Secrecy and Safety

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August 2003
Revised: April 2004

* This research was supported by NSF Grant SES-0239908. We thank Jon Hamilton, Xinyu Hua, the referees, the Co-Editor, and participants in seminars at the University of Southern California, the University of Virginia and Vanderbilt University for comments on an earlier version.
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ABSTRACT

We employ a simple two-period model to show that the use of confidential settlement as a strategy for a firm facing tort litigation leads to lower average safety of products sold than that which would be produced if a firm were committed to openness. Moreover, confidentiality can even cause this measure to decline over time. We also show that a rational risk-neutral consumer’s response to a market environment, wherein a firm engages in confidential settlement agreements, may be to reduce demand. We discuss how firm profitability is influenced by the decision to have open or confidential settlements; all else equal, a firm following a policy of openness will incur higher liability and R&D costs, though product demand will not be diminished (as it may be for a firm employing confidentiality). Further, we characterize the choice of informational regime, providing conditions such that, if the cost of credible auditing (to verify openness) is low enough, a firm will choose to pay for auditing and eschew confidentiality.
1. Introduction

What is the effect of secrecy about the existence or extent of product-generated harms on the provision of safe products? Such secrecy naturally arises when firms negotiate and settle lawsuits (filed by harmed product users) with “sealing” orders provided by courts, or private “contracts of silence,” that keep everything from initial discovery through the actual details of a settlement secret, under pain of court-enforced contempt citations or damages for breach of contract, respectively.\(^1\) According to attorneys, these practices are widespread and routine in products liability cases.\(^2\) Recent revelations of the past sexual abuse of minors by priests, much of which was concealed by confidential settlements, make clear that this practice is not confined to product markets alone.\(^3\)

We employ a simple two-period model to show that the use of confidential settlement as a strategy for a firm facing tort litigation leads to lower average quality of inputs used, and lower average safety of products sold, than that which would be produced if a firm were committed to openness. Moreover, confidentiality can even cause this latter measure to decline over time. We also show that a rational risk-neutral consumer’s response to a market environment, wherein a firm engages in confidential settlement agreements, may be to reduce demand. Finally, we discuss how firm profitability is influenced by the decision to have open or confidential settlements; all else equal, a firm following a policy of openness will incur higher liability and R&D costs, though product demand will not be diminished (as it may be for a firm employing confidentiality). Moreover, an open firm may face costs of making the commitment to openness credible.\(^4\)

The extensive provision of secrecy by courts is becoming, both for the states and the federal government, an important policy issue. For some time, approximately one-fifth of the states (and the federal government) have been considering eliminating or severely restricting confidentiality, though the focus of such “sunshine” laws tends to be only about conditions that significantly
endanger public health and safety (leaving much of products liability untouched). Recently all federal judges in one state (South Carolina) agreed to no longer provide confidentiality in “everything from products liability cases to child-molestation claims and medical malpractice suits.”

The legal literature on confidentiality is quite large; for a discussion of some of the (conflicting) legal issues, see Miller (1991), Doggett and Mucchetti (1991), Garfield (1998), Dore (1999) and Fromm (2001). There are basically three arguments made by those desiring elimination of confidentiality and three arguments made by those in favor of continuing to allow confidentiality. Those favoring eliminating confidentiality stress the benefits to third parties: 1) other injured people who have not realized they may have a cause of action (both consumers who bought the product and were harmed, as well as non-consumers harmed by externalities, such as occur in second-hand smoke or toxic chemical spills) will realize that they have a case; 2) further risks to health and safety will be averted; and 3) discovery sharing among plaintiffs harmed by the same product (which might improve the viability of plaintiffs’ cases, or reduce the costs associated with pursuing a suit) will be facilitated.

Those favoring continuing to allow confidential settlements argue that: 4) discovery sharing is likely to inspire nuisance suits; 5) important privacy interests of the parties, such as protecting trade secrets or highly personal information, will be protected; and 6) many settlements are made contingent upon sealing (promoting settlement is an important goal of the civil justice system; see Federal Rule of Civil Procedure 16(a), Yeazell, 1996).

Related Literature

This paper naturally fits into (and bridges) two literatures, namely that concerned with signaling product quality via price, and that concerned with confidentiality and bargaining. Previous
papers in which a monopoly signals quality via price include Bagwell and Riordan (1991), Bagwell (1992) and Daughety and Reinganum (1995). This paper abstracts from competitive considerations such as entry or the presence of other firms, as well as advertising and other non-price avenues for signaling, but expands the quality signaling model to consider a continuum type-space which is endogenously determined by the firm’s decision to retain or replace an input. It is closest to Daughety and Reinganum (1995), since (as there) the post-market-transaction continuation game reflects the firm’s liability for harms due to its choices regarding safety provision.

The economics literature concerned with confidentiality and bargaining is much smaller. Yang (1996) briefly discusses exogenously-determined regimes of confidentiality or openness and their effect on sequential bargaining by a defendant with a series of plaintiffs. Daughety and Reinganum (1999, 2002) also consider a sequence of settlement bargaining games, but model bargaining as being over both money and the choice of confidentiality versus openness. Noe and Wang (forthcoming) provide a model of confidentiality in sequential negotiations in which a buyer faces a sequence of sellers. They show that, when the items to be purchased are sufficiently complementary, it is profitable for the buyer to randomize the order in which he approaches the sellers, and to keep secret this order and the outcome of previous negotiations.

None of the above analyses connects the presence or absence of confidentiality to the endogenous determination of product safety, which we do here. We show that commitment to a particular informational regime (confidentiality versus openness) influences a firm’s downstream incentives to improve safety and a consumer’s willingness to purchase the product. We characterize the choice of regime, providing conditions such that, if the cost of credible auditing (to verify openness) is low enough, a firm will choose to pay for the auditing and eschew confidentiality.
Thus, if society were to ban (or substantially limit) the use of confidential settlements, then under the relevant conditions, a firm would prefer this (as the cost of credible auditing would then be zero). However, there may be conditions under which even free auditing would not make a firm prefer openness, in which case it would prefer that the law allow confidential agreements.

**Plan of the Paper**

In Section 2 the model set-up, structure and notation are detailed. In Section 3 we characterize the equilibrium under openness or confidentiality, while Section 4 compares the equilibria for the two regimes. Section 5 examines the endogenous choice of regime. The analysis of these sections is under a parametric restriction that guarantees the existence of a (unique) revealing equilibrium; Section 6 provides the essential results when only a pooling equilibrium exists. Section 7 summarizes the results and discusses the policy implications of banning or allowing confidentiality. Formal statements of the equilibria are in the Appendix while proofs, derivations and supplementary material are provided in a Web Appendix available at (XXXX).

**2. Model Set-Up, Structure and Notation**

We consider a two-period model of a firm producing a product with a safety attribute. Within each period, three distinct interactions occur. First, a firm chooses an input whose quality affects the safety of its product. Second, the firm chooses a price, which affects the purchasing decisions of consumers. Third, the firm engages in settlement negotiations with consumers who are harmed by the product. Prior to the start of Period 1, we assume that the firm has an opportunity to choose the regime under which it will conduct its settlement negotiations: the settlements are confidential (denoted C) unless the firm has committed itself to a regime of openness (denoted O). Commitment to a regime of openness will require a fixed expenditure on external monitoring.
We describe each of these interactions, and the linkages between them both within and across periods, in turn. We begin by defining some notation that will be common to the two periods, and then we specify the timing and the information structure of the model. We will indicate parameters which are assumed to vary with the regime by a superscript “i,” where i = O or C.

**Notation**

Let $\theta$ denote the quality of an input, such as a production technology. We also identify $\theta$ with the safety of a unit of the product produced by this technology, and interpret $\theta$ as the probability that the consumer uses the product without incident; that is, $\theta$ is the probability that the product does not cause harm. We will also typically refer to $\theta$ as the technology’s, the firm’s, or the product’s “type.” Assume that $\theta$ is distributed according to a continuously differentiable distribution function, $G(\theta)$, with positive density, $g(\theta)$, on the interval $[\theta, \bar{\theta}]$. Let $\mu = E(\theta)$ be the expected value of $\theta$.

We assume that the technology can also be employed in alternative activities for the firm, should it not be fully-utilized in producing the primary product, which may generate a second product or revenue stream for the firm. In this alternative use, the technology generates profits for the firm that are proportional (at the rate $\beta$) to its quality.\(^8\) We assume that the firm makes more profit when it produces the primary product, so the firm will only engage in the alternative activity when consumer demand falls short of its capacity, which we denote by $N$.\(^9\) Initial acquisition of the technology, or its subsequent replacement, occurs at a cost denoted $t$. For simplicity, we assume there are no other costs associated with producing the product.

Let $V$ denote the value of consumption of one unit of the product. We assume that there are $N$ consumers (so the technology provides the capacity to serve the entire market), and that each
consumer demands at most one unit. Let the prevailing price for Period j be denoted $p_j$, for $j = 1, 2$. In order to determine her willingness to pay for the product, the consumer must form expectations (or beliefs, depending upon the information available to her) about the likelihood that she will be harmed by the product, and the associated losses she will bear.

