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Abstract. When providing professional services, an expert may misbehave by either prescribing the "wrong" treatment for a consumer's problem or failing to exert proper effort to diagnose it. We show that under a range of liabilities the expert will recommend the appropriate treatment based on his private information if price margins for alternative treatments are close enough; however, a well-designed liability rule is essential for also motivating efficient diagnosis effort. We further demonstrate that unfettered price competition between experts may undermine the efficient role of liability, whereas either a minimum-price constraint or an obligation-to-serve requirement can restore it.

Keywords: Credence goods, experience goods, experts, liability, diagnosis effort, undertreatment, overtreatment.

JEL Codes: D82, I18, K13, L23

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1. Introduction

When providing professional services, an expert often has superior information about the appropriate "treatment" for a consumer's problem. An extensive literature has studied how to prevent the expert from prescribing the "wrong" treatment for financial gains, with one major insight being that the expert's incentive to "cheat" can be removed if the price margins for alternative treatments are equalized (e.g., Dulleck and Kerschbamer, 2006). In practice, the expert may also need to exert costly effort to diagnose the consumer's problem. The issue is then more complex and less understood, especially because the equal price margin condition could eliminate the expert's incentive to exert diagnosis effort. In this paper, we investigate the role of liability in disciplining the expert's behavior in a model with both adverse selection and moral hazard. We demonstrate that a well-designed liability can lead to efficiency in both the treatment recommendation and the diagnosis effort by the expert. We further show when the market may fail to be efficient even under the optimal liability, and what can be done to restore efficiency.

We consider a model in which a consumer needs a treatment for a problem (e.g., a medical condition) from an expert (e.g., a physician). The problem is either minor or major, and there are two alternative treatments that are competitively provided in the market. Upon seeing the consumer, an expert may immediately learn which treatment is appropriate from his expertise, or can exert (additional) private effort to obtain this information. The expert may then either provide a treatment or decline to serve the consumer without receiving any payment. He may prescribe the wrong treatment—a major treatment for a minor problem (*overtreatment*) or a minor treatment for a major problem (*undertreatment*)—if doing so increases his payoff. The type of treatment provided by the expert is observed publicly but the outcome of treatment is verifiable only with some probability.

Our setup departs from the existing literature on expert markets in two significant ways. First, we consider a general service product that differs from a pure credence or a pure experience good, with each as a limiting case, and we study broadly the optimal design of liability in expert markets. The literature has often considered goods/services in expert markets as a credence goods (e.g., Darby and Karni, 1973; Taylor, 1995; Emons, 1997, 2001; Fong, 2005; Alger and Salanie, 2006; Liu, 2011), which makes the key assumption that consumers do not learn the treatment outcome afterwards—particularly in the case of overtreatment—and naturally precludes the use of liability to motivate experts. However, there is abundant evidence that service outcomes in expert markets, including healthcare, financial services, car repair services, auditing, taxi rides, can sometimes be verified, either through the use of modern technology (e.g., video recording the treatment process and comparative big data analysis) or with the help of third-party experts. Moreover, professional liabilities targeted at curbing negligent and fraudulent behavior in expert markets are an inherent part of tort law in many countries. Second, unlike the focus in the literature on adverse selection, we also consider moral hazard in the model.[1] We believe a model of both adverse selection and moral hazard captures more realistic features of many expert markets.[2] For example, a patient with a bad cough and a fever may need only a minor treatment (home rest, possibly with some medication) or a major treatment that requires hospitalization, and the physician may need the incentive to exert diagnosis effort to determine which treatment is appropriate, in addition to the incentive for truthful information reporting.[3]

We find that for a wide range of liabilities the expert will recommend the appropriate treatment based on his private information if price margins for alternative treatments are sufficiently close, which will be true in equilibrium. Remarkably, here the "equal price margin" condition is no longer necessary to solve the adverse selection problem, because the presence of liability relaxes the incentive constraint for the expert to reveal his private information truthfully. In fact, the familiar result that price margins are equalized for the two treatments emerges in

[1] Dulleck and Kerschbamer (2009) also investigates the incentives of experts to exert diagnostic effort and to report truthfully when the experts face competition from discounters who cannot perform diagnosis. Another notable exception is Bester and Dahm (2018), which analyzes the design of optimal contract when payment can be made contingent upon the consumer's report of her subjective evaluation of the treatment outcome in a combined model of adverse selection and moral hazard.

[2] Bardey, et al (2020) analyzes a market for experience goods that also combine both adverse selection and moral hazard. They study optimal regulation and to what extent competition can substitute for regulation to curb the distortions from these two problems. Different from them, our paper studies liability design in markets that also share features of a credence good.

[3] The expert service could also be to repair a consumer's car, to fix a client's malfunctioning air-conditioning system, to provide advice on a client's legal problem, or to improve the security of a client's computer network. In all these situations, the expert may need to be provided with incentives both to incur (private) diagnosis cost and to report the consumer's problem honestly.

equilibrium as a special case of our model under zero liability.

While there are many liability rules under which the expert will recommend the appropriate treatment given his private information, they generally do not provide the efficient incentive for the expert's diagnosis effort. We derive the necessary and sufficient condition for a liability rule to result in both honest recommendation and efficient diagnosis. The efficient liability rule, when it exists, specifies damage payments for verified losses from wrong treatments that will induce equilibrium prices under which (i) the price margin for each treatment is equal to its expected liability cost and (ii) the expected price margin for the two treatments is equal to the efficient critical value of the expert's diagnosis cost. Then, the expert will conduct the additional diagnosis if and only if its cost does not exceed its expected social benefit; and he will also choose the efficient treatment—the treatment that maximizes the expected total surplus—based on his information.

We demonstrate that the efficient liability exists when, for instance, the expected loss to the consumer from no treatment is sufficiently high. However, it may fail to exist. Inefficiency can arise in our model for three possible reasons: the expert prescribes the wrong treatment given his information, he chooses diagnosis effort inefficiently, or he declines to serve the consumer after seeing her.[4] When the consumer may be (partially) compensated through liability for her loss from a "wrong" treatment, the social cost of such a loss is not fully born by the consumer. To reduce the expert's information rent when he learns the consumer's problem without additional diagnosis, the prices may become too low to incentivize the expert to exert the efficient diagnosis effort or to be willing to serve the consumer when the diagnosis cost is too high. Consequently, unfettered competition between experts can undermine the efficient role of liability, causing socially deficient diagnosis effort and treatment. Our analysis will also characterize the second-best liability rule in such situations, where the expert will choose the appropriate treatment given his information (or prior belief), but his diagnosis effort is below the efficient level.

We further show that, when the first-best outcome can not be attained under unfettered competition, an efficient liability always exists if either (i) price margins are constrained to be

[4]We assume that welfare is always higher for the consumer to receive some treatment than not to have any treatment.

above certain minimum levels, or (ii) the expert is obligated to serve after seeing the consumer. Each of these two (regulatory) constraints, when feasible, ensures that under optimal liability the expert will both exert efficient diagnosis effort and provide the proper treatment based on his information, thereby restoring full efficiency. Intuitively, the (proper) minimum-price constraint directly provides the incentive for implementing efficient diagnosis effort. On the other hand, the obligation to serve removes the option for the expert not to treat the consumer after seeing her, so that the expert will efficiently choose between incurring additional diagnosis cost or treating the consumer based only on his prior belief. In each of these two cases, the liability rule is judiciously designed to satisfy the necessary and sufficient condition for efficiency and, in the case with obligation to serve, to also ensure the expert's willingness to participate in the market.

The economic analysis of liability goes back to the seminal contributions by Brown (1973) and Shavell (1980). In markets where consumers can detect and verify a product's failure, the literature has studied how product liability rules affect a producer's incentives to improve product safety ex ante and to provide ex post remedy for an unsafe product (e.g., Daughety and Reinganum, 1995, 2008; Spier, 2011; Hua, 2011; Chen and Hua, 2012). Shavel (2007) presents a survey on the analysis of liabilities for accidents. In credence goods markets where consumers are assumed to rely on experts to determine which treatment is appropriate, there has been little attention to the role of liability in motivating the experts' effort and honesty, presumably because of the view that if consumers cannot tell whether or not a treatment is appropriate, liability would not be effective as an incentive mechanism. In an alternative credence goods setting, consumers are assumed to be able to verify undertreatment, and the institution of liability, defined as "the necessity for a seller to provide a good of sufficient quality to meet the consumer's needs" (Balafoutas and Kerschbamer, 2020), prevents experts from providing insufficient services.[5] By taking the broader view of legal liability in the tradition of Brown (1973) and Shavell (1980) and recognizing that products in expert markets often share properties of both credence and experience goods, we analyze the judicious design of expert liability in a

[5] See also Fong, Liu, and Wright (2014) that emphasizes the importance of verifiability relative to liability in a model of adverse selection, and Fong and Liu (2018) that considers how liability may affect the expert's incentive to maintain reputation.

model of probabilistic verification for the treatment outcome, in accordance with the observed feature in many expert markets.

