dealing with a case, a lawyer's basic responsibility is to defend her client's interests and furthermore, that each client in our model is choosing the lawyer that she considers can best defend her interest. Thus, we can treat a pair lawyer-client as a partnership where the two parts have their interests perfectly aligned. Admittedly, this might not always be the case: e.g. legal aid[3] could represent a case of potential misalignment between a lawyer and her client's interest. Exceptions aside, we do believe that it is reasonably safe to assume that, in general, lawyers do defend their clients' interests. Thus, henceforth, we will treat the pair lawyer – client as one single agent.

Consequently, we can reasonably base our litigation model in the assumption that any lawyer involved in a case has a clear objective: to win the case when plausible and subsidiary, in cases when the latter is not possible, to minimize her client's loss. However, such a task is not an easy one in nowadays' legal context. There are many loose ends in a legal case, especially in one concerning to legal liability where both key factual statements to prove the parties' arguments (i.e. the existence of harm and/or negligence) might entail subjectivity or even intentionality issues[4]. Some authors, see e.g. Shavell (1996), emphasize the importance of asymmetric information, both regarding the relevant facts for the process and their distribution belief´s distribution about victory[5]. Also, closely related is asymmetry of information regarding legal costs, or the other party's attitude towards risk[6].

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[3] When a party cannot meet legal expenses in civil or criminal proceedings, most governments provide free legal advice and assistance. In such situations, lawyers cannot easily refuse to defend their assigned client, even in cases where the lawyer herself may not be certain that she will have her client's interest at heart.

[4] E.g., harm can be a matter of pretending, whereas the incurrence in negligence during doctor's performance is often to be found with certainty only during the process.

[5] Although we do assume in our model that before trial each party's information about the facts and beliefs about their winning probability are similar, we must take into account that such assumptions rule out situations in which either, as Shavell (p. 500) points out, *'litigants' information about trial outcomes is far from accurate and it is often decidedly unequal'* because, for example, *'one or the other party does not usually have very accurate information about trial outcomes and those in which one or the other party has substantially superior knowledge to the other'*.

[6] We do, however, include in our model a party's ignorance about the counterpart's tendencies, i.e. their strategic option regarding honesty about the facts and aggressivity.

As a result, in order to pursue her goal, a lawyer may follow a number of different litigation postures, depending on her perception[7] and beliefs. For instance, in situations where winning the case may require holding an argument that is known by the lawyer to be false, different lawyers may adopt different postures. Lawyers may also differ in their risk preferences to go to court: some lawyers are keen to reach agreements outside court, while others are less prone to do so. Undoubtedly, institutional context and the individual's perception of it, has a great impact on her behavior, and hence, our proposed research question is our model is: *which litigation posture (i.e. strategy) will be more successful in a given judicial framework?*

The latter is by no means a trivial question. Indeed, experimental and behavioural literature on context-dependant strategies has repeatedly argued against the existence of a single optimal strategy[8]. In our concrete case, it is in fact not difficult to sense that there is not a unique strategy that will be most advantageous in every possible judicial environment. Which strategy performs best will generally depend on a number of factors such as, for example, the other party's strategy, the costs deriving from the litigation process, or the judges' abilities to tell truth from falsehood when presented with conflicting arguments. We will focus in some of them in our analysis.

In order to keep the model as intuitive as possible, we shall limit the scope of our research in this paper to legal trials dealing with cases of medical liability. More precisely, we consider the eventual conflict that may arise between a patient and a doctor, concerning the issue of whether the doctor negligently damaged the patient, and should therefore compensate him, or not. In such cases, the success[9] of a certain litigation strategy will depend on several important factors. First of all, it will depend on the strategy that the adversary is playing (which justifies modelling the legal interaction as a game). Second, the concrete factual circumstances of the case variant that is in discussion will also have an important impact on the procedural outcome (e.g. was there harm? was there negligence?); this will determine whether the factual propositions can be proved and defended as legal evidence in the process or not. Third, the legal context in which the litigation is taking place is essential in our framework. In particular, we ought to consider diverse contextual variables, such as the legal expenses cost structure for both parties involved in the procedure (i.e. the costs of participating in the proceedings and providing evidence, in relation with the value of the case), or the accuracy of the judges (namely their ability to recognize true factual propositions, given the evidence presented by the counterparts during the process). In other words, the best strategy to follow in a certain situation generally depends on a number of uncontrollable factors.

