Cooperation Without Enforcement: A Comparative Analysis of Litigation and Online Reputation As Quality Assurance Mechanisms

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Abstract

Commerce depends on buyers and sellers fulfilling their contractual obligations; mechanisms inducing such performance are essential to well functioning markets. Internet-enabled reputation mechanisms that collect and disseminate consumer feedback have emerged as prominent means for inducing seller performance in online and offline markets. This article compares the ability of reputation and more traditional litigation-like mechanisms for dispute resolution to induce efficient economic outcomes. We use a game theoretic formulation and derive results for their relative efficiency and effectiveness individually or as complements. We find that the popular view of reputation as an efficient and relatively costless way to induce seller effort under all circumstances is incorrect; reputation is less efficient than litigation in inducing any given level of effort. Thus reputation improves efficiency only in settings where the high cost of litigation, insufficient damage levels or low court accuracy induce sub-optimal effort or cause market failure. When adverse selection is important, reputation helps reveal the true types of market participants, which may offset its higher cost of inducing effort. Finally, adding reputation to existing litigation mechanisms increases seller effort and may require adjusting damage awards to avoid inducing over-effort.

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1 Introduction

Trade and commerce depend on effective mechanisms to guarantee that buyers and sellers fulfill their contractual obligations. In medieval times, before the emergence of strong nation-states, trade was largely based on reputation networks that spread information about a trader's past behavior (Greif 1989). The price of violating one's promises was exclusion from future trade. Since the emergence of nation-states in the late middle ages, tort litigation, backed by the coercive power of the state, has replaced reputation as the main mechanism for providing such guarantees (Benson 1989). The tort system allows a party with a complaint about a commercial transaction to initiate a costly process (typically carried out within the public court system) that examines the facts of a dispute and, if it finds for the plaintiff, forces the defendant to pay damages.

Recent advances in information technology have dramatically reduced the cost of mechanisms collecting and disseminating consumer feedback (to which we collectively refer as "reputation"), thus enabling low-cost online reputation mechanisms with global reach to once again become viable for guaranteeing transactions in settings where traditional legal sanctions are either difficult, or prohibitively expensive relative to the value of the goods being traded (Dellarocas 2003). Such mechanisms have been used successfully by global marketplaces, such as eBay, as their primary means of eliciting honest behavior (Resnick and Zeckhauser 2002). At the same time, a number of firms are taking advantage of new technology to offer dispute resolution services that have several elements in common with the tort system but which, typically, incur much lower costs to the parties of a dispute. Online arbitration services, credit card dispute resolution mechanisms, Paypal buyer protection[1] and escrow services all allow a party to a transaction to initiate a dispute. Similar to traditional litigation, these dispute resolution processes engage in fact-finding (that incurs costs for both parties) and might result in a transfer of damages from the defendant to the plaintiff (typically limited to a partial or full refund of the price paid). We use the term "litigation" broadly to encompass these litigation-like mechanisms for dispute resolution as well as traditional mechanisms that depend on contract enforcement through the public legal system .

The continuing developments in IT and the growing power of Internet media suggest an increasing variety and functionality of available litigation and reputation mechanisms. It is therefore important and timely to examine how these two broad classes of sanctioning mechanisms compare in terms of their ability to sustain market entry, induce effort from market participants, generate consumer surplus and lead to efficient outcomes. We study these issues using a game-theoretic framework and we derive a rich set of implications for buyers, sellers, market designers and social planners. We find that, if adverse selection is not an important consideration, the popular view of reputation as an efficient and relatively costless way to induce seller effort under all circumstances is incorrect. Specifically, our analysis shows that any given level of effort can be induced more efficiently by litigation than reputation. At the same time, there are several practical settings where the levels of effort that are induced by the available litigation mechanisms are either too high or too low. There are also settings where the available litigation mechanisms would make market entry altogether

[1] See http://pages.ebay.com/help/buy/PayPal-buyer-protection.html

unprofitable. These situations occur when legal costs are too high or when damage awards and court accuracy are too low. It is (only) in such settings that reputation mechanisms improve efficiency. When adverse selection considerations are important reputation helps reveal the types of market participants. This can partly or fully compensate for the inherently higher social cost of inducing effort via a reputation mechanism.

We study litigation and reputation both as substitutes and as complements, since both cases have important practical ramifications for today's business environment. For instance, a market designer may treat reputation and dispute resolution ("litigation") as substitutes in selecting the mechanism or combination of mechanisms that induces seller effort in the most efficient manner.[2]

The emergence of consumer review websites, blogs and other types of online forums where consumers discuss a broad range of professionals such as physicians, lawyers and home contractors means that certain market participants are now finding themselves in settings that *de facto* combine litigation and reputation as complements. In such settings a bad transaction outcome not only might trigger costly litigation, but also negative online feedback accessible to future prospective customers. Thus several markets designed under the assumption of quality assurance based on litigation mechanisms alone are now effectively employing combinations of litigation and reputation. Our analysis can help understand what adjustments may be needed to maintain efficiency in such settings.

We develop our arguments by analyzing a setting where a single seller offers goods (products or services) to a population of buyers and each transaction can result in either a high-quality or a low-quality good. The probability of a high-quality outcome depends on the effort exerted by the seller, such effort is costly to the seller, and the buyers are heterogeneous in their valuations for a high-quality good. A litigation-like mechanism for dispute resolution can induce the seller to exert effort in order to avoid the cost and penalties that may follow low-quality outcomes. Alternatively, reputation mechanisms can provide performance incentives by inducing the seller to exert effort in order to avoid the negative consequences from the public dissemination of information about low-quality outcomes, such as the loss of profits from future business.

The novelty of this work stems from its integrative approach; while both reputation and litigation mechanisms have been previously studied individually as discussed below, this is the first analytical work we are aware of that studies their interaction in a single setting. This enables us to properly compare the two mechanisms, analyze the cases where they act as substitutes as well as complements, and derive results with significant implications for the design of online markets and in particular for the balance between dispute resolution and reputation mechanisms. We also show that the often popular view of reputation mechanisms as an efficient and relatively costless way to induce effort from market participants under all circumstances is incorrect.

Our definition of reputation mechanisms encompasses any mechanisms that aggregate and publish perfect or imperfect information about the participants' history of actions. Such mechanisms

[2]While market participants typically can choose to resort to litigation in the traditional court system, this option can be curtailed through mechanisms such as mandatory arbitration agreements or it can be unavailable in practice because of high legal costs. In such cases, market designers may have the opportunity to choose between employing litigation-like mechanisms for dispute resolution and employing reputation mechanisms.

have been extensively studied in the economics literature (see Wilson (1985) and Dellarocas (2003) for literature overviews). Also, there is a significant tradition in the economics literature studying aspects of reputation formation in settings with imperfect monitoring, adverse selection, and/or moral hazard, such as Green and Porter (1984), Diamond (1989), Fudenberg and Levine (1992), Holmstrom (1999), and Cripps, Mailath and Samuelson (2004).

Game-theoretic analyses of litigation are the subject of a rich, and growing, body of literature as well (see Cooter and Rubinfeld (1989) and Baird, Gertner and Picker (1995) for surveys). The litigation model developed in this paper is an example of a one-sided private information model, *i.e.*, a model in which the defendant has information that is not available to the plaintiff (in our case, the level of seller effort) but the plaintiff has no information that is not available to the defendant. Examples of such models in the literature include Bebchuk (1984), Nalebuff (1987), Reinganum and Wilde (1986) and P'ng (1983).

There are relatively few economic studies that look into the interaction between aspects of the legal system and reputation. Lott (1996) and Karpoff and Lott (1999) consider the consequences of legal judgments for firm reputation; their main thesis is that the efficient calculation of punitive damages needs to take into consideration the "intangible" penalties to defendants, such as reputation loss. Johnston and Waldfogel (2002) study the ability of lawyers to develop reputation among each other and show that this can facilitate future settlements among clients. Drahozal and Hylton (2003) study the reputational tradeoffs between litigation and alternative dispute resolution in the context of franchise contracts. Maze and Menard (2010) offer an empirical study of complementarities between the use of private ordering and regulation in the French livestock industry.

Another related literature is the legal literature on private ordering, which aims to understand how parties enforce contracts without relying on public courts (Bernstein 1992; McMillan and Woodruff 2000; Schwarcz 2002; Richman 2004). Our study complements the legal literature on the topic, that is almost exclusively based on qualitative and empirical arguments, by offering a formal analytical framework that clearly exposes the key variables that determine the tradeoffs between the two mechanisms.

2 A Model of Litigation and Reputation

2.1 The setting

We analyze a multi-period setting with a long-lived monopolist seller facing a sequence of short-lived buyers. In each period the seller offers a single unit of a good (which can be thought of as a product or service) to the next buyer in the sequence. If a transaction takes place, it results in a good that is either of high quality or low quality. Buyers have type k that is uniformly distributed in $[0, 1]$ and a buyer of type k has valuation $u_k = kw$ for the high-quality good, where w is a constant.[3] In addition, buyer valuations are independent and identically distributed across periods, all buyers

[3] We assume uniformly distributed buyer valuations (i.e., linear demand) for analytic convenience. However, our results will qualitatively apply to more general distributions with k having a continuous density f and cumulative distribution F with support $[0, 1]$.

have zero valuation for the low-quality good[4] and buyer lifetime is exactly one period, indicating that there are no repeat purchases. Each buyer's realization of k is privately known, while the other aspects of the setting are common knowledge.

Seller effort in each period determines the probability that the corresponding good will be of high quality. We normalize effort to be denoted by the resulting probability $x \in [0,1]$ of obtaining a high-quality good. The cost of effort is characterized by a continuous twice differentiable cost function $c(x)$ that satisfies $c(0) = 0$, $c'(x) > 0$ and $c''(x) > 0$ for all $x > 0$ and $\lim_{x\to 1} c(x) = \infty$. The last condition implies that, at equilibrium, the probability of a low quality outcome will never be zero. The game is repeated indefinitely and the seller has a period discount factor δ reflecting the frequency of transactions within the community, or the probability that the game will end after each period. Buyers do not observe the effort exerted by the seller and they observe the quality of the good received after the transaction is consummated and payment has been completed (e.g., upon delivery of the good). Moral hazard is introduced because effort is costly to the seller, who can reduce his costs by exerting lower effort, although that would offer the buyer a lower probability of a high-quality good.

Throughout the paper we assume that the good is allocated via a posted price mechanism. Specifically, we assume that in each period the seller sets a price p and the buyer decides to either buy or not buy the good. Each period's demand $d(p, x)$ (i.e., the probability of a sale) is then a function of p and of buyers' beliefs regarding the seller's effort x; at equilibrium, buyer beliefs are consistent with seller actions.

The seller's objective is to maximize the present value $V = \sum_{t=0}^{\infty} \delta^t d(p_t, x_t)(p_t - c(x_t))$ of his expected lifetime profits by selecting appropriate price and effort levels p_t and x_t, whereas each buyer's objective is to maximize her stage game surplus $s_{k_t} = \max(0, x_t u_{k_t} - p_t)$ by deciding whether to buy. The total expected discounted surplus of the buyers is $S = \sum_{t=0}^{\infty} \delta^t E_{k_t}[\max(0, x_t u_{k_t} - p_t)]$, and the expected discounted total surplus is $T = V + S$.

