December 2002

Cooperation Without Enforcement? A Comparative Analysis of Litigation and Online Reputation as Quality Assurance Mechanisms

Yannis Bakos
New York University

Chrysanthos Dellarocas
Massachusetts Institute of Technology

COOPERATION WITHOUT ENFORCEMENT? A COMPARATIVE ANALYSIS OF LITIGATION AND ONLINE REPUTATION AS QUALITY ASSURANCE MECHANISMS

Yannis Bakos
Stern School of Business
New York University
New York, NY USA
bakos@stern.nyu.edu

Chrysanthos Dellarocas
Sloan School of Management
Massachusetts Institute of Technology
Cambridge, MA USA
dell@mit.edu

Abstract

Online reputation mechanisms are emerging as a promising alternative to more traditional mechanisms for promoting trust and cooperative behavior, such as legally enforceable contracts. As information technology dramatically reduces the cost of accumulating, processing, and disseminating consumer feedback, it is plausible to ask whether such mechanisms can provide an economically more efficient solution to a wide range of moral hazard settings where societies currently rely on the threat of litigation in order to induce cooperation. In this paper, we compare online reputation to legal enforcement as institutional mechanisms in terms of their ability to induce cooperative behavior and we explore the impact of information technology on their relative economic efficiency. We find that although both mechanisms result in losses relative to the maximum possible social surplus, under certain conditions online reputation outperforms litigation in terms of maximizing the total surplus, and thus the resulting social welfare.

1 INTRODUCTION

Economic activity requires economic agents to abide by the terms of explicit or implicit promises. For example, a merchant is expected to ship a good that has been purchased and paid for, or to provide the quality explicitly or implicitly promised to the customer.

Most commercial transactions rely on the legal system to assure performance of promises, which are written into explicit or implicit contracts. The legal system is expensive, however, in terms of the cost of the institutions necessary to adjudicate claims (lawyers, courts, etc.) and to enforce decisions (police, correctional facilities, etc.). It is also dependent on access to the enforcement power of a sovereign state.

Electronic markets operate on a global scale and typically span multiple jurisdictions. Litigation across jurisdictions is very costly and often infeasible. Online reputation mechanisms (Resnick et al. 2000) have emerged as a viable alternative to the legal system in such settings. On eBay, for instance, an online feedback mechanism that encourages buyers and sellers to rate one another seems to have succeeded in encouraging cooperative behavior in an otherwise very risky trading environment (Bajari and Hortascu 2000; Dewan and Hsu 2001; Houser and Wooders 2000; Lucking-Reiley et al. 2000; Resnick and Zeckhauser 2002).

The potential applications of online reputation mechanisms go beyond the relatively narrow domain of trust building in electronic marketplaces. The appeal of reputation mechanisms is that, when they work, they facilitate cooperation without the need for costly enforcement institutions (Wilson 1985). They have, therefore, the potential of providing more economically efficient outcomes in a wide range of moral hazard settings where societies currently rely on the threat of litigation in order to induce cooperation.

The concept of reputation is as old as society itself. In the early middle ages, before the emergence of sovereign states of substantial geographical span, reputation networks were the primary mechanism for inducing cooperative behavior in European trade (Milgrom et al. 1990). It was only during the 16th century that state-enforced commercial law took over as the primary mechanism for adjudicating trade disputes (Benson 1989). Milgrom et al. argue that the primary reason for this evolution was economic: at those times, communication of information about a trader's past record was costly and error-prone. Therefore, once state enforcement became possible because of the emergence of extended sovereign states, it provided an economically more *efficient* solution to the problem of policing exchange.

Information technology is having dramatic impacts on the cost and performance of reputation mechanisms. For instance, online reputation mechanisms greatly reduce the cost of collecting and disseminating reputation information on a worldwide scale and enable the cost effective pooling of experiences into a single feedback repository. Thus information technology, and the Internet in particular, underlies the increasing applicability of reputation tracking systems, as evidenced by the increasing body of research on reputation mechanisms in the IS literature (Dellarocas 2002a). On the other hand, the impact of information technology on the cost of traditional enforcement mechanisms, such as courts, lawyers, and the police, is likely to be moderate. Given this difference in the likely impact of technology, it is appropriate for IS researchers and economists to revisit the question of which is the most socially efficient mechanism for inducing honest trade.

The novelty of our work stems from its comparative focus; while both reputation and litigation mechanisms have been previously studied in the economics literature, ours is the first work we are aware of that studies these two types of institutional mechanisms in the same setting. This allows us to compare their ability to induce cooperative behavior, and to explore the impact of information technology on their relative economic efficiency.

Game theoretic analyses of litigation are the focus of a rich, and growing, body of literature (for literature surveys, see Cooter and Rubinfeld 1989; Baird et al. 1995, Chapter 8). The litigation model developed in this paper is a simple version of a one-sided private information model—a model in which the defendant has information that is not available to the plaintiff (in our case, the true level of effort exerted) but the plaintiff has no information to which the defendant does not have access. Examples of such models in the literature include Bebchuk (1984), Nalebuff (1987), P'ng (1983), and Reinganum and Wilde (1986).

Reputation formation has also been extensively studied by economists (for surveys, see Dellarocas 2002a; Wilson 1985). Several papers in the economic literature study aspects of reputation formation in settings where player strategies are imperfectly observed by their opponents include Diamond (1989), Fudenberg and Levine (1992), Holmstrom (1999), and Mailath and Samuelson (1998). The reputation model in this paper, however, differs to the extent that it is inspired by online reputation tracking systems, such as eBay's feedback mechanism. Specifically, our model emphasizes the ability of online reputation mechanisms to succinctly summarize large volumes of past feedback into properly designed statistics that facilitate decision making without sacrificing efficiency.

2 THE SETTING

In this paper, we offer a comparative analysis of reputation and enforcement-based mechanisms for quality assurance, focusing on the likely impact of information technology on the relative efficiency of these types of institutional mechanisms. We study these two types of mechanisms in a setting with a merchant (seller) who in each period provides one unit of a product or a service (good) to one of multiple consumers (buyers). The good is either high quality or low quality, but only high quality is acceptable to the buyers. Following receipt of payment, the seller can exert either high effort (cooperate) or low effort (cheat). The buyer observes the quality of the good delivered, but not the effort exerted by the seller. Moral hazard is introduced because high effort is costlier to the seller, who can reduce his costs by failing to exert high effort, providing the buyer with a good of lower expected quality.

More formally, we analyze a setting with a monopolist seller who each period offers for sale a single unit of a good to m buyers. Buyer i has valuation w_i for a high quality good and all buyers value a low quality good at zero. Buyer lifetime is exactly one period and in each period the m buyers are drawn from the same probability distribution, thus buyer valuations are independent and identically distributed within and across periods. There is an infinite number of periods and the seller has a period discount factor δ reflecting the frequency of transactions, or the probability that the game will end after each period. Seller effort determines the probability that the good provided will be of low quality: if the seller exerts low effort, the good will be of low quality with probability ρ, whereas if the seller exerts high effort he will incur an additional cost c and the good will be of low quality with a smaller probability π ($\pi < \rho$). The seller's objective is to maximize the present value of his payoffs over the entire span of the game, while the buyers' objective is to maximize their short-term (stage game) payoff.