Thus, as we explained in previous paragraphs, the main objective of this paper is to illustrate how agent-based modelling can provide us with useful insights to understand the dynamics of such judicial processes. Taking into account the above-mentioned framework, the dynamics of our agent-based analysis are based on an evolutionary approach: we assume that the more successful litigation attitudes tend to persist and spread in the population of lawyers by means of imitation. Using this approach, we investigate what kind of strategies will prevail and persist in a certain population under various different institutional conditions concerning the legal system. Institutional conditions are determined by specific instances of each of the uncontrollable factors mentioned above, mainly the legal expenses and the judges' ability to tell truth from falsehood.

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7 The reader ought to understand here "her perception" as "her client's perception" too, due to the above-mentioned lawyer – client identification assumption in our model.

8 See, for example, Gigerenzer and Selten (2001), who postulate bounded rationality as the key to understanding how real people make decisions. Among its features, they advance the so-called "priority heuristic" model for choices among risky options, or the the "recognition heuristic" strategy, that values higher objects that can be recognized by the individual, over those that cannot, as a way to make inferences about a given environment.

9 Note that, for the sake of clarity, we adopt a fairly limited meaning of "success": we consider success merely in terms of either maximizing the payoff obtained by a lawyer's client, in those cases in which winning is feasible, or to minimize the monetary amount to pay, when the former is not possible.

3. The Model

3.1. Overall View of the Model

As mentioned in the introduction, our contribution focuses on the study of the mechanism that drive lawyers' interaction in civil proceedings. By means of assimilating their litigation postures to strategies in the game theoretical sense, we can model such cases as a game using an agent-based model programmed in Netlogo. To be more precise, our model refers to medical liability trials, where the main area under discussion is whether the doctor negligently damaged the patient, and the latter is therefore entitled to compensation, or not.

Events in the model occur in discrete time-steps. The basic functioning of the model in each time-step is as follows: At the beginning of each time-step, lawyers are randomly paired. One of the lawyers in the pair will defend the doctor, and the other lawyer will defend the patient. Each pair of lawyers is then assigned a random case (which may involve harm or not, and negligence or not). Lawyers then engage in legal litigation, and will act following their own particular strategy and taking into account previous similar experiences they have lived in the past. This legal interaction will result in a certain outcome (i.e. payoff) for each of the two lawyers involved in any particular case. Lawyers then record in their memory the experience they have just lived, storing information such as whether they defended the doctor or the patient, the case they had to deal with, the strategy they followed and, of course, the resulting outcome. Finally, there is a final stage where lawyers consider changing their strategy by means of imitation, if they observe that a randomly chosen peer obtained a better result. There is also a small probability that lawyers may choose to experiment with a new strategy. The following sections describe this sequence of events in detail.

3.2. Clients

Every round, our lawyers are assigned a client[10]. Therefore, the same lawyer will act either on a Patient's or a Doctor's behalf, depending on the round. Lawyers advise Patients and Doctors on their litigation strategy, making the choices for them, and the clients' gains and losses are gains and losses also for their lawyers. Thus, in the following we shall speak of Patient and Doctor meaning the patient's lawyers and the doctor's lawyer.

Furthermore, even though both Patient's and Doctor's respond to the same typology of strategies, these will result in slightly different litigation postures. This is due to the fact that we have modelled the judicial procedure as a sequential game, where, obviously, it is first for the Patient to decide whether she wants to go to court (i.e. demand her Doctor or not), and only later the Doctor decides whether she will defend herself or not from her Patient's claims.

3.3. Case Variants

In our model, we assume that a lawyer working on medical liability cases can be assigned one of four possible types of cases, whose characterization is based on two basic boolean parameters: **(a)** whether the Patient has suffered Harm (H) as a consequence of the operation or not, and **(b)** whether the Doctor has performed the medical procedure incurring in Negligence (N) or not. Hence, according to the existence or not of these two facts, there exist four different case variants:

[10] Note that, as we explained in the introductory section, we assume that the lawyer's interests are perfectly aligned with her client's, in every case.