The only Nash equilibrium in this setting is one where the seller always exerts zero effort, no buyer is willing to buy at a positive price, and thus no trade takes place.[5] Sanctioning mechanisms can be used to induce positive seller effort, and thus to enable profitable transactions, by charging sellers penalties Q_i (or rewards, that can be modeled as negative penalties) that are contingent on the transaction outcomes $i \in \{+, -\}$, where "+" denotes a high-quality outcome and "−" denotes a low-quality outcome, possibly transferring a part $R_i \le Q_i$ of this penalty to the buyer. As we discuss in the following sections, both litigation and reputation mechanisms can be viewed as special cases of this general formulation.

The introduction of a sanctioning mechanism changes a buyer's expected transaction surplus to $s_{k_t} = x_t u_{k_t} + x_t R_+ + (1 - x_t)R_- - p_t$ and the seller's expected cost of effort to $\kappa(x_t) = c(x_t) + x_t Q_+ + (1 - x_t)Q_-$. Straightforward analysis shows that *all equilibria induced by a sanctioning mechanism*

[4]This condition implies that no transactions would occur without an implicit or explicit contract that the seller will deliver a high-quality good.

[5]This is because the seller receives payment *before* the buyer can assess the quality of the received good. Thus, the seller's dominant strategy is to minimize his cost by exerting zero effort.

with parameters Q_+, Q_-, R_+, R_- *are characterized by* $S = \frac{1}{2}V$ *and* $T = \frac{3}{2}V$. Thus a sanctioning mechanism that maximizes the present value of expected seller profits also maximizes the present values of buyer surplus and of total surplus, and the incentives of the buyers, the sellers and the social planner are aligned in choosing a sanctioning mechanism. In the rest of the paper we focus on comparisons of seller payoffs (i.e., the present value of seller profits), since a mechanism that maximizes seller payoffs also maximizes buyer payoffs, and, thus, total surplus.

2.2 Litigation mechanisms

Litigation (more broadly, dispute resolution) provides one possible solution to the moral hazard problems of bilateral exchange. Specifically, it allows a buyer to sue/initiate a dispute and attempt to collect monetary damages from a seller that fails to deliver a high-quality good. For instance, there are two different types of malpractice legal systems in use today (Brown 1973; Green 1976). Under the *strict liability* system the seller is strictly liable for low-quality outcomes, irrespective of his level of effort. In contrast, under the *negligence* system the state sets a "duty of care," *i.e.*, a minimum effort level required by sellers of a given good or service. In case of a lawsuit, the court finds for the buyer if it asserts that the seller's effort level was below the legislated minimum. Our setting is similar to a strict liability system, but our results would also qualitatively apply to other types of legal regimes, such as a negligence-based malpractice system.

Our litigation model is a one-sided private information model synthesizing aspects of the models proposed by Bebchuk (1984), Nalebuff (1987), Reinganum and Wilde (1986) and P'ng (1983). Specifically, we assume that transaction outcomes are observable by the buyer but not easily verifiable in court and thus court decisions are subject to noise: the court will find for the buyer with probability a if the quality of the good received is high, and with probability b if the quality of the good is low (with $1 \geq b > a \geq 0$). If the court finds for the buyer, the seller must pay the buyer damages D. Whatever the decision of the court, each party incurs litigation costs $L \geq 0$ such as legal fees, trial fees, and the opportunity cost of time spent by each party on the case.

It is easy to see that the above model also captures the essential elements of many online dispute resolution mechanisms, such as credit card dispute resolution, Paypal buyer protection and escrow services. Such services give buyers the right to dispute a transaction and initiate a process as a result of which buyers may obtain "damages" that typically consist of partial or full refund of their payment for a product or service (and in some cases additional compensation in the form of vouchers and store credits). The discovery process of dispute resolution is costly for both the buyer and the seller since it requires both of them to fill out forms, provide documentation, etc. Such mechanisms can, therefore, be thought of as a special case of our litigation model.

Buyers will sue if and only if the expected payment for damages (aD for a high-quality good and $bD > aD$ for a low-quality good) is higher than the litigation costs L. There are three cases:

1. If $L > bD$, it is never optimal for buyers to sue, even if a low-quality good has been received. In this case, the seller cannot be induced to exert positive effort, as he receives no benefit offsetting the cost of effort.

2. If $aD \leq L \leq bD$, the buyer will sue if and only if a low-quality good is received. The result is a special case of the general sanctioning mechanism we introduced above, with $Q_+ = 0$, $Q_- = L + bD$, $R_+ = 0$ and $R_- = -L + bD$. The seller will exert the effort level x_l that minimizes the expected total cost of the transaction, including litigation costs and damages:

$$x_l = \arg\min_{x\in[0,1]} c(x) + (1-x)(L+bD) \tag{1}$$

Solving for the first-order conditions we get:

$$c'(x_l) = L + bD \tag{2}$$

The constraints on $c(\cdot)$ ensure that $0 \leq x_l < 1$ and that the second-order conditions are met.

3. If $L < aD$, then the buyer will always sue, even when a high-quality good was received. The result is a sanctioning mechanism with $Q_+ = L + aD$, $Q_- = L + bD$, $R_+ = -L + aD$ and $R_- = -L + bD$. The seller will exert the effort level y_l that minimizes the expected total cost of the transaction (including litigation costs and damages):

$$y_l = \arg\min_{y\in[0,1]} c(y) + L + (ya + (1-y)b)D$$

Solving for the first-order conditions we get:

$$c'(y_l) = (b-a)D \tag{3}$$

As before, the constraints on $c(\cdot)$ ensure that $0 \leq y_l < 1$ and that the second-order conditions are satisfied. By comparing (2) and (3) it is easy to see that $y_l < x_l$: since the seller expects to be sued irrespective of the outcome of the transaction, he has lower incentives to avoid low-quality outcomes and will exert lower effort than in Case 2.

Since Case 1 results in no seller effort and Case 3 results in higher litigation costs, lower seller effort and lower social surplus than Case 2, in most real-life settings such mechanisms will not be socially acceptable. In the rest of the paper we assume that courts are sufficiently capable to recognize high-quality outcomes to satisfy $aD \leq L$, and that damages are sufficiently high to satisfy $L \leq bD$. Under these conditions buyers will sue the seller if and only if they receive a low-quality good.

The following proposition shows that in this case the unique subgame perfect equilibrium that is induced by a litigation mechanism supports profitable entry by the seller provided that the product valuation is high enough relative to litigation costs:

Proposition 1: *(Litigation payoffs and minimum valuation requirement) If $aD \leq L \leq bD$, then a litigation mechanism with parameters L, a, b, D induces a unique subgame perfect equilibrium where it is profitable for the seller to enter the market if and only if buyer valuations are high enough* *relative to litigation costs and damages. Specifically, it must be*

$$w \geq \frac{c(x_l) + (1 - x_l)2L}{x_l}$$

where the seller's effort x_l *is the unique solution of* $c'(x_l) = L + bD$, $0 \leq x_l < 1$ *and his expected discounted profit is*

$$V_l = \frac{(x_l w - c(x_l) - (1 - x_l)2L)^2}{4x_l w(1 - \delta)} \tag{4}$$

Proposition 1 implies that litigation fails to sustain the market if buyer valuations are too low relative to the cost of effort and legal costs. The requirement that buyer valuations should exceed the seller's cost of effort is obvious. On top of that, the litigation mechanism implies that with probability $(1 - x_l)$ the seller will be sued, in which case both trading partners will spend non-refundable legal costs L each. These costs increase the seller's direct transaction cost by $(1 - x_l)L$ and reduce the buyers' willingess to pay by another factor $(1 - x_l)L$, ultimately resulting in a transaction cost $(1 - x_l)2L$ on top of the seller's cost of effort.[6]

Even when litigation can sustain the market, the resulting outcomes are less efficient than the theoretical first-best outcome obtained if the seller could credibly and costlessly commit to any desired level of effort. This is primarily due to the expected per-transaction litigation cost of $(1 - x_l)2L$, but also from the fact that, in general, the seller effort x_l induced by litigation will differ from the first-best effort level x_{fb} that maximizes $V_{fb} = (x_{fb}w - c(x_{fb}))^2 / 4x_{fb}w(1 - \delta)$. If damages are too low litigation will induce *under-effort* whereas if damages are too high it will induce *over-effort*. These types of inefficiency can be minimized by properly choosing the level of damages D. Specifically, given the level of litigation costs L and the parameters a and b that determine the accuracy of court decisions, by adjusting damages D the mechanism designer can change the level of buyer valuations w required to sustain the market, as well as the resulting seller profit and total surplus. The following proposition characterizes the level of damages that maximizes seller (and, according to the discussion of Section 2.1, social) payoffs.

Proposition 2: *(Optimum level of damages) If the level of legal costs* L *is given and the social planner has full freedom to set damages* D *at any level that satisfies* $aD \leq L \leq bD$, *then if* w *is sufficiently high then the maximum seller payoff that can be induced through the litigation mechanism is obtained when damages are set to* $D = \min\left(D^*, \frac{L}{a}\right)$ *where*

$$D^* = \frac{1}{2b}\left(w + \frac{c(x_l^*) + 2L}{x_l^*}\right)$$

and x_l^* *solves* $c'(x_l^*) = L + bD^*$ *and satisfies the second-order condition* $4c''(x_l^*)(x_l^*)^2 + c(x_l^*) + (1 - x_l^*)2L - x_l^* w > 0$.

By taking the limit as $L \to 0$ and $a \to 0$ we can derive the following corollary:

Corollary 1: *(Optimum level of damages) In the limit as* $L \to 0$ *and* and $a \to 0$, *the litigation*

[6] Damages are not included in this argument because they represent a transfer between the seller and the buyer and are, thus, factored into the prices that buyers are willing to pay.

mechanism can attain first-best efficiency by setting damages to $D_{fb} = (w + c(x_{fb})/x_{fb})/2b$*, where* $c'(x_{fb}) = bD_{fb}$.

In practice damage awards are often the result of complex social and political processes and, thus, not always set at their optimal levels. In the rest of our analysis we, therefore, consider the performance of litigation mechanisms both when damages are optimally calibrated as well as when they are not.

2.3 Reputation mechanisms

An alternative approach for inducing positive seller effort is the use of a reputation mechanism. A reputation mechanism aggregates information related to the outcomes of a seller's past transactions and makes some aspects of this information publicly available to prospective buyers. The advent of the Internet has dramatically decreased the cost and increased the effectiveness of reputation mechanisms (Dellarocas 2003).

There is a wide variety of possible reputation mechanisms. Some mechanisms publish the entire history of past outcomes, while others publish a truncated history (for example, the N most recent transaction outcomes) or a relevant statistic (for example, the number of positive outcomes over the last N transactions). In all cases, however, reputation mechanisms are characterized by a public *reputation profile* h that is a function of the seller's history of past outcomes, and a pair of *reputation profile transition functions* $h_+(h)$, $h_-(h)$ that determine how the mechanism updates the seller's reputation profile following a high-quality and a low-quality outcome respectively.[7]

The solution concept that we use in our analysis of reputation mechanisms is the *perfect public equilibrium* (PPE) (Fudenberg and Levine 1994). A strategy for a long-run player is public if at each period it depends only on the publicly known information and not on any private information of that player. A PPE is a profile of public strategies such that, at every period and for every public history, these strategies are a Nash equilibrium from that date on.