In order to focus on other issues, we assume a simple litigation subgame structure. In particular, suppose that it is common knowledge that each harmed consumer (each plaintiff, denoted P) suffers an injury in the amount $\delta$. Under the assumption that the firm (the defendant, denoted D) is strictly liable for the harms it causes, this is the amount of damages P would receive if successful at trial. However, merely knowing that one has been harmed by use of a product is not sufficient to be successful at trial; rather, convincing evidence of causation is required, even under strict liability. We assume that there is a probability, denoted $\lambda$, that a consumer will be able to provide convincing evidence. With the complementary probability other intervening factors may cloud the relationship between product use and harm, undermining the viability of the consumer’s case. We index the likelihood of a viable case by the regime to indicate that confidential versus open settlement may affect the likelihood that a case is viable. In particular, we assume that $\lambda^c \leq \lambda^o$; that is, one effect of confidential settlement (which usually results in a blanket gag order) is that it prevents plaintiffs from learning about each other’s cases and possibly sharing information that might improve the viability of their cases (see Hare, et. al., 1988; they argue that this is an important reason for defendants to seek confidentiality). Moreover, we assume that when a consumer complains of harm to the firm, it is common knowledge (between the parties) whether the consumer’s case is viable or not. Thus, plaintiffs with non-viable cases receive nothing, while plaintiffs with viable cases receive a settlement. We assume that the amount of the settlement is
provided by finding the Nash Bargaining Solution to a complete information game, taking into account the parties’ relevant costs of settlement versus trial.\textsuperscript{12}

We are assuming here that compensation is determined by the tort system, rather than by \textit{ex ante} contracting between the firm and a consumer. In the case of injury, a firm cannot limit its liability for a consumer’s harm through contractual means. Under the penalty doctrine, the common law does not enforce stipulated damages in excess of expected damages (Rea, 1998, p.24). Thus, the maximum value of enforceable stipulated damages would be $\delta$. But then, assuming that the firm cannot commit not to dispute causation (that is, the consumer would still have to be able to prove that the firm’s product caused the consumer’s harm in order to have the contract enforced), the consumer’s expected loss would be unchanged.

Let $k_{SP}$ and $k_{SD}$ denote the costs of negotiating a settlement for P and D, respectively, and let $k_{TP}$ and $k_{TD}$ denote the incremental costs of trial for P and D, respectively. Since most product liability suits involve a plaintiff’s attorney being paid a contingency fee, $k_{SP}$ is actually likely to be substantial (from 1/4 to 1/3 of the settlement P receives), while the incremental costs of trial, $k_{TP}$, may be relatively small. On the other hand, since the defendant is likely to pay his attorney an hourly fee, $k_{SD}$ may be relatively small compared to the incremental cost of trial, $k_{TD}$. The model, however, allows these costs to take on arbitrary values.

\textbf{Timing and Information Structure}

Prior to the first period, the firm commits itself to a regime of either open, or confidential, settlement negotiations. A commitment to a regime of openness will require a public expenditure on independent monitoring; failure to make such a costly and visible commitment results in an inference that the firm will engage in confidential settlement.
At the beginning of Period 1, the firm in regime i incurs R&D costs of t to acquire a technology. We assume that the realized value of \( \theta \) associated with this technology is not observed by the firm until after the product has been sold and consumers begin reporting harm. Thus the firm sets its price \( p_1 \), under symmetric, but imperfect, information vis-a-vis the consumer. Consumers make their purchase decisions, and some suffer harm. We assume that all consumers report their harms to the firm, seeking compensation, but only those with viable suits receive settlements. At this point, since harmed consumers are not aware of the totality of the complaints, only the firm is able to construct the realized value of \( \theta \).^{13}

At the beginning of Period 2, it is now common knowledge that the firm knows the safety of its own product. If the firm is credibly committed to a policy of openness, then consumers can costlessly ascertain the firm’s realized first period value of \( \theta \). Furthermore, independent of its policy of openness or confidentiality, if the firm chooses to replace its technology with a new one, we assume that this is observable to consumers. If the technology is replaced, then Period 2 plays out the same as Period 1. If the firm chooses to retain its Period 1 technology, then under a regime of openness, consumers also know the product’s second-period safety. However, under a regime of confidentiality, since the consumer is uninformed about the product’s continuing level of safety, she is at an informational disadvantage compared to the firm, and takes this into account in her subsequent purchasing behavior. In particular, she draws an inference about product safety from the price \( p_2 \) and bases her purchasing decision on this inference. As in Period 1, consumers harmed in Period 2 seek compensation and those with viable cases receive a settlement.

3. Analysis of the Model under Alternative Regimes

We solve the model by backward induction. We first characterize the settlement subgame
equilibrium, which is the same for both periods. We then briefly discuss the alternative use of the technology by the firm. Then we characterize equilibrium play in Period 2, and then in Period 1, first under the assumption of an open regime and then under a regime of confidentiality.

**Settlement Subgame Equilibrium**

By negotiating and settling rather than going to trial, \( P \) (respectively, \( D \)) individually spends the amount \( k_{SP} \) (respectively, \( k_{SD} \)), but they jointly save the amount \( K_T = k_{TP} + k_{TD} \). Thus, the resulting Nash Bargaining Solution involves the plaintiff with a viable case receiving her disagreement payoff, \( \delta - k_{SP} - k_{TP} \), plus one-half of the saved incremental trial costs. Therefore, the plaintiff receives \( \delta - k_{SP} - k_{TP} + K_T/2 \). Similarly, the defendant pays his disagreement payoff, \( + k_{SD} + k_{TD} - K_T/2 \), less one-half of the saved incremental trial costs, for a resulting payment of \( \delta + k_{SD} + k_{TD} - K_T/2 \).

Since not all cases are viable, we compute the continuation payoffs for the consumer and the firm, conditional upon the consumer being harmed. A harmed consumer will suffer a loss of \( \delta \) and receive a settlement of \( \delta - k_{SP} - k_{TP} + K_T/2 \) if she has a viable case, which occurs with probability \( \lambda_i \) in regime \( i \). Thus, the expected loss borne by a harmed consumer in regime \( i \), denoted \( L_p^i \), is given by \( L_p^i = \delta - \lambda_i(\delta - k_{SP} - k_{TP} + K_T/2) \). Similarly, the expected loss borne by the firm when a consumer is harmed in regime \( i \), denoted \( L_d^i \), is given by \( L_d^i = \lambda_i(\delta + k_{SD} + k_{TD} - K_T/2) \). We assume that each party bears some loss; that is, \( L_p^i > 0 \) and \( L_d^i > 0 \). For simplicity, let \( L^i \) denote the combined loss due to consumer harm and settlement costs: \( L^i = L_p^i + L_d^i = \delta + \lambda_i K_S \), where \( K_S = k_{SP} + k_{SD} \).

**Alternative Use of the Firm’s Technology**

Recall that the firm can either produce the product with the safety attribute, or engage in alternative productive activities with the same technology. For example, a technology could be used to produce both therapeutic drugs and multi-vitamins. A “better” technology may promote greater
safety when used to produce therapeutic drugs, and greater output when used to produce multi-
vitamins. The social value of using a technology of type $\theta$ to produce a unit of the primary product is $V - (1 - \theta)L^i$, while the social (and private) value of using the technology in an alternative activity is given by $\beta \theta$. We make the following assumption regarding the parameters.

**Assumption 1.** For $i = O, C$: (a) $V > L^i > \beta$; and (b) $t < (\mu - \theta)NL^i$.

Part (a) implies that the net social value, $V - (1 - \theta)L^i - \beta \theta$, is positive for all $\theta \in [\underline{\theta}, \bar{\theta}]$ and increasing in the safety of the product (since $L^i > \beta$). This assumption is actually stronger than is necessary; some product types with negative net social value could be accommodated. Assumption 1(a) also implies that using the technology to produce the primary product is always more valuable (socially) than using it in an alternative activity. Part (b) implies that $N[V - (1 - \mu)L^i] - t > N[V - (1 - \theta)L^i]$, so it is preferable to acquire a new technology of unknown quality rather than to produce with the worst technology. For the analysis in Sections 3 - 5 we will further assume that $\beta > L_O^C$, the alternative case will be taken up in Section 6.