1. Harm – Negligence (H,N).
2. Harm – NoNegligence (H, ¬N).
3. NoHarm – Negligence (¬H,N).
4. NoHarm – NoNegligence (¬H, ¬N).

As mentioned before, at every round each couple of lawyers is assigned a case variant randomly. Also, note that for simplicity's shake[11], we assume that both parties can truly assess the reality, that is, both know with certainty which case variant corresponds to what truly happened. However, note that, as we shall see in the following sections, independently of the existence of Harm and Negligence, it is the judicial assessment of the truthfulness of the facts alleged by each party what determines the probability of such arguments being accepted as valid evidence in the trial.

3.4. Strategies

We assume that lawyers are characterized by two features, aggressiveness and honesty. An honest lawyer only attacks or defends herself by providing arguments based on true factual propositions (we assume that both parties know what really happened, i.e. which case variant is in litigation). Therefore, she will refuse to engage in any action that would require him to lie. On the contrary, a non-honest lawyer may use arguments based upon facts that are not true.

As far as aggressiveness is concerned, we can distinguish between two postures as well: aggressive and non-aggressive lawyers. A non-aggressive lawyer only attacks (when representing a Patient) or defends (when working for a Doctor) when she expects her gains to be higher than those of her counterpart. On the other hand, an aggressive lawyer always advances arguments, regardless of their cost. Expected gains are estimated by lawyers using their past experience; this is explained in detail in section 3.7.

By combining the two features, we obtain the following four litigation strategies, each one defining a lawyer's type in a certain round:

1. *Honest and non aggressive* (HoNAg). The lawyer advances an argument whenever (1) the argument is right (it is based upon true factual propositions) and (2) it is cost-effective (its expected gains outweigh its expected costs).
2. *Honest and aggressive* (HoAg). The lawyer advances an argument whenever it is right, regardless of its cost.
3. *Non honest and non aggressive* (NHoNAg). The lawyer advances an argument whenever it is cost-effective, regardless of its rightness.
4. *Non honest and aggressive* (NHoAg). The lawyer advances every argument available, regardless of its rightness and its cost.

Thus, for instance, an honest patient (regardless of her aggressiveness) would not take a case to court when she knows that there was no fault of the doctor, while an honest doctor would not provide arguments in a case where she knows that she negligently caused damage.

[11] As we mentioned in the introduction, the existence of harm might be relative in its grade, or even faked, and many times negligence can only be proved through the same judicial process. The reason why we do not take them into account in our analytical framework is because we believe that including such uncertainty factors in our model, would not only increase the complexity exponentially, but also diminish its clarity and explanatory potential.

3.5. Procedural Costs and Value of the Case

In our simulation, we assume that each party involved in legal proceedings has to support the following procedural costs:

- Participation cost (PartCost). It represents a sunk cost that has to be paid in order to initiate the legal proceedings (i.e., for suing or resisting).
- Contested participation surcharge (ConPartSurch). This surcharge has to be paid in addition to the PartCost, in case the counterpart decides to take part in the process too. It covers lawyer's fees and other costs involved in replying to the arguments of the adversarial party. Thus, such cost ought to be taken into account always when computing Doctor's procedural costs, while in the Patient's case it will only be added in case the Doctor decides to defend herself.
- Evidence cost (EvCost). This cost has to be paid by a party for each factual proposition appearing within her arguments. EvCost for a factual proposition covers the expert or lawyer's work required for building or presenting the evidence related to that proposition. Note that, in the case of the Patient, in order to win the case, she must prove both that there was Harm and that such Harm came as a consequence of the Doctor's Negligence. The Doctor, however, will only need to prove evidence on the contrary on either one of the two facts.
- Contested evidence surcharge (ConEvSurch). This extra cost ought to be paid when the evidence provided on a factual proposition is contested through counterevidence by the other party, namely by means of presenting evidence for the negation of such factual proposition. ContEvSurch covers matters such as contestation of the counterevidence or the cost of providing additional evidence, for instance.