While our model applies to markets with expert services in general, its most prominent application is probably the health care market where physicians' incentives are regulated by medical malpractice liabilities (e.g., Danzon, 1991).[6] Studies suggest that 4 to 18 percent of patients seeking care in hospitals in the U.S. are victims of medical malpractice, which could cost between $17-29 billion per year (Arlen, 2013). Liability for medical malpractice has emerged to discipline physicians and protect patients, but its performance has been controversial, and studies on its optimal design are scarce.[7] Our analysis sheds light on this issue. In particular, our results suggest that malpractice liability is essential for motivating physicians to exert proper diagnosis efforts. The efficient liability level depends not only on the magnitude of the loss, but also on whether there is overtreatment or undertreatment, because their probabilities of detection often differ. Also, the efficient liability is sometimes punitive, (much) exceeding the patient's loss from a malpractice incident. Furthermore, unfettered price competition for services among potential experts could undermine efficiency, causing the failure of the existence of an efficient liability rule.

We present our model in Section 2. Section 3 describes the efficient benchmark, characterizes market equilibrium under a given liability rule, and analyzes the optimal design of liability. Sections 4 and 5 establish our results under a minimum-price constraint and under the obligation-to-serve requirement, respectively. Section 6 concludes. Lengthier proofs are relegated to an appendix.

[6] Many studies have found that physicians respond to financial incentives in treatment choices, including Gruber, Kim and Mayzlin (1999) on cesarean deliveries, Dickstein (2016) on the choice of drugs that treat depression, and Coey (2015) on treatment choices in heart attack management.

[7] As important exceptions, Simon (1982) compares negligence rule with strict liability in the health care market; Arlen and MacLeod (2005) analyzes optimal liability when the physician invests in expertise and there may be inadequate treatment. The key conflict in both papers is a moral hazard problem. Demougin and Fluet (2006, 2008) analyze the optimal assignment of liabilities under different rules of proof in lawsuits, which is applicable to the healthcare markets, but their focus is very different from ours.

2. The Model

A consumer needs a treatment from an expert for a problem that can be either minor or major, $t \in \{m, M\}$, where $\Pr(t = m) = \theta = 1 - \Pr(t = M)$ and $\theta \in (0, 1)$. The expert can provide either a minor treatment T_m or a major treatment T_M, which is appropriate respectively if t is m or M. The consumer's gross utility from the treatment is

$$v(t, T) = \begin{cases} 0 & \text{if } T = T_t \text{ for } t = m, M \\ -z_u & \text{if } t = M \text{ and } T = T_m \\ -z_o & \text{if } t = m \text{ and } T = T_M \end{cases} . \tag{1}$$

Thus, the consumer's gross utility is normalized to zero if she receives the appropriate treatment for her problem. If her type is M but the treatment is T_m, *undertreatment* occurs and the consumer suffers a loss $z_u > 0$. On the other hand, *overtreatment* occurs when problem type m is treated with T_M, in which case the harm to the consumer is $z_o > 0$.[8] We further assume that the consumer is able to verify her loss z_u or z_o with probability $\alpha_u \in (0, 1]$ or $\alpha_o \in (0, 1]$, when undertreatment or overtreatment has occurred, respectively. This formulation allows us to analyze a full spectrum of possibilities concerning the verifiability of the treatment outcome, encompassing pure credence and experience goods as the limit cases. In particular, the case of $\alpha_o \to 0$ and $\alpha_u \to 0$ corresponds to pure credence goods for which a consumer is unable to know the outcome after the treatment, the case of $\alpha_o \to 0$ and $\alpha_u = 1$ corresponds to full verifiability on undertreatment but no verifiability on overtreatment, and the case of $\alpha_o = \alpha_u = 1$ corresponds to an experience good for which the consumer perfectly learns the treatment outcome. Most goods and services in expert markets probably fall between pure credence and experience goods with intermediate values of α_o and α_u.[9]

Note that the way we define consumer's utility also differs from that in the credence goods

[8] Our analysis and results would be essentially the same if we interpret z_u and z_o as the expected losses associated with undertreatment and overtreatment.

[9] The loss might be verified not directly by the consumer, but by third party experts or the legal discovery process. In health care markets, overtreatment cases may center on the medical necessity of a procedure. For example, Dignity Health pays $37 million in False Claims Action, entering a settlement for improper and medically unnecessary hospital admissions (Modern Healthcare, Oct. 30, 2014).

literature, where the harm from overtreatment is usually normalized to zero, and undertreatment leads to the same utility as no treatment. (See, e.g. Emons, 1997; Dulleck and Kerschbamer, 2006). We depart from this modeling by assuming that overtreatment also leads to a harm for the consumer (but allowing $z_o = 0$ as a special case) and undertreatment may lead to a loss different from no treatment (but with the two being equal as a special case). By adopting this more realistic setup, we wish to explicitly account for the increasing concern over the harm from overtreatment in practice (e.g., Brownlee, 2008; Buck, 2013, 2015).[10]

If the problem is not treated by the expert, the consumer suffers an expected loss in the (absolute) amount of x. Treatments T_m and T_M cost the expert 0 and $C > 0$, respectively, and we assume

$$\text{(i)} \quad C + \theta z_o < x, \quad \text{and} \quad \text{(ii)} \quad C < z_u(1-\theta), \tag{2}$$

so that (i) applying a major treatment without knowing whether $t = m$ or M is more efficient than leaving the problem untreated, and (ii) without knowing whether $t = m$ or M, there exist parameter values under which T_M is more efficient than T_m. The type of treatment provided to the consumer—e.g., whether a certain procedure is carried out—is assumed to be publicly observed. Thus, if the expert recommends treatment T_M, cost C must be incurred to implement the treatment.

The expert is better informed about the nature of the consumer's problem and, if necessary, can exert extra effort to diagnose the problem. Specifically, we assume that upon seeing the consumer, with probability $\beta \in [0, 1)$ the expert is informed about the realization of t (i.e., whether $t = m$ or M), while with probability $1 - \beta$ he is not informed of t but privately learns the realization of k, his private cost of diagnosis effort to learn the realization of t.[11] Ex ante, k follows a continuous probability distribution $F(k)$ on support $\left[0,\ \bar{k}\right]$. We denote the expert's decision on whether to incur k—if he does not observe the realization of t upon seeing the

[10] Buck (2015) reported that John Dempsey Hospital was discovered in 2011 to administer chest combination CT scans at nearly 10 times the national average while health experts noted that combination scans do not provide more valuable information in comparison to a single CT scan in most of those situations. Excess combination scans expose patients to large doses of radiation which increases the risk of developing cancer at later stage.

[11] This effort is beyond the observable normal effort associated with seeing the consumer. The extra cost k may include the additional time the expert spends with the consumer, the effort to gather additional information or to learn new developments in treatment technology.

consumer—by $e \in \{E, N\}$. If he chooses E by incurring k, the expert learns the realization of t, while if $e = N$ (i.e., incurring no k) the expert maintains his prior belief about t. Whether the expert incurs the diagnosis cost is his private information.

The expert may be liable for a bad outcome that is a result of maltreatment. The liability rule specifies damage payments $D \equiv (D_o, D_u)$, so that the expert is required to pay $D_u > 0$ if it is verified that the consumer has received undertreatment with loss z_u, and he is required to pay $D_o > 0$ if it is verified that the consumer has received overtreatment with loss z_o.

The timing of the game, given a liability rule D, proceeds as follows:

1. The consumer sets prices (P_M, P_m) for treatments T_M and T_m, respectively, to maximize her expected surplus.[12] The consumer then visits the expert with her problem.

2. Upon seeing the consumer, the expert either learns the realization of t or, without learning t, the realization of his private cost of diagnosis effort k. In the latter case, he can privately choose either to incur k (denoted as E) or not to do so (denoted as N). He then chooses $T \in \{T_m,\ T_M,\ R\}$, where R denotes his action of refusing to treat the consumer, for which he and the consumer will receive payoffs zero and $-x$, respectively.[13] The game ends if the expert chooses $T = R$, and it proceeds to the next stage otherwise.

3. The treatment recommended by the expert is implemented and payment (P_M or P_m) is made.

4. If a loss from treatment is *verified*, the expert compensates the consumer according to the liability rule D.

Notice that there are potentially four dimensions of asymmetric information in our model: the expert's private information about (i) whether he learns the realization of t upon seeing the consumer, (ii) the realization of k, (iii) whether he incurs the diagnosis cost, and (iv) whether $t = m$ or M, with or without incurring k.

[12] We interpret this as resulting from unrestricted competition among potential experts. Relatedly, Arlen and MacLeod (2005) analyzes a setting in which the patients are price setters while the physician market is fully competitive.

[13] Notice that, as the expected value for the consumer's outside option, $-x$ could reflect the possibility that the consumer may visit other experts, for which there could be costs associated with delay or other frictions.

3. Analysis

In this section, we first describe the efficient benchmark. We then characterize the equilibrium of the game between the expert and the consumer, for a given liability rule. Finally, we analyze the design of an optimal liability rule that maximizes welfare (as measured by expected total surplus), and provide conditions under which full efficiency may or may not be attained.