The introduction of a reputation mechanism forces sellers to take into consideration the impact of their current actions on future payoffs. Assuming that the seller's current reputation profile is h, at any PPE where buyers condition their beliefs regarding the seller's actions on his reputation profile, the seller's value function can be written as:

$$\begin{aligned} V_r(h) = {} & d(p(x_r(h)), x_r(h))[p(x_r(h)) - c(x_r(h)) + \delta(x_r(h)V_r(h_+(h)) + (1 - x_r(h))V_r(h_-(h)))] \\ & + (1 - d(p(x_r(h)), x_r(h)))\delta V_r(h) \end{aligned} \tag{5}$$

where $d(p(x_r(h)), x_r(h))$ is the probability of a sale in the current period if the seller charges price

[7] In many real-life settings transactions are privately monitored and thus the possibility of untruthful reports (or no reports) may be a concern, requiring special mechanisms to make truthful reporting incentive-compatible (see, for example, Miller, Resnick and Zeckhauser 2005; Friedman et al. 2007; Jurca and Faltings 2007). Although important, addressing such implementation-level considerations is orthogonal to the goal of our paper, which is to derive (tight) upper bounds on the efficiency obtainable through the use of reputation mechanisms. We, therefore, assume that truthful reporting is incentive-compatible (*e.g.*, through the use of a budget-balancing mechanism that is orthogonal to the reputation mechanism), or, equivalently, that transaction outcomes are publicly monitored.

$p(x_r(h))$ and buyers (correctly) believe that he will exert effort $x_r(h)$. Intuitively, reputation induces positive seller effort if the present value of future payoffs that is associated with the profile state $h_+(h)$ that follows a high-quality outcome is sufficiently higher than the present value of future payoffs that is associated with the profile state $h_-(h)$ that follows a low-quality outcome; the seller will then find it profitable to exert effort and thus increase the probability of a high-quality outcome. Note that the above reputation mechanism is a special case of the general sanctioning mechanism formulation that we introduced in Section 2.1, with $Q_+ = -\delta V(h_+(h))$, $Q_- = -\delta V(h_-(h))$ and $R_+ = R_- = 0$. This (see Section 2.1) implies that seller and buyer payoffs are proportional to each other, enabling us to focus the subsequent analysis on seller payoffs only.

At equilibrium, the seller chooses effort $x_r(h)$ that minimizes the expected total cost of the transaction, inclusive of expected future gains or losses due to reputation:

$$x_r(h) = \arg\min_{x \in [0,1]} c(x) - x\delta V_r(h_+(h)) - (1-x)\delta V_r(h_-(h))$$

Solving the first-order conditions we obtain:

$$c'(x_r(h)) = \delta(V_r(h_+(h)) - V_r(h_-(h))) \tag{6}$$

If $V_r(h_+(h)) > V_r(h_-(h))$, our assumptions on $c(\cdot)$ ensure that the second-order conditions are always satisfied. Reputation then provides performance incentives proportional to the difference between the present value of a reputation profile improvement and the opportunity cost of a reputation profile deterioration that respectively result from a high and a low-quality outcome.

The equilibria induced by any specific reputation mechanism may depend in complicated ways on the actual reputation profile and profile transition functions implemented by that mechanism. To characterize the outcomes that are achievable via reputation mechanisms in our setting, we introduce a stylized reputation mechanism that we call a *sticky binary reputation mechanism* (SBRM) and use it to derive (tight) upper bounds on the PPE payoffs that can be induced by *any* reputation mechanism; we then compare these bounds against the corresponding payoffs that can be induced through litigation.

A *sticky binary reputation mechanism* (SBRM), is characterized by a binary reputation profile that each period can be either "positive" or "negative" and profile transition functions with the following properties:

- if the seller's current profile is "positive", it will stay "positive" after a high-quality transaction outcome, and will become "negative" after a low-quality transaction outcome.
- if the seller's current profile is "negative", it is "sticky" because after a high-quality transaction outcome it will become "positive" with transition probability τ and stay negative with probability $1-\tau$, where $0 \leq \tau < 1$; a "negative" profile will stay "negative" after a low-quality transaction outcome.

The SBRM can be thought of as a simplified abstraction of certain real-life reputation mechanisms.

For example, eBay's feedback mechanism prominently displays the number of negative ratings that a trader has received during the past 12 months. Given the evidence that buyers are sensitive to the presence of even one negative rating on the seller's profile (Cabral and Hortacsu 2010), eBay's mechanism is "sticky" in the sense that a negative rating persists for 12 months even if, during those months, the seller receives nothing but positive ratings.

Denote by x_r^+, x_r^- the seller effort induced by the SBRM in the "positive" and "negative" profile states respectively, and let V_r^+, V_r^- be the associated discounted payoffs. The SBRM can induce positive seller effort in both profile states, but seller effort and payoffs are both higher when the seller's profile is in the "positive" state, i.e., $V_r^+ > V_r^- \geq 0$ and $x_r^+ > x_r^- \geq 0$. Intuitively, the SBRM (like all reputation mechanisms) induces positive effort by threatening to shift the seller to a lower-effort, lower-payoff state upon occurrence of low-quality outcomes.[8] Since any PPE induced by the SBRM has $V_r^+ \geq V_r^-$ (equality holds if and only if $V_r^+ = V_r^- = 0$), we can write $V_r^- = (1-\pi)V_r^+$ for some $0 \leq \pi \leq 1$. The parameter π expresses the fraction by which the payoffs of the "negative" profile state are lower than the payoffs of the "positive" state, and is important in characterizing the outcomes resulting from employing a given reputation mechanism. We refer to π as the *punishment severity* of the SBRM. In the appendix we show that, by appropriately choosing τ, the SBRM can induce any punishment severity $0 \leq \pi \leq 1$.

Proposition 3: *(Reputation payoffs and minimum valuation requirement) The maximum PPE seller payoff that can be induced by any reputation mechanism is less than or equal to the maximum payoff that can be induced by some SBRM with* $0 \leq \pi \leq 1$. *The latter is equal to:*

$$V_r = \frac{(x_r w - c(x_r) - (1-x_r)c'(x_r))^2}{4x_r w(1-\delta)} \tag{7}$$

where positive state seller effort x_r *solves* $c'(x_r) = \delta\pi V_r$. *Profitable seller entry additionally requires:*

$$w \geq \frac{c(x_r) + (1-x_r)c'(x_r)}{x_r}$$

Proposition 3 provides us with the power to make general statements regarding the maximum efficiency that can be induced through the use of reputation mechanisms by focusing our attention on the analytically tractable SBRM. For instance, it can be used to characterize the range of results that can be induced through the use of such mechanisms under the assumption that the social planner has the ability to set the mechanism's punishment severity π at any level $0 \leq \pi \leq 1$. This has several interesting implications:

First, reputation mechanisms can only induce positive seller effort if the buyers' valuation w is sufficiently high so that the transaction profit margin $x_r w - c(x_r)$ is high enough to make V_r (and

[8] Once in the "negative" profile state, the seller knows that even if the current transaction results in a high-quality outcome, he might not revert back to the "positive" state. Thus the difference in his expected payoffs between a high-quality and a low-quality outcome is lower (by a factor τ) than the corresponding difference in the "positive" profile state, reducing his incentives to exert effort. Such seller behavior is consistent with empirical evidence. For instance, Cabral and Hortacsu (2010) found that once an eBay seller receives a negative rating, the rate of arrival of subsequent negative ratings *increases*, which suggests a reduction in seller effort.

thus the marginal difference in the seller's future profits $\delta\pi V_r$ that arises from exerting higher effort) high enough to compensate the seller for the marginal cost of higher effort $c'(x_r)$.[9]

Second, the seller's discount factor δ plays an important role in both the feasibility and efficiency of reputation mechanisms. This can be seen by observing that the seller effort $c'(x_r) = \delta\pi V_r$ that is induced by reputation is both directly proportional to δ as well as indirectly proportional since, by (7), given effort x_r, V_r is an increasing function of δ Intuitively, since reputation induces effort based on the "shadow of the future," the discount factor must be high enough for the seller to care about the future. In real settings, this means that sellers must transact frequently enough with a population of buyers *who are informed about the seller's past behavior*, and that reputation information should be disseminated rapidly and widely so that a sufficiently large fraction of prospective buyers condition their beliefs on the seller's most current reputation profile. The emergence of online reputation mechanisms is instrumental in achieving these requirements and an important reason why the ancient concept of reputation has acquired a new significance in the Internet age.

Third, the negative term $-(1-x_r)c'(x_r)$ in the numerator of V_r shows that the maximum seller payoff that can be induced by reputation mechanisms is always lower than the first-best payoff that sellers could obtain if they could credibly commit to any specified level of effort. This is because reputation induces positive seller effort by threatening to shift sellers to states of lower profitability whenever negative outcomes occur. In such low-reputation (punishment) states, buyers expect sellers to exert lower effort, which is, in turn, optimal for sellers given the buyers' beliefs. Since at the optimal level of seller effort x_r low-quality transaction outcomes will occur with positive probability $1 - x_r$, over the course of the game such states will be reached with virtual certainty, reducing the seller's expected lifetime payoff. Since buyer surplus is proportional to seller payoffs, states of lower seller profitability also result in lower buyer surplus and thus in lower total surplus.

3 Comparison of Reputation and Litigation

In this section we use the models developed in the previous section to compare the efficiency of reputation and litigation. Specifically, we explore the conditions under which (a) reputation mechanisms can induce higher efficiency than litigation, (b) reputation mechanisms can sustain markets that cannot be sustained in litigation-based settings; and (c) the combination of reputation and litigation attains more efficient outcomes than the use of either of these mechanisms alone. As explained in the Introduction, these are questions of immediate practical interest to market designers, operators and participants.

3.1 Can reputation mechanisms induce higher efficiency than litigation?

If it is possible to construct reputation mechanisms that induce higher seller payoffs (and, as discussed in Section 2.1, higher consumer surplus and social efficiency) than the most efficient feasible litigation

[9] The underlying argument that reputation requires a minimum expected per-transaction seller profit margin in the future to induce positive effort in the present, was first articulated by Klein and Leffler (1982).

mechanism, in settings where the necessary conditions are satisfied, one should expect the emergence of economically attractive online reputation-based markets that will partly or fully substitute more traditional litigation-based markets. The following proposition limits this possibility to situations involving levels of effort that cannot be induced by litigation alone:

Proposition 4: *If a given level of seller effort can be induced by both reputation and litigation, litigation always results in higher seller profit and total surplus for that level of effort.*

The above result is based on the following reasoning: According to Proposition 3, a reputation mechanism that induces effort x from sellers with a positive reputation state, results in maximum seller payoff:

$$V_r(x) = \frac{(xw - c(x) - (1-x)c'(x))^2}{4xw(1-\delta)} \tag{8}$$

According to Proposition 1, a litigation mechanism that induces the same effort x, where $c'(x) = L + bD$ and $aD \leq L \leq bD$, results in seller payoff:

$$V_l(x) = \frac{(xw - c(x) - (1-x)2L)^2}{4xw(1-\delta)} = \frac{(xw - c(x) - (1-x)(c'(x) + L - bD))^2}{4xw(1-\delta)} \tag{9}$$

The assumption $L \leq bD$ implies that $c'(x) \geq c'(x) + L - bD$. Comparing (8) and (9) it follows that $V_l(x) \geq V_r(x)$, with the inequality strict if $L < bD$. For similar reasons, if a seller finds it profitable to enter the market under reputation, i.e. if $xw - c(x) - (1-x)c'(x) > 0$, he will always find it profitable to do so under litigation.