Thus the procedural cost (ProcCost) to be sustained by a party Patient in a particular litigation history is given by the formula

$$\begin{aligned}\text{ProcCost} = X * \text{PartCost} + Y\ \text{ContPartSurch} + \text{num-evidence} * \text{EvCost} + \\ + \text{num-evidence-of-counterpart} * \text{ContEvSurch}\end{aligned} \quad (\mathbf{1})$$

where

— X equals 1 or 0 depending on whether the party has taken part in the proceedings,

— Y is 1 or 0 depending on whether the adversary participates in the proceedings,

— num-evidence is the number of factual propositions upon which the party provides evidence; therefore it can be equal to 0, 1 or 2, depending on whether the party proves Harm, Negligence, neither or both of them.

— num-evidence-of-counterpart is the number of such factual propositions on which counterevidence is provided; similarly to W, it can also equal 0, 1 or 2.

Let us consider, for instance, a case where Patient sues and Doctor denies Harm, we would have that the Patient would have to pay

$$\text{ProcCost}_{\text{Patient}} = \text{PartCost} + \text{ContPartSurch} + 2 * \text{EvCost} + 1 * \text{ContEvSurch} \quad (\mathbf{2})$$

whereas the Doctor's costs would be

$$ProcCost_{Doctor} = PartCost + ContPartSurch + 1 * EvCost + 1 * ContEvSurch \quad (3)$$

The value of the case is a parameter of the model, namely *ValCase*.

3.6. Judges' Accuracy

As previously mentioned, we assume both parties to have full knowledge of nature of the case they have been assigned to. Namely, they know whether there was harm and negligence (this assumption could be relaxed to model situations where one or both parties are uncertain about the facts of the case but, for simplicity's sake, we shall keep it here).

On the contrary, judges do not have such knowledge, and have to decide on the basis of the evidence and arguments provided by the parties. Henceforth, by considering that each proposition may be true or false, and uncontested (only evidence by the alleging party is provided) or contested (besides evidence for it, also evidence against is provided by the counterpart), we can specify the probability of a proposition being considered as true and therefore valid evidence, in all four possible cases. In order to do so, we introduce a function PrAcc, defining the probability that the judge accepts a proposition φ according to the status of φ, denoted as Status(φ). Though the (average) values for PrAcc should be established through empirical inquiry, we just make some general considerations that will serve as a basis for establishing reference values.

In the following section we consider 4 different scenarios. In our baseline scenario we assume that judges have cognitive capacities with regard to factual circumstances, that is, they are more likely to accept a factual proposition when it is true than when it is false, and when evidence for it is provided rather than the contrary. We use this baseline scenario as an illustration in this section. According to the above assumptions[12], the following table reflects the probability of judicial acceptance in each of the four possible situations:

[12] Firstly, the probability of judicial acceptance of a true and uncontested proposition (PrAcc(φ) when Status(φ) = {True, ¬ Contested}) must be very high. Secondly, the probability of judicial acceptance of a true and contested proposition (PrAcc(φ) when Status(φ) = {True, Contested}) must be lower than the probability of acceptance of a true and uncontested one (when Status(φ) = {True, ¬Contested}). However, it must still be higher than 0.5 (if we assume that sincere and insincere parties have the same capacity of providing evidence, and that judges have some cognitive capacity). Thirdly, the probability of judicial acceptance of a false and uncontested proposition (PrAcc(φ) when State(φ) = {False, ¬Contested}) depends on the possibility for the judge to get evidence not provided by the parties. When, as usually in private law, the judge does not have this possibility, the judge would tend to align with what is falsely indicated by the uncontested evidence provided by the lying party. Thus this probability too must be higher than 0.5. Fourthly, the probability of judicial acceptance of a false and contested proposition (PrAcc(φ) when State(φ) = {False, Contested}) must be lower than 0.5 (assuming that sincere and insincere parties have the same capacity of providing evidence, and that judges have some cognitive capacity).