In each period, a mechanism is used to allocate the good among the m buyers by determining the buyer that receives the good and the price she pays to the seller. Without loss of generality, we assume that buyers are indexed according to their valuations ($w_1 \geq w_2 \geq \ldots \geq w_m$). We further assume that a second price Vickrey auction is used to award the good to the buyer with the highest valuation w_1 for a high quality good. The winning bidder pays a price equal to the second-highest bid G; the valuation of the second-highest bidder for a high quality good is w_2.[1]

While stylized, the above setting captures the essential properties of a large number of important real-life economic settings, ranging from the provision of professional services, to online purchasing, and auctions like eBay. In professional services (medical consultations, auditing, construction projects, etc.), there are well-defined standards of high quality service and the uncertainty is focused on whether the provider will adhere to those standards or try to "cut corners." In mail order or online purchasing, the moral hazard is focused on whether, following receipt of payment, the seller will provide a good of the quality advertised.

3 REPUTATION FRAMEWORK

3.1 Modeling a Reputation Mechanism

In the above setting, we consider a reputation mechanism that allows buyers to rate the seller based on the quality of the good received. Buyers report the outcome of a transaction as either positive or negative, with positive ratings indicating high quality of the good received, and negative ratings indicating low quality. The mechanism aggregates past ratings and provides buyers with a summary of the seller's most recent ratings. Specifically, buyers can see the total number of each type of rating received by the seller during the most recent N transactions, while earlier ratings are discarded. This mechanism attempts to capture the essence of online reputation tracking systems, such as eBay's "ID Card," which summarizes ratings received during the most recent 6-month period (Figure 1). Since we have assumed a binary feedback mechanism (ratings are either positive or negative), a seller's feedback profile can be represented as (x,N), where $x \in \{0,1,\ldots,N\}$ is the number of negative ratings currently contained within that window. At the end of each period, the rating received during the current period is added to the profile whereas the rating received N periods ago is discarded.

Several characteristics of this model capture the role of information technology in online reputation systems: First, once an online system has been developed, the per period cost of collecting, processing, and communicating ratings information is much lower compared to a traditional offline system. In the setting we consider in this paper, we assume that this per period cost is zero; this assumption is only appropriate for online systems. Second, the type of structured design that we assume for the reputation mechanism in our setting is only feasible in the context of an online system. Third, we assume that consumers provide truthful feedback on the quality of a good received, which hinges on the cost of providing this feedback being low enough so that consumers can be given incentives that induce participation and truth-telling. For instance, this can be accomplished through side-payment mechanisms like the one proposed by Miller et al. (2002). While mechanisms of this type might be infeasible in traditional reputation settings, they can be easily incorporated into online systems. Finally, as information technology makes the outcome of any single transaction immediately known to the entire population of prospective buyers, it increases the proportion of transactions affected by the seller's reputation, which in turn increases the seller's discount factor. As discussed in section 5, this affects significantly the ability of the reputation mechanism to promote cooperative behavior, and thus is central to our comparative analysis of reputation and litigation based mechanisms.

Dellarocas (2002b) has shown that the maximum efficiency attainable by the type of mechanism we model in this paper, in two-outcome settings like the one we consider here, is independent of the size N of the time window. Consequently, in this paper we focus on the special case where $N = 1$, which corresponds to a reputation mechanism that only publishes the *single* most recent rating received for the seller and discards all past ratings. A seller's reputation profile can then be denoted by a binary state variable $x \in \{0,1\}$ ($x = 0,1$ corresponds to good and bad reputation respectively). The corresponding stage game is summarized in Figure 2. Even this very simple mechanism allows us to illustrate the ability of reputation mechanisms to induce cooperative behavior. More sophisticated mechanisms are likely to perform even better, especially in more complex settings.

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[1]While in order to proceed with our analysis we need to assume some mechanism for determining the buyer that will receive the good in each period and the price paid by that buyer, our results qualitatively apply to any mechanism that is reasonably efficient in awarding the good to a high valuation buyer and at a price increasing in line with her valuation.