The intuition driving this result can be traced to the sources of inefficiency in each of the two mechanisms. The efficiency loss from litigation is related to the size of litigation costs L that are incurred by each party in the case of a dispute. As seller effort x solves $c'(x) = L + bD$, only part of this effort is induced by the threat of litigation costs. The other part is induced by the threat of damages, and since D is a net transfer from the seller to the buyer, it does not reduce total surplus. Thus by increasing D one can induce higher seller effort without increasing the efficiency loss of the litigation mechanism. In contrast, the efficiency loss from the reputation mechanism is caused by the positive probability of welfare-reducing punishment states. Since the entire performance incentives induced by reputation mechanisms are derived from the present value of this efficiency loss, the only way to increase performance incentives is by increasing this efficiency loss.

Proposition 4 implies that reputation can only be superior to litigation as a mechanism for inducing effort in settings where (a) it induces positive state effort levels that cannot be induced by litigation and (b) these effort levels result in higher efficiency than the best efficiency attainable through litigation. By adjusting the level of damages within the range $aD \leq L \leq bD$ a litigation mechanism can induce seller effort in the range $[\underline{x_l}, \overline{x_l}] \cap \{x | w \geq \frac{c(x)+(1-x)2L}{x}\}$ where:

$$c'(\underline{x_l}) = 2L; \qquad c'(\overline{x_l}) = \left(1 + \frac{b}{a}\right) L$$

There are two cases when the range of efforts that can be induced by litigation will likely fail to achieve efficiency:

- The legal costs L are too high relative to the value of the product. Then the entire range of effort induced by litigation (bounded below by $c'(\underline{x_l}) = 2L$) will be excessive, leading to economic inefficiency.

- The court's decision accuracy ratio b/a is too low. The feasible level of damages may be limited in settings where the court cannot reliably verify the outcome of a transaction (*i.e.*, a is high and/or b is low) as, for instance, setting damages above L/a would encourage frivolous litigation. Then the maximum effort that can induced by litigation may be too low.

The following proposition formalizes these intuitions:

Proposition 5: *There is a threshold $L_0 > 0$ for litigation costs that is a function of the level of buyer valuations w, the accuracy of court decisions a and b, and the cost of effort $c(x)$, such that the maximum seller payoffs that can be induced by a reputation mechanism are higher than the maximum payoffs that can be induced by a litigation mechanism if and only if $L > L_0$. This threshold satisfies $\partial L_0/\partial a \leq 0$, i.e., it is lower as the court's accuracy increases.*

While the specific values of this threshold depend on the form of the cost function, it is easy to find examples where reputation can be more efficient than litigation.[10] On the other hand, as mentioned earlier, litigation-like online sanctioning mechanisms effectively reduce the level of legal costs and can, thus, greatly expand the markets where litigation (broadly defined) outperforms reputation.

3.2 When can reputation mechanisms sustain the creation of new markets?

Both litigation and reputation fail to sustain positive seller effort and profitable market entry in settings where the buyers' valuation w is small compared to the level of legal costs L (in the case of litigation) or to the seller's discount factor δ (in the case of reputation). In the case of litigation Proposition 1 determines a lower bound $\underline{w_l}(L)$ below which it is impossible to sustain a market through the legal system. Proposition 3 determines a similar lower bound $\underline{w_r}(\delta)$ for reputation mechanisms. If $\underline{w_l}(L) > \underline{w_r}(\delta)$ then in markets where buyer valuations $w \in (\underline{w_r}(\delta), \underline{w_l}(L))$ it is possible to design reputation mechanisms that sustain positive effort and profitable seller entry whereas it is impossible to do so through litigation. The following proposition shows that if legal costs exceed a certain threshold then the range of buyer valuations for which reputation can sustain positive effort is always broader than the corresponding range of valuations in litigation-based settings.

Proposition 6: *For every $0 < \delta \leq 1$ there is a threshold $L_1(\delta)$, such that $\underline{w_l}(L) > \underline{w_r}(\delta)$ for all $L > L_1(\delta)$.*

Proposition 6 implies that when legal costs are high relative to product valuation and sellers have a high discount factor, online reputation mechanisms may enable new markets that were not

[10] For instance, when the cost of effort is given by $c(x) = x^2/(1-x)$, it can be shown that reputation mechanisms become capable of inducing higher economic efficiency than litigation if (and only if) legal costs are higher than about $25\% - 30\%$ of the highest buyer's valuation of the good. Given the magnitude of typical legal costs, such a threshold is likely exceeded for a significant number of markets.

possible in litigation-based settings. The most direct way to achieve high values of δ is to increase the frequency of interaction between the seller and buyers, which implies that reputation mechanisms become more attractive compared to dispute resolution in larger markets with relatively frequent transactions. An important alternative is to increase transaction frequency by aggregating reputations across individual marketsor by ensuring that more of the buyers interacting with the seller are informed about the seller's reputation. All these options suggest ways in which the Internet can expand the range of markets where reputation mechanisms can add value.

3.3 Litigation and reputation as complements

The emergence of online user-generated content such as review websites, blogs and online forums means that many markets originally designed assuming a purely litigation-based environment are now operating in settings that effectively combine litigation and reputation as complements. In such settings a bad transaction outcome not only might trigger costly litigation, but also might result in negative feedback accessible to future prospective customers. This section examines some of the implications of this new situation for seller effort and economic efficiency.

We develop the core intuitions by studying a litigation mechanism of the type analyzed in Section 2.2 that has been augmented by a simplified reputation mechanism equivalent to the SBRM analyzed in Section 2.3 with the following properties: (a) there are two states (positive, negative) (b) the seller starts in the positive state, (c) upon receipt of negative feedback, the mechanism switches to the negative state with probability π, and (d) once in the negative state, the mechanism stays there forever. The seller's value function in the two states is given by:

$$\begin{aligned} V_{lr}^{+} &= d(p_{lr}^{+}, x_{lr}^{+})[p_{lr}^{+} - c(x_{lr}^{+}) - (1 - x_{lr}^{+})(L + bD) + \delta((1 - \pi(1 - x_{lr}^{+}))V_{lr}^{+} + \pi(1 - x_{lr}^{+})V_{lr}^{-})] \\ &\quad + (1 - d(p_{lr}^{+}, x_{lr}^{+}))\delta V_{lr}^{+} \\ V_{lr}^{-} &= d(p_{lr}^{-}, x_{lr}^{-})[p_{lr}^{-} - c(x_{lr}^{-}) - (1 - x_{lr}^{-})(L + bD) + \delta V_{lr}^{-}] + (1 - d(p_{lr}^{-}, x_{lr}^{-}))\delta V_{lr}^{-} \end{aligned}$$

where $d(p_{lr}^{i}, x_{lr}^{i})$ is the demand function as a function of price p_{lr}^{i} and effort x_{lr}^{i}, $i \in \{+, -\}$. As before, the seller chooses effort levels x_{lr}^{+}, x_{lr}^{-} that minimize the expected total cost of fulfilling the transaction, inclusive of legal costs, damages, and future gains or losses due to reputation:

$$\begin{aligned} x_{lr}^{+} &= \arg\min_{x \in [0,1]} c(x) + (1 - x)(L + bD) + \delta((1 - \pi(1 - x_{lr}^{+}))V_{lr}^{+} + \pi(1 - x_{lr}^{+})V_{lr}^{-}) \\ x_{lr}^{-} &= \arg\min_{x \in [0,1]} c(x) + (1 - x)(L + bD) + \delta V_{lr}^{-} \end{aligned}$$

From the first-order conditions we obtain:

$$\begin{aligned} c'(x_{lr}^{+}) &= (L + bD) + \delta\pi(V_{lr}^{+} - V_{lr}^{-}) \\ c'(x_{lr}^{-}) &= (L + bD) \end{aligned} \tag{10}$$

We observe that x_{lr}^{-} and V_{lr}^{-} are identical to their counterparts in a litigation-only setting, whereas $x_{lr}^{+} > x_{lr}^{-}$ if and only if $V_{lr}^{+} > V_{lr}^{-}$. Intuition suggests that the latter condition occurs if and only if exerting higher effort than x_{lr}^{-} results in higher per-transaction seller profits or, equivalently, if the effort x^-_{lr} that is induced by litigation alone is below the optimal levels. In contrast, if litigation induces over-effort then increasing effort above x^-_{lr} will reduce per-transaction profits and thus V^+_{lr}. From equation (10) the only equilibrium will then be one where $x^+_{lr} = x^-_{lr}$ and $V^+_{lr} = V^-_{lr}$, i.e. an equilibrium where the reputation mechanism is effectively ignored and where effort levels and payoffs are identical to those induced by litigation alone. The following Proposition formalizes this intuition and shows that it applies to any reputation mechanism.

Proposition 7: *Consider a legal mechanism with parameters L, a, b, D where $aD \leq L \leq bD$. Let D^* denote the level of damages that maximizes the seller payoff that can be induced through the legal system. The following statements are true:*

1. *If the level of damages is sufficiently below D^* then it is possible to increase seller effort in the positive reputation state and economic efficiency by complementing the legal mechanism with a reputation mechanism.*

2. *If the level of damages satisfies $D \geq D^*$ then complementing the legal mechanism with a reputation mechanism does not change the maximum attainable economic efficiency.*

3. *Any seller effort that can be induced by the combination of reputation and litigation can be induced more efficiently by litigation alone.*

The intuition behind the first two parts of Proposition 7 is the following: If damages are sufficiently low so that the effort induced by the legal system is below economically optimal levels, introducing the reputation mechanism allows the seller to credibly exert additional effort in the positive reputation mechanism state, to avoid the lower value associated with transitioning to the negative reputation state. On the other hand, if damages (and, thus, seller effort induced by the legal system) are at or above the optimal level where the seller's marginal cost of exerting additional effort equals the corresponding marginal benefit, the seller will not find it optimal to exert further effort and rational buyers will not expect him to do so either. The addition of the reputation mechanism will then have no impact on maximum efficiency.[11]

The intuition behind the last part of Proposition 7 is that any effort level $x \geq \underline{x_l}$ ($c'(\underline{x_l}) = 2L$) that can be induced through the combination of reputation and litigation can also be induced through litigation alone by appropriately increasing the level of damages. For reasons similar to those driving Proposition 4, it is always more efficient to induce effort using litigation alone than using a combination of reputation and litigation.

In summary, when damage awards are at or near optimal levels, complementing litigation with a reputation mechanism does not improve efficiency. Complementing the legal mechanism with a reputation mechanism in situations where damages are below efficient levels can increase efficiency. This result is consistent with the viewpoint that private order is particularly beneficial in settings where public order is dysfunctional (McMillan and Woodruff 2000).

[11]It is important to note that augmentation of the legal mechanism by a reputation mechanism might introduce additional equilibria. What Proposition 7 shows is that, if damages are set sufficiently high, none of these equilibria results in higher economic efficiency than an equilibrium where buyers and sellers ignore the information provided by reputation mechanism and rely exclusively on the legal system for performance incentives.

4 Introducing Adverse Selection

The previous analysis focused on pure moral hazard settings. In this section we explore the impact of adverse selection on the relative power and efficiency of reputation and litigation, and on the ability of reputation to augment litigation.