3.1 Efficient Benchmark

Suppose all information is public and the expert can be required to act efficiently in all possible situations. If the expert learns t upon seeing the consumer, it is clearly efficient for him to choose T_t for $t \in \{m, M\}$. So we focus on the case where the expert needs to incur k in order to learn t. The expert can then choose (N, T_M): implementing T_M without incurring diagnosis cost k; or (N, T_m): implementing T_m without incurring cost k; or E_T: choosing E followed by T_t for $t \in \{m, M\}$. The total surplus of the expert and the consumer for each of these strategies is

$$W(N, T_M) = -\theta z_o - C; \qquad W(N, T_m) = -(1-\theta) z_u \qquad W(E_T) = -k - (1-\theta) C. \tag{3}$$

By the assumption on C from part (i) of (2),

$$W(N, T_M) = -\theta z_o - C > -x,$$

and thus if the expert has no additional information about t beyond his prior belief, a major treatment has higher welfare than no treatment. Therefore it is never efficient for the expert to choose R. Moreover, $W(N, T_M) \geq W(N, T_m)$ if and only if

$$z_o \leq \frac{z_u(1-\theta) - C}{\theta} \equiv z_o^* \qquad \text{or} \qquad z_u \geq \frac{\theta z_o + C}{1-\theta} \equiv z_u^*. \tag{4}$$

That is, if the expert must choose the treatment based on his prior belief about t, it is efficient to choose T_M if the harm from overtreatment is relatively small compared to undertreatment ($z_o \leq z_o^*$), and to choose T_m otherwise. Notice that z_o^*, which is positive by the assumption on

C from part (ii) of (2), is increasing in z_u and decreasing in C.

Incurring the diagnosis cost is efficient when $W(E_T) \geq \max\{W(N,T_M),\ W(N,T_m)\}$, which holds if and only if

$$k \leq \min\{\theta(C+z_o),\ (1-\theta)(z_u - C)\} \equiv k^*, \tag{5}$$

and we assume $k^* < \bar{k}$ throughout the paper to focus on the more interesting case that it is not always efficient to incur k.

Lemma 1 summarizes the efficient benchmark.

Lemma 1 *If the expert learns t upon seeing the consumer, it is efficient for him to choose T_t for $t \in \{m, M\}$. Otherwise, it is efficient to choose (i) (N, T_M) if $k > k^*$ and $z_o \leq z_o^*$; (ii) (N, T_m) if $k > k^*$ and $z_o > z_o^*$; (iii) E_T if $k \leq k^*$.*

Thus, when additional diagnosis effort is required to learn t, the efficient decision by the expert depends straightforwardly on the realized value of k and on the value of z_o relative to z_o^*: When the diagnosis cost is sufficiently high, it is efficient to have T_M without incurring k if the loss from overtreatment is small enough, while it is efficient to have T_m without incurring k if the loss from overtreatment is high enough; when the diagnosis cost is sufficiently low, it is efficient to incur k and then choose the appropriate treatment.

3.2 Equilibrium of the Expert-Consumer Game

We now analyze the game between the expert and the consumer, taking the liability rule (D) as given. Without loss of generality, denote any pair of prices by $P_M = C + \Phi_M$ and $P_m = \Phi_m$, where $\Phi_M \geq 0$ and $\Phi_m \geq 0$ are the price margins or markups for the expert if he provides treatments T_M and T_m, respectively. Each pair of prices—or equivalently (Φ_M, Φ_m)—posted by the consumer is followed by a choice of the expert.

Since $\Phi_t \geq 0$ for $t \in \{m, M\}$, the expert never refuses to treat the consumer ($T = R$) if he knows the realization of t. Furthermore, if the expert knows the realization of t, either upon seeing the consumer or after incurring k, it would be optimal for him to choose T_t for $t \in \{m, M\}$ *if and only if*

$$\Phi_M \geq \Phi_m - \alpha_u D_u, \qquad \Phi_m \geq \Phi_M - \alpha_o D_o. \tag{6}$$

Our analysis will proceed under the presumption that (6) holds—so that the expert will choose the appropriate treatment if he knows what t is—and we later confirm that this is indeed the case in equilibrium and a pair of prices that satisfy (6) is indeed optimal for the consumer.[14]

Notice that for (6) to hold, $\Phi_M = \Phi_m$ if $D_u = D_o = 0$. That is, in order for the expert to recommend the appropriate treatment given his information, equal price margins from different treatments are required when no liability can be imposed on the expert (e.g., Dulleck and Kerschbamer, 2006). When there are liabilities—as we allow in this paper—$\Phi_M = \Phi_m$ is sufficient but no longer necessary for (6): as long as the price margins for the two treatments are not too different, the expert will have the right incentive to recommend the appropriate treatment if he knows t.[15] Thus, the presence of malpractice liability relaxes the constraint on price margins to encourage the right treatment from the expert.

Given (6), the expert will choose T_t for $t \in \{m, M\}$ if he learns the realization of t. Hence, we can focus our analysis on the expert's choice between R and the following three options if he does not initially learn t: (i) (N, T_M); (ii) (N, T_m); and (iii) E_T. For a given D and k, the expert's profit from R is always zero. His profits from each of the other three choices are, respectively:

$$\pi(N, T_M) = \Phi_M - \theta\alpha_o D_o, \qquad \pi(N, T_m) = \Phi_m - (1-\theta)\alpha_u D_u, \tag{7}$$

$$\pi(E_T) = \theta\Phi_m + (1-\theta)\Phi_M - k, \tag{8}$$

where $\theta\alpha_o D_o$ is the expert's expected liability payment to the consumer under (N, T_M), since overtreatment occurs with probability θ; and, similarly, $(1-\theta)\alpha_u D_u$ is the expert's expected liability payment to the consumer under (N, T_m). The expert will make his choice to maximize his expected payoff; when he has the same expected payoff from any two options, we assume that he will choose the option that is favorable to the consumer.

[14] For the design of an optimal liability, it is without loss of generality to devote our attention to situations where (6) is satisfied. If (6) is violated, the expert will have the perverse incentive to choose the "wrong" treatment even when he knows t, which cannot maximize welfare.

[15] This observation is related to the idea in Bardey, et al (2020) that to incentivize a seller to collect information and provide truthful advice on a consumer's choice between two goods, the profits from both goods must lie within an implementability cone. However, in our environment, price margins close to each other do not guarantee the exertion of diagnosis efforts, and liability is crucial for such efforts.

Thus, following a pair of prices $\Phi \equiv (\Phi_M, \Phi_m)$, the expert's optimal choice when he does not initially learn t is E_T if and only if

$$\pi(E_T) \geq \max\{0, \pi(N, T_M), \pi(N, T_m)\}, \tag{9}$$

or, equivalently, if $k \leq \hat{k}(D, \Phi)$, where

$$\hat{k}(D, \Phi) \equiv \min\{\theta\Phi_m + (1-\theta)\Phi_M, \quad \theta\left(\Phi_m - \Phi_M + \alpha_o D_o\right), \quad (1-\theta)\left(\Phi_M - \Phi_m + \alpha_u D_u\right)\}. \tag{10}$$

If $\Phi_M \geq \theta\alpha_o D_o$ and $\Phi_m \geq (1-\theta)\alpha_u D_u$, we have $\pi(N, T_M) \geq 0$ and $\pi(N, T_m) \geq 0$, and the expert will not choose R. However, if $\Phi_M < \theta\alpha_o D_o$ or $\Phi_m < (1-\theta)\alpha_u D_u$, the expert may earn negative expected profit when choosing T_M or T_m based on prior belief about t, in which case he may choose R if k is high. Note that as D_o and D_u increase, $\hat{k}(D, \Phi)$ is higher. This suggests that it is desirable for the consumer to implement E_T with a positive probability—when the expert does not initially learn t— only if the total expected liability payments are not too high. This consideration is reflected in the condition below:

$$\alpha_u D_u + \alpha_o D_o \leq \min\left\{\frac{C + z_o}{1-\theta}, \ \frac{z_u - C}{\theta}\right\}. \tag{11}$$

In what follows, we proceed assuming condition (11) holds, and will later confirm that the condition indeed holds under any welfare-maximizing liability. The lemma below establishes some useful properties concerning the expert's and the consumer's optimal choices.

Lemma 2 *In equilibrium:*

(i) if $\Phi_M < \theta\alpha_o D_o$ and $\Phi_m < (1-\theta)\alpha_u D_u$, then $\hat{k}(D, \Phi) = \theta\Phi_m + (1-\theta)\Phi_M$;

(ii) if $\Phi_M \geq \theta\alpha_o D_o$ or $\Phi_m \geq (1-\theta)\alpha_u D_u$, then $\Phi_M = \theta\alpha_o D_o$ and $\Phi_m = (1-\theta)\alpha_u D_u$, with

$$\hat{k}(D, \Phi) = \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u).$$

Proof. See the appendix. ■

Notice that $\theta\alpha_o D_o$ and $(1-\theta)\alpha_u D_u$ are the expected liability cost when the expert chooses

(N, T_M) and (N, T_m), respectively. In equilibrium, the prices are either just high enough so that the expert will always treat the consumer even when he does not know t (case (ii) in Lemma 2), or they are low enough so that the expert will not treat the consumer unless he knows t (case (i) in Lemma 2).

An implication of Lemma 2 is that liability is essential for the expert to exert diagnosis effort. If $D_o = D_u = 0$, then case (ii) applies and at the optimal prices $\Phi_M = \Phi_m$, with $\hat{k}(D, \Phi) = 0$ so that the expert never invests in diagnosis effort for any $k > 0$.

Let the (expected) price margin for the two treatments be

$$\bar{\Phi} \equiv \theta \Phi_m + (1 - \theta) \Phi_M.$$

Then, from Lemma 2, in equilibrium we only need to consider

$$\bar{\Phi} \begin{cases} = \quad \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u) & \text{for } \Phi_M = \theta \alpha_o D_o \text{ and } \Phi_m = (1-\theta)\alpha_u D_u \\ < \quad \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u) & \text{for } \Phi_M < \theta \alpha_o D_o \text{ and } \Phi_m < (1-\theta)\alpha_u D_u \end{cases}. \tag{12}$$

Lemma 3 below characterizes the equilibrium prices.