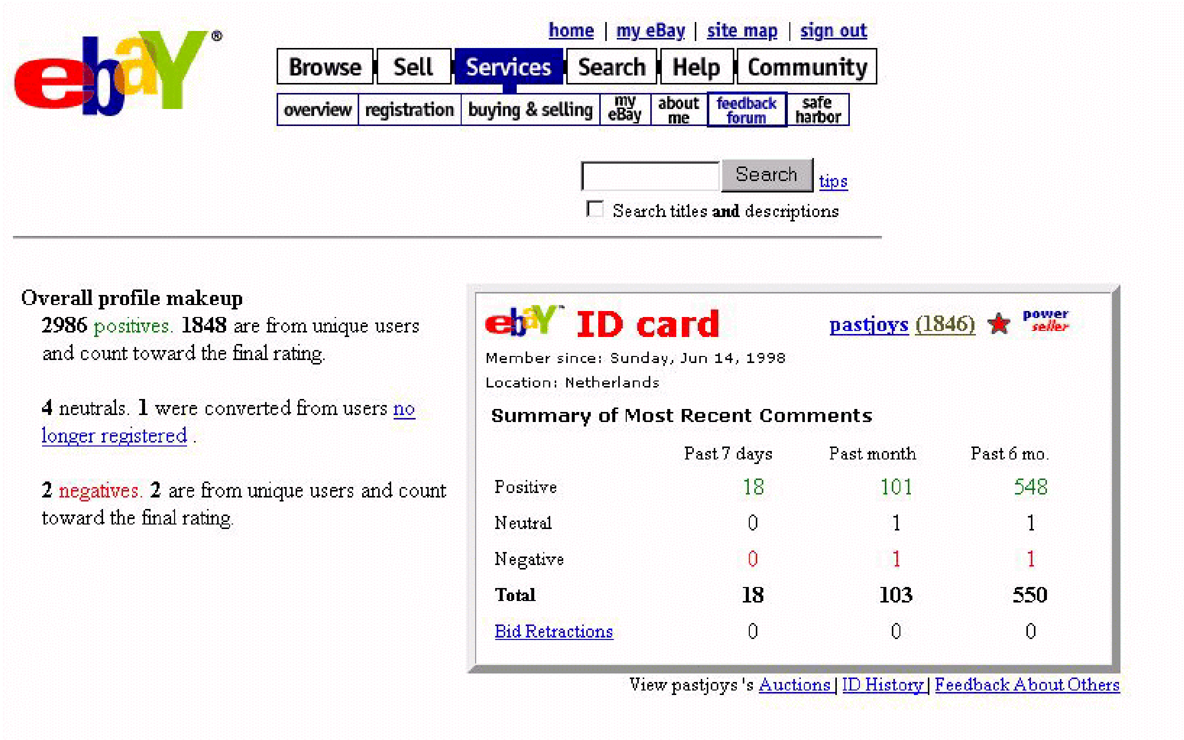

Figure 1. Sample eBay Feedback Profile

1. Seller offers a single unit of a good, promising to deliver a high quality good (as there is no demand for a low quality good).
2. System provides a binary (positive or negative) rating for the seller, based on the rating received by the buyer in the most recent period. The rating is positive if the buyer in the most recent period received a high quality good, and negative otherwise.
3. Buyers bid their expected valuations for the good in a second price Vickrey auction; the winning bidder pays G, which is the second-highest bid; we denote by w_1 and w_2 the respective valuations for a high quality good of the winning bidder and the second-highest bidder.
4. Seller decides on whether to exert high effort at cost c, or low effort at cost 0, with corresponding probabilities that the resulting good is of low quality being π and ρ ($\pi < \rho$).
5. Buyer receives the good, experiences its quality, and realizes the corresponding valuation w_1 for a high quality good or 0 for a low quality good. Buyer reports the quality of the good received to the system, and the rating of the seller reported in the next period is changed accordingly.

Figure 2. Stage Game for Reputation Mechanism

Let $s(x,f) \in [0,1]$ denote the seller's strategy in period t, equal to the probability the seller will cooperate (i.e., exert high effort) in period t if his current reputation profile contains $x \in \{0,1\}$ negative ratings at the beginning of the period. We will restrict the seller to stationary strategies, where $s(x,t)$ does not depend on t, and thus $s(x,t) \equiv s(x)$. Let $\mathbf{s} = [s(0), s(1)]$. The buyer's optimal bid in each period will be equal to her expected valuation

$$G_i(x,\mathbf{s}) = \{s(x)\cdot(1-\pi) + [1-s(x)]\cdot(1-\rho)\}\cdot w_i = [s(x)\cdot(\rho-\pi) + (1-\rho)]\cdot w_i \tag{1}$$

resulting in expected auction revenue for that period

$$G(x,\mathbf{s}) = [s(x)\cdot(\rho-\pi) + (1-\rho)]\cdot w_2 \tag{2}$$

where w_2 is the second highest bidder's valuation of a high quality good. The expected surplus for the winning bidder is

$$V_b(x,\mathbf{s}) = [s(x)\cdot(\rho-\pi) + (1-\rho)]\cdot(w_1 - w_2) \tag{3}$$

where w_1 is the winning bidder's valuation of high quality.

Since a seller's choice of effort takes place after payment for the current period has been received, the seller's objective is to select **s** so as to maximize the present value of his payoff in the remaining game. Let $U(x,\mathbf{s})$ denote the seller's expected *future* payoff, i.e., excluding the payment G from the current auction, when the seller's current reputation profile contains x negatives.

If the seller exerts high effort in the current period, he incurs an immediate cost c; the resulting quality of the good will be high with probability $1-\pi$ and low with probability π. Since we have assumed that buyers provide truthful feedback, if quality is high, the reputation profile in the next round will contain $x = 0$ negative ratings, otherwise it will contain $x = 1$ negative rating. The expected future payoff is

$$U_{coop}(x,\mathbf{s}) = -c + \delta\cdot\{(1-\pi)\cdot[G(0,\mathbf{s}) + U(0,\mathbf{s})] + \pi\cdot[G(1,\mathbf{s}) + U(1,\mathbf{s})]\} \tag{4}$$

If the seller exerts low effort, he avoids the cost c in the current period. However, the resulting quality of his product will be high with probability $1-\rho$ and low with probability $\rho > \pi$, which increases the probability that the seller will enter the next period with a bad reputation ($x = 1$). In this case, the expected future payoff is

$$U_{cheat}(x,\mathbf{s}) = \delta\cdot\{(1-\rho)\cdot[G(0,\mathbf{s}) + U(0,\mathbf{s})] + \rho\cdot[G(1,\mathbf{s}) + U(1,\mathbf{s})]\} \tag{5}$$

Let $\alpha = w_2/c$; α provides a measure for the ratio of the valuation of a high quality good to the cost of high effort. The following proposition shows the seller's optimal strategy:

Proposition 1:

(a) If $\alpha < \dfrac{1}{\delta\cdot(\rho-\pi)^2}$ then the seller's optimal strategy is $\mathbf{s}^* = [0,0]$: always exert low effort.

(b) If $\alpha \geq \dfrac{1}{\delta\cdot(\rho-\pi)^2}$ then the seller's optimal strategy is $\mathbf{s}^* = [1, 1 - \dfrac{c/W_2}{\delta\cdot(\rho-\pi)^2}]$: always exert high effort if the seller has zero negative ratings and follow a mixed strategy with probability of cooperation $1 - \dfrac{c/w_2}{\delta\cdot(\rho-\pi)^2}$ if the seller has one negative rating.

Proof: See Appendix.

Proposition 1 expresses the fact that, in order for a reputation mechanism to succeed in inducing cooperation, the additional revenue from exerting high effort must be high enough so that discounted future payoffs from sustained cooperation are greater than the short-term benefit from cheating (for a similar result, see Klein and Leffler 1981).

3.2 Total Surplus

If the seller's profile has x negatives, his current period payoff is

$$V_s(x,\mathbf{s}) = G(x,\mathbf{s}) - s(x)\cdot c = [s(x)\cdot(\rho-\pi)+(1-\rho)]\cdot w_2 - s(x)\cdot c \tag{6}$$

From (3) and (6) the total surplus $V(x,\mathbf{s}) = V_b(x,\mathbf{s}) + V_s(x,\mathbf{s})$ is equal to:

$$V(x,\mathbf{s}) = \left[s(x)\cdot(\rho-\pi)+(1-\rho)\right]\cdot w_1 - s(x)\cdot c \tag{7}$$

The average total surplus is given by:

$$V(\mathbf{s}) = p_0(\mathbf{s})\cdot V(0,\mathbf{s}) + p_1(\mathbf{s})\cdot V(1,\mathbf{s}) \tag{8}$$

where $p_0(\mathbf{s})$, $p_1(\mathbf{s})$ are the stationary probabilities that a seller who follows strategy $\mathbf{s}$ will find himself in states $x = 0$, $x = 1$ respectively. Proposition 2 shows the total surplus corresponding to the seller strategy of Proposition 1.

Proposition 2: If $\alpha \geq \dfrac{1}{\delta\cdot(\rho-\pi)^2}$ then the average total surplus per period is:

$$V = [(1-\pi)w_1 - c] - \frac{w_1(\rho-\pi)-c}{\delta w_2(\rho-\pi)-c}\frac{\pi c}{\rho-\pi} \tag{9}$$

Proof: See Appendix.