4.1 Seller types

We extend the setting of Section 2.1 by allowing sellers to have a type $\theta \in [0,1]$ that affects their cost of effort. As in our previous setting, the cost of effort for a seller of type θ is characterized by a continuous twice differentiable cost function $c_\theta(x)$ that satisfies $c_\theta(0) = 0$, $c'_\theta(x) > 0$ and $c''_\theta(x) > 0$ for all $x > 0$ as well as $\lim_{x \to \theta} c_\theta(x) = \infty$. We further assume that for all $\theta_1, \theta_2 \in [0,1]$ if $\theta_2 > \theta_1$, $x > 0$ and $c_{\theta_1}(x)$, $c_{\theta_2}(x)$ are defined, then $c_{\theta_1}(x) > c_{\theta_2}(x)$, $c'_{\theta_1}(x) > c'_{\theta_2}(x)$ and $c''_{\theta_1}(x) > c''_{\theta_2}(x)$. In words, for all positive effort levels, seller of a higher type have lower cost of effort as well as lower first and second cost function derivatives. In this section we consider a setting with two types of seller θ_1 and θ_2 with $\theta_2 > \theta_1$; we refer to θ_1 as the low-effort or low-type seller and θ_2 as the high-effort or high-type seller. We denote by λ the probability that the seller is of low type θ_1; consequently the probability that the seller is of high type θ_2 is $1 - \lambda$.

In the subsequent analysis we compare the relative impact of litigation and reputation on the effort and profits of a high-type seller. We focus on high-type sellers because this is the type of seller that markets are interestied in attracting. Furthermore, we focus our attention to pooling equilibria where both types of seller charge the same price. That price maximizes the high-type seller's profits (Milgrom and Roberts 1986). The alternative situation when both types of seller enter the market, i.e., a separating equilibrium, requires sellers to effectively reveal their type by charging different prices; thus adverse selection disappears and the setting reverts to the pure moral hazard case previously analyzed.

Similar to our earlier setting, in the absence of a reputation or a litigation mechanism the only equilibrium is for both seller types to exert no effort, leading to a market breakdown.

4.2 Litigation mechanisms

Consider a litigation mechanism identical to the one introduced in Section 2.2. As in the pure moral hazard setting, if $L \geq bD$ the buyer will never find it profitable to sue and the threat of litigation will have no impact on the behavior of the sellers. If $aD < L < bD$, buyers will sue if and only if a low-quality good is received. In that case, sellers face the same incentive calculus as in Section 2.2, and therefore will exert effort $x_{l\theta}$ that satisfies $c'_\theta(x_{l\theta}) = L + bD$. Our assumptions regarding the cost function of different seller types imply $x_{l\theta_1} < x_{l\theta_2}$, i.e., that high-type sellers will always exert greater effort. Lastly, if $L < aD$ buyers will always sue, seller effort $y_{l\theta}$ will satisfy $c'_\theta(y_{l\theta}) = (b-a)D$ and the outcome will be suboptimal as the excessive litigation will both be costly and reduce seller effort ($y_{l\theta} < x_{l\theta}$).

As before, we focus our attention on the case where $aD < L < bD$. We denote the price charged by a seller of type θ in the pure moral hazard setting of Section 2.2 by $p_{l\theta}$ (since $x_{l\theta_1} < x_{l\theta_2}$ it can be easily seen that $p_{l\theta_1} < p_{l\theta_2}$). There are two interesting possibilities:

1. Given buyer valuations and the parameters of the legal mechanism, low-type sellers find market entry unprofitable and only high types stay in the market. This setting reverts to the pure moral hazard setting. Specifically, this happens if $c_{\theta_1}(x_{l\theta_1}) + (1 - x_{l\theta_1})(L + bD) > p_{l\theta_2}$, that is, if the transaction cost for low-type sellers (inclusive of the cost of litigation) exceeds the price charged by the high-type seller in the pure moral hazard setting. When this condition holds, low-type entry is not profitable even if low-type sellers masquerade as high-type sellers.

2. Both seller types enter the market and charge the same price (i.e., we have a pooling equilibrium). The following proposition characterizes the resulting equilibrium:

Proposition 8: *Consider a litigation mechanism where $aD \le L \le bD$. If a pooling equilibrium exists then it is unique and the expected discounted lifetime profit for a seller of high type θ_2 is given by:*

$$V_{l\theta_2} = \frac{[\overline{x}_l w - c_{\theta_2}(x_{l\theta_2}) - (1 - x_{l\theta_2})2L + (x_{l\theta_2} - \overline{x}_l)(-L + bD)]^2}{4\overline{x}_l w(1-\delta)} \tag{11}$$

where $\overline{x}_l = \lambda x_{l\theta_1} + (1-\lambda)x_{l\theta_2}$.

Comparing (4) and (11) we observe that the inefficiency that is associated with legal costs (operationalized by the term $-(1 - x_{l\theta_2})2L$) exists in both pure moral hazard and mixed settings. In settings with adverse selection the buyers' uncertainty about the seller's type affects the high seller's profits in two ways. First, buyers expect lower effort to what the high seller actually exerts (it is $\overline{x}_l < x_{l\theta_2}$). This reduces their willingness to pay and hurts the high seller's profits, relative to settings without adverse selection. Second, buyers expect that they will sue the seller with higher probability than what is warranted by the high seller's actual effort. Since the net payoff of litigation following a bad outcome $(-L + bD)$ is assumed to be positive, this increases their willingness to pay and partly compensates the high seller for the impact of adverse selection. In equation (11) this last effect is captured by the presence of the positive term $(x_{l\theta_2} - \overline{x}_l)(-L + bD)$.

If at the equilibrium both seller types stay in the market, then low-type sellers free ride on the high-type sellers' superior effort but high-type sellers free ride on the low-type sellers' expected liability. The former effect is stronger and thus high-type sellers may desire increasing the level of damages to drive the low-type sellers out of the market; however this may result in setting the level of damages and the corresponding seller incentives too high relative to the social optimum. In the general case with multiple seller types, the parameters of the litigation mechanism may drive out all types below a certain threshold, but in general will leave more than one type in the market.

To summarize, the presence of adverse selection introduces additional considerations to the design of litigation mechanisms but their essence remains identical to the pure moral hazard case.

4.3 Reputation mechanisms

The presence of adverse selection adds an important new dimension to the role and function of reputation mechanisms: buyers now can use the seller's reputation to update their prior beliefs about the seller's type. This process of learning creates additional incentives for performance. Since the history of outcomes affects the seller's reputation and thus the buyers' posterior beliefs and willingness to pay, sellers will exert effort to maximize the probability that the history path leads to more favorable buyer beliefs.

It is important to distinguish between two broad classes of reputation mechanisms:

1. *Unbounded learning mechanisms.* Given a sufficiently long time horizon, these mechanisms allow buyers to learn the true type of a seller with an arbitrary degree of accuracy. If a seller's type remains constant over time and if the reputation mechanism makes the entire history of outcomes publicly available, it is well known that unbounded learning occurs (see, for example, Holmstrom 1999). In such settings *adverse selection is a transient phenomenon.* At the limit buyers' beliefs converge to a seller's true type and the setting reverts to one with pure moral hazard, where the only incentive for performance must come from efficiency-reducing punishment states. The analysis of the preceding sections will therefore characterize settings with adverse selection and unbounded learning once buyers have learned the seller's type.

2. *Bounded learning mechanisms.* In such mechanisms there is always some residual uncertainty about a seller's type. Examples of such mechanisms include settings where seller types can change over time or finite state reputation mechanisms that only make a finite subset of a seller's history are available to buyers (e.g. ratings received during past month or past year).

Since reputation mechanisms with unbounded learning eventually revert to pure moral hazard settings, we focus our attention to adverse selection settings with bounded learning reputation mechanisms. Even though adding adverse selection to our setting introduces significant changes, it is important to note that as shown below a reputation mechanism still induces effort by relying on what, from the perspective of the seller, amounts to profit-reducing punishment states.

As in Section 2.3 we consider a two-state reputation mechanism with the following properties: All sellers start at the positive state and the mechanism only publishes the seller's most recent transaction outcome. This effectively means that, irrespective of the current state, a seller transitions into the negative state following a bad outcome, and into the positive state following a good outcome. The corresponding value functions of a seller of type θ are:

$$\begin{aligned} V_\theta^+ &= d^+[p^+ - c_\theta(x_\theta^+) + \delta(x_\theta^+ V_\theta^+ + (1-x_\theta^+)V_\theta^-)] + (1-d^+)\delta V_\theta^+ \\ V_\theta^- &= d^-[p^- - c_\theta(x_\theta^-) + \delta(x_\theta^- V_\theta^+ + (1-x_\theta^-)V_\theta^-)] + (1-d^-)\delta V_\theta^- \end{aligned} \tag{12}$$

where x_θ^s denotes effort, d^s denotes demand and p^s denotes the common price charged by both sellers at state $s \in \{+,-\}$. This corresponds to a SBRM with transition probability $\tau = 1$.

The following proposition characterizes seller effort in this setting:

Proposition 9:

(a) *Both types of seller will exert the same effort in both reputation states; and*

(b) *The effort induced by the high-type seller monotonically increases as the type of the low-type seller decreases.*

Proposition 9(a) holds because the marginal payoff of effort is the same in both reputation states, thus at equilibrium each seller type will solve $c'_\theta(x_{r\theta}) = \delta(V_\theta^+ - V_\theta^-)$ and will exert the same effort $x_{r\theta} = x_\theta^+ = x_\theta^-$ irrespective of the reputation state. It was shown in Section 2.3 that in settings with pure moral hazard such a mechanism induces zero effort;[12] in order to induce positive effort it was necessary to introduce stickiness in the negative reputation state (i.e., $\tau < 1$). In contrast, when adverse selection is present the above mechanism can induce positive seller effort because buyers' demand and willingness to pay, and, thus, seller value functions, depend both on seller effort and on buyers' posterior beliefs about the seller's type. The latter change depending on the seller's reputation state as buyers expect seller effort $\overline{x}^+ = (1-\rho^+)x_{r\theta_1} + \rho^+ x_{r\theta_2}$ in the positive state and effort $\overline{x}^- = (1-\rho^-)x_{r\theta_1} + \rho^- x_{r\theta_2}$ in the negative state, where ρ^+, ρ^- are the buyers' posterior beliefs that a seller is of high type θ_2 conditional on his most recent transaction outcome being good or bad respectively. Since the probability of a positive outcome is equal to $x_{r\theta}$ for each type θ, application of Bayes rule gives:

$$\varrho^+ = \frac{(1-\lambda)x_{r\theta_2}}{(1-\lambda)x_{r\theta_2} + \lambda x_{r\theta_1}}; \qquad \varrho^- = \frac{(1-\lambda)(1-x_{r\theta_2})}{(1-\lambda)(1-x_{r\theta_2}) + \lambda(1-x_{r\theta_1})}.$$

Since $x_{r\theta_1} < x_{r\theta_2}$ this implies that $\varrho^+ > \varrho^-$, which in turn implies that willingness to pay, demand and, ultimately, the seller's value function are higher in the positive state. For a given θ_2, decreasing θ_1 increases ϱ^+ and decreases ϱ^-, thus increasing $\varrho^+ - \varrho^-$, $V_{\theta_2}^+ - V_{\theta_2}^-$ and ultimately $x_{r\theta_2}$, which proves Proposition 9(b).