Notice that, because each consumer has unit demand and the firm is a monopolist, the firm will extract the full value of the product to the consumer as long as there is symmetric information about $\theta$. Thus, in the case of a new technology (when no one knows $\theta$), all consumers will want a unit of the product at the symmetric-information monopoly price, and the firm’s entire capacity will be devoted to producing the product. In addition, in a regime of openness, the consumer and the firm will both know the retained technology’s quality. Thus, all consumers will want a unit of the product at the full-information monopoly price and again the firm’s entire capacity will be devoted to producing the product. Only in the case of a confidential regime, in which asymmetric information prevails, might the firm employ a portion of its capacity in an alternative activity.
Equilibrium in a Regime of Openness

We solve the model by backward induction, first characterizing the equilibrium in Period 2 and then in Period 1. Let $\theta_j$ denote the quality of the technology in Period $j$, $j = 1, 2$. If the technology from Period 1 has not been replaced, then it is common knowledge (under an O regime) that $\theta_2 = \theta_1$. In this case, the consumer’s maximum willingness to pay for the good is given by $V - (1 - \theta_1)L_P^O$. Thus, the firm will charge $p_2 = V - (1 - \theta_1)L_P^O$ and each consumer will buy one unit. In this case, since the firm’s capacity is exhausted by the demand for the primary product, no capacity will be devoted to the alternative use. Thus, the firm’s continuation profit from retaining a technology of type $\theta_1$, denoted $\Pi^O_2(r; \theta_1)$, is given by: $\Pi^O_2(r; \theta_1) = N[V - (1 - \theta_1)L_P^O - (1 - \theta_1)L_D^O] = N[V - (1 - \theta_1)L_O]$. Notice that, because the consumer adjusts her willingness to pay to account for her potential downstream losses, the firm faces the full loss $L^O$.

If the technology has been replaced, then it is common knowledge that neither the firm nor the consumer knows the true value of $\theta_2$. In this case, the consumer’s maximum willingness to pay for the good is $V - (1 - \mu)L_P^O$. The firm will set $p_2 = V - (1 - \mu)L_P^O$ and each consumer will buy one unit. The firm’s continuation profit from acquiring a new technology, denoted $\Pi^O_2(n)$, is given by: $\Pi^O_2(n) = N[V - (1 - \mu)L_P^O - (1 - \mu)L_D^O] - t = N[V - (1 - \mu)L_O] - t$.

In making its retention decision at the beginning of Period 2, the firm compares $\Pi^O_2(r; \theta_1)$ to $\Pi^O_2(n)$, and retains the Period 1 technology whenever $\Pi^O_2(r; \theta_1) \geq \Pi^O_2(n)$; that is, whenever:

$$\theta_1 \geq \theta^O = \mu - t/NL^O. \quad (1)$$

Given this retention rule, the firm’s expected continuation profits from the beginning of Period 2 is:

$$E \Pi^O_2 = \Pi^O_2(n)G(\theta^O) + \int_0^{\theta^O} \Pi^O_2(r; \theta_1)g(\theta_1)d\theta_1,$$

$$= \{N[V - (1 - \mu)L_O] - t\}G(\theta^O) + \int_0^{\theta^O} N[V - (1 - \theta_1)L_O]g(\theta_1)d\theta_1. \quad (2)$$
where $\int^0$ indicates that the domain of integration is $[\theta^0, \bar{\theta}]$.

The analysis of Period 1 is quite straightforward, since this period looks exactly like Period 2 when the firm acquires a new technology. Thus, the firm’s profit from Period 1 on (that is, the two-period profit under the O regime, gross of any monitoring costs it must pay to credibly commit to O), denoted $\Pi^0_1$, is given by:

$$\Pi^0_1 = N[V - (1 - \mu)L^0] - t + E\Pi^0_2$$

$$= \{N[V - (1 - \mu)L^0] - t\}(1 + G(\theta^0)) + \int^0 N[V - (1 - \theta)L^0]g(\theta)d\theta.$$  \hspace{1cm} (3)

**Equilibrium in a Regime of Confidentiality**

Again, we begin with Period 2. We sketch the derivation of a revealing perfect Bayesian equilibrium; a formal statement is in the Appendix while the proof is in the Web Appendix. Recall that in a regime of confidentiality, information regarding Period 1 suits is not observable to consumers in Period 2, as it has been suppressed through the use of confidentiality agreements. Thus, if the technology has been retained, Period 2 consumers need to form beliefs about the product’s safety based on choices made by the firm that are observable to Period 2 consumers. These are (1) the firm’s decision to retain the technology, and (2) the firm’s choice of price for Period 2.

We assume that, upon observing that the firm has retained the technology from Period 1, consumers believe that the firm’s type belongs to an interval $[\Theta, \bar{\Theta}]$; that is, the marginally-retained technology is of type $\Theta$. Thus, consumers believe that the firm would have retained the technology if its quality were sufficiently high. Moreover, upon observing that the firm is charging $p_2$, consumers believe that the firm’s type is $b(p_2; \Theta)$. Since we will be characterizing a revealing equilibrium, we employ “point beliefs” by specifying that $b$ is a singleton rather than a set. In a
revealing equilibrium, the beliefs \(b(\cdot; \Theta)\) will be correct, as will the conjectured value of \(\Theta\).

Since each firm would be tempted to inflate its price (if the consumer were to purchase a unit for sure at every price), the consumer must respond to higher prices with increasing “wariness.” That is, the consumer must confront higher prices with a lower probability of concluding a sale. Let \(s(p_2; \Theta)\) denote the probability of a sale when the firm charges \(p_2\), given the conjectured value of \(\Theta\). The firm’s continuation payoff from retaining a technology of type \(\theta_1\), denoted \(\Pi^C_2(r; \theta_1, \Theta)\), is:

\[
\Pi^C_2(r; \theta_1, \Theta) = \max_{p_2} Ns(p_2; \Theta)[p_2 - (1 - \theta_1)L^C_\theta] + N(1 - s(p_2; \Theta))\beta\theta_1. \tag{4}
\]

The firm uses \(Ns(p_2; \Theta)\) units of capacity to produce the primary product, and the remaining \(N(1 - s(p_2; \Theta))\) units of capacity on the alternative activity, where each capacity unit yields a payoff of \(\beta\theta_1\).

The first-order-condition for the firm’s problem is:

\[
s'[p_2 - (1 - \theta_1)L^C_\theta - \beta\theta_1] + s = 0, \tag{5}
\]

where \(s'\) denotes the derivative of \(s(p_2; \Theta)\) with respect to \(p_2\). A consumer (who must randomize in a revealing equilibrium) will only be willing to randomize if she is indifferent about buying; that is, if \(V - (1 - b(p_2; \Theta))L^C_\theta - p_2 = 0\). Thus, the revealing equilibrium price must be \(p_2 = p_2^*(\theta_1) = V - (1 - \theta_1)L^C_\theta\). In order to convert equation (5) to a differential equation in \(p_2\), we can solve for \(\theta_1\) as a function of \(p_2\) to obtain \(\theta_1 = (L^C_\theta - V + p_2)/L^C_\theta\). Substituting this result into equation (5) yields an ordinary differential equation for \(s(p_2; \Theta)\):

\[
s'[p_2(L^C_\theta - \beta) + \beta V - \beta L^C_\theta - VL^C_\theta] + sL^C_\theta = 0. \tag{6}
\]

We also need a boundary condition to select among the family of solutions to the ordinary differential equation (6). Since the consumer believes that \(\Theta\) is the worst type that would have been retained, she anticipates strictly positive surplus from any out-of-equilibrium price \(p_2 < p_2^*(\Theta) = V - (1 - \Theta)L^C_\theta\), and thus would buy with probability 1 at such a price. This in turn implies that she must
buy with probability 1 at $p^*_2(\Theta)$ as well for, if she did not, then type $\Theta$ could profitably deviate to some $p_2 < p^*_2(\Theta)$. Thus, the appropriate boundary condition is $s(p^*_2(\Theta); \Theta) = 1$. The solution to the ordinary differential equation (6) through this boundary condition is given by:

$$s(p_2; \Theta) = \left\{ \frac{[p^*_2(\Theta)(L^C - \beta) + \beta V - \beta L^C - \gamma L_D^C]/[p_2(L^C - \beta) + \beta V - \beta L^C - \gamma L_D^C]}{\alpha} \right\}$$

(7)

where $\alpha = L^C_p/(L^C - \beta) > 1$ under our maintained assumption that $\beta > L^C_D$. It can be shown that the function $s(p_2; \Theta)$ is declining and convex in $p_2$. Upon substituting the firm’s optimal price function $p^*_2(\theta_1) = V - (1 - \theta_1)L^C_p$ into equation (7) and simplifying, we can write the equilibrium probability of a sale as a function of the firm’s type. Let $s^*(\theta_1; \Theta) = s(p^*_2(\theta_1); \Theta)$; then:

$$s^*(\theta_1; \Theta) = \left\{ \frac{[V - (1 - \Theta)L^C - \beta\Theta)]/[V - (1 - \Theta)L^C - \beta\Theta]}{\alpha} \right\}$$

(8)

Observe what $s^*(\theta_1; \Theta)$ entails. First, consider the ratio inside the braces. The numerator is the net social value associated with one unit produced by the marginally-retained type of technology; this is also the net unit profit for the firm’s product (since welfare and profit are the same for this unit-demand analysis). Likewise, the denominator is the net unit profit for the firm’s product for a retained technology of type $\theta_1 > \Theta$. Thus, this ratio is a fraction, the purpose of which is to reduce the incentive for mimicry of high-type firms by low-type firms. However, what the analysis tells us is that this degree of wariness by the consumer is not sufficient to deter mimicry. The exponent, $\alpha$, which is $L^C_p/(L^C - \beta)$, reflects both the losses borne by the consumer (and greater losses should make her more wary) as well as the degree of sensitivity of the firm to the consumer’s means for responding to price increases. Higher $\beta$ means that the firm’s alternative use of the technology is proportionally more profitable, making the loss of a sale in response to a price increase less costly. Recognizing this means that the consumer must be yet more wary. This is why $\alpha$, which is greater than one, further amplifies the effect of the ratio inside the braces, so as to further deter mimicry.
Since this is the unique revealing equilibrium, the resulting response by the consumer is both necessary and sufficient to achieve revelation in equilibrium. As will be seen in Section 6, if $\beta$ is too low ($\beta < L^C_D$), then higher types of the firm will be overly-sensitive to the loss of sales due to a price increase (which would reveal their higher safety), and pooling will result.