The term $[(1-\pi)\cdot w_1 - c]$ equals the total surplus when the seller always cooperates, which is the first best outcome if $c < w_1(\rho-\pi)$. The second term represents the loss in total surplus due to the less than perfect ability of the reputation mechanism to induce cooperation when $x = 1$.

4 ENFORCEMENT-BASED FRAMEWORK (LITIGATION): MODELING A LITIGATION MECHANISM

In this section, we present a model for a simple litigation mechanism. Instead of reporting on the quality of the good received, the buyer may sue the seller for failing to deliver a high quality good. Since buyers directly experience the quality of the received product or service while courts usually rely on indirect testimony, we assume that court decisions are subject to noise. The court will find for the buyer with probability p if the quality of the good received is high, and with probability r if the quality of the good is low ($p < r$). 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, which include legal fees, trial fees, the opportunity cost of time spent by the parties involved, and the amortized cost of sustaining the adjudication and enforcement institutions. The corresponding stage game is summarized in Figure 3 and is shown in extensive form in Figure 4.

As each period is independent, analysis of this game consists of analyzing the stage game. In the last move of the stage game, the buyer will sue if the expected payment for damages (pD if the good is high quality and rD if the good is low quality) is higher than the litigation cost L. Propositions 3 and 4 show the outcomes of this game.

Proposition 3: In the litigation game,

(a) if $L > rD$, then the buyer will never sue and the seller will always exert low effort.

(b) if $L < pD$, then the buyer will always sue and the seller will exert high effort if and only if $D > \frac{c}{(\rho - \pi)(r - p)}$.

(c) if $pD < L < rD$, then the buyer will sue if and only if when a good of low quality is received and the seller will exert high effort if and only if $c < (\rho - \pi)(L + rD)$.

1. Seller offers a single unit of a good, promising to deliver a high quality good (as there is no demand for a low quality good).
2. Buyers bid their expected valuations for the good in a second price Vickrey auction; the winning bidder pays G, which is the second-highest bid; the valuations for a high quality good of the winning bidder and the second-highest bidder are w_1 and w_2 respectively.
3. Seller decides on whether to exert high effort at cost c, or low effort at cost 0, with corresponding probabilities that the resulting good is low quality being π and ρ ($\pi < \rho$).).
4. Buyer receives the good, experiences its quality, and realizes the corresponding valuation w_1 for a high quality good or 0 for a low quality good.
5. Buyer decides whether or not to sue seller. If buyer does not sue, the stage game ends.
6. If the buyer sues, the court finds for the buyer with probability p if the good received was high quality, and with higher probability r if the good received was low quality. Independent of the decision of the court, each party incurs litigation costs L.
7. If the court finds for the buyer, then the seller has to pay to the buyer damages D.

Figure 3. Stage Game for Litigation Mechanism

Proposition 4: If $c < (\rho - \pi)(L + rD)$ and $L < \frac{(\rho - \pi)w_1 - c}{2\pi}$, then social surplus in the litigation game is maximized by setting the level of damages to satisfy $\frac{L}{r} < D < \frac{L}{p}$, leading to an outcome where the seller always exerts high effort and the buyer sues when she receives a low quality good. Otherwise, social surplus is maximized by setting damages $D < \frac{L}{r}$, leading to an outcome where the seller always exerts low effort and the buyer never sues.

Proof: Propositions 3 and 4 follow directly from the analysis of cases L1, L2, and L3 in the Appendix.

5 DISCUSSION

As we mentioned in the Introduction, both reputation and litigation mechanisms have been previously studied in the economics literature. The novelty of our work stems from its comparative focus: ours is the first work we are aware of that studies these two types of institutional mechanisms in the same setting, comparing their economic efficiency in inducing cooperative behavior, and thus allowing us to assess the likely relative impact of information technology.