A key observation here is that although according to Proposition 9(a) the same seller effort is sustained in both reputation states, this change in buyers' beliefs ends up having consequences for the profits of a high-type seller similar to the punishment state in the pure moral hazard case. While seller effort is not reduced in negative reputation states, buyers' updated beliefs result in lower demand and reduced profits for a seller in that state. Therefore, even in settings with adverse selection, reputation systems must rely on what effectively amounts to profit-reducing punishment states in order to induce the high-type seller to exert effort. Significantly, however, the reduction in seller profits does not in its entirety decrease social surplus, as, unlike the pure moral hazard case, it is partially captured by the buyers, who effectively receive a discount from high-quality sellers given the effort exerted by these sellers, correspondingly increasing buyer surplus. This is possible because sellers are partially compensated for this discount by the expected change in buyers' beliefs about sellers' type; in the pure moral hazard case there is no uncertainty about sellers' type, resulting in pricing consistent with seller effort, no transfer to buyers, and thus seller incentives provided entirely through expected surplus dissipation.

[12] Since the form of V_θ^+ and V_θ^- is identical, in pure moral hazard settings their value depends only on the effort exerted by the seller in each state. If seller effort is identical then it must be $V_\theta^+ = V_\theta^-$, which implies $c'_\theta(x_\theta) = 0$.

According to Proposition 9(b) the more severe the reduction in the expected quality of a high-type seller in the case of a negative outcome, the higher the cost of a low reputation state for that seller and the higher the incentive to avoid it. The maximum incentive will be provided when the low-type seller has type $\theta_1 = 0$, i.e., will never exert any effort and is thus guaranteed to provide a bad outcome. For instance, if fraudulant sellers manage to infiltrate the market, the cost of being in a low reputation state will increase, and thus high-type sellers, assuming they stay in the market, will increase their effort to avoid the low reputation state.

The following result is analogous to Proposition 3 in Section 2.3 for the state where the seller's expected discounted payoff attains the highest value among all states, which we call the mechanism's *highest state*. Typically this is the state where the seller's history profile is "perfect", i.e. consists of only good outcomes.

Proposition 10: *In any finite state reputation mechanism the payoffs of the high seller type θ_2 are bounded above by:*

$$V_r = \frac{\left(\overline{x}_r w - c_{\theta_2}(x_{r\theta_2}) - (1 - x_{r\theta_2})c'_{\theta_2}(x_{r\theta_2})\right)^2}{4\overline{x}_r w(1-\delta)} \tag{13}$$

where $x_{r\theta_2}$ is the high-type seller's effort in the highest state of the reputation mechanism and $\overline{x}_r$ are the corresponding buyer beliefs about seller effort in the same state.

Proposition 10 derives the maximum seller payoff as a function of effort in a setting with adverse selection and a reputation mechanism with a finite number of history profile states. In a well-designed finite state reputation mechanism, the difference between this highest state payoff and the payoff in lesser reputation states is what motivates the seller to exert effort so that the probability of transition to a lower reputation state can be decreased, and the probability of transition to a higher reputation state (or remaining in the highest state) can be increased. This result allows us to compare the ability of reputation and litigation mechanisms to increase the level of effort by high-type sellers.

4.4 Comparing reputation and litigation in the presence of adverse selection

The key result of Section 3.1 carries over to settings with adverse selection but with some important additional nuances. According to Proposition 10, a reputation mechanism that induces effort x at the highest state results in high-type discounted lifetime seller payoffs that are bounded above by:

$$V_r(x) = \frac{\left(\overline{x}_r w - c_{\theta_2}(x) - (1 - x)c'_{\theta_2}(x)\right)^2}{4\overline{x}_r w(1-\delta)} \tag{14}$$

In contrast (Proposition 8), a litigation mechanism that induces the same effort x, where $c'_{\theta_2}(x) = L + bD$ and $aD \leq L \leq bD$, results in seller payoff:

$$\begin{aligned} V_l(x) &= \frac{[\overline{x}_l w - c_{\theta_2}(x) - (1-x)2L + (x - \overline{x}_l)(-L+bD)]^2}{4\overline{x}_l w(1-\delta)} \\ &= \frac{[\overline{x}_l w - c_{\theta_2}(x) - (1-x)c'_{\theta_2}(x) + (1 - \overline{x}_l)(-L+bD)]^2}{4\overline{x}_l w(1-\delta)} \end{aligned} \tag{15}$$

The assumption $L \leq bD$ implies that $-L + bD \geq 0$. Direct comparison of (14) and (15) then shows that if $\overline{x}_l = \overline{x}_r$, it is $V_l(x) \geq V_r(x)$, with the inequality strict if $L < bD$. We have thus proven the following result:

Proposition 11: *If a given level of high-type seller effort can be induced by both the highest state of a finite state reputation mechanism and litigation for identical buyer beliefs about the seller's type, litigation always results in higher seller profit.*

The core intuition behind this result is similar to the equivalent result in the pure moral hazard case (Proposition 4). Part of the effort induced by litigation is due to the threat of damages. Damages are a net transfer from the seller to the buyer that is factored into prices and demand, and thus does not reduce seller profits. In contrast, the entire performance incentives induced by reputation are derived by the positive probability of states where buyers have lower beliefs about the seller. Even when the seller does not reduce his effort in such states, lower buyer beliefs force lower prices and lower demand and result in lower profits.

Despite the similarity between Propositions 4 and 11, some important new characteristics are introduced as a result of adverse selection. First, when both types of seller enter the market, the profits of the high-type seller are lower relative to a case with full information, both in the case of reputation and in the case of litigation. This is because keeping seller effort x constant, both $V_r(x)$ and $V_l(x)$ are increasing functions of $\overline{x}_r$ and $\overline{x}_l$ respectively: the closer buyer beliefs are to the true effort of the high-type seller, the higher their willingness to pay and the higher that seller's profits. Second, while in the case of reputation part of these lost profits are captured by buyers who therefore increase their surplus, the lower expected profits reduce the overall seller effort compared to what would be achieved in a setting where the buyers can observe the actual effort level, resulting in a lower total surplus. Third, reputation mechanisms provide information about the type of the seller that allows buyers to update thier prior beliefs. When this updating of beliefs is important, for instance when the types of sellers are very different as when $\theta_1 \approx 0$ and $\theta_2 \approx 1$, it will be $\overline{x}_r > \overline{x}_l$. The improved accuracy of information provided by reputation mechanisms works in favor of the high seller type and can partly or fully compensate sellers for the reputation mechanism's higher cost of inducing effort.

In practice, direct comparison of reputation and litigation in settings with adverse selection requires taking into consideration all the above effects. An important implication of Proposition 11 is that as a general rule in markets where the primary concern is moral hazard (e.g., because seller types are similar and thus the primary challenge is to induce seller effort), litigation is likely to achieve this with higher profits for high quality sellers, making it more likely they will be attracted to that market. On the other hand when the primary concern is adverse selection (e.g., because seller types are widely different and inducing seller effort does not greatly affect the outcome,[13] a well-designed reputation mechanism may be more successful in attracting high-quality sellers while avoiding low-quality ones, and thus in maximizing social surplus.

[13]For instance, the probability of a good outcome could depend on the seller's already acquired knowledge or ability that are captured by his type, rather than on effort (as long as the effort level is not zero), then $c_\theta(x)$ could be almost flat until x approaches θ and then very rapidly increase to infinity. In that case a seller would always exert effort close to θ, as lower effort would not offer significant savings while higher effort would be infeasible.

4.5 Reputation and litigation as complements in the presence of adverse selection

The presence of adverse selection affects some of our conclusions about the impact of the simultaneous presence of reputation and litigation. As before, we distinguish between bounded and unbounded learning reputation mechanisms.

When unbounded learning reputation mechanisms are combined with litigation, the analysis of Section 3.3 applies at the limit where learning is complete. The advantage of combining the two mechanisms is that it helps eliminate the inefficiencies that are due to incomplete knowledge about seller types while retaining the efficiency advantages of litigation at the pure moral hazard limit.

In constrast, the co-existence of bounded learning reputation and litigation leads to some qualitatively different conclusions relative to the case of pure moral hazard. We illustrate the key intuition by studying a litigation mechanism that has been augmented by the two-state reputation mechanism we studied in Section 4.3. The seller's value function in the two states is given by:

$$\begin{aligned} V_\theta^+ &= d^+[p^+ - c(x_\theta^+) - (1-x_\theta^+)(L+bD) + \delta(x_\theta^+ V_\theta^+ + (1-x_\theta^+)V_\theta^-)] + (1-d^+)\delta V_\theta^+ \\ V_\theta^- &= d^-[p^- - c(x_\theta^-) - (1-x_\theta^-)(L+bD) + \delta(x_\theta^- V_\theta^+ + (1-x_\theta^-)V_\theta^-)] + (1-d^-)\delta V_\theta^- \end{aligned} \tag{16}$$

As before, the marginal payoff of effort is the same in both states, meaning that at equilibrium each seller type will solve $c'_\theta(x_\theta) = (L+bD) + \delta(V_\theta^+ - V_\theta^-)$ and will exert the same effort irrespective of the reputation state. Furthermore, because of the different buyer beliefs in the two states it will always be $V_\theta^+ > V_\theta^-$, which implies that the presence of the reputation system induces additional effort on top of what the litigation system alone can induce. Contrast this with the pure moral hazard case where the addition of a reputation mechanism on top of a litigation mechanism induces additional effort only in settings where the parameters of the litigation mechanism lead to undereffort.

In practice this has two important implications: First, legal systems that were calibrated to induce optimal effort when they act as stand-alone enforcement mechanisms end up inducing over-effort and, thus, becoming suboptimal once reputation mechanisms are added on top of them. It may thus be important to reduce the level of damages so that the level of effort that is induced by the combined system of litigation and reputation reverts back to optimal levels. Second, litigation-type mechanisms that fail to provide adequate incentives, for instance because the need to keep their legal costs low limits their accuracy, which in turn reduces the maximum level of damages that can be imposed,[14] may benefit from the addition of reputation. Similarly, reputation-based markets that desire to induce higher effort levels from their participants may benefit from the addition of litigation-like dispute resolution mechanisms. Consistent with this possibility, over time eBay has increased its reliance on dispute resolution mechanisms such as Paypal buyer protection or online escrow services in addition to reputation.

[14]For instance, buyer protection mechanisms typically limit the damages to the price paid by the buyer, and often require the buyer to bear shipping or restocking fees; this is at least in part due to the difficulty in determining whether a claim is justified, which could allow opportunistic behavior if higher damages were allowed.

5 Discussion, Implications and Further Research

Information technology can have a profound impact on institutions that promote trust and cooperation among economic agents; for instance, it has dramatically reduced the cost of mechanisms for the collection and dissemination of consumer feedback, to which we collectively referred in this paper as "reputation." Meanwhile, technology's impact on mechanisms for dispute resolution, which in this paper we collectively referred to as "litigation," has been more ambiguous: while the Internet is enabling new mechanisms for online arbitration, escrow services and other types of private dispute resolution, it is having less impact on the costs of traditional mechanisms that depend on contract enforcement through the public tort system or through traditional arbitration services.

In this paper we modeled litigation and reputation in a common game-theoretic setting, which allowed us to compare their respective ability to induce efficient economic outcomes, and we derived results for their relative efficiency and effectiveness when used individually or as complements. Litigation uses the threat of monetary damages to induce sellers to exert effort and increase the probability of high-quality transaction outcomes. While damages represent a net transfer among market participants and do not reduce total surplus, the process of litigation involves potentially significant costs for both the buyer and the seller and these costs reduce economic efficiency. Reputation works by making a seller's track record available to future buyers, and is often presumed to involve minimal costs for market participants. In our analysis it was important to distinguish between settings without substantial uncertainty about a seller's type and settings where such uncertainty exists: In the former, the concern of litigation and reputation is to address moral hazard, i.e., to induce effort that is costly to the seller; in the latter, adverse selection plays a key role and introduces the additional concern of dealing with different types of sellers.