We can re-write the firm’s continuation profits as:

$$\Pi_c^C(r; \theta_1, \Theta) = Ns^*(\theta_1; \Theta)[p_2^*(\theta_1) - (1 - \theta_1)L^C_D] + N[1 - s^*(\theta_1; \Theta)]\beta \theta_1$$

$$= Ns^*(\theta_1; \Theta)[V - (1 - \theta_1)L^C - \beta \theta_1] + N\beta \theta_1,$$

where $s^*(\theta_1; \Theta)$ is as given in equation (8). The equilibrium profits are increasing in $\theta_1$; that is, firms with safer products (equivalently, higher-quality technologies) make higher profits, despite the fact that they face demand withdrawal from wary consumers.

Since firm profits are increasing in type, the form of the consumer’s beliefs about retention is confirmed: firms with higher-quality technologies will retain them, while firms with sufficiently low-quality technologies will replace them. If the technology was replaced rather than retained, then it is common knowledge that neither the firm nor the consumer knows the true value of $\theta_2$.

Analogously to this case in the $O$ regime, the consumer’s maximum willingness to pay for the good is $V - (1 - \mu)L^C_P$, the firm sets $p_2 = V - (1 - \mu)L^C_P$ and each consumer buys one unit. The firm’s continuation profit from acquiring a new technology is: $\Pi_c^C(n) = N[V - (1 - \mu)L^C] - t$.

To determine the type of the worst technology retained, we need to find $\theta^C$ such that $\Pi_c^C(r; \theta^C, \Theta^C) = \Pi_c^C(n)$. That is, if the consumer conjectures that $\theta^C$ is the worst type of technology retained, then the firm must be indifferent between retaining and replacing that type. Since $s(p_2^*(\theta^C); \Theta^C) = 1$, $\Pi_c^C(r; \theta^C, \Theta^C) = N[p_2^*(\theta^C) - (1 - \theta^C)L^C_D] = N[V - (1 - \theta^C)L^C_P - (1 - \theta^C)L^C_D] = N[V - (1 - \theta^C)L^C]$. Setting this equal to $\Pi_c^C(n)$ and solving for $\theta^C$ yields:
\[ \theta^C = \mu - t/NL^C. \]  

Thus, under confidentiality, the firm retains the technology if \( \theta_1 \geq \theta^C \), and otherwise replaces it.

Upon substituting \( \Theta = \theta^C \) into equation (8), we can finally write the reduced-form equilibrium probability of a sale as a function of firm type \( \theta_1 \) as follows:

\[ s^*(\theta_1; \theta^C) = \left\{ \frac{[V - (1 - \theta^C)L^C - \beta \theta^C]}{[V - (1 - \theta_1)L^C - \beta \theta_1]} \right\}^a. \]  

The following proposition (which is proved in the Web Appendix) summarizes the impact of several parameters on the equilibrium probability of a sale.

**Proposition 1.** The equilibrium probability of a sale is decreasing and convex in its argument \( \theta_1 \); moreover, it is increasing in \( V \), \( N \) and \( \mu \) and decreasing in \( \beta \) and \( t \).

The parameters \( V \) and \( \beta \) enter \( s^* \) directly; an increase in \( V \) makes the consumer less wary while (as discussed earlier) an increase in \( \beta \) increases the incentive for low types to mimic high types, thereby increasing the consumer’s wariness. \( N \), \( \mu \) and \( t \) enter indirectly via \( \theta^C \); since consumers are less wary when \( \theta^C \) is higher, increases in \( N \) and \( \mu \) increase \( s^* \) while increases in \( t \) reduce \( s^* \). Revealing equilibria do not normally depend on the distribution function (here, \( G \)), but only on the support (here, \( [\theta, \bar{\theta}] \)). However, in this case the consumer’s beliefs about the support have been updated (i.e., the type space is determined endogenously in this model), and the resulting probability of sale function \( s^*(\theta_1; \theta^C) \) now depends on other attributes of the distribution (here, \( \mu \)) through \( \theta^C \).

Given the retention rule and the equilibrium strategies \( p^*_2(\theta_1) \) and \( s^*(\theta_1; \theta^C) \), we can write the firm’s expected continuation profits from the beginning of Period 2 as:

\[
\begin{align*}
E \Pi^*_2 &= \Pi^*_2(n)G(\theta^C) + \int^C \Pi^*_2(r; \theta_1, \theta^C)g(\theta_1)d\theta_1 \\
&= \{N[V - (1 - \mu)L^C] - t\}G(\theta^C) \\
&\quad + \int^C \{Ns^*(\theta_1; \theta^C)[V - (1 - \theta_1)L^C] + N[1 - s^*(\theta_1; \theta^C)]\beta \theta_1\}g(\theta_1)d\theta_1.
\end{align*}
\]  

(11)
where $\int^C$ indicates that the domain of integration is $[\theta^C, \tilde{\theta}]$.

Again, the analysis of Period 1 looks exactly like Period 2 when the firm replaces its technology. Thus, the firm’s profit from Period 1 on (in the C regime), denoted $\Pi_1^C$, is given by:

$$\Pi_1^C = N[V - (1 - \mu)L^C] - t + E\Pi_2^C$$

$$= \{N[V - (1 - \mu)L^C] - t\}(1 + G(\theta^C))$$

$$+ \int^C \{N*s*(\theta_1; \theta^C)[V - (1 - \theta_1)L^C] + N[1 - s*(\theta_1; \theta^C)]\beta\theta_1\}g(\theta_1)d\theta_1.$$ (12)

4. Comparison of the Regimes

In this section, we compare the O and C regimes’ ex ante performance in terms of the average quality of the technology in Period 2, the average safety of products sold in Period 2, the volume of trade in Period 2, and the time path of the average safety of products sold. Recall that the retention threshold in regime i is given by $\theta_i = \mu - t/NL_i = \mu - t/N(\delta + \lambda'K_s)$. Proposition 2 summarizes the effect of confidentiality on the decision to replace the technology and the expected costs of R&D.

**Proposition 2.** $\theta^C < (=) \theta^O$ as $\lambda^C < (=) \lambda^O$: the technology retention threshold, and the associated expected R&D investment, are lower in a confidential regime.

The expression $E(\theta_2; \theta^i) = \mu G(\theta^i) + \int^i \theta g(\theta)d\theta$, where the domain of integration is $[\theta^i, \tilde{\theta}]$, denotes the average quality of the technology in Period 2 under regime i. Since $\theta_2 = \theta_1$ when the technology is retained, this can be re-written as:

$$E(\theta_2; \theta^i) = \mu + \int^i (\theta_1 - \mu)g(\theta_1)d\theta_1 = \mu + h(\theta^i),$$

where $h(\theta^i) = \int^i (\theta_1 - \mu)g(\theta_1)d\theta_1$. Since $h(\theta) = 0$ and $h'(\theta^i) = -(\theta^i - \mu)g(\theta^i)$, it follows that $h'(\theta^i) > 0$ (and therefore that $h(\theta^i) > 0$) for all $\theta^i < \mu$. Since $\theta^C < \theta^O < \mu$, the following proposition summarizes the average quality of the technology both within-regime but across periods, and within-
Period 2 but across regimes. This proposition indicates that technology quality improves over time, but less so in a confidential regime than in an open regime.

**Proposition 3.** (a) \( E(\theta_2; \theta^i) > \mu, i = C, O \): the average quality of the technology improves from Period 1 to Period 2. (b) \( E(\theta_2; \theta^c) < (=) E(\theta_2; \theta^o) \) as \( \lambda^c < (=) \lambda^o \): the average quality of the technology in Period 2 is lower in a confidential regime than in an open regime.

A similar question can be asked regarding the average safety of products sold (that is, the quality-weighted number of units sold). In an open regime, this measure in Period 2 is simply \( N \) times the average quality of the technology in Period 2. Let \( \sigma(\theta_2; \theta^o) = N\mu \) if \( \theta_i < \theta^o \) and \( \sigma(\theta_2; \theta^o) = N\theta_i \) if \( \theta_i \geq \theta^o \). Then \( E(\sigma; \theta^o) = N\mu G(\theta^o) + \int^\theta N\theta_i g(\theta_i) d\theta_i = N\mu + Nh(\theta^o) \).