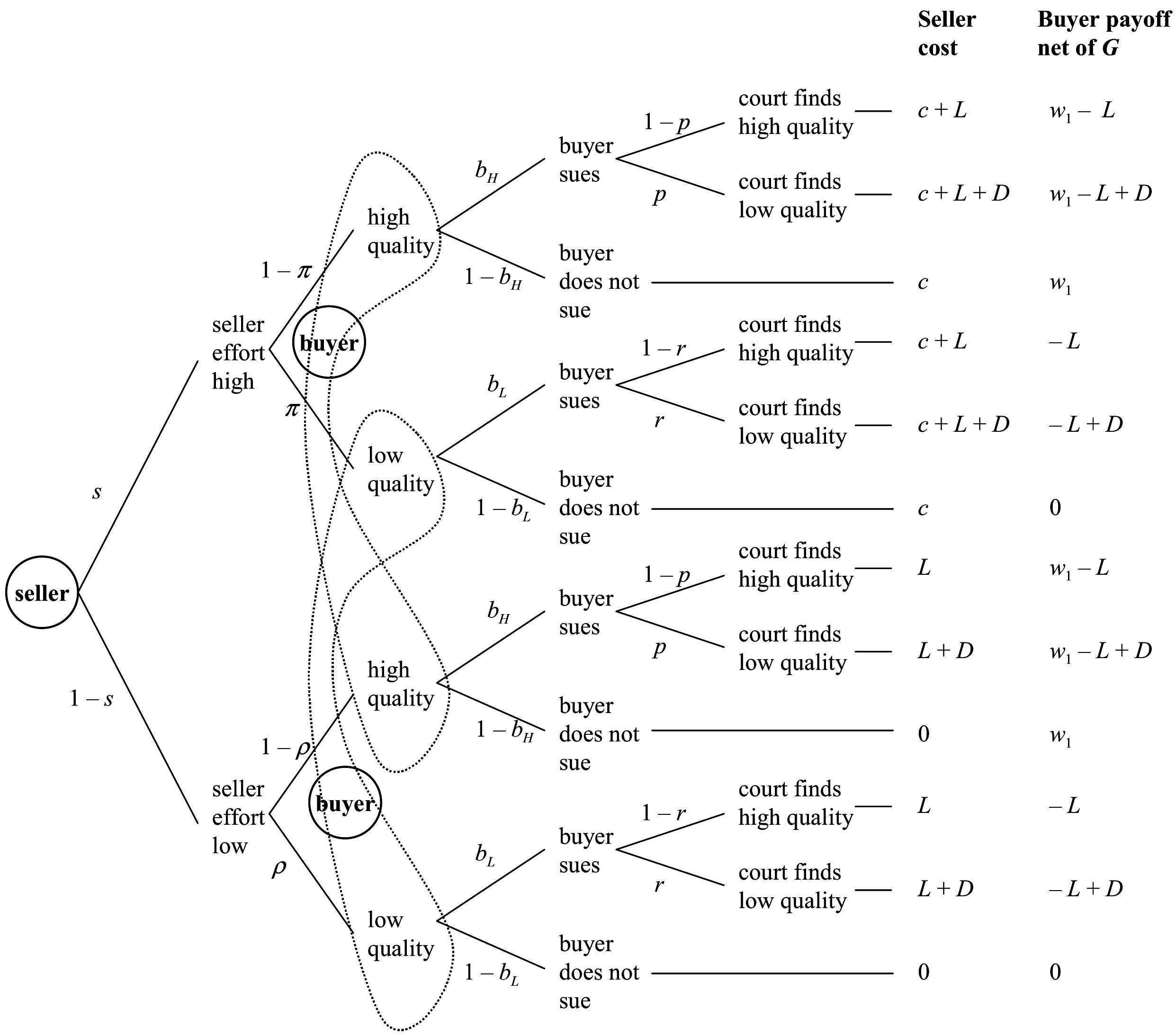

Figure 4. Stage Game for Litigation Mechanism

5.1 Comparing the Efficiency of Reputation Versus Litigation Mechanisms

The total surplus generated in each period is $(1 - \rho)w_1$ when the seller exerts low effort, and $(1 - \pi)w_1 - c$ when the seller exerts high effort. Thus in the first best outcome the seller would exert high effort when $(1 - \rho)w_1 < (1 - \pi)w_1 - c$, or $c < (\rho - \pi)w_1$.

In the absence of a mechanism to induce cooperation, the seller's dominant strategy is to always exert low effort, which reduces the total surplus generated by $(\rho - \pi)w_1 - c$ when $c < (\rho - \pi)w_1$. Our analysis shows that both the reputation and the litigation mechanisms under certain conditions can improve on this outcome by inducing the seller to exert high effort.

As shown in Proposition 1, the simple reputation mechanism analyzed in section 3 induces the seller to exert high effort most of the time, provided that $c < w_2\delta(\rho - \pi)^2$. Specifically, a seller with a good reputation ($x = 0$) will always cooperate, while a seller with a bad reputation ($x = 1$) will cooperate with probability $1 - \dfrac{c / w_2}{\delta \cdot (\rho - \pi)^2}$.

According to Proposition 2, the resulting total surplus is $V = [(1-\pi)w_1 - c] - \dfrac{w_1(\rho-\pi)-c}{\delta w_2(\rho-\pi)-c}\dfrac{\pi c}{\rho-\pi}$, i.e., the reputation mechanism reduces the total surplus by $\dfrac{w_1(\rho-\pi)-c}{\delta w_2(\rho-\pi)-c}\dfrac{\pi c}{\rho-\pi}$ compared to the high-effort first best outcome.

The efficiency implications of the litigation mechanism we analyzed depend on the litigation costs L. If $L < \dfrac{(\rho-\pi)w_1 - c}{2\pi}$, then for a properly selected level of damages D (i.e., $L/r < D < L/p$), the litigation mechanism will induce the seller to always cooperate. The resulting surplus in this case is $[(1 - \pi)w_1 - c] - 2\pi L$ (see Appendix for derivation), i.e., the reputation mechanism reduces total surplus by $2\pi L$ compared to the high effort first best outcome, a reduction equal to the expected litigation costs of the two parties.

- Low cost of high effort
- High frequency of seller transactions ($\delta \to 1$)
- High valuation of high quality relative to cost of high effort $\alpha = w_2/c$
- High litigation costs L relative to cost of high effort

Figure 5. Summary of Factors Affecting the Relative Efficiency of Reputation and Litigation

Figure 5 provides a qualitative summary of the preceding results. The relative efficiency of the reputation and litigation mechanisms depends on the relative magnitude of these reductions in total surplus. If $\delta \approx 1$ (a reasonable assumption if the frequency of seller transactions is high), and if $w_1 \approx w_2$ (a reasonable assumption if the number of buyers in each period is large, so that the valuations of the highest two bidders are approximately equal), then the reduction in surplus for the reputation mechanism simplifies to $\dfrac{\pi c}{\rho-\pi}$. In that case, the reputation mechanism is more efficient than litigation in terms of the total surplus generated if and only if $2\pi L > \dfrac{\pi c}{\rho-\pi}$, or $L > \dfrac{c}{2(\rho-\pi)}$. The crucial determinant of the relative efficiency of the two mechanisms is the magnitude of litigation costs relative to the incremental cost of high effort. When $\delta \approx 1$ and $w_1 \approx w_1$, and for most reasonable values of ρ, π, r, and p, reputation will be more efficient than litigation when litigation costs are higher than a threshold value linked to the incremental cost of high effort. For instance, if $\rho = r = 0.9$ and $\pi = p = 0.1$, reputation will result in a higher total surplus if $L > c/1.6$, provided that $< 0.64\, w_2$ so that the reputation mechanism can induce high seller effort.

5.2 Impact of Information Technology

We have identified several characteristics in our setting that capture the role of information technology in online reputation systems: First, IT dramatically lowers the marginal per period cost of collecting, processing, and communicating ratings information compared to a traditional offline system. Second, the structured design that we assume for the reputation mechanism we study is only feasible in the context of an online system. Third, the very low cost of entering feedback information in online reputation systems and the possibility to implement incentive mechanisms that encourage truthful participation greatly increase the ability to elicit truthful consumer feedback on the quality of a good received. Finally, as information technology makes the outcome of any single transaction immediately known to the entire population of prospective buyers, it increases the frequency of transactions affected by the seller's reputation, which in turn increases the seller's discount factor.

Before the advent of the Internet, word-of-mouth regarding professionals and merchants took place within relatively small and (almost) mutually disjoint groups of neighbors, friends, co-workers, etc. From a modeling perspective, the situation is equivalent to a setting where each such group operates an independent reputation mechanism that only receives and disseminates feedback from members of that small group regarding their experiences with sellers. If the seller operates over a large, fragmented territory, the number of such groups would be very large. Since the seller would transact relatively infrequently with members of any given group, his decision problem would be identical to that captured by the preceding analysis, except that his discount factor would be smaller.

Internet-based online reputation mechanisms provide easily accessible, low cost focal points for previously disjoint groups to pool their experiences with service providers and merchants into a single feedback repository. At the limit, the spread of these mechanisms means that the outcome of any single transaction becomes immediately known to the entire population of prospective buyers. In our setting, this would be equivalent to the seller's discount factor getting closer to one, as the frequency of affected transactions increases. If transactions within a reputation-driven marketplace are frequent enough, then it is reasonable to assume that δ is very close to one.