	¬ *Cont*	*Cont*
True	1	0.8
False	0.9	0.2

Table 1. Judge's Accuracy

Let us consider, for instance, a case variant where it is indeed true that the Patient has suffered harm and provided evidence for it. According to the previous table, two situations must be distinguished: **(a)** if the evidence for harm is uncontested (Doctor provides no evidence against Harm), with probability 1 the judge will be persuaded that there harm has been indeed infringed on the Patient; while if **(b)** the evidence is contested (Doctor provides evidence against Harm), the chances that the judge will be convinced would decrease to 0.8.

3.7. Memory

Lawyers store the experiences they live in each round in their memory, and use this memory of past events to estimate future payoffs in situations that they perceive as similar. Two situations are perceived as similar by a lawyer if and only if the lawyer is (a) defending the same type of client (doctor or patient), (b) the case variant is the same (in terms of Harm and Negligence), (c) the lawyer is following the same strategy, and (d) the number of factual propositions upon which the relevant party provides evidence or counterevidence is also the same.

When facing any particular situation, a lawyer will look back at the 5 most recent times she experienced a similar situation in the past, and use the average of the payoffs she obtained in these 5 previous experiences as an estimate for the payoff she will obtain in the present situation.

3.8. Imitation and Experimentation

Once every lawyer in the population has received her corresponding payoff, lawyers will consider changing their strategy for the next round. Each lawyer will look at another randomly selected peer with the same type of client and the same case variant. If and only if the payoff obtained by the peer was greater, then the imitating lawyer will adopt the same strategy as the peer.

There is also a certain probability, namely *Prob-Experimentation*, that each lawyer will adopt a randomly chosen strategy.

4. Preliminary Results in Four Different Scenarios

This section presents some preliminary simulation results for 4 different scenarios. We are interested in exploring the impact of (a) procedural costs and of (b) judges' ability to tell truth from falsehood, on the evolution of lawyers' strategies. Thus we define the following four scenarios: "Baseline", "Gullible Judges", "Barrier to Entry", and "Gullible Judges & Barrier to Entry". The parameterisation of each scenario is the following:

Parameterization of the four different scenarios

Parameter	*Baseline*	*Gullible Judges*	*Barrier to Entry*	*Gullible Judges & Barrier to Entry*
Ticks	10.000	10.000	10.000	10.000
Initial-stratification	Random	Random	Random	Random
Case-generator	Random	Random	Random	Random
Prob-imitation	1	1	1	1
Prob-Experimentation	0.010	0.010	0.010	0.010
Memory-size	5	5	5	5
Initial-population	200	200	200	200
True-no-cont	1	1	1	1
True-cont	0.8	0.5	0.8	0.5
False-no-cont	0.9	1	0.9	1
False-cont	0.2	0.5	0.2	0.5
Part-cost	1	1	3	3
Cont-part-cost	4	4	3	3
Ev-cost	1	1	1	1
Cont-ev-cost	2	2	1	1
Val-case	10	10	10	10