However, since consumers respond to asymmetric information in a C regime by being wary of purchasing (i.e., reducing the likelihood of a sale), the average safety of products sold in Period 2 is more complicated. Let \( \sigma(\theta_2; \theta^c) = N\mu \) if \( \theta_i < \theta^c \) and \( \sigma(\theta_2; \theta^c) = N\theta_i s^*(\theta_i; \theta^c) \) if \( \theta_i \geq \theta^c \). Then \( E(\sigma; \theta^c) \) is the average safety of products sold in Period 2 in a C regime, where:

\[
E(\sigma; \theta^c) = N\mu G(\theta^c) + \int^\theta N\theta_i s^*(\theta_i; \theta^c) g(\theta_i) d\theta_i = N\mu + \int^\theta N[\theta_i s^*(\theta_i; \theta^c) - \mu] g(\theta_i) d\theta_i < N\mu + \int^\theta N[\theta_i - \mu] g(\theta_i) d\theta_i = N\mu + Nh(\theta^c) < N\mu + Nh(\theta^o) = E(\sigma; \theta^o).
\]

This is an interesting measure because it reflects both the decrease in sales volume, and the change in composition, generated by confidentiality. The effect of confidentiality on the average safety of products sold in Period 2 is summarized below.

**Proposition 4.** \( E(\sigma; \theta^c) < E(\sigma; \theta^o) \): the average safety of products sold in Period 2 is lower in a confidential regime than in an open regime.

This result holds even if \( \lambda^c = \lambda^o \). This is because there are two reasons why confidentiality reduces the average safety of products sold in Period 2. First, if \( \lambda^c < \lambda^o \), then the average quality
of technology will be lower in Period 2 under confidentiality (as compared to openness), so if a unit were sure to be produced, it would be of lower average safety. But even if $\lambda^C = \lambda^O$ (so that retention thresholds, R&D expenditures and the average quality of technology in Period 2 are the same for the two regimes), the average safety of products sold in Period 2 will still be lower in a confidential regime due to consumer wariness, since the equilibrium probability of a sale is lower for safer products (since they have higher prices).

Indeed, rational consumer wariness can be so extreme that the average safety of products sold in a confidential regime can actually decrease from Period 1 to Period 2 (we provide examples of this below). To ascertain parameter combinations (in terms of $V$ and $t/N$) under which this is likely to occur, we first note that $E(\sigma; \theta^C) < N\mu$ if and only if $\int C N[\theta_i s(\theta_i; \theta^C) - \mu]g(\theta_i)d\theta_i < 0$.

Let:

$$H(V, t/N) = \int C [\theta_i s(\theta_i; \theta^C) - \mu]g(\theta_i)d\theta_i.$$  

Then the average safety of products sold is the same in both periods when $H(V, t/N) = 0$. Suppose we begin at a parameter pair $(V, t/N)$ at which $H(V, t/N) = 0$. Then, since it can be shown (see the Web Appendix) that $\partial H/\partial V > 0$ and $\partial H/\partial (t/N) < 0$, it follows that the average safety of products sold is more likely to decline from Period 1 to Period 2 when $V$ is low, or when $t/N$ is high. In particular, this means that $H(V, t/N) = 0$ yields an increasing function when graphed in $(V, t/N)$ space.

**Some Examples Illustrating Declining versus Improving Intertemporal Safety Provision**

It is difficult to explore $H$ in more detail analytically, so we use some examples to illustrate this surface between declining and improving intertemporal safety provision. We now fix the region of analysis and the parameter values. Since $0 \leq \theta^C \leq \mu$, this means that $0 \leq t/N L^C \leq \mu$. Further, from Assumption 1, we require $V/L^C > 1$; this is also the economically relevant region, since otherwise
the product potentially generates higher social costs than value. Figure 1 below illustrates these computations, for selected members of the family of Beta distributions (see Johnson and Kotz, 1970, Chapter 24); that is \( G(\theta) = \text{Beta}(\theta; p, q) \), where we have chosen to use the parameter values \((p,q)\) to be \((1,1)\), \((2,2)\), and \((3,3)\). These \((p,q)\) values provide symmetric distributions, all with mean equal to \(\frac{1}{2} \), and with increasing “peakedness,” as illustrated in the left panel of Figure 1 below.

In the figure the density functions are on the left, while (for each \( G \)) the boundary between declining and improving intertemporal safety of the product sold is displayed on the right. For example, the case \((p,q) = (1,1)\) is the uniform density, illustrated on the left of the figure. The curve on the right labeled \((1,1)\), is the resulting \( H = 0 \) locus, which implicitly defines levels of \( t/NLC \), as a function of \( V/LC \), that induce Period 2 average safety of products sold exactly equal to the average safety of products sold in Period 1. Points above this curve are associated (under the uniform distribution) with declining intertemporal safety, while points below this curve are associated (under the uniform distribution) with increasing intertemporal safety. Thus, starting at a point on the curve,
an increase in $t$ results in a higher cost of R&D, a lower threshold $\theta^C$ and a lower value of $s^*(\theta_1; \theta^C)$ at any $\theta_1 > \theta^C$ (see Proposition 1). Such an increase results in sufficient demand reduction to make the average safety of products sold in Period 2 lower than that of Period 1. A reverse effect would occur if we had increased $V$ instead. This same discussion applies for the other densities illustrated.

Figure 1 also suggests that a distribution $\tilde{G}$ which is a mean-preserving spread of $G$ (as, for example, the distribution represented by $(p,q) = (1,1)$ yields a mean-preserving spread of the distribution represented by $(p,q) = (2,2)$) will result in an associated curve in $(V/L^C, t/NL^C)$ space which is everywhere higher than that curve associated with $G$. Unfortunately, we have not been successful in characterizing when (or under what conditions on $G$) mean-preserving spreads provide the dominance suggested by the right-hand-side panel of Figure 1. However, this property is intuitively reasonable. A mean-preserving spread $\tilde{G}$ of $G$ places more weight on high types and on low types than $G$ does. Now consider a specific level of $t/NL^C$ (equivalently, fix a value of $\theta^C$). While a larger proportion of types under $\tilde{G}$ is rejected due to $\theta^C$ than is rejected under $G$, more high types are left, too. Thus, for a given level of $t/NL^C$, $H$ should be larger under $\tilde{G}$ than under $G$ for higher values of $V$. This is the pattern observed above.

5. The Firm’s Choice of Regime

In this section, we compare the firm’s profitability under an open versus a confidential regime. In particular, we ask when a firm would find it profitable to eschew confidentiality in favor of a regime of openness; we will also consider additional factors that affect this choice.

We re-write the firm’s *ex ante* expected profits, indexing profits in the open regime by $\lambda^0$. *Ex ante* expected profits in an open regime, gross of any monitoring costs required to ensure credible commitment to openness, are:
\[
\Pi_1^O(\lambda^O) = \{N[V - (1 - \mu)L^O] - t\} (1 + G(\theta^O)) + \int^O N(V - (1 - \theta)i)L^O g(\theta)i d\theta_i. \tag{14}
\]

Ex ante expected profits in a confidential regime (suppressing \(\lambda^C\), which is held fixed) are:

\[
\Pi_1^C = \{N[V - (1 - \mu)L^C] - t\} (1 + G(\theta^C)) + \int^C \{N s*(\theta_i; \theta^C)[V - (1 - \theta)i]L^C] + N[1 - s*(\theta_i; \theta^C)]\beta(\theta_i)g(\theta_i)d\theta_i, \tag{15}
\]

An open regime involves both costs and benefits relative to a confidential one. The costs of adopting an open regime involve paying more settlements (due to a higher fraction of viable suits), as well as higher R&D costs (due to more frequent replacement of the technology) as compared to a confidential regime. In addition, a public expenditure is required to engage in a credible commitment to openness. On the other hand, a firm adopting a regime of openness need not deal with wary consumers, which is a benefit relative to a confidential regime.

Let \(M(\lambda^O) = \Pi_1^O(\lambda^O) - \Pi_1^C\) represent the maximum amount that a firm would be willing to pay in order to make a credible commitment to openness. When \(\lambda^O = \lambda^C\), then \(L^O = L^C\) and \(\theta^O = \theta^C\), so \(M(\lambda^C) = \Pi_1^O(\lambda^C) - \Pi_1^C = \int^C \{N s*(\theta_i; \theta^C)[V - (1 - \theta)i]L^C\}g(\theta_i)d\theta_i. \) This expression is clearly positive; thus, when openness does not increase the fraction of viable suits in comparison with confidentiality, the firm would be willing to pay \(M(\lambda^C) > 0\) to ensure a credible commitment to openness (e.g., to hire an external auditor). As shown in the Web Appendix, \(M'(\lambda^O) < 0\) and \(M''(\lambda^O) > 0\). While \(M(\lambda^O)\) may remain positive for all \(\lambda^O \in [\lambda^C, 1]\), it might also become negative for sufficiently high \(\lambda^O\). These properties of \(M(\lambda^O)\) are summarized below in Proposition 5.

**Proposition 5.** \(M(\lambda^C) > 0; M'(\lambda^O) < 0\) and \(M''(\lambda^O) > 0\) for all \(\lambda^O \in [\lambda^C, 1]\).