Changing the discount factor δ in our analysis is significant, in terms of both the applicability as well as the efficiency of reputation as a mechanism for inducing cooperation. Proposition 1 shows that our simple reputation mechanism can only induce cooperative behavior when $\alpha = \frac{w_2}{c} \geq \frac{1}{\delta \cdot (\rho - \pi)^2}$. As δ increases, the minimum required ratio of valuation of high quality to cost of high effort w_1/c *declines*, and thus it becomes possible for reputation mechanisms to induce cooperation in more settings. Furthermore, from equation (9), as δ increases, the total surplus achieved by the reputation mechanism increases, approaching the total surplus in the high-effort first best outcome. This increase is shown in Figure 6, for illustrative values of π, ρ, c, w, and L. Figure 6 also shows that as δ increases, reputation becomes more efficient relative to litigation, since the efficiency of litigation is not affected by δ: while reputation may be less efficient than regulation for lower values of δ (many fragmented reputation networks), it may become more efficient than litigation as δ increases and approaches 1 (single large reputation network).

The preceding discussion demonstrates how information technology enables institutional mechanisms based on online reputation systems to become a feasible alternative to litigation in promoting cooperative behavior in markets. As a result, the design of online reputation mechanisms and the comparative analysis of reputation vs. litigation mechanisms is a promising area of study for IS researchers, in the vein of earlier streams of research on the institutional implications of IT, such as the markets versus hierarchies literature (e.g., see Malone et al. 1987).

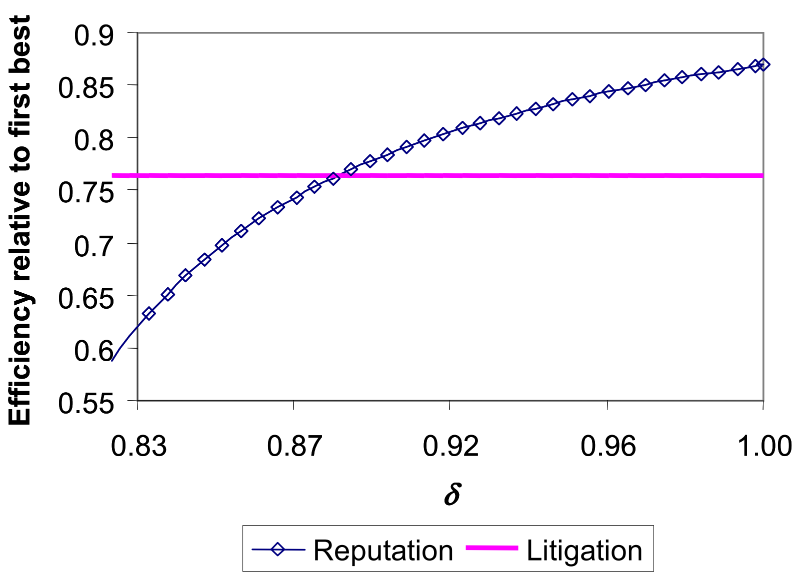

Figure 6. Impact of Changes in the Discount Factor δ
(for $\pi = 0.05$, $\rho = 0.95$, C - 1000, w_1 - 1500, and $L = 1000$)

6 CONCLUDING REMARKS

Recent advances in information technology are causing us to rethink many institutions that shape relationships in our everyday life. One important area where information technology can have a profound impact is the institutions that promote trust and cooperation among economic agents. The emergence of online communities has enabled the creation of low cost reputation networks of global reach. On the other hand, technology is having only a moderate impact on the costs of traditional mechanisms that depend on contract enforcement through litigation. As a result, online reputation mechanisms are likely to emerge as the preferred institutions to promote cooperation among economic agents in a large number of settings, augmenting or substituting for traditional litigation-based mechanisms, or enabling a more efficient outcome in markets where cooperative behavior was heretofore unsustainable.

The comparative analysis in this paper was based on a rudimentary binary reputation mechanism. Future research should explore more sophisticated mechanisms (e.g., with reputation profiles based on multi-valued ratings that can distinguish multiple levels of quality); such mechanisms may perform better, and thus will strengthen our results. Similarly, more sophisticated litigation models can be used in the comparison, for example, ones that allow for a settlement offer before resorting to the court. Furthermore, we ignored the fixed costs of setting up the legal system and the fixed and variable cost of setting up and running the reputation mechanism. Since the variable cost of online reputation mechanisms is close to zero, it should not significantly affect the outcomes we derived. As the fixed costs of the legal system are sunk, the efficiency improvement introduced by a reputation mechanism provides an estimate of the maximum socially desirable investment in developing such a mechanism. Our analysis can also be extended to more general settings where the price and allocation of the good are determined by mechanisms other than a per-period auction.

The role of reputation mechanisms is likely to be particularly important in markets for professional services, such as legal, medical, accounting, home improvement, etc. In these cases, legal costs are likely to be high compared to the cost of high effort, it may be costly for a court to verify the quality of the service provided, and the outcome of the court's evaluation may be noisy; all of these factors favor the relative attractiveness of reputation mechanisms for providing trust. This is particularly significant in view of predictions that information technology will increase the role of markets for professional services. For instance, Malone and Laubacher (1998) have argued that we are moving toward an "e-Lance economy" with professional services auctioned off on an *ad hoc* basis. Our analysis suggests that reputation mechanisms would play a central role in enabling this type of markets.

Finally, a central function of markets (electronic or otherwise) is the provision of an institutional infrastructure, such as a legal and regulatory framework; this infrastructure is especially important when market participants may behave opportunistically, and without it markets may fail to function efficiently, or break down completely. Consequently, reputation mechanisms may enable the emergence of new markets, to the extent that such mechanisms may be able to induce sellers to exert high effort, and the resulting surplus may be sufficient to sustain the market in situations where a litigation mechanism will fail to do so. It has been previously argued (e.g., Bakos 1997, 1998) that intermediaries like eBay enable new markets to emerge by lowering search costs, when otherwise it would be too costly for potential buyers and sellers to find each other. Our analysis in this article shows that for such intermediaries, the provision of a reputation mechanism may play an equally important role in enabling the emergence of new markets.

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Appendix

Proof of Proposition 1

Because the seller decides his level of effort for the current period *after* receiving payment and because past ratings are discarded, the seller's decision problem is independent of the current state x of his reputation profile. Therefore, we can write $U(0,\mathbf{s}) = U(1,\mathbf{s}) \equiv U(\mathbf{s})$, $U_{coop}(0,\mathbf{s}) = U_{coop}(1,\mathbf{s}) \equiv U_{coop}(\mathbf{s})$ and $U_{cheat}(0,\mathbf{s}) = U_{cheat}(1,\mathbf{s}) \equiv U_{cheat}(\mathbf{s})$. By substituting the above, plus the expressions for $G(x, \mathbf{s})$ from (2) into (4) and (5) we get:

$$U_{coop}(\mathbf{s}) = -c + \delta \cdot \{[((1-\pi)\cdot s(0) + \pi \cdot s(1)) \cdot (\rho - \pi) + (1-\rho)] \cdot w_2 + U(\mathbf{s})\} \tag{A.1}$$

$$U_{cheat}(\mathbf{s}) = \delta \cdot \{[((1-\rho)\cdot s(0) + \rho \cdot s(1)) \cdot (\rho - \pi) + (1-\rho)] \cdot w_2 + U(\mathbf{s})\} \tag{A.2}$$

There are three possible cases:

(i) $U_{coop}(\mathbf{s}) > U_{cheat}(\mathbf{s})$. In this case, the seller would always find it preferable to cooperate. Therefore, **s** = [1,1]. By substituting **s** into (A.1) and (A.2) we get:

$$U_{coop}(\mathbf{s}) = -c + \delta \cdot \{(1-\pi)\cdot w_2 + U(\mathbf{s})\} \tag{A.3}$$

$$U_{cheat}(\mathbf{s}) = \delta \cdot \{(1-\pi)\cdot w_2 + U(\mathbf{s})\} \tag{A.4}$$

Thus, $U_{coop}(\mathbf{s}) < U_{cheat}(\mathbf{s})$, which contradicts the original assumption. Therefore, the strategy **s** = [0,0] is not an equilibrium.