Lemma 3 *For given liability $D \equiv (D_o, D_u)$, there exists a market equilibrium with $\bar{\Phi} = \bar{\Phi}^*$, and either (i) $\bar{\Phi}^* = \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u)$ with $\Phi_M^* = \theta \alpha_o D_o$ and $\Phi_m^* = (1-\theta)\, \alpha_u D_u$, or (ii) $\bar{\Phi}^* < \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u)$ with $\Phi_M^* < \theta \alpha_o D_o$ and $\Phi_m^* < (1-\theta)\, \alpha_u D_u$.*

Proof. See the appendix. ■

3.3 Optimal Liability

We can now establish a necessary and sufficient condition for any efficient liability: a liability rule that, together with the equilibrium prices it induces, results in full efficiency in the expert's diagnosis and treatment of the consumer's problem.

Proposition 1 *Full efficiency can be achieved if and only if there exists liability $D^* \equiv (D_o^*, D_u^*)$*

under which the equilibrium price satisfies

$$\bar{\Phi}^* = \theta(1-\theta)(\alpha_o D_o^* + \alpha_u D_u^*) = k^*, \tag{13}$$

where $\bar{\Phi}^*$ *and* k^* *are respectively defined in Lemma 3 and Equation (5).*

Proof. Suppose there is a pair (D_o^*, D_u^*) under which $\bar{\Phi}^* = \theta(1-\theta)(\alpha_o D_o^* + \alpha_u D_u^*) = k^*$. Then, case (ii) of Lemma 2 applies and we have $\Phi_M^* = \theta\alpha_o D_o^*$ and $\Phi_m^* = (1-\theta)\alpha_u D_u^*$. The expert will choose T_t if he learns t upon seeing the consumer. Moreover, when he does not initially observe t, the expert will choose E_T if and only if

$$k \leq \hat{k}(D^*, \bar{\Phi}^*) = \theta(1-\theta)(\alpha_o D_o^* + \alpha_u D_u^*) = k^*.$$

Thus, under liability (D_o^*, D_u^*) full efficiency will be achieved.

On the other hand, suppose efficiency is attained in equilibrium under some liability (D_o^*, D_u^*). We show that the equilibrium price must then satisfy (13). Suppose, to the contrary, that $\bar{\Phi}^* < \theta(1-\theta)(\alpha_o D_o^* + \alpha_u D_u^*) = k^*$. Then $\Phi_M < \theta\alpha_o D_o^*$ and $\Phi_m < (1-\theta)\alpha_u D_u^*$. It follows from Lemma 2 (i) that $\hat{k}(D, \bar{\Phi}^*) = \bar{\Phi}^*$ so that R will be chosen when $k \in (\hat{k}, k^*]$, which occurs with a positive probability in equilibrium and is not efficient. Moreover, if $\bar{\Phi}^* = \theta(1-\theta)(\alpha_o D_o^* + \alpha_u D_u^*) \neq k^*$, then $\hat{k}(D^*, \bar{\Phi}^*) \neq k^*$, and the diagnosis choice is not efficient. ■

When full efficiency can be achieved, under the equilibrium prices in Proposition 1, $\Phi_M^* = \theta\alpha_o D_o^*$ and $\Phi_m^* = (1-\theta)\alpha_u D_u^*$, Condition (6) is indeed satisfied. In equilibrium, the expert has the same (zero) expected profit in treatments T_M and T_m if his information is only the prior belief about t. Unlike the result in the literature, in our model the two treatments need not have equal price margins to induce the expert to choose the appropriate treatment when he knows the realization of t. Rather, the two treatments need to have the same expected profit—given the expected liability cost—under the expert's prior belief about t. The efficient liability D^* equates the expected liability cost under prior belief to the efficient k^*, and incentivizes the expert to fully internalize the social benefit from choosing the efficient diagnosis effort.

Also, if liability D_u or D_o is high enough so that (11) is violated, it might be to the advantage of the consumer that the expert does not learn the realization of t and provides the wrong treatment, in which case the consumer could collect the (excessively) high damage payment. Thus, if the liability is not properly designed, the equilibrium incentive could be perverse. This situation will not arise if the liability satisfies (11), which also induces price margins for the two treatments to be close enough to satisfy (6).

Proposition 1 implies that to achieve full efficiency, there must exist liability rule (D_o^*, D_u^*) that satisfies $\theta(1-\theta)(\alpha_o D_o^* + \alpha_u D_u^*) = k^*$, and at the same time it induces $\bar{\Phi}(D^*) = \theta(1-\theta)(\alpha_o D_o^* + \alpha_u D_u^*)$ with $\Phi_M^* = \theta\alpha_o D_o^*$ and $\Phi_m^* = (1-\theta)\alpha_u D_u^*$ in equilibrium. Furthermore, full efficiency fails if for all liability (D_o, D_u) satisfying $\theta(1-\theta)(\alpha_o D_o + \alpha_u D_u) = k^*$, the induced equilibrium price margins are $\Phi_M^* < \theta\alpha_o D_o$ and $\Phi_m^* < (1-\theta)\alpha_u D_u$ with $\bar{\Phi}(D) < \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u)$. This can happen if the consumer finds it optimal to set low prices to reduce the expert's information rent in the event that the expert knows the consumer's type without exerting diagnosis effort.

Using these observations, Proposition 2 below provides explicit conditions under which full efficiency may or may not be attained. In particular, in part (i), the loss from no treatment, x, is sufficiently large to ensure that (13) holds under some D^*; in part (ii), when β is sufficiently large, for all (D_o, D_u) satisfying $\theta(1-\theta)(\alpha_o D_o + \alpha_u D_u) = k^*$, the induced equilibrium price is $\bar{\Phi}(D) < \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u)$. In stating the proposition, we assume $z_o < z_o^*$, so that $k^* = \theta(C + z_o)$ and $W(N, T_M) > W(N, T_m)$. The analysis for the case $z_o > z_o^*$ is analogous and is briefly discussed after Proposition 2.

Proposition 2 *Suppose $z_o < z_o^*$. Given other parameter values, there exist $\hat{x} > 0$ and $\hat{\beta} < 1$ such that: (i) if $x > \hat{x}$, then $D_o^* = \frac{C+z_o}{(1-\theta)\alpha_o}$ and $D_u^* = 0$ induce the efficient outcome in equilibrium, with $\Phi_M^* = \frac{\theta(C+z_o)}{1-\theta}$ and $\Phi_m^* = 0$; (ii) if $\beta > \hat{\beta}$, there exists no (D_o, D_u) under which the equilibrium is efficient.*

Proof. See the appendix. ■

In part (i) of Proposition 2, when x is sufficiently large, the consumer is always better off with treatment T_M than without treatment, even if the expert does not learn t. Hence the consumer optimally offers $\Phi_M = \theta\alpha_o D_o$ so that the expert will choose (N, T_M) in case he does not learn t initially and k turns out to be too high, and she optimally offers $\Phi_m = 0$ to minimize the expert's rent when he learns t initially or after incurring k. If $D_o^* = \frac{C+z_o}{(1-\theta)\alpha_o}$ and $D_u^* = 0$, then

$$\hat{k} = \theta\Phi_m^* + (1-\theta)\,\Phi_M^* = (1-\theta)\,\frac{\theta\,(C+z_o)}{1-\theta} = \theta\,(C+z_o) = k^*,$$

so that the expert will incur diagnosis effort efficiently, and he will also report information truthfully since (6) is satisfied.

To see the intuition for part (ii) of Proposition 2, notice that when the consumer can be (partially) compensated for the loss associated with an inappropriate treatment by liability, she does not bear the full social cost of the loss. Indeed, in choosing the optimal prices, the consumer faces the tradeoff of extracting more surplus by reducing the prices when the expert knows t, and incentivizing the expert to exert diagnosis effort when the expert does not know t. Hence, in order to reduce the expert's information rent, the consumer may want to lower the prices below the level that would induce the efficient effort, and she will indeed do so when β is high so that the expert will choose the appropriate treatment sufficiently often even without incurring k. As a result, when β is sufficiently high, an efficient liability—one that will ensure $\hat{k} = k^*$—fails to exist. Proposition 2 highlights the subtlety in the design of an efficient liability: while liability is necessary to provide incentives for the expert to exert effort, it also creates a divergence between the social and private costs of a loss to the consumer. Consequently, while unconstrained competition in the expert market maximizes consumer surplus, inefficiency may arise even under an optimally designed liability rule.

When $z_o \geq z_o^*$, a similar analysis can establish that there exist some $\tilde{x} > 0$ and $\tilde{\beta} < 1$ such that if $x > \tilde{x}$, then $D_o^* = 0$ and $D_u^* = \frac{z_u - C}{\theta\alpha_u}$ induce the efficient outcome, with $\Phi_M^* = 0$ and $\Phi_m^* = \frac{(1-\theta)(z_u - C)}{\theta}$; whereas if $\beta > \tilde{\beta}$, no (D_o, D_u) can lead to full efficiency.

A liability rule that would induce the efficient outcome in equilibrium is clearly optimal from the social welfare point of view. When full efficiency cannot be achieved, there is a second-best liability rule that maximizes the expected total surplus in equilibrium.