In Figure 2 below, we illustrate two cases. The case in which \(M(\lambda^O)\) remains positive for all \(\lambda^O \in [\lambda^C, 1]\) is illustrated using a solid line, while the case in which \(M(\lambda^O)\) eventually falls below zero is illustrated using a dashed line; in this case, let \(\hat{\lambda}\) be such that \(M(\hat{\lambda}) = 0\). If the actual cost of
Figure 2: Maximum Willingness to Pay for Credible Commitment for Openness

credible monitoring, denoted m, is less than M(λ^O), then the firm itself will choose an open regime. If m > M(λ^O) > 0, then the firm would prefer a regime of openness (if monitoring were costless), but is unwilling to pay the required amount. Finally, if M(λ^O) < 0, then the firm would prefer a confidential regime, even if credible monitoring were costless.

The Impact of Loss-Shifting on the Choice of Regime

In either regime, the firm currently faces an expected loss of L^i for each harmed consumer, while the consumer herself faces an expected loss of L^i if harmed by the product. The combined losses are L^i = δ + λ^iK^p. One variation of interest would be to shift some of the firm’s losses to the consumer, holding total losses constant. For instance, recently-imposed limits on compensatory damages for pain and suffering would have this effect. While the expected harm remains unchanged, the expected award is reduced by the caps.

If some of the firm’s losses were shifted to the consumer, while total losses were held constant, then Π^i^O(λ^O) would be completely unchanged, since it depends on the losses only through L^O, which is being held fixed. On the other hand, Π^i^C depends upon both L^C, which is being held fixed, and on L^C, through the exponent in s*(θ; θ^C), which was denoted by α. Thus, to determine
the effect on $M(\lambda^0; \alpha) = \Pi^0_i(\lambda^0) - \Pi^t_i(\alpha)$ of a shift of losses from D to P, holding total losses fixed, we need only determine the sign of $\partial M/\partial \alpha = -\partial \Pi^t_i/\partial \alpha$. Differentiating equation (15) with respect to $\alpha = L_p^C/(L^C - \beta)$, holding $L^C$ fixed, yields:

$$-\partial \Pi^t_i/\partial \alpha = -\int^t C N(\partial s^*(\theta_i; \theta^C)/\partial \alpha)[V - (1 - \theta_i)L^C - \beta \theta_1]g(\theta_i)d\theta_i.$$  

The integrand is negative for all $\theta_i \in (\theta^C, \bar{\theta})$, since $\partial s^*(\theta_i; \theta^C)/\partial \alpha = s^*(\theta_i; \theta^C)\ln\{[V - (1 - \theta^C)L^C - \beta \theta^C]/[V - (1 - \theta_i)L^C - \beta \theta_1]\} < 0$. Thus, an increase in $L_p^i$, holding $L^i$ fixed (i.e., an increase in $\alpha$), increases $M(\lambda^0; \alpha)$ for all $\lambda^0$. A firm is willing to pay more for openness as $L_p^C$ increases because this shift makes consumers more wary, and the further reduction in their purchases (in a C regime) makes confidentiality less appealing. Alternatively, a shift of losses from P to D (through shifting of settlement costs or awarding multiple damages) will reduce consumer wariness and thus make confidentiality more attractive to the firm.

**Impact of Liability for Third-Party Harms on the Firm’s Choice of Regime**

If a product is subject to failure causing harm, it need not harm only those who purchased the product. Often there will be innocent bystanders or other third parties who are also harmed. For instance, when a defective gun misfires, both the user and nearby individuals are at risk. Similarly, when a defective part in an automobile fails, the resulting crash may injure both the driver and third parties (passengers, people in other vehicles, pedestrians). According to tort law for products liability, “... the courts have almost unanimously allowed recovery for bystanders where injury to them is reasonably foreseeable, ...” (See Keeton, et. al., 1989, p. 179).

We could define parameters for third-party victims that are analogous to $\delta$ and $\lambda^i$, which would result in expressions analogous to $L_p^i$, $L_d^i$ and $L^i$, but this complicates the exposition unnecessarily. Rather, we will assume that these parameters are the same for consumer victims and
third-party victims, and we will simply assume that the consumption of one unit by a consumer exposes an additional $\phi$ individuals to the same risk of harm. This interpretation allows us to simply substitute $\bar{L}_D = (1 + \phi)L_D$ into the profit functions. The consumer still faces the same $L^i_p$, so $\bar{L}^i = L^i_p$ + $\bar{L}_D^i$ = $L^i_p$ + $(1 + \phi)L_D^i$. Moreover, each of the $\phi$ individuals per consumer also faces a loss of $L^i_p$, which does not get transmitted back through the market or the legal system to the firm. Thus, we can conclude immediately that $\partial \theta^i/\partial \phi > 0$; an increase in third-party exposure increases the retention threshold. However, since the uncompensated losses borne by the third parties are not reflected in market prices or firm liability costs, the retention threshold increases less than it should. Note that, in order to preserve the existence of a revealing equilibrium, we now must have $\beta > \bar{L}_D^i$.

We can now write the firm’s maximum willingness to pay for a credible commitment to openness as $M(\lambda^o; \phi) = \Pi^o_i(\lambda^o; \phi) - \Pi^c_i(\phi)$ and ask how an increase in $\phi$ (that is, greater liability for third-party losses) affects the firm’s preference between the O and C regimes. First note that $M(\lambda^o; \phi)$ is of the same form as before (except that $L^i$ and $L_D^i$ have been replaced by $\bar{L}^i$ and $\bar{L}_D^i$). Thus, for any fixed value of $\phi$ the graph of $M(\lambda^o; \phi)$ looks similar to that displayed in Figure 2. Notice also that $\Pi^c_i(\phi)$ can be re-written as follows:

$$\Pi^c_i(\phi) = \Pi^c_i(\lambda^c; \phi) - \int^c N[1 - s^*(\theta_1; \theta^c)] [V - (1 - \theta_1)\bar{L}^c - \beta \theta_1] g(\theta_i) d\theta_i. \quad (17)$$

This implies that $M(\lambda^o; \phi)$ is of the form:

$$M(\lambda^o; \phi) = \Pi^o_i(\lambda^o; \phi) - \Pi^c_i(\lambda^c; \phi)$$

$$+ \int^c N[1 - s^*(\theta_1; \theta^c)] [V - (1 - \theta_1)\bar{L}^c - \beta \theta_1] g(\theta_i) d\theta_i. \quad (18)$$

While we are unable to determine the sign of $\partial M(\lambda^o; \phi)/\partial \phi$ for all values of $\lambda^o$, we can provide sufficient conditions for $\partial M(\lambda^o; \phi)/\partial \phi < 0$ for $\lambda^o$ sufficiently close to $\lambda^c$. The derivatives of the first two terms in equation (18) cancel out when $\lambda^o = \lambda^c$; moreover, the derivative involving
the lower limit of integration in the third term is also zero (upon recalling that 1 - s*(θC; θC) = 0). Since the second bracketed term in the integrand is decreasing in φ, the derivative of the integrand will be negative if ∂s*(θ1; θC)/∂φ ≥ 0. This derivative is actually quite complex, since s*(θ1; θC) depends on \( \bar{\Gamma}_C = L_pC + (1 + \phi)L_D C \) directly, through \( \theta_C = \mu - t/N\bar{\Gamma}_C \) and through \( \alpha = L_pC/(\bar{\Gamma}_C - \beta) \). In the Web Appendix we derive a sufficient condition for \( \partial s(\theta_1; \theta_C)/\partial \phi \geq 0 \) for all \( \theta_1 \in [\theta_C, \bar{\theta}] \).

Under the condition that \( \partial s(\theta_1; \theta_C)/\partial \phi \geq 0 \) for all \( \theta_1 \), an increase in the firm’s liability costs associated with third-party harms permits the consumers to moderate their wariness. Essentially, incentives for the firm to reveal its type come from two sources: lawsuits (either from consumers or third parties) and demand reduction on the part of consumers. When the firm faces higher costs of dealing with third parties’ lawsuits, the consumers need not engage in as much demand reduction; they can “free ride” on the third-party lawsuits. This reduction in consumer wariness increases the firm’s sales in a C regime, making confidentiality more profitable, at least for \( \lambda_C^0 \) in a neighborhood of \( \lambda_C \). While this intuition seems plausible as \( \lambda_C^0 \) increases, we are unable to sign \( \partial^2 M(\lambda_C^0; \phi)/\partial \lambda_C^0 \partial \phi = \partial^2 \Pi(\lambda_C^0; \phi)/\partial \lambda_C^0 \partial \phi \), whose dependence on \( \lambda_C^0 \) is complex.