4.1. The Model as a Time-Homogeneous Markov Chain

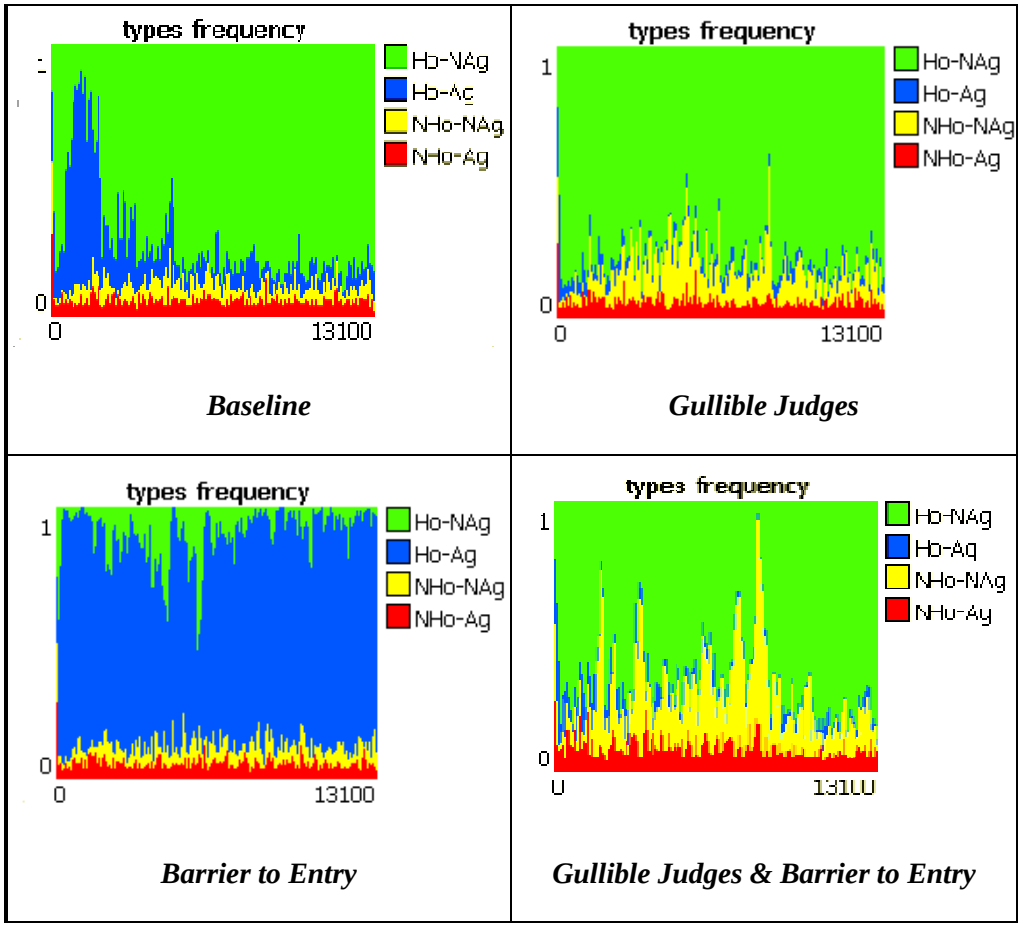
Before proceeding to the presentation of the simulation results, it is worth mentioning that the model presented here can be usefully seen as a time-homogeneous Markov chain (Izquierdo et al. 2009). The state of this system can be defined as the number of lawyers that are following each specific strategy at any given time. With this definition, the number of possible states is:

$$\text{Number of possible states: } \binom{4 + 200 - 1}{200} \qquad (4)$$

It is straightforward to see that if the *prob-Experimentation* is greater than 0, then it is possible to go from any state to any other state in one single step. Consequently the model is an irreducible and aperiodic time-homogeneous Markov chain, also called ergodic. This basically means that the probability of finding the system in each of its states in the long run is strictly positive and independent of the initial conditions. It also means that the limiting distribution of the system coincides with its occupancy distribution. Clearly, calculating such distributions analytically is rather impractical, but we can approximate them as much as we want by running the computer model.

4.2. Simulation Results

In this section we report simulation results for each of the four different scenarios. The figure below shows the evolution of the relative frequency of strategies in one representative run for each of the 4 possible scenarios.



After conducting several tests (see paragraph 9.11 in Izquierdo et al. 2009 for details), we came to the conclusion that gathering data in between time-steps 10001 and 11000 was sufficient to characterise the occupancy distribution over strategies for each of the 4 scenarios. Thus, the table below reports the average values for the fraction of the main strategies between stages 10001 and 11000 for each of the 4 scenarios. Each reported value has been calculated over 200 simulated runs of the process, with random initial conditions. The values in brackets show the standard deviation of the averages across runs.

	Cum-strategy-freq			
	HoNAg	***HoAg***	***NHoNAg***	***NHoAg***
Baseline	90.80% (0.96%)	4.92% (0.83%)	2.93% (0.38%)	1.33% (0.14%)
Gullible Judges	89.82% (1.45%)	2.81% (0.29%)	5.99% (1.36%)	1.39% (0.14%)
Barrier to Entry	15.16% (5.24%)	79.50% (5.48%)	3.85% (0.62%)	1.49% (0.15%)
Gul. Judges & Barrier to Entry	83.84% (3.59%)	3.92% (0.55%)	9.89% (3.44%)	2.35% (0.33%)

These preliminary results show an interesting and unexpected phenomenon: departing from baseline conditions, judges' ability to tell truth from falsehood does not seem to have a significant effect on the adoption of different strategies in the population of lawyers[13]. However, the picture is completely different when studying a system with an existing barrier to entry the procedure. It seems that barriers to entry, on their own, dramatically change the composition of strategies being used by lawyers, favouring Honest and Aggresive behaviours over Honest and Not Aggressive. Having said that, the effect is only observable if judges have some ability to tell truth from falsehood. If, using our informal terminology, judges are gullible, then entrance barriers do not seem to make any significant difference.