Corollary 1 *When the first-best liability fails to exist, there is a second-best liability $D^{**} = (D_o^{**}, D_u^{**})$ that maximizes expected total surplus. The equilibrium expected price margin is*

$\bar{\Phi}(D^{**}) = \theta(1-\theta)(\alpha_o D_o^{**} + \alpha_u D_u^{**})$, *and the expert's diagnosis effort is below the efficient level:* $\hat{k}(D^{**}, \bar{\Phi}(D^{**})) = \bar{\Phi}(D^{**}) < k^*$.

Proof. See the appendix. ■

Therefore, when an optimally-designed liability rule is unable to achieve fully efficiency, it can implement the second best outcome by inducing equilibrium prices under which the expert expects the same (zero) profit from both treatments and will thus choose them efficiently when he does not learn t, but in general his choice of diagnosis effort is not efficient. In particular, in the case of pure credence goods with $\alpha_o \to 0$ and $\alpha_u \to 0$, given liabilities satisfying (11), there exists no equilibrium prices such that condition (13) holds, and therefore, full efficiency cannot be achieved and the expert underinvests in diagnosis effort under the second-best liability rule. In the next two sections, we explore potential remedies that may help to restore incentives in such environment through regulating the prices (Section 4) or by imposing the obligation for the expert to serve (Section 5).

4. Minimum Price Constraint

As we demonstrated in Section 3, competitive equilibrium in the expert market need not be efficient, even when liability is optimally chosen. In this section, we show that efficiency can be restored with an optimally-designed liability if there is minimum-price regulation that, for given $D = (D_o, D_u)$, requires[16]

$$\Phi_M \geq \theta \alpha_o D_o, \quad \Phi_m \geq (1-\theta)\alpha_u D_u. \tag{14}$$

When (14) is satisfied, Φ_M and Φ_m are high enough so that the expert, whose outside option is zero profit, will always receive non-negative expected profit from providing each treatment, i.e.

[16] This minimum-price constraint may also arise without regulation if the expert and the consumer share bargaining power in setting prices because, for example, the consumer has cost to compare prices from potential service providers. The expert may then be able to insist on prices that would ensure non-negative profit for each treatment as in (14).

$\pi(N, T_M) \geq 0$ and $\pi(N, T_m) \geq 0$. In equilibrium, from Lemma 2, Constraint (14) implies

$$\Phi_M^* = \theta \alpha_o D_o, \quad \Phi_m^* = (1-\theta)\alpha_u D_u. \tag{15}$$

The result below establishes that there exists an optimal liability rule that induces the efficient outcome in equilibrium.

Proposition 3 *Suppose that (14) holds. Then, the following liability rule results in the efficient outcome in equilibrium:*

$$D_u^* = \frac{k^*}{(1-\theta)\alpha_u}, \qquad D_o^* = \frac{k^*}{\theta \alpha_o}. \tag{16}$$

Proof. When (14) holds, making use of the equilibrium price in (15) we have

$$\begin{aligned}
\bar{\Phi}^* &= \theta \Phi_m^* + (1-\theta)\,\Phi_M^* = \theta\,(1-\theta)\,(\alpha_o D_o^* + \alpha_u D_u^*) \\
&= \theta\,(1-\theta)\left[\alpha_o \frac{k^*}{\theta \alpha_o} + \alpha_u \frac{k^*}{(1-\theta)\alpha_u}\right] = k^*.
\end{aligned}$$

Then, from Proposition 1, full efficiency is achieved under D^*. ■

Notice that with the liability rule that implements the efficient outcome, the equilibrium price margin from each treatment is equal to the efficient critical value of k, k^*. Thus, while there exist a range of liabilities that would induce the equilibrium markups given in (15) for the two treatments and these markups generally differ, they are the same under the efficient liability, being equal to the expert's expected liability cost for each treatment without knowing t. By selecting D^* that equates this liability cost to the efficient k^*, the efficient liability incentivizes the expert to fully internalize the social benefit from choosing the efficient diagnosis effort. In Section 3, where the price offered by the consumer is not constrained, the consumer may not fully internalize this benefit due to liability protection and may thus set a too low price for the expert, inefficiently reducing his diagnosis effort. The minimum-price constraint removes this possibility and helps to restore efficiency.

The efficient liability in (16) can be expressed as a multiplier of the loss from undertreatment or overtreatment: $D_u^* = \gamma_u z_u$ and $D_o^* = \gamma_o z_o$, where

$$\gamma_u = \frac{k^*}{(1-\theta)\alpha_u z_u}, \qquad \gamma_o = \frac{k^*}{\theta \alpha_o z_o}.$$

It's possible that $\gamma_u > 1$ or $\gamma_o > 1$; that is, there can be punitive damages. Moreover, under the efficient liability, as the loss from overtreatment becomes more likely to be verifiable relative to the loss from undertreatment, the penalty for undertreatment will increase (in the sense that γ_u becomes higher relative to γ_o). Notice that since in general $\gamma_u \neq \gamma_o$, if the liability multipliers are constrained to be the same—say, γ—for both types of losses, the market outcome will generally be inefficient.

5. Obligation to Serve

We now show that, instead of price regulation, full efficiency can also be restored with a properly-chosen liability rule if there is regulation on the expert's obligation to serve. Specifically, suppose that upon seeing the consumer, the expert is not allowed to choose R. If the expert agrees to see the consumer, he will incur k if and only if

$$\pi(E_T) = \theta\Phi_m + (1-\theta)\Phi_M - k \geq \max\{\pi(N, T_M), \pi(N, T_m)\},$$

or, equivalently,

$$k \leq \hat{k}(D, \Phi) = \min\{\theta(\Phi_m - \Phi_M + \alpha_o D_o), (1-\theta)(\Phi_M - \Phi_m + \alpha_u D_u)\}.$$

Given (D_o, D_u), the consumer chooses (Φ_m, Φ_M) to maximize her expected surplus, subject to the constraints that the expert will incur k if and only if $k \leq \hat{k}(D, \Phi)$ and that he receives non-negative expected profit by agreeing to see the consumer.

The expert is willing to accept (Φ_m, Φ_M) with the obligation to serve if:

$$\Pi(D,\Phi) = \left[\beta + (1-\beta)F(\hat{k})\right][\theta\Phi_m + (1-\theta)\Phi_M] - (1-\beta)\int_0^{\hat{k}} t dF(t)$$
$$+ (1-\beta)\left[1 - F(\hat{k})\right]\max\{\Phi_M - \theta\alpha_o D_o, \Phi_m - (1-\theta)\alpha_u D_u\} \geq 0.$$

Define

$$D_o^* = \frac{k^*}{\theta\alpha_o}, \qquad D_u^* = \frac{k^*}{(1-\theta)\,\alpha_u}; \tag{17}$$

$$\Phi_M^* = (1-\beta)\left[k^* - \int_0^{k^*} F(t)dt\right] = \Phi_m^*. \tag{18}$$

Notice that (D_o^*, D_u^*) satisfy (11).

Proposition 4 *Suppose that the expert is obligated to treat the consumer after seeing her. Then, liability rule (17), under which the equilibrium prices satisfy (18), leads to full efficiency as described in Lemma 1.*

Proof. First, from the proof of part (ii) in Lemma 2, the equilibrium prices $(\Phi_M^*,\ \Phi_m^*)$ satisfy

$$\Phi_M^* - \theta\alpha_o D_o = \Phi_m^* - (1-\theta)\,\alpha_u D_u.$$

Thus, under (17), the expert will choose k efficiently:

$$\hat{k}(D^*, \Phi^*) = \min\{\theta\left(\Phi_m^* - \Phi_M^* + \alpha_o D_o^*\right), (1-\theta)\left(\Phi_M^* - \Phi_m^* + \alpha_u D_u^*\right)\}$$
$$= \theta(1-\theta)(\alpha_o D_o^* + \alpha_u D_u^*) = k^*.$$

Next, since

$$\pi(N, T_M) = \Phi_M^* - \theta\alpha_o D_o^* = \Phi_m^* - (1-\theta)\alpha_u D_u^* = \pi(N, T_m),$$

if $k > k^*$, the expert will choose (N, T_M) when $z_o \leq z_o^*$ and (N, T_m) when $z_o > z_o^*$. Moreover:

$$\begin{aligned}
\Pi(D^*, \Phi^*) = {} & [\beta + (1-\beta)F(k^*)] \{\Phi_M^* + \theta [(1-\theta)\alpha_u D_u^* - \theta\alpha_o D_o^*]\} \\
& + (1-\beta)[1 - F(k^*)](\Phi_M^* - \theta\alpha_o D_o^*) - (1-\beta)\int_0^{k^*} tf(t)dt \\
= {} & \Phi_M^* - \theta\alpha_o D_o^* - (1-\beta)\int_0^{k^*} tf(t)dt + [\beta + (1-\beta)F(k^*)]\, k^* \\
= {} & \Phi_M^* - \theta\alpha_o D_o^* + \beta k^* + (1-\beta)\int_0^{k^*} F(t)dt = 0
\end{aligned}$$

if Φ_M^* and Φ_m^* satisfy

$$\Phi_M^* = \theta\alpha_o D_o^* - \beta k^* - (1-\beta)\int_0^{k^*} F(t)dt, \qquad \Phi_m^* = (1-\theta)\alpha_u D_u^* - \beta k^* - (1-\beta)\int_0^{k^*} F(t)dt,$$

which simplify to (18). Note that these prices are optimal for the consumer subject to $\Pi(D, \Phi) \geq 0$, and (Φ_M^*, Φ_m^*) indeed satisfy (6). They are thus equilibrium prices. ■

The obligation to serve restores efficiency by forcing the expert to provide a treatment upon seeing the consumer even when he has no precise information about the consumer's type. This eliminates the inefficiency that arises when the prices are not high enough to motivate the expert to treat the consumer if he does not learn t. Essentially, this requirement enables the consumer to extract all information rents from the expert. In reality, the obligation to serve may be imposed under certain situations, such as for emergency care. However, in other cases, it may be difficult to enforce the obligation to serve. After an initial consultation, it would seem reasonable that the expert, without taking any payment from the consumer, will have the right not to provide treatment. A dentist, for example, may simply refer a patient to a "specialist" after seeing her.