Our analysis has significant implications for the design of online markets and in particular for the balance between dispute resolution and reputation mechanisms, especially as technology is allowing different variations and combinations of these types of mechanisms. We show that the popular view of reputation mechanisms as an efficient and relatively costless way to induce seller effort under all circumstances is incorrect, especially in moral hazard settings. Specifically, reputation induces effort by threatening to switch sellers to punishment states following bad outcomes in which they receive lower prices. This causes the seller to exert lower effort, and because punishment states end up hurting everybody, reputation is an inherently inefficient mechanism in addressing moral hazard. In contrast, litigation induces seller effort partially by the threat of (welfare-reducing) legal costs and partially by the threat of (efficiency neutral) damage awards; therefore only part of the performance incentives leads to efficiency losses. Thus, if adverse selection is not an important consideration, an appropriately designed litigation mechanism is always more efficient in inducing a given level of seller effort than either reputation or a combination of litigation and reputation.

While litigation is theoretically more efficient in inducing a *given* level of effort, there are several practical settings where the available litigation mechanisms induce effort that is either too high or too low or make market entry altogether unprofitable. For instance, while resorting to the public court system is always a theoretical choice, practical considerations such as high costs relative to the possible benefit or restrictions such as mandatory arbitration agreements may make this option unattractive. And while the Internet has enabled litigation-type mechanisms for dispute resolution with significantly lower costs, these mechanisms typically offer limited accuracy, which in turn limits the feasible level of damages in order to prevent opportunistic behavior (e.g., damages are often limited to a partial or full refund of the purchase price). Damage awards may also be limited by social or political considerations and thus it may not be possible to set them at or near their optimal level. We have thus identified two situations where reputation can be an attractive substitute or complement of litigation-like dispute resolution mechanisms:

- In markets where high legal costs induce excessive effort, or make market entry altogether unprofitable, firms can realize higher profits by shifting to reputation-based online markets and potentially also requiring consumers to waive litigation rights; such a switch will typically benefit consumers as well by increasing consumer surplus.

- In markets where litigation provides incentives below their optimal level and it is not feasible to reform the underlying legal regime, firms (or consumers) can induce higher performance incentives by supplementing the existing litigation regime with a reputation mechanism. Such a change could be either strategically initiated by market participants, or could be externally imposed by social and technological developments.

In settings with adverse selection, reputation helps market participants learn each other's true types; when differences among types are important, this may partly or fully compensate for the higher cost of inducing effort via reputation. In such settings the above results change in three important ways:

- First, reputation now can sustain high seller effort in states that follow bad outcomes because sellers are incentivized by the desire to avoid unfavorable buyer beliefs about their type. In such states high quality sellers are undercompensated but buyers enjoy higher surplus. From the perspective of high quality sellers, reputation mechanisms are still less desirable than litigation in inducing a given level of effort, but this may no longer be true in terms of maximizing total social welfare.

- Second, reputation helps market participants learn each other's types. This benefits the highest quality market participants who can then command higher prices and demand.

- Third, if there is enough uncertainty about types, the combination of reputation and litigation always induces higher effort than litigation alone. In settings where the levels of damages were calibrated to induce optimal effort under litigation alone this may require reducing the level of damages as otherwise the joint use of both mechanisms induces socially inefficient excessive effort. It is thus important for market designers or social planners to be aware of the planned or unplanned availability of reputation information about market participants.

Our analysis thus suggests that as a general rule in markets where the primary concern is moral hazard (e.g., because seller types are similar and thus the primary challenge is to induce seller effort), litigation is likely to achieve this with higher profits for high quality sellers, making it more likely they will be attracted to that market. On the other hand when the primary concern is adverse selection (e.g., because seller types are widely different and inducing seller effort does not greatly affect the outcome), a well-designed reputation mechanism may be more successful in attracting high-quality sellers while avoiding low-quality ones, and thus in maximizing social surplus.

The role of reputation mechanisms is therefore likely to be particularly important in markets for professional services, such as legal, medical, accounting, or financial advice. In these cases legal costs are likely to be high compared to the consumer valuations of high-quality outcomes, and it may be costly or unreliable for a court or other dispute resolution mechanism to verify the quality of the service provided. Furthermore, the probability of a good outcome could largely depend on the seller's already acquired knowledge or ability that are captured by his type, rather than on effort (as long as the effort level is not zero). All of these factors favor the relative attractiveness of reputation mechanisms, which is especially significant in view of predictions that information technology will increase the role of electronic markets for professional services (see, for example, Malone and Laubacher 1998).

On the other hand, reputation-based markets that desire to induce higher effort levels from their participants may benefit from the addition of litigation-like dispute resolution mechanisms. Consistent with this possibility, over time eBay has increased its reliance on dispute resolution mechanisms such as Paypal buyer protection or online escrow services. Crowdsourcing markets like Amazon's Mechanical Turk that face a combination of moral hazard and adverse selection challenges may find it appropriate to rely on a combination of reputation and litigation-like mechanisms; a single type of mechanism is unlikely to be able to address both the adverse selection and moral hazard issues within the constraints of very low operating costs necessitated by the very low price (frequently under $1) of a typical task in that market.

Since reputation mechanisms greatly depend on their participant's valuation of the future, their power and feasibility are critically affected by the discount factor of market participants. In real settings, this means that sellers must transact frequently enough with the population of buyers, and that reputation information should be disseminated rapidly and widely so that a sufficiently large fraction of prospective buyers condition their beliefs on the seller's most current reputation profile. Alternatively, transaction frequency can be increased by aggregating reputations across different markets (like credit bureaus aggregate information about a consumer's performance in a multitude of settings). All these options suggest ways in which the Internet can expand the range of markets where reputation mechanisms can add value. Online reputation mechanisms are instrumental in achieving these requirements and are an important reason for the increased significance of reputation in the Internet age. On the other hand, online mechanisms for dispute resolution such as Paypal buyer protection effectively reduce the cost of litigation-like mechanisms and thus can expand the markets where litigation (broadly defined) outperforms reputation.

In conclusion, the growing practical applications of online reputation and dispute resolution mechanisms are motivating a lot of research in this area. More study is needed to better understand how various design aspects of online communities and markets relate to the resulting indirect incentives, and how such incentives can be conveniently quantified and compared against those induced by more traditional institutions. Our results show that such work has direct economic implications.

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Proofs[15]

Proof of Proposition 1. The justification for the formula $c'(x_l) = L + bD$ is given in the main body of the text. From the first-order conditions, the price that maximizes seller profits is equal to $p(x_l) = (x_l w + c(x_l))/2 + (1 - x_l)bD$. The seller's expected per-period profits are equal to $v(x_l) = (x_l w - c(x_l) - (1 - x_l)2L)^2/4x_l w$. Since all periods are identical, his expected discounted lifetime payoff is simply $V = v(x_l)/(1 - \delta)$.The seller will only stay in the market if $p \geq \kappa(x_l)$, or, equivalently, if $w \geq [c(x_l) + (1 - x_l)2L]/x_l$.

Proof of Proposition 2. Let $x_l^* = x_l^*(D^*)$ denote the seller effort that maximizes the seller's single-period payoff $v(x_l^*) = (x_l^* w - c(x_l^*) - (1 - x_l^*)2L)^2/4x_l^* w$ and assume that a is small enough so that $D^* \leq L/a$. Solving for D^* by taking first-order conditions we obtain the result $D^* = (w + (c(x_l^*) + 2L)/x_l^*)/2b$. The corresponding second-order condition is obtained by further differentiating with respect to D. For $D < D^*$ it is $\frac{\partial v(x_l^*)}{\partial D} > 0$. Therefore, if $D^* > L/a$ the maximum payoff that satisfies $D \leq L/a$ obtains when $D = L/a$.

Proof of Proposition 3 (Sketch). Lemmas 3.1 and 3.2 below show that if w is sufficiently high so that positive seller effort can be induced by the SBRM, then the equilibria induced by the SBRM are equivalent to those induced by a probabilistic sanctioning mechanism that in the event of a low-quality transaction outcome punishes the seller by banishing him from the market with probability π ($0 \leq \pi \leq 1$). In other words, the SBRM is equivalent to a sanctioning mechanism which, when a low-quality transaction outcome is observed, sets all future seller payoffs to zero with probability π. We refer to this mechanism as a proper π-PSM (PSM=Probabilistic Sanctioning Mechanism). If V_{PSM} denotes the seller's value function in the unsanctioned state of a π-PSM, the present value of a high-quality outcome for the seller is equal to δV_{PSM}, whereas the present value of a low-quality outcome is $\delta((1 - \pi)V_{PSM} + \pi \times 0) = \delta(1 - \pi)V_{PSM}$, and thus:

$$V_{PSM} = d(x_{PSM})[p(x_{PSM}) - c(x_{PSM}) + \delta(x_{PSM}V_{PSM} + (1 - x_{PSM})(1 - \pi)V_{PSM})] + (1 - d)\delta V_{PSM} \tag{17}$$

where demand $d(x) = 1 - p(x)/xw$ and the equilibrium seller effort x_{PSM} solves the FOC:

$$c'(x_{PSM}) = \delta\pi V_{PSM} \tag{18}$$

Lemma 3.1: *For each $\pi \in [0, 1]$, there exists a $\tau \in [0, 1]$ such that the payoffs V_+, V_- induced by a SBRM with transition probability τ satisfy $V_- = (1 - \pi)V_+$.*

[15] The proofs for Propositions 4 and 9 are found in the main body of the article. Due to space limitations the proofs of the remaining Propositions have been shortened and the proofs of certain statements have been omitted. Complete proofs can be found in the working paper version on the authors' websites.

Lemma 3.2: *If w is sufficiently high to induce positive seller effort, then the maximum payoff that can be induced by a SBRM with transition probability $\tau \in [0,1]$ can also be induced by a π-PSM for some punishment probability $\pi \in [0,1]$ and vice-versa.*

The next part of the proof shows that the maximum payoffs that can be induced by any reputation mechanism are less than or equal to the maximum payoffs that can be induced by some π-PSM. Lemma 3.2 then implies that the maximum payoffs that can be induced by any reputation mechanism are less than or equal to the maximum payoffs that can be induced by the SBRM for some $\tau \in [0,1]$.

Consider a reputation mechanism defined by a reputation profile h and profile transition functions $h_-(h), h_+(h)$. Any equilibrium induced by this mechanism is characterized by a seller value function $V_r(h)$ for each reputation profile state h. Let h_0 be the state associated with the highest value function, i.e. $V_r(h_0) = max_h V_r(h)$. The maximum discounted (lifetime) seller payoff that can be induced by the reputation mechanism is less than or equal to $V_r(h_0)$. The proof shows that we can always construct a π-PSM that induces maximum payoffs greater than or equal to $V_r(h_0)$.