(ii) $U_{coop}(\mathbf{s}) < U_{cheat}(\mathbf{s})$. In this case, the seller will always prefer to cheat and thus **s** = [0,0]. By substituting **s** into (A.1) and (A.2) we get:

$$U_{coop}(\mathbf{s}) = -c + \delta \cdot \{(1-\rho)\cdot w_2 + U(\mathbf{s})\} \tag{A.5}$$

$$U_{cheat}(\mathbf{s}) = \delta \cdot \{(1-\rho)\cdot w_2 + U(\mathbf{s})\} \tag{A.6}$$

It is easy to see that $U_{coop}(\mathbf{s}) < U_{cheat}(\mathbf{s})$. Therefore, $\mathbf{s}_0$ = [0,0] is an equilibrium. In this equilibrium, $U(\mathbf{s_0}) \equiv U_{cheat}(\mathbf{s_0})$, which by substitution into (A.6) gives $U(\mathbf{s_0}) = \dfrac{\delta\cdot(1-\rho)\cdot w_2}{1-\delta}$. From (2), the expected auction revenue then becomes $G(\mathbf{s_0}) = (1-\rho)\cdot w_2$ irrespective of the current profile state. Finally, the seller's discounted lifetime payoff corresponding to strategy $\mathbf{s}_0$ is equal to:

$$W(\mathbf{s_0}) = G(\mathbf{s_0}) + U(\mathbf{s_0}) = \frac{(1-\rho)\cdot w_2}{1-\delta} \tag{A.7}$$

(iii) $U_{coop}(\mathbf{s}) = U_{cheat}(\mathbf{s})$. In this case, the seller would be indifferent between cheating and cooperation. From (A.1) and (A.2), equality of the payoffs implies:

$$s(0) - s(1) = \frac{c / w_2}{\delta\cdot(\rho-\pi)^2} \tag{A.8}$$

or, equivalently, $\mathbf{s} = \mathbf{s}(s(0)) = [s(0), s(0) - \dfrac{c/w_2}{\delta\cdot(\rho-\pi)^2}]$. Therefore, any strategy of this form where $\dfrac{c/w_2}{\delta\cdot(\rho-\pi)^2} \le s(0) \le 1$ is an equilibrium strategy. Such mixed strategy equilibria will exist only if $\dfrac{c/w_2}{\delta\cdot(\rho-\pi)^2} \le 1$. Let $\alpha = w_1/c$. . Then the above inequality for the existence of mixed strategy equilibria becomes

$$\alpha \ge \frac{1}{\delta\cdot(\rho-\pi)^2} \tag{A.9}$$

The corresponding payoff function is given by substitution of **s**(s(0)) into either (A.1) or (A.2):

$$U(\mathbf{s}(s(0))) = \frac{\delta \cdot [(\rho - \pi) \cdot s(0) + (1 - \rho)] \cdot w_2}{1 - \delta} - \frac{\rho \cdot c}{(1 - \delta) \cdot (\rho - \pi)} \tag{A.10}$$

Equation (A.10) is linear in $s(0)$ and is maximized for $s(0) = 1$. Therefore, the mixed equilibrium strategy that maximizes the seller's payoff is $\mathbf{s}_1 = \mathbf{s}(1) = [1, 1 - \frac{c / w_2}{\delta \cdot (\rho - \pi)^2}]$. The seller's remaining payoff then becomes $U(\mathbf{s}_1) = \frac{\delta \cdot (1 - \pi) \cdot w_2}{1 - \delta} - \frac{\rho \cdot c}{(1 - \delta) \cdot (\rho - \pi)}$. From (2) the expected auction revenue becomes a function of the seller's current profile state and equal to $G(x, \mathbf{s}_1) = (1 - \pi) w_2 - x \cdot \frac{c}{\delta \cdot (\rho - \pi)}$. Finally, the seller's discounted lifetime payoff corresponding to strategy $\mathbf{s}_1$ is maximized when new sellers begin the game with a good reputation ($x_0 = 0$). Their lifetime discounted payoff then becomes equal to:

$$W(\mathbf{s}_1) = G(0, \mathbf{s}_1) + U(\mathbf{s}_1) = \frac{\delta \cdot (1 - \pi) \cdot w_2}{1 - \delta} - \frac{\rho \cdot c}{(1 - \delta) \cdot (\rho - \pi)} \tag{A.11}$$

By comparing (A.7) and (A.11), we see that $W(\mathbf{s}_1) > W(\mathbf{s}_0) \Leftrightarrow \alpha > \frac{\rho}{\delta \cdot (\rho - \pi)^2}$. Furthermore, in order for strategy $\mathbf{s}_1$ to be an equilibrium strategy, (A.9) must hold. However, since $\frac{\rho}{\delta \cdot (\rho - \pi)^2} < \frac{1}{\delta \cdot (\rho - \pi)^2}$, if (A.9) is satisfied, then strategy $\mathbf{s}_1$ results in higher payoff relative to strategy $\mathbf{s}_0$ (therefore, $\mathbf{s}' = \mathbf{s}_0$), whereas if (A.9) is not satisfied, then strategy $\mathbf{s}_0$ is the only equilibrium strategy (therefore trivially $\mathbf{s}' = \mathbf{s}_0$). This completes the proof.