6. Analysis of the Confidential Regime when \( \beta < L_D C \)

In the interests of brevity, we now report on the case of \( \beta < L_D C \), wherein a revealing equilibrium fails to exist (See Claim 2 in the Appendix; complete details of this analysis, and associated proofs, are provided in the Web Appendix). Let \( \mu(\Theta) = \int \theta_1 g(\theta_1) d\theta_1/(1 - G(\Theta)) \), where the integration is over \( \theta_1 \in [\Theta, \bar{\Theta}] \), be the expected value of \( \theta_1 \) when the consumer believes \( \theta_1 \in [\Theta, \bar{\Theta}] \). In the pooling case, the consumer’s equilibrium beliefs are of the form \( \theta_1 \in [\theta_C^P, \bar{\theta}] \), where \( \theta_C^P \) equates the firm’s profits if the input is retained to those if it replaces the input at a cost of t:

\[
N[V - (1 - \mu(\theta_C^P))L_pC - (1 - \theta_C^P)L_D C] = N[V - (1 - \mu)L_C] - t.
\] (20)
Since $N[V - (1 - \mu(\theta^C))L_P - (1 - \theta^C)L_D] > N[V - (1 - \mu)L^C] - t$, equation (20) implies that the retention threshold when $\beta < L_D$ (i.e., in the pooling equilibrium) is yet lower than the retention threshold when $\beta > L_D$ (i.e., in the revealing equilibrium); that is, $\theta^{CP} < \theta^C$, and thus, $\theta^{CP} < \theta^0$. All of the previous propositions apply to the pooling case, and $M(\lambda^0)$ is as depicted earlier.

7. Summary and Policy Implications

We provide a simple model illustrating the tradeoffs facing a firm choosing between a regime of open versus confidential settlements. Focusing on the revealing equilibrium, we find that an open regime involves higher liability costs and higher R&D costs, while a confidential regime involves consumer wariness, which exacts a cost associated with signaling safety. We identify circumstances under which the firm would be willing to pay for a credible commitment to openness.

Is it reasonable to posit firms paying for independent auditing to guarantee credibility of a commitment to openness? As mentioned in the Introduction, in the GE-Westinghouse competition in large turbine generators in the 1960’s and 1970’s, GE ended up doing just that: they employed an accounting firm to monitor all contracts and provide independent authority that GE was adhering to an announced “most-favored-customer” policy which gave full rebates to early buyers from any price cuts provided to later buyers. This was the means by which GE and Westinghouse stabilized otherwise intense price competition which repeatedly had involved secret price concessions.21

We have taken the liability regime as given (strict liability, in which the firm is allocated the liability for harm caused). However, the use of the court system is costly in this model. In the case of two parties in an open regime, the market would transfer liability even if it were not nominally imposed on the firm, suggesting perhaps that one should not assign liability to the firm. But this is a misleading special case. In the two-party case in a confidential regime, shifting liability to
consumers worsens consumer wariness. While the retention decision still reflects the full social costs, the volume of trade will be further reduced. In the three-party case in either regime, the retention threshold is already too low, and would be made worse if the firm bears no liability. Moreover, the effect on the volume of trade in a confidential regime is even worse, since firm liability for third party harms substitutes for consumer wariness; without this liability, consumer wariness would increase. Finally, we note that some markets may involve downward-sloping demand, in which case the marginal unit produced should reflect the full social costs.

At the beginning of the paper we noted that judges and legislatures are considering banning confidentiality. Both the feasibility and the optimality of banning confidentiality are problematical. In order to truly eliminate confidentiality, courts would have to refuse to seal documents and settlements. In addition, they would have to refuse to enforce private contracts of silence. Otherwise, confidential settlements would simply be pushed into this area of contracts, where they would be subject to even less judicial oversight.22

Under what circumstances might it be welfare-improving to ban confidentiality? While our simple model is inadequate to provide a full answer, some suggestive results emerge. Again we focus on the revealing equilibrium for brevity (and some results, which we note below, differ for the pooling equilibrium). For the two-party case, the firm’s retention choice is based on full liability costs, so it chooses the correct threshold in both regimes.23 Moreover, since the firm extracts all the surplus, confidentiality (and the concomitant lower product quality) can be Pareto superior to openness. If the firm’s willingness to pay for openness is positive, the firm itself would presumably support a ban on confidentiality, while it would oppose such a ban when it prefers confidentiality.

For the three-party case, the firm’s retention choice is not based on full liability costs (since
third parties bear uncompensated losses), so the resulting threshold is too low in both regimes. Preferences of the parties are complicated. Third parties always prefer an open regime, conditional on being harmed; they also always prefer an open regime in the pooling equilibrium, and thus confidentiality cannot be Pareto superior in that case. However, in the revealing equilibrium, on an *ex ante* basis, third parties prefer confidentiality when \( \lambda^O \) is close to \( \lambda^C \). This is because the extent of third party recovery is the same, but consumer wariness in the confidential regime reduces the exposure of third parties to harm. Third parties’ preference for confidentiality occurs in the portion of the parameter space wherein the firm and the consumer (weakly) prefer an open regime.

When \( \lambda^O \) is substantially larger than \( \lambda^C \), it seems likely that third parties will, *ex ante*, prefer openness, yet this is the portion of the parameter space wherein the firm and the consumer (weakly) prefer confidentiality. Thus, confidentiality seems unlikely to be Pareto superior to openness.

Finally, casual observation indicates that, from the perspective of products liability: 1) few (if any) firms commit to openness; and 2) most consumers (if newspaper accounts and recent legislative ire are indicative) are only now becoming aware of confidentiality’s widespread use. Increasing awareness of the widespread use of confidentiality suggests that consumers will become more wary. Firms employing confidentiality can then expect to suffer either reduced demand (in the case of the revealing equilibrium), or a lower expected second-period price (in the case of the pooling equilibrium). Thus, firms should increasingly find it preferable to eschew confidentiality, and they could be assisted by the private provision of specialized auditing services, by well-tailored sunshine laws and by increased judicial restraint with respect to issuing protective and sealing orders, all of which would lower the cost of achieving a credible commitment to openness.
References


Herrnreiter v. Chicago Housing Authority, 281 F.3d 634, 636-637 (7th Circuit, 2002).


Appendix A

Definition. A perfect Bayesian equilibrium (in a confidential regime) consists of:
(a) beliefs $\Theta$ and $b(p_2; \Theta) \in [\Theta, \bar{\Theta}]$ for the consumer;
(b) a probability of sale function $s(p_2; \Theta)$ for the consumer; and
(c) a retention threshold $\theta^C$ and a price function $p^*_2(\theta_i)$ for retained technologies such that:
(i) $s(p_2; \Theta)$ maximizes the consumer’s expected payoff, given her beliefs $\Theta$ and $b(p_2; \Theta)$;
(ii) $p^*_2(\theta_i)$ and the retention threshold $\theta^C$ maximize the firm’s expected payoff, given $s(p_2; \Theta)$; and
(iii) beliefs are correct in equilibrium; that is, $\Theta = \theta^C$ and $b(p^*_2(\theta_i); \theta_i) = \theta_i$ for all $\theta_i \in [\theta^C, \bar{\Theta}]$.

Claim 1. When $\beta > L^C_D$, then: (a) The following beliefs and strategies provide a revealing perfect Bayesian equilibrium in a confidential regime; and (b) this is the unique perfect Bayesian equilibrium that survives refinement using $D_1$ (Cho and Kreps, 1987).
(i) Upon observing that the technology was retained, the consumer believes that $\Theta = \mu - t/NL^C$. Upon observing a price $p_2 \in [V - (1 - \Theta)L^C_p, V - (1 - \bar{\Theta})L^C_p]$, the consumer believes that $\theta_1$ is given by $b(p_2; \Theta) = 1 - (V - p_2)/L^C_p$. Upon observing a price outside this interval, the consumer’s beliefs are arbitrary elements of $[\Theta, \bar{\Theta}]$.
(ii) The probability of sale function is $s(p_2; \Theta) = \{A/B\}^\alpha$, where $A = V - (1 - \Theta)L^C_p + [\beta V - \beta L^C_p - VL^C_p]/[L^C_p - \beta]$, $B = p_2 + [\beta V - BL^C_p - VL^C_p]/[L^C_p - \beta]$, and $\alpha = L^C_p/(L^C_p - \beta) > 1$, for $p_2 \in [V - (1 - \Theta)L^C_p, V - (1 - \bar{\Theta})L^C_p]$. Note that $A > 0$, $B > 0$ and $B > A$ for all $p_2 \in [V - (1 - \Theta)L^C_p, V - (1 - \bar{\Theta})L^C_p]$. For $p_2 < V - (1 - \Theta)L^C_p$, the probability of sale is $s(p_2; \Theta) = 1$ and for $p_2 > V - (1 - \bar{\Theta})L^C_p$, the probability of sale is $s(p_2; \Theta) = 0$.
(iii) The retention threshold is $\theta^C = \mu - t/NL^C$; that is, technologies with $\theta_1 < \mu - t/NL^C$ are replaced, while those with $\theta_1 \geq \mu - t/NL^C$ are retained. The price function for products produced by retained technologies is $p^*_2(\theta_i) = V - (1 - \theta_1)L^C_p$ for $\theta_i \in [\theta^C, \bar{\Theta}]$.