The preceding proof shows that the maximum payoff that can be induced by a π-PSM, and thus by any reputation mechanism, is equal to:

$$V_r = \frac{d(x_r)\left(p(x_r) - c(x_r) - (1-x_r)c'(x_r)\right)}{1-\delta}$$

where $c'(x_r) = \delta\pi V_r$, $d(x_r) = 1 - p(x_r)/x_r w$ and $p(x_r)$ is chosen to maximize V_r. From first-order conditions we obtain:

$$p(x_r) = \frac{x_r w + c(x_r) + (1-x_r)c'(x_r)}{2} \text{ and } d(x_r) = \frac{x_r w - c(x_r) - (1-x_r)c'(x_r)}{2x_r w}$$

Substituting we obtain the final expression for V_r:

$$V_r = \frac{\left(x_r w - c(x_r) - (1-x_r)c'(x_r)\right)^2}{4x_r w(1-\delta)}$$

The mechanism will induce profitable seller entry if and only if it induces nonnegative demand and nonnegative per-transaction seller profits $p(x_r) - c(x_r)$. The most restrictive condition is nonnegative demand, which requires that $w \geq [c(x_r) + (1-x_r)c'(x_r)]/x_r$.

Proof of Proposition 5. Let V_l^*, V_r^* denote the maximum payoffs that can be induced by litigation and reputation for given L, a, b, δ by varying D and π respectively. If $L = 0$ and $a = 0$ then, from Corollary 1 it is $V_l^* = V_{fb} > V_r^*$. On the other hand, if L high enough so that $w < (c(x_l) + (1-x_l)2L)/x_l$, $c'(x_l) = L + bD$, then, from Proposition 1, $V_l^* = 0 < V_r^*$. From equation (9) and the envelope theorem it is $\partial V_l^*/\partial L = \partial V_l(x_l^*(L))/\partial L < 0$. Finally, for given L, b, δ, from Proposition 2 it is $\partial V_l^*/\partial a \leq 0$. The combination of the these properties implies the result.

Proof of Proposition 6. Given damages D, litigation induces profitable market entry if and only if $w \geq [c(x_l) + (1 - x_l)2L]/x_l$, where $x_l \in [0, 1]$ solves $c'(x_l) = L + bD$. We define

$$\underline{w}_l(L) = \min_{c'(x_l)=L+bD,\, aD \leq L \leq bD} \frac{c(x_l) + (1 - x_l)2L}{x_l}$$

to be the minimum valuation needed to make market entry profitable under litigation (fixing L, b but varying D). The minimum obtains at the point $x_0 \in [0, 1]$ where the function $f(x) = [c(x) + (1 - x)2L]/x$ is minimized. First-order conditions give $c'(x_0) = (c(x_0) + 2L)/x_0$. Second-order conditions require $c''(x_0)/x_0 > 0$, which is always satisfied. Let D_0 denote the level of damages that induces effort x_0. D_0 solves $c'(x_0) = L + bD_0 = (c(x_0) + 2L)/x_0$. Substituting $c(x_0) = x_0 c'(x_0) - 2L = x_0(L + bD_0) - 2L$ into $[c(x_0) + (1 - x_0)2L]/x_0$ we obtain an expression for the lower bound $\underline{w}_l(L) = -L + bD_0$ and can show that it is $\lim_{L\to\infty} \underline{w}_l(L) \to \infty$. We further define

$$\underline{w}_r(\delta) = \min_{c'(x_r)=\delta\pi V_r,\, V_r = \frac{(x_r w - c(x_r) - (1-x_r)c'(x_r))^2}{4x_r w(1-\delta)},\, \pi\in[0,1]} \frac{c(x_r) + (1 - x_l)c'(x_r)}{x_r} \tag{19}$$

to be the minimum valuation to make market entry profitable under reputation (fixing δ but varying π). It is obvious that $\underline{w}_r(\delta)$ is finite for all $0 < \delta < 1$. Therefore, for any positive δ, there will be a threshold $L_1(\delta)$ such that $\underline{w}_l(L) > \underline{w}_r(\delta)$ for all $L > L_1(\delta)$.

Proof of Proposition 7. Let V_{lr} denote the seller's discounted payoff in the highest value state of a setting that combines litigation and reputation. The seller's value function is given by:

$$V_{lr} = d(x_{lr})[p(x_{lr}) - c(x_{lr}) - (1 - x_{lr})(L + bD) + \delta(x_{lr}V_{lr} + (1 - x_{lr})(V_{lr} - \epsilon))] + (1 - d(x_{lr}))\delta V_{lr}$$

or, equivalently, by:

$$V_{lr} = \frac{d(x_{lr})\,(p(x_{lr}) - c(x_{lr}) - (1 - x_{lr})(L + bD + \delta\epsilon))}{1 - \delta} \tag{20}$$

where $d(x_{lr}) = 1 - (p(x_{lr}) - (1 - x_{lr})(-L + bD))/x_{lr}w$, $c'(x_{lr}) = L + bD + \delta\epsilon$ and $V_{lr} \geq \epsilon \geq 0$ denotes the difference between the expected NPV payoff of the highest state and that of the state to which the mechanism transitions following a low-quality outcome. For a given effort $x_{lr} = x(\epsilon)$, substituting the profit-maximizing price $p(x(\epsilon))$ into $d(x(\epsilon))$ and (20) we obtain:

$$V_{lr}(\epsilon) = \frac{(x(\epsilon)w - c(x(\epsilon)) - (1 - x(\epsilon))(2L + \delta\epsilon))^2}{4x(\epsilon)w(1 - \delta)} \tag{21}$$

Any setting that combines litigation and reputation admits an equilibrium where the reputation mechanism is ignored by buyers. In such an equilibrium the seller's value function is identical in all states of the reputation mechanism, which implies $\epsilon = 0$. The question of interest to this Proposition is to identify conditions under which there exists some $V_{lr}(\epsilon) \geq \epsilon > 0$ such that $V_{lr}(\epsilon) > V_{lr}(0)$. Differentiating (21) with respect to ϵ and substituting $c'(x(\epsilon)) = L + bD + \delta\epsilon$ (which also implies

$c''(x(\epsilon))\partial x(\epsilon)/\partial\epsilon = \delta$) we obtain:

$$\begin{aligned}\frac{\partial V_{lr}(\epsilon)}{\partial\epsilon} &= \delta\frac{x(\epsilon)w - c(x(\epsilon)) - (1-x(\epsilon))(2L+\delta\epsilon))}{4x(\epsilon)^2 w(1-\delta)c''(x(\epsilon))} \\ &\times (x(\epsilon)w + c(x(\epsilon)) + 2L + \delta\epsilon(1-x(\epsilon)) - 2x(\epsilon)(1-x(\epsilon))c''(x(\epsilon)) - 2x(\epsilon)bD)\end{aligned} \tag{22}$$

We assume that market entry is profitable for the seller, therefore it is $x(\epsilon)w - c(x(\epsilon)) - (1 - x(\epsilon))(2L + \delta\epsilon) > 0$. The sign of $\partial V_{lr}(\epsilon)/\partial\epsilon$ is thus equal to the sign of the last factor of (22).

A sufficient condition for the existence of $\epsilon > 0$ such that $V_{lr}(\epsilon) > V_{lr}(0)$ is $\partial V_{lr}(\epsilon)/\partial\epsilon > 0$ at $\epsilon = 0$. This occurs if:

$$\begin{aligned}&\phi(0) = x(0)w + c(x(0)) + 2L - 2x(0)(1-x(0))c''(x(0)) - 2x(0)bD > 0 \\ &\Rightarrow D < D_0 = \frac{1}{2b}\left[w + \frac{c(x(0))+2L}{x(0)} - 2(1-x(0))c''(x(0))\right]\end{aligned}$$

where $c'(x(0)) = L + bD_0$. Comparing with the optimal $D^* = (w + (c(x_l^*) + 2L)/x_l^*)/2b$, $c'(x_l^*) = L + bD^*$ (Proposition 4, Part 2) it is $D_0 < D^*$.

(Parts 2 and 3.) From (9) the seller payoff induced by litigation alone satisfies:

$$V_l(x) = \frac{(xw - c(x) - (1-x)2L)^2}{4xw(1-\delta)} \qquad c'(x) = L + bD_l$$

whereas, from (21), the payoff induced by the combination of reputation and litigation is:

$$V_{lr}(x,\epsilon) = \frac{(xw - c(x) - (1-x)(2L+\delta\epsilon))^2}{4xw(1-\delta)} \qquad c'(x) = L + bD_{lr} + \delta\epsilon$$

Direct comparison shows that any effort that can be induced by the combination of litigation and reputation, can be induced more effectively by litigation alone by setting $D_l = D_{lr} + \delta\epsilon/b$. We now use the above result to show that for $D \geq D^*$ and for all $\epsilon > 0$ it is $V_{lr}(x(\epsilon),\epsilon) < V_{lr}(x(0),0) = V_l(x(0))$, which implies that the addition of a reputation mechanism on top of litigation cannot increase seller payoffs. Let x^* denote the effort induced by litigation alone when $D = D^*$. Recall that, for $x > x^*$ it is $\frac{\partial V_l(x)}{\partial x} < 0$. Let $x(\epsilon)$ be defined by $c'(x(\epsilon)) = L + bD + \delta\epsilon$. For any $\epsilon > 0$ equivalent effort can be induced by a litigation mechanism where damages are equal to $D + \delta\epsilon/b$. If $D \geq D^*$ it is also $D + \delta\epsilon/b > D^*$ and, therefore, $V_l(x(\epsilon)) < V_l(x(0))$. Since we have shown that, for $\epsilon > 0$, it is $V_{lr}(x,\epsilon) < V_l(x)$, this implies that $V_{lr}(x(\epsilon),\epsilon) < V_l(x(\epsilon)) < V_l(x(0)) = V_{lr}(x(0),0)$.

Proof of Proposition 8. The proof is analogous to the Proof of Proposition 1.

Proof of Proposition 10. Let $x_{r\theta}$ denote the corresponding equilibrium seller effort in the highest value state of a finite state setting with reputation where both types are present in the market and there is price pooling. If buyers believe that a seller who is in the reputation mechanism's highest state is of high-type with probability ρ then a buyer of type k who transacts with a random seller expects effort $y = (1-\rho)x_{r\theta_1} + \rho x_{r\theta_2}$. Her expected valuation of the transaction is $u_k(y) = kyw$. The buyer will purchase the good if and only if $u_k(y) \geq p$, or equivalently, if $k \geq p/yw$. The probability of a sale at price p is then given by $d(p, y) = \Pr[k \geq p/yw] = 1 - p/yw$. The corresponding high-type seller value function is:

$$V_{r\theta_2} = d(p, y)(p - c_{\theta_2}(x_{r\theta_2}) + \delta x_{r\theta_2} V_{r\theta_2} + \delta(1 - x_{r\theta_2})(V_{r\theta_2} - \epsilon)) + (1 - d(p, y))\delta V_{r\theta_2}$$

where ϵ is the difference between the value of the highest state and the value of the next state. Per our previous analysis of reputation mechanisms it is $c'_{\theta_2}(x_{r\theta_2}) = \delta\epsilon$. From the first-order conditions, the profit maximizing price is equal to $p(x_{r\theta_2}, y) = [yw + c_{\theta_2}(x_{r\theta_2}) + \delta(1 - x_{r\theta_2})\epsilon]/2$. Substituting into the above value function we obtain:

$$V_{r\theta_2} = \frac{[yw - c_{\theta_2}(x_{r\theta_2}) - (1 - x_{r\theta_2})\delta\epsilon]^2}{4yw(1 - \delta)} = \frac{[yw - c_{\theta_2}(x_{r\theta_2}) - (1 - x_{r\theta_2})c'_{\theta_2}(x_{r\theta_2})]^2}{4yw(1 - \delta)}$$