Proof of Proposition 2

The reputation game described in section 3 can be viewed as a Markov process with state x and transition probabilities $\tau_{ij}(\mathbf{s}) = \Pr[x_{t+1} = j \mid x_t = i, \mathbf{s}]$ given by:

$$\tau_{ij}(\mathbf{s}) = \Pr[x_{t+1} = j \mid x_t = i] = s(i) \cdot \Pr[x_{t+1} = j \mid cooperate] + (1 - s(i)) \cdot \Pr[x_{t+1} = j \mid cheat] \tag{A.13}$$

where

$\Pr[x_{t+1} = 0 \mid cooperate] = 1 - \pi$ $\qquad$ $\Pr[x_{t+1} = 0 \mid cheat] = 1 - \rho$

$\Pr[x_{t+1} = 1 \mid cooperate] = \pi$ $\qquad$ $\Pr[x_{t+1} = 1 \mid cheat] = \rho$

Since we have assumed that $\alpha \geq \frac{1}{\delta \cdot (\rho - \pi)^2}$, by Proposition 1 the seller strategy that maximizes the expected total surplus in the stage game is $\mathbf{s}_1 = [1, 1 - \frac{c / w_2}{\delta \cdot (\rho - \pi)^2}]$. By substituting $\mathbf{s}_1$ into (A.13) we get the transition probability matrix:

$$\boldsymbol{\tau}(\mathbf{s}_1) = \begin{bmatrix} \tau_{00}(\mathbf{s}_1) & \tau_{01}(\mathbf{s}_1) \\ \tau_{10}(\mathbf{s}_1) & \tau_{11}(\mathbf{s}_1) \end{bmatrix} = \begin{bmatrix} 1 - \pi & \pi \\ 1 - \pi - \frac{c}{\delta \cdot (\rho - \pi) \cdot w_2} & \pi + \frac{c}{\delta \cdot (\rho - \pi) \cdot w_2} \end{bmatrix} \tag{A.14}$$

It is known from the theory of Markov processes that the stationary probabilities $[p_0(\mathbf{s}), p_1(\mathbf{s})]$ are equal to the normalized eigenvector corresponding to the unit eigenvalue of matrix $\boldsymbol{\tau}(\mathbf{s})$. After some algebraic manipulation we get:

$$[p_0(\mathbf{s}_1), p_1(\mathbf{s}_1)] = \left[\frac{\delta \cdot w_2 \cdot (\rho - \pi) \cdot (1-\pi) - c}{\delta \cdot w_2 \cdot (\rho - \pi) - c}, \frac{\delta \cdot w_2 \cdot (\rho - \pi) \cdot \pi}{\delta \cdot w_2 \cdot (\rho - \pi) - c} \right] \tag{A.15}$$

If we now substitute $p_0(\mathbf{s}_1), p_1(\mathbf{s}_1)$ into (8), we get the final expression (9) for the average total surplus.

Analysis of the litigation game

<u>Case L1</u>: $L > rD$ and the buyer never sues.

In this case, the dominant strategy for the seller is to choose $s = 0$, i.e, the seller will never exert high effort. The buyer will realize a payoff $(1 - \rho)w_1 - G$, , while the seller's payoff is G. The total surplus is $(1 - \rho)w_1$. Both the buyer and the seller will participate in the game, as both payoffs will be positive.

<u>Case L2</u>: $L < pD$ and the buyer always sues.

In this case, the seller will choose his optimal strategy s^* to minimize its total cost K, where

$$\begin{aligned} K = {} & s[(1-\pi)(1-\rho) + \pi(1-r)](c+L) + s[(1-\pi)p + \pi r](c+L+D)s + \\ & (1-s)[(1-\rho)(1-p) + \rho(1-r)]L + (1-s)[(1-\rho)p + \rho r](L+D) \end{aligned} \tag{A.16}$$

Differentiating (A.16) we obtain $\dfrac{\partial K}{\partial s} = c - (\rho - \pi)(r-p)D$.

The optimal strategy for the seller is $s^* = 0$ if $\dfrac{\partial K}{\partial s} > 0$ and $s^* = 1$ if $\dfrac{\partial K}{\partial s} < 0$. We thus distinguish the following two subcases:

<u>Case L2a</u>

$$\frac{\partial K}{\partial s} > 0 \text{ implies } c - (\rho - \pi)(r-p)D > 0, \text{ or } D < \frac{c}{(\rho - \pi)(r-p)} \tag{A.17}$$

If (A.17) holds, then $s^* = 0$, and the seller always exerts low effort. The corresponding buyer and seller payoffs are $(1 - \rho)w_1 - L + [\rho r + (1 - \rho)p]D - w_1$ and $w_1 - L - [\rho r + (1 - \rho)p]$D, and their total surplus is $(1 - \rho)w_1 - 2L$; this surplus must be nonnegative for the buyer and the seller to participate in the market.

It is easy to see that L2a is dominated by case L1, where the seller also exerts low effort, but the litigation costs are avoided because the buyer never sues.

<u>Case L2b</u>

If $\dfrac{\partial K}{\partial s} < 0$, i.e., $D > \dfrac{c}{(\rho - \pi)(r-p)}$, then $s^* = 1$, and the seller always exerts high effort. The buyer realizes payoff $(1 - \pi)w_1 - L + [\pi r + (1 - \pi)p]D - G$, the seller realizes payoff $G - L - [\pi r + (1 - \pi)p]$D, and the total surplus is $(1 - \pi)w_1 - 2L - $c. This outcome is dominated by case L3b below, where the buyer sues only if quality is low.

Cases L2a and L2b show that setting $D > L/p$ leads to inefficient outcomes due to excessive litigation costs.

<u>Case L3</u>: $pD < L < rD$; ; the buyer will sue only if quality is low.

In this case the seller faces cost $K = s(1-\pi)c + s\pi(c + L + rD) + (1-s)\rho(L + rD)$. (A.18)

Thus $\dfrac{\partial K}{\partial s} = (1-\pi)c + \pi(c + L + rD) - \rho(L + rD) = c - (\rho - \pi)(L + rD)$. We distinguish two cases:

<u>Case L3a</u>: If $c > (\rho - \pi)(L + rD)$, then $\dfrac{\partial K}{\partial s} > 0$, and seller will minimize his cost by setting s* = 0.

This results in seller payoff $G - \rho(L + rD)$, buyer payoff $(1 - \rho)w_1 + \rho rD - \rho L - G$, and total surplus $(1 - \rho)w_1 - 2pL$. Not surprisingly, this outcome is dominated by case L1, where the effort of the seller is also low, but litigation costs are avoided.

<u>Case L3b</u>: If $c < (\rho - \pi)(L + rd)$, then $\dfrac{\partial K}{\partial s} < 0$, and the seller will minimize his cost by setting s* = 1.

This results in buyer payoff $(1 - \pi)w_1 - G - \pi L + \pi rD$, seller payoff $G - \pi L - \pi rD - c$, and total surplus $(1 - \pi)w_1 - 2\pi L - c$.

The participation constraints are $G - \pi L - \pi rD - c > 0$ for the seller, and $(1 - \pi)w_1 - G - \pi L + \pi rD > 0$ for the buyer.

Comparing the total surplus in cases L1 and L3b, case L3b will result in a higher surplus if $L < \dfrac{(\rho - \pi)w_1 - c}{2\pi}$. In other words, if $L < \dfrac{(\rho - \pi)w_1 - c}{2\pi}$ then D should be chosen to satisfy $\dfrac{L}{r} < D < \dfrac{L}{p}$. Otherwise, the damages should satisfy $D < \dfrac{L}{r}$, leading to an equilibrium where the seller never exerts high effort and there is no litigation.