Note also that changes in the relative success and prevalence of different argumentation strategies in each of the scenarios have wider implications. Changes in strategy adoption have an effect on the efficiency of the judicial system. This can be appreciated in the following table, which reports the average number of cases that go to court in each round for each of the possible scenarios. Each reported value corresponds to the average between stages 10001 and 11000 and has been calculated over 200 simulated runs of the process, with random initial conditions. The values in brackets show the standard deviation of the averages across runs.

	Baseline	**Gullible Judges**	**Barrier to Entry**	**Gul. Judges & Barrier to Entry**
% Cases that go to court	36.42 (0.25)	33.16 (0.57)	48.72 (0.80)	37.09 (1.41)

In addition, the table below describes the distribution of victories in those cases that indeed go to court. We can appreciate how, in this case, judges' ability to distinguish true facts does have a great impact on the result of the process.

	Baseline	**Gullible Judges**	**Barrier to Entry**	**Gul. Judges & Barrier to Entry**
% Successful patients (doctors)	27.51 (72.49)	90.95 (9.05)	35.18 (64.82)	44.14 (55.86)

[13] It does, however, have a significant effect on the proportion of cases won by doctors, as shown later.

5. Conclusions and Future Work

This paper proposes a novel approach to study legal interactions. In particular, it illustrates how agent-based modelling can provide insightful explanations that help us understand the dynamics of legal litigation during judicial processes. Our agent-based model studies the mechanisms that govern the adoption of diverse litigation attitudes, and their interplay with given parameters in a certain judicial environment. More concretely, our analysis intends to extrapolate the influence of judicial accuracy and legal expenses structure in the evolution and prevalence of certain strategies in lawyers dealing with cases of medical liability.

In the model presented, the chances of success of a litigation posture are determined by the case variant and its concrete factual propositions, the strategy adopted by both parties involved, i.e. their argumentative and probatory activities; and the assessment capacity of the judges. Furthermore, our agent-based simulation is analysed in four particular sample scenarios, with two different cost structures – the baseline and one where the costs of participating in the process are incremented, thus, resulting in a barrier to entry the procedure – and two diverse levels of judges' capacity to assess the truthfulness of the evidence provided by the parties – i.e. one where judges can with a high probability discern true from false facts, and another where, if a fact is counter-proved, they are equally likely to assess it as true or not.

A basic question in the literature about litigation concerns the frequency of plaintiff victory at trial and how cases that go to trial relate to settled cases. In an interesting paper, Priest and Klein (1984) advance a model in which there is a tendency for plaintiffs to prevail at trial with probability 50 percent. However, their hypothesis was tested later on by S. Shavell with differing results. By relaxing Priest and Klein's assumption of symmetric information, Shavell claims that it does not seem appropriate to regard 50 percent plaintiff victories as a central tendency, either in theory or in comparison with real data[14]. On the contrary, his claim is that, for the cases that go to trial, plaintiff victory occurs with any probability.

As we can extrapolate from the figures in the previous section, none of the results obtained in any of our four scenarios corresponds with the 50 percent assumption drew by Priest and Klein. Furthermore – even though, as we explained in the introduction, we do introduce a simplifying assumption regarding the parties' capacity of truly assessing the existence of both harm and negligence – the fruits of our simulation seem to fairly match Shavell's assertion. If, for instance, we take a look at the "Baseline" scenario, we can see how, when judges are not credulous and legal expenses are lower, patients win approximately one fourth of the cases that go to trial, which roughly corresponds to the percentage that, a priori, they should be entitled to win[15]. Moreover, though both the outcomes obtained in the "Barrier to Entry"and the "Barrier to Entry & Gullible Judges" scenarios fall within Eisenberg's empirical results, that is not the case when judges' ability to tell truth from falsehood. The latter results in patients becoming extremely successful, effect that is however neutralized when participating costs are increased.