Claim 2. When $\beta < L^C_D$, then any perfect Bayesian equilibrium must involve pure pooling. The following beliefs and strategies provide a perfect Bayesian equilibrium that survives $D_1$. Technically, any price $p_2 \in [V - (1 - \Theta)L^C_p, V - (1 - \Theta)L^C_p]$ can be supported as a PBE since upward deviations are inferred to come from type $\theta^{CP}$, and are therefore rejected. However, the PBE specified below is the natural analog of that characterized in Section 3.
(i) Upon observing that the technology was retained, the consumer believes that $\Theta = \theta^{CP}$, which is defined implicitly (and uniquely) by $N[V - (1 - \mu(\theta^{CP}))L^C_p, V - (1 - \Theta)L^C_p] = N[V - (1 - \mu)L^C_p]$ - $t$. Upon observing the price $p_2 = V - (1 - \mu(\theta^{CP}))L^C_p$, the consumer believes $\theta_1 \in [\theta^{CP}, \bar{\Theta}]$ and is distributed according to $g(\theta_1)/(1 - G(\theta^{CP}))$ on this interval. Upon observing a price $p_2 < V - (1 - \mu(\theta^{CP}))L^C_p$, the consumer may entertain arbitrary beliefs, and upon observing a price $p_2 > V - (1 - \mu(\theta^{CP}))L^C_p$, the consumer believes that $\theta_1 = \Theta = \theta^{CP}$.
(ii) The consumer buys with probability one for $p_2 = V - (1 - \mu(\theta^{CP}))L^C_p$, and buys with probability zero for $p_2 > V - (1 - \mu(\theta^{CP}))L^C_p$. The consumer buys according to her beliefs for $p_2 < V - (1 - \mu(\theta^{CP}))L^C_p$ (since she buys for sure at $p_2 = V - (1 - \mu(\theta^{CP}))L^C_p$, no firm type will ever price lower).
(iii) The retention threshold is $\theta^{CP}$ as defined above; that is, technologies with $\theta_1 < \theta^{CP}$ are replaced, while those with $\theta_1 \geq \theta^{CP}$ are retained. The price function for products produced by retained technologies is $p^*_2(\theta_i) = V - (1 - \mu(\theta^{CP}))L^C_p$, for all $\theta_i \in [\theta^{CP}, \bar{\Theta}]$. 

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Endnotes


2. See Hare, et. al., (1988), a text for attorneys on obtaining/opposing confidentiality orders; they indicate that seeking such orders in products liability cases is “routine.” See also Nissen (1994).

3. See *Boston Globe* (2002) on the employment of confidential settlements by the Catholic Archdiocese of Boston. Weiser and Walsh (1988a,b,c,d) unearthed a number of examples wherein confidential settlements have been used, including: products liability in the automobile (GM’s gas tank placement) and pharmaceutical (Pfizer’s Feldene and McNeil’s Zomax) industries; professional malpractice (by doctors, nurses, lawyers and hospitals); safety hazards in public facilities; and race- and sex-based employment discrimination cases.

4. An example of a firm paying for a credible commitment to openness is discussed in Porter and Ghemawat (1980) and Porter (1980a,b); we return to this example in Section 7 below.

5. See, for example, Collins (2002). Such court-instigated changes, and some recently-considered state “sunshine” statutes (with the exception of one enacted in Texas), generally do not apply to unfiled agreements (see Gale Group, 2003). Thus, contracts of silence with penalties for breach would likely still be enforceable.

6. In addition, some argue that using courts to resolve private settlement contract disputes implies a public right of access to judicial proceedings; see, Dore (1999) and *Herrnreiter v. Chicago Housing Authority*, 281 F.3d 634, 636-637 (7th Circuit, 2002).

7. Milgrom and Roberts (1986) first considered a formal model of a monopoly signaling unobservable quality via price and advertising; see also Hertzendorf (1993), which assumes imperfectly-observed advertising. Some papers have considered quality signaling via price and advertising when there are competitive forces, either because of entry deterrence considerations (e.g., Linnemer, 1998) or in response to existing rivalry (e.g., Hertzendorf and Overgaard, 2001, and Fluet and Garella, 2002).

8. If this activity involves production of an alternative product, we assume that its sale takes place after the primary product has been sold. That is, consumers of the primary product cannot observe θ by monitoring the alternative activity prior to making their purchase decisions.

9. We also assume that the firm has a managerial capacity of N, so it will only run one “plant.”

10. If harm is stochastic, but verifiable at settlement, then δ can be viewed as the expected harm.
11. This paper takes the liability regime as given. Although scholars, judges and policymakers have debated the desirability of “tinkering” with the system around the margins (e.g., with respect to confidentiality, and various marginal re-allocations of liability through damages caps and fee-shifting), to our knowledge there is no serious contemplation of wholesale changes in the allocation of liability or in the use of settlement as alternative dispute resolution. There are many arguments that support allocating liability for harm to the firm (when its choices govern safety; see, e.g., Shavell, 1987). Since the liability system is generated by broader considerations than are captured in our simplified model of a single market (and broader, even, than economic considerations), it seems appropriate to treat it as exogenous here.

12. Since settlement and litigation are represented by a complete information game, there will be no trials. Empirically, a high percentage of suits result in settlement (or are withdrawn); see Gross and Syverud (1996) or Dore (1999). Theoretically, the model could be extended to allow for settlement bargaining failure, such as might result under asymmetric information (e.g., if the level of damages were private information for each plaintiff); see Hay and Spier (1998) or Daughety (2000) for surveys of this literature. The possibility of trial would mean that even under confidentiality, there would be some possibility of consumers using this to update their estimate of \( \theta \), which would substantially complicate the analysis of the model; we abstract from this possibility.

13. Under the assumption of a large, but finite, number of consumers, the estimate of \( \theta \) will be inexact. Alternatively, we could assume a continuum of consumers of measure \( N \); in this case, the estimate of \( \theta \) will be exact. While the model can accommodate either interpretation, we will treat the estimate of \( \theta \) as exact, but continue to speak of \( N \) as the “number” of consumers because this is less technical and more intuitive.

14. Here D’s disagreement payoff does not include effects on his continuation payoffs. None arise in an open regime (or in Period 2 in either regime). We abstract from such effects in a confidential regime as well, under the assumption that any single P choosing trial has a negligible effect on \( \lambda^C \) and on the consumer’s estimate of \( \theta \) (e.g., trial establishes that D’s product harmed this P, but does not reveal the extent of others who might have been harmed). Alternatively, if D has all the bargaining power, each P settles for her disagreement payoff (D’s disagreement payoff is irrelevant).

15. For example, if there exists \( \theta' > \theta \) such that \( V - (1 - \theta)\lambda^C - \beta\theta < 0 \) for all \( \theta \in [\theta, \theta') \), then none of the analysis below would change, provided that \( \theta' < \theta^c \), a cutoff level to be determined in the discussion of the incomplete information model of the confidentiality regime. If \( \theta' > \theta^c \), that analysis would be substantially more complex.

16. While consumers harmed in Period 1 who did not have viable suits are not constrained by a confidentiality agreement, neither can they prove their harm was due to use of the product.

17. These out-of-equilibrium beliefs (\( b(p_2; \Theta) \in [\Theta, \hat{\Theta}] \)) assume that the retention decision was made correctly, but an error in pricing occurred. If an error were made in retention instead, the firm has the ability subsequently to choose the best price in the range of those expected by the consumer, which would be \( p_2^*(\Theta) \) for any \( \theta_1 < \Theta \), at which a sale to the consumer is certain (and more profitable than a sure sale at any \( p_2 < p_2^*(\Theta) \)). Thus, assuming that the probability of double-
mistakes is zero, it is reasonable to make this assumption about beliefs.

18. In the computations below: 1) $1 < V/L^C < 3$; 2) $L_p^C/L^C = 0.5$; and 3) $[\Theta, \bar{\Theta}] = [0, 1]$. Note that $L_p^C/L^C = 0.5$ and $\beta > L_p^C$ implies that $\beta/L^C > 0.5$; we have chosen to use $\beta/L^C = 0.6$. Runs with higher values of $\beta/L^C$ gave very similar results. The calculations were performed using Mathematica 4.2.

19. In the Web Appendix we investigate some Beta distributions which are left- or right-skewed, and they evidence the same mean-preserving-spread property for the associated $H = 0$ curves.

20. This condition is $-(V - L^C)\ln\{(V - L^C)/(V - \bar{\beta})\} - (\bar{\beta} - \beta) + (t/N)((\bar{\beta} - \beta)/\bar{L}^C)^2 \geq 0$. This is a very strong (but non-empty) sufficient condition, ensuring against the worst of the worst-case scenarios, namely when $\mu$ is as small as possible (i.e., $\mu = t/NL^C$), making $\Theta^C = 0$, and when $\bar{\Theta} = 1$.


22. But see Weiser (1989) for an example of the use of judicially-supervised sealing that prevented information about leaks of trichloroethylene, a suspected carcinogen, by the Xerox Corporation’s Webster (NY) plant, into the groundwater. The court’s sealing order on the settlement between plaintiffs and Xerox limited the ability of victims to cooperate with public health agencies.

23. By “correct,” we mean the same threshold as would be chosen by a social planner who is constrained to the same timing and information as the firm, and is subject to the firm’s subsequent pricing behavior.

24. Confidential settlement recently figured in the Ford/Firestone product recalls. Womeldorf and Cravens (2001) report that “One consequence of the recent Firestone recalls has been a resurgence of legislative proposals aimed at ferreting out ‘secrecy’ in litigation.”