6. Conclusion

This paper has studied the design of efficient liability in a model of expert markets where proper incentives are needed for the expert to exert diagnosis effort and to recommend the appropriate treatment. We characterize the necessary and sufficient condition for a liability rule to implement full efficiency, and identify situations where the condition is satisfied. The efficient liability rule imposes penalty on the expert that increases with the size of consumer loss associated with verified overtreatment or undertreatment. The penalty may be punitive and is higher when the probability of detecting "malpractice" is lower. We also show that while liability is necessary to provide incentives to the expert, it creates a divergence between the social and private costs of a loss to the consumer. Consequently, unfettered price competition between experts, while maximizing consumer surplus, can render it impossible to achieve full efficiency. Under a second-best liability rule, the expert generally under-invests in diagnosis effort. A (regulatory) constraint on minimum prices or on obligation to serve enables an optimally-designed liability rule to restore full efficiency.

We have analyzed a stylized model. There are other factors that can potentially impact the performance of expert markets. For example, if there are repeat purchases, reputation concerns can motivate experts to exert efforts and behave honestly in serving consumers. But reputation may be fragile, and a well-designed liability rule can achieve efficiency even when reputation does not. It is also possible that the expert and the consumer will rely on private contracts, instead of legal liability, for damage payments in the case of a consumer loss; in such situations we may interpret the optimal liability in our model as privately-stipulated damages. However, private contracting for damage payments can have high transaction costs and contract enforcement may still rely on the legal system. Moreover, if the damage payments through private contracting are designed by the consumer or offered by (perfectly) competitive experts, they will generally differ from the welfare-maximizing liability, because of the difference between social and private costs from maltreatment.

The difficulties in providing proper incentives to experts (such as physicians and dentists) are well known. The fact that malpractice liabilities are a prominent feature of markets such as those for health care further suggests that legal liability plays important roles in expert markets.[17] By showing how an efficient liability can be designed in a model of adverse selection and moral hazard, this paper offers new insights on improving the performance of expert markets.

[17]In our model, the expert perfectly observes the consumer's problem with diagnosis effort. Our main results can still hold if we extend the model to a setting where the expert obtains only a noisy signal about the nature of the consumer's problem.

6. Appendix

The appendix contains proofs for Lemma 2, Lemma 3, Proposition 2, and Corollary 1.

Proof of Lemma 2.

(i) If $\Phi_M < \theta\alpha_o D_o$ and $\Phi_m < (1-\theta)\alpha_u D_u$, we have $\pi(N, T_M) < 0$ and $\pi(N, T_m) < 0$. Then, condition (9) becomes $\pi(E_T) \geq 0$, and hence $\hat{k}(D, \Phi) = \theta\Phi_m + (1-\theta)\Phi_M$.

(ii) Suppose $\Phi_M \geq \theta\alpha_o D_o$. We have

$$\theta\Phi_m + (1-\theta)\Phi_M \geq \theta\left(\Phi_m - \Phi_M + \alpha_o D_o\right).$$

Condition (9) then becomes

$$k \leq \min\{\theta\left(\Phi_m - \Phi_M + \alpha_o D_o\right),\ (1-\theta)\left(\Phi_M - \Phi_m + \alpha_u D_u\right)\}. \tag{19}$$

Let

$$\Phi_M - \Phi_m = \Delta + \theta\alpha_o D_o - (1-\theta)\alpha_u D_u. \tag{20}$$

From (19), if the expert does not learn t upon seeing the consumer, he will choose to incur k if and only if k does not exceed

$$\begin{aligned}
\hat{k}(D,\Phi) &= \min\left\{\theta\left(\Phi_m - \Phi_M + \alpha_o D_o\right), (1-\theta)\left(\Phi_M - \Phi_m + \alpha_u D_u\right)\right\} \\
&= \min\left\{\theta\left[-\Delta + (1-\theta)\left(\alpha_o D_o + \alpha_u D_u\right)\right],\ (1-\theta)\left[\Delta + \theta\left(\alpha_o D_o + \alpha_u D_u\right)\right]\right\} \\
&= \begin{cases} \theta\left[-\Delta + (1-\theta)\left(\alpha_o D_o + \alpha_u D_u\right)\right] & \text{if} \quad \Delta > 0 \\ (1-\theta)\left[\Delta + \theta\left(\alpha_o D_o + \alpha_u D_u\right)\right] & \text{if} \quad \Delta < 0 \end{cases}.
\end{aligned}$$

We show that

$$\Phi_M - \Phi_m = \theta\alpha_o D_o - (1-\theta)\alpha_u D_u \tag{21}$$

holds, or $\Delta = 0$, by demonstrating that the consumer can benefit from deviating to different prices if $\Delta \neq 0$. When the expert does not learn t upon seeing the consumer, there are two cases to consider:

Case 1: $\Delta > 0$. It follows that

$$\pi(N, T_M) - \pi(N, T_m) = \Phi_M - \theta\alpha_o D_o - [\Phi_m - (1-\theta)\alpha_u D_u] > 0.$$

Then $\pi(N, T_M) > \pi(N, T_m)$ and the expert would choose T_M if he is not initially informed about t and also does not incur k.

On the other hand, consumer surpluses under the expert's choice (N, T_M) and E_T are respectively:

$$S(N, T_M) = \theta\left[-z_o - \Phi_M - C + \alpha_o D_o\right] + (1-\theta)\left[0 - \Phi_M - C\right], \tag{22}$$

$$S(E_T) = -\theta\Phi_m - (1-\theta)(\Phi_M + C). \tag{23}$$

The consumer surplus is higher if Φ_m and Φ_M are lower in each of the above cases. Note that

$$\begin{aligned} S(E_T) - S(N, T_M) &= \theta\left[\Phi_M - \Phi_m + C + z_o - \alpha_o D_o\right] \\ &= \theta\left[\Delta + \theta\alpha_o D_o - (1-\theta)\alpha_u D_u + C + z_o - \alpha_o D_o\right] \\ &= \theta\left[\Delta + C + z_o - (1-\theta)(\alpha_u D_u + \alpha_o D_o)\right] > 0. \end{aligned}$$

Thus the consumer prefers E_T to (N, T_M). By reducing Φ_M slightly, Δ becomes smaller and $\hat{k}(D, \Phi)$ will rise—so that the expert incurs k more often while (6) continues to hold—and the consumer will also pay a lower expected price. Therefore this change increases the consumer's expected surplus. Thus, a pair of prices with $\Delta > 0$ is not optimal for the consumer.

Case 2: $\Delta < 0$. Then we have

$$\pi(N, T_m) - \pi(N, T_M) = \Phi_m - (1-\theta)\alpha_u D_u - [\Phi_M - \theta\alpha_o D_o] > 0.$$

The expert would choose T_m if he is not initially informed about t and also does not incur k. The consumer surplus under the expert's choice (N, T_m) is

$$S(N, T_m) = \theta\left[-\Phi_m\right] + (1-\theta)\left[-z_u + \alpha_u D_u - \Phi_m\right], \tag{24}$$

and it follows that

$$
\begin{aligned}
S\left(E_T\right)-S(N,T_m) &= (1-\theta)\left(\Phi_m-\Phi_M-C+z_u-\alpha_u D_u\right) \\
&= (1-\theta)\left[-\Delta+z_u-C-\theta\left(\alpha_u D_u+\alpha_o D_o\right)\right]>0.
\end{aligned}
$$

Using similar argument from Case 1 shows the consumer can increase her surplus by reducing Φ_m.

Moreover, if the expert learns t upon seeing the consumer, the reduction in Φ_M or Φ_m always increases consumer surplus given that (6) is satisfied. In this case, if $\Delta \neq 0$, consumer surplus can be increased by reducing either Φ_M or Φ_m. Thus (21) holds in equilibrium. Applying (21) to (19), we obtain

$$
\begin{aligned}
\hat{k}(D,\Phi) &= \min\left\{\theta\left(\Phi_m-\Phi_M+\alpha_o D_o\right),(1-\theta)\left(\Phi_M-\Phi_m+\alpha_u D_u\right)\right\} \\
&= \theta(1-\theta)(\alpha_o D_o+\alpha_u D_u).
\end{aligned}
$$

Finally, if $\Phi_M \geq \theta\alpha_o D_o$ is optimal for the consumer, then $\Phi_M = \theta\alpha_o D_o$. If $\Phi_M > \theta\alpha_o D_o$, the consumer will pay a higher price if a major treatment is provided but $\hat{k}(D,\Phi)$ is the same as when $\Phi_M = \theta\alpha_o D_o$. Thus $\Phi_M = \theta\alpha_o D_o$ leads to (weakly) higher surplus for the consumer than a price with $\Phi_M > \theta\alpha_o D_o$. Then, from (21) and $\Delta = 0$, $\Phi_m = (1-\theta)\alpha_u D_u$.

Applying the same logic to the case $\Phi_m \geq (1-\theta)\alpha_u D_u$ completes the proof. ■

Proof of Lemma 3. For given (D_o, D_u), making use of (12), consumer surplus can be written as the following function of $\bar{\Phi}$:

$$
S\left(\bar{\Phi}\right)=\begin{cases} S^a(\bar{\Phi}) & if \quad \bar{\Phi}=\theta(1-\theta)(\alpha_o D_o+\alpha_u D_u) \\ S^b(\bar{\Phi}) & if \quad \bar{\Phi}<\theta(1-\theta)(\alpha_o D_o+\alpha_u D_u) \end{cases},
$$

where

$$
\begin{aligned}
S^a(\bar{\Phi}) &\equiv \left[\beta+(1-\beta)F(\hat{k})\right]S\left(E_T\right)+(1-\beta)\left[1-F(\hat{k})\right]\max\{S\left(N,T_M\right),S\left(N,T_m\right)\}, && (25) \\
S^b(\bar{\Phi}) &\equiv \left[\beta+(1-\beta)F(\hat{k})\right]S\left(E_T\right)+(1-\beta)\left[1-F(\hat{k})\right](-x), && (26)
\end{aligned}
$$

in which $S(N,T_M)$, $S(E_T)$ and $S(N,T_m)$ are respectively given in (22), (23) and (24) and

$$\hat{k}(D,\bar{\Phi}) = \begin{cases} \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u) & \text{if} \quad \bar{\Phi} = \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u) \\ \theta\Phi_m + (1-\theta)\Phi_M & \text{if} \quad \bar{\Phi} < \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u) \end{cases} . \tag{27}$$

For $S^a(\bar{\Phi})$ the consumer will always be served because $\Phi_M = \theta\alpha_o D_o$ and $\Phi_m = (1-\theta)\alpha_u D_u$, whereas for $S^b(\bar{\Phi})$ the expert will choose R with probability $(1-\beta)\left[1 - F(\hat{k})\right]$.

Note that $S(\bar{\Phi})$ is upper semi-continuous in $\bar{\Phi}$ on the support $[0, \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u)]$, being discontinuous only at $\bar{\Phi} = \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u)$. Therefore, there exists some $\bar{\Phi}^*$ such that

$$\bar{\Phi}^* = \bar{\Phi}(D) = \arg\max_{\bar{\Phi}\in[0,\theta(1-\theta)(\alpha_o D_o+\alpha_u D_u)]} S\left(\bar{\Phi}\right). \tag{28}$$

■

Proof of Proposition 2. (i) We show that if x is sufficiently large, then there exists D^* such that (13) holds and full efficiency is achieved. Given liability D, by choosing $\bar{\Phi} = \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u)$, the consumer will always be served because in equilibrium $\Phi_M = \theta\alpha_o D_o$ and $\Phi_m = (1-\theta)\,\alpha_u D_u$. Note that $S(E_T) \geq S(N,T_M)$ by (11) and $\max\{S(N,T_M), S(N,T_m)\} = -\theta z_o - C$. From (12) and (25), the consumer surplus satisfies

$$S^a(\bar{\Phi})\mid_{\bar{\Phi}=\theta(1-\theta)(\alpha_o D_o+\alpha_u D_u)} \geq -\left(C + \theta z_o\right).$$

On the other hand, if the price satisfies $\bar{\Phi} < \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u)$, the expert will choose R with probability $(1-\beta)\left[1 - F(\hat{k})\right]$, and the consumer receives a surplus given by $S^b(\bar{\Phi})$ in (26). Note that

$$\hat{k}(D,\bar{\Phi}) \leq k^* = \theta\left(C + z_o\right), \qquad S\left(E_T\right) = -\theta\Phi_m - (1-\theta)\left(\Phi_M + C\right) \leq -(1-\theta)C.$$

Thus

$$\begin{aligned}
S^b(\bar{\Phi}) &= \beta S\left(E_T\right) + (1-\beta)(-x) + (1-\beta)F(\hat{k})\left[S\left(E_T\right) - (-x)\right] \\
&\leq \beta\left[-(1-\theta)C\right] + (1-\beta)(-x) + (1-\beta)F\left[\theta\left(C+z_o\right)\right]\left[-(1-\theta)C - (-x)\right] \\
&= -\beta(1-\theta)C - (1-\beta)x\left[1-F\left(\theta\left(C+z_o\right)\right)\right] - (1-\beta)F\left[\theta\left(C+z_o\right)\right](1-\theta)C.
\end{aligned}$$

It follows that, for any $S^b(\bar{\Phi})$,

$$\begin{aligned}
& S^a(\bar{\Phi})\mid_{\bar{\Phi}=\theta(1-\theta)(\alpha_o D_o+\alpha_u D_u)} - S^b(\bar{\Phi}) \\
\geq\quad & -\left(C+\theta z_o\right) + \beta(1-\theta)C + (1-\beta)x\left[1-F\left(\theta\left(C+z_o\right)\right)\right] + (1-\beta)F\left[\theta\left(C+z_o\right)\right](1-\theta)C \\
=\quad & -\left(C+\theta z_o\right) + (1-\theta)C\left[\beta + (1-\beta)F\left[\theta\left(C+z_o\right)\right]\right] + (1-\beta)x\left[1-F\left(\theta\left(C+z_o\right)\right)\right] \geq 0 \\
\Longleftrightarrow\quad & x \geq \frac{\left(C+\theta z_o\right) - (1-\theta)C\left[\beta+(1-\beta)F\left(\theta\left(C+z_o\right)\right)\right]}{(1-\beta)\left[1-F\left(\theta\left(C+z_o\right)\right)\right]} > 0.
\end{aligned}$$

Then, combined with part (i) of assumption (2), when

$$x \geq \max\left\{C+\theta z_o,\ \frac{\left(C+\theta z_o\right) - (1-\theta)C\left[\beta+(1-\beta)F\left(\theta\left(C+z_o\right)\right)\right]}{(1-\beta)\left[1-F\left(\theta\left(C+z_o\right)\right)\right]}\right\} \equiv \hat{x},$$

$\bar{\Phi}^* = \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u)$. Moreover, $D_o^* = \frac{(C+z_o)}{(1-\theta)\alpha_o}$ and $D_u^* = 0$ induce $\bar{\Phi}^* = \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u)$, with $\Phi_M^* = \frac{\theta(C+z_o)}{1-\theta}$ and $\Phi_m^* = 0$, as well as

$$\hat{k}(D^*, \bar{\Phi}^*) = \theta(1-\theta)(\alpha_o D_o^* + \alpha_u D_u^*) = \theta(1-\theta)\alpha_o \frac{(C+z_o)}{(1-\theta)\alpha_o} = \theta\left(C+z_o\right) = k^*.$$

Both Conditions (11) and (6) are satisfied. Hence, the expert will choose T_t for $t \in \{m, M\}$ when he knows t (either initially or by incurring k), and will also incur k efficiently when he does not know t initially. Therefore, when $x > \hat{x}$, full efficiency is indeed implemented with D^*.

(ii) Recall that

$$S^b(\bar{\Phi})|_{\bar{\Phi}<\theta(1-\theta)(\alpha_o D_o+\alpha_u D_u)} = \beta S\left(E_t\right) + (1-\beta)(-x) + (1-\beta)F(\hat{k})\left[S\left(E_t\right) - (-x)\right],$$

where

$$S\left(E_T\right) = -\theta\Phi_m - (1-\theta)\left(\Phi_M + C\right) = -\bar{\Phi} - (1-\theta)C \leq -(1-\theta)C$$

and $\hat{k}(D, \bar{\Phi}) = \theta\Phi_m + (1-\theta)\,\Phi_M = \bar{\Phi}$. Thus,

$$\frac{\partial S^b(\bar{\Phi})|_{\bar{\Phi}<\theta(1-\theta)(\alpha_o D_o + \alpha_u D_u)}}{\partial\bar{\Phi}} = -\beta + (1-\beta)\, f(\hat{k})\left[S\left(E_t\right) - (-x)\right] - (1-\beta)\, F(\hat{k}) < 0$$

if $(1-\beta)\, f(\hat{k})\left[S\left(E_t\right) - (-x)\right] - (1-\beta)\, F(\hat{k}) < \beta$, which holds if

$$\beta > \arg\max_{k\in\left[0,\bar{k}\right]} \frac{f\left(k\right)\left[x - \left(1-\theta\right)C\right] - F\left(k\right)}{1 + f\left(k\right)\left[x - \left(1-\theta\right)C\right] - F\left(k\right)} \equiv \beta',$$

where $\beta' < 1$.

Now suppose (D_o, D_u) satisfies $\theta(1-\theta)(\alpha_o D_o + \alpha_u D_u) = k^*$. Then, if $\beta > \beta'$, we have $\frac{\partial S^b(\bar{\Phi})|_{\bar{\Phi}<k^*}}{\partial\bar{\Phi}} < 0$ and

$$\max_{\bar{\Phi}} S^b\left(\bar{\Phi}\right)\Big|_{\bar{\Phi}<k^*} = S^b\left(0\right) = \beta\left[-\left(1-\theta\right)C\right] + \left(1-\beta\right)\left(-x\right),$$

while

$$S^a(\bar{\Phi})\mid_{\bar{\Phi}=k^*} = -\left(C + \theta z_o\right);$$

hence

$$\begin{aligned}
&\max_{\bar{\Phi}} S^b\left(\bar{\Phi}\right)\Big|_{\bar{\Phi}<k^*} - S^a(\bar{\Phi})\mid_{\bar{\Phi}=k^*} \\
&\quad = -\beta\left[\left(1-\theta\right)C\right] - \left(1-\beta\right)x + \left(C + \theta z_o\right) > 0 \\
&\quad \Leftrightarrow \beta > \frac{x - \left(C + \theta z_o\right)}{x - \left(1-\theta\right)C} \equiv \beta'',
\end{aligned}$$

where $\beta'' < 1$.

Therefore, if $\beta > \hat{\beta} \equiv \max\left\{\beta', \beta''\right\}$, for liability rule D that satisfies $\theta(1-\theta)(\alpha_o D_o + \alpha_u D_u) = k^*$, we have

$$\max_{\bar{\Phi}} S^b\left(\bar{\Phi}\right)\Big|_{\bar{\Phi}<k^*} - S^a(\bar{\Phi})\mid_{\bar{\Phi}=k^*} > 0$$

and the induced price is $\bar{\Phi}^* = 0$, with $\Phi_M = \Phi_m = 0$ and $\hat{k}(D, \bar{\Phi}^*) = 0 < k^*$. Furthermore, if $D_o > 0$, the expert will choose R even when treatment (N, T_M) is efficient. Making use of the results in Proposition 1, we therefore conclude that, if $\beta > \hat{\beta}$, there exists no D under which the equilibrium is fully efficient. ■

Proof of Corollary 1. First, we show that a second-best liability D, if it exists, must induce $\bar{\Phi}(D) = \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u)$ in equilibrium. Suppose to the contrary that D is a second-best liability under which the consumer's optimal price satisfies

$$\bar{\Phi}^b(D) = \arg\sup_{\bar{\Phi}\in[0,k^*)} S^b(\bar{\Phi}) \equiv \delta < k^*.$$

Then, $S^b(\delta)$ is attained, $\hat{k}(D, \bar{\Phi}) = \delta$, and

$$W(D) = S^b(\delta) + (\beta + (1-\beta)F(\delta))\delta - (1-\beta)\int_0^\delta kf(k)dk.$$

Consider another liability rule $\hat{D} \equiv (\hat{D}_o, \hat{D}_u)$ satisfying $\theta(1-\theta)(\alpha_o \hat{D}_o + \alpha_u \hat{D}_u) = \delta$. Then, under $\hat{D}$ we have $\sup_{\bar{\Phi}\in[0,\delta)} S^b(\bar{\Phi}(\hat{D})) \le S^b(\delta) = \sup_{\bar{\Phi}\in[0,k^*)} S^b(\bar{\Phi}^b(D))$, because $\delta < k^*$ and $S^b\left(\bar{\Phi}\right)$ depends on D only through $\bar{\Phi}$. Under liability $\hat{D}$, if the consumer chooses $\bar{\Phi} = \delta = \theta(1-\theta)(\alpha_o \hat{D}_o + \alpha_u \hat{D}_u)$, with $\Phi_M = \theta\alpha_o \hat{D}_o$ and $\Phi_m = (1-\theta)\alpha_u \hat{D}_u$, then $\hat{k}(\hat{D}, \bar{\Phi}) = \delta$ and the consumer obtains surplus

$$\begin{aligned} S^a(\delta) &= [\beta + (1-\beta)F(\delta)]\,[-\delta - (1-\theta)C] + (1-\beta)\,[1 - F(\delta)] \max\{-C - \theta z_o, -(1-\theta)z_u)\} \\ &> [\beta + (1-\beta)F(\delta)]\,[-\delta - (1-\theta)C] + (1-\beta)\,[1 - F(\delta)]\,(-x) = S^b(\delta). \end{aligned}$$

Thus liability $\hat{D}$ induces $\bar{\Phi}(\hat{D}) = \delta$ and leads to welfare

$$W(\hat{D}) = S^a(\delta) + [\beta + (1-\beta)F(\delta)]\,\delta - (1-\beta)\int_0^\delta kf(k)dk > W(D).$$

Therefore, any D that induces $\bar{\Phi}^b(D)$ can not be a second-best liability.

It follows that for a liability rule $D^{**} \equiv (D_o^{**}, D_u^{**})$ to be a second-best, it must induce expected price margin $\bar{\Phi}(D^{**}) = \theta(1-\theta)(\alpha_o D_o^{**} + \alpha_u D_u^{**})$ in equilibrium, with $\Phi_M^* = \theta\alpha_o D_o^{**}$

and $\Phi_m^* = (1-\theta)\alpha_u D_u^{**}$. Furthermore, $\hat{k}(D^{**}, \bar{\Phi}) = \bar{\Phi}(D^{**})$, and welfare is

$$W(\hat{k}(D^{**})) = (1-\beta)\left[1 - F(\hat{k})\right] \max\{-\theta z_o - C, -(1-\theta)z_u\} \\ + \left[\beta + (1-\beta)F(\hat{k})\right][-(1-\theta)C] - (1-\beta)\int_0^{\hat{k}} kf(k)dk.$$

Notice that

$$\begin{aligned} \frac{dW}{d\hat{k}} &= (1-\beta)f(\hat{k})\,[-(1-\theta)C] \; - (1-\beta)f(\hat{k})\max\{-\theta z_o - C, -(1-\theta)z_u\} - (1-\beta)\hat{k}f(\hat{k}) \\ &= (1-\beta)f(\hat{k})\left[-(1-\theta)C \; - \max\{-\theta z_o - C, -(1-\theta)z_u\} - \hat{k}\right] \\ &= (1-\beta)f(\hat{k})\left(k^* - \hat{k}\right) > 0 \text{ for } \hat{k} < k^*. \end{aligned}$$

Thus, for $\hat{k} < k^*$, welfare increases with $\hat{k}$.

We next show that a second-best liability, D^{**}, indeed exists. Suppose a liability rule $D = (D_o, D_u)$ is such that $\bar{\Phi}_1 = \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u) = k^*$. Because the first-best is not attainable, the equilibrium expected price margin $\bar{\Phi}(D) = \theta\Phi_m(D) + (1-\theta)\Phi_M(D) < \bar{\Phi}_1 = k^*$, where $\Phi_m(D)$ and $\Phi_M(D)$ are equilibrium price margins given D, and we have $S\left(\bar{\Phi}(D)\right) = S^b\left(\bar{\Phi}(D)\right) > S^a\left(\bar{\Phi}_1\right)$.

Because $S^a\left(\bar{\Phi}(D)\right) > S^b\left(\bar{\Phi}(D)\right)$ for given $\bar{\Phi}(D)$, we have $S^a\left(\bar{\Phi}(D)\right) > S^b\left(\bar{\Phi}(D)\right) > S^a\left(\bar{\Phi}_1\right)$. Thus, since $S^a\left(\bar{\Phi}\right)$ is continuous on $\left[\bar{\Phi}(D), \bar{\Phi}_1\right]$, there exists a number $\bar{\Phi}_2 \in \left(\bar{\Phi}(D), \bar{\Phi}_1\right)$ such that $S^a\left(\bar{\Phi}_2\right) = S^b\left(\bar{\Phi}(D)\right)$. Therefore, the optimal liability, when the first-best fails to exist, is $D^{**} = (D_o^{**}, D_u^{**})$ that induces the highest equilibrium $\bar{\Phi} = \theta(1-\theta)(\alpha_o D_o + \alpha_u D_u)$ on $\bar{\Phi} \in \left[0, \bar{\Phi}_2\right]$. That is, $D^{**} = (D_o^{**}, D_u^{**})$ satisfies

$$\bar{\Phi}(D^{**}) = \theta(1-\theta)(\alpha_o D_o^{**} + \alpha_u D_u^{**}) = \bar{\Phi}_2$$

with equilibrium price margins $\Phi_M^* = \theta\alpha_o D_o^{**}$ and $\Phi_m^* = (1-\theta)\alpha_u D_u^{**}$, the consumer's surplus is $S\left(\bar{\Phi}\right) = S^a\left(\bar{\Phi}(D^{**})\right)$, the expected price margin is $\bar{\Phi}(D^{**})$, and $\hat{k}(D^{**}, \bar{\Phi}(D^{**})) = \bar{\Phi}(D^{**}) < k^*$. ■

References

[1] Alger, I., and F. Salanie (2006): "A Theory of Fraud and Overtreatment in Expert Markets," Journal of Economics and Management Strategy, 15, 853–881.

[2] Arlen, J. (2013): "Economic Analysis of Medical Malpractice Liability and Its Reform," Research Handbook on the Economics of Torts, PP. 33-68, Edward Elgar, Cheltenham, UK · Northampton, MA, USA.

[3] Arlen, J., and W. B. MacLeod (2005): "Torts, expertise, and authority: liability of physicians and managed care organizations," Rand Journal of Economics, 36, 494–519.

[4] Balafoutas, L., and R. Kerschbamer (2020): "Credence Goods in the Literature: What the Past Fifteen Years Have Taught Us About Fraud, Incentives, and the Role of Institutions," Journal of Behavioral and Experimental Finance, 26, 100285.

[5] Bardey, D., Gromb, D., Martimort, D. and J. Pouyet (2020): "Controlling Sellers Who Provide Advice: Regulation and Competition," Journal of Industrial Economics, https://doi.org/10.1111/joie.12228

[6] Bester, H., and M. Dahm (2018): "Credence Goods, Costly Diagnosis, and Subjective Evaluation," Economic Journal, 128, 1367-1394.

[7] Buck, I. D. (2013): "Caring