Following this argumentation path regarding the influence of judges' valuation of the facts, we should mention Gennaioli and Shleifer, who conclude (p. 43) that judges exercising discretion in finding facts in a trial leads to setting of damages unpredictable from true facts and, furthermore, it not only raises the incidence of litigation, but also encourages litigants to take extreme positions in court. Indeed, we

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[14] One of Shavell's sources of empirical data is, Eisenberg (1990), *supra* note 3, p. 357, where he also subjects the 50 percent hypothesis to statistical test and rejects it. On the contrary, Eisenberg reports plaintiff success rates ranging between 52% and 84% for different categories of contract cases, between 12% and 84% for real property cases, and between 25% and 60% for personal injury cases. The latter will correspond to the applicable rate to our case of study.

[15] Remember that in our model, there are four different types of cases, namely (H,N), (H ¬N), (¬H,N).and (¬H, ¬N). Patients are only right in one of those case variants, when there has been Harm as a result of the doctors incurring in Negligence (H, N).

do appreciate very different results in both scenarios involving judicial discretion, with defendants' successful rate ranging from a minimum 9 percent to more than half. However, no augmentation in the frequency of extreme positions – the term "extreme" would resemble our model's aggressive and/or non honest strategies – is observed.

One suspects, however, that litigants' strategies should also follow different paths, depending on the magnitude of legal expenses. This question is indeed, as we have argued extendedly throughout the article, a main focal point of the literature on legal litigation. However, most formal models are mainly static and, though they are able to reflect some implications of procedural costs variance, they generally give little or no consideration to the evolution over time of such consequences. Inspired by P. Rubin's 'Why is The Common Law Efficient?' article's spirit, but borrowing some tools of evolutionary analysis from biology, in 1981 P. Terrebone develops one of the few legal models involving dynamism. Terrebone evaluates the impact that rule efficiency[16] has on litigation, and concludes that plaintiffs and defendants adopt strategies that result in a high rate of litigation when legal rules are inefficient and a low rate of litigation when they are efficient. This conclusion matches the results of our simulation – note that we should consider the baseline case as representative of an efficient-rule-based system, in contrast with that in which a barrier of entry is imposed, increasing the cost that parties' ought to bare, once they enter the process – where the percentage of cases that are resolved in a courtroom increases substantially, when the legal expenses are augmented. Indeed, the percentage of cases that go to trial is almost 34% higher in the case with higher legal expenses, rising from 36.42% to 48.72%.

All this said, we can conclude that the evolutionary framework that agent-based simulation provides enables us to show to what extent contextual variables may impact on the adoption of certain argumentation strategies in a population of heterogeneous lawyers, showing how different postures may evolve and eventually become prevalent and over time. In addition, further developments of models such as the one described in this paper could help anticipating the impact of new policies regarding the structure of the judicial process would have on the attitudes of legal operators and on the general efficiency of the legal system.

Though in this paper we have only considered one possible change in the structure of the proceedings' costs, other changes may be considered, such as increasing or decreasing costs in a different way, making the losing party bare all the procedural costs, adding a penalty in addition to the costs upon the losing party, increasing or decreasing the accuracy of the judges, etc. Moreover, different attitudes to risk and loss could also impact on agent's choices. Another possible change, could be introducing the option of settlement; in such case, a way of managing the corresponding negotiation space should also be considered.

Moreover, the pattern here proposed could also be developed by relaxing our knowledge assumptions about the lawyers, namely, that they are aware of the variant of the case they are dealing with, that is, whether Harm and Negligence have occurred. In addition, we could let them share their memory with other lawyers, as if they were part of a law firm.

Thus, we consider that our dynamic analysis, while still being very preliminary, could lead to interesting results and, more important, we the ideas presented in the paper pave may pave the way for future developments where law and agent-based simulation interact.

[16] In the related literature it is generally accepted that that inefficient legal rules are those that impose greater costs on the parties subject to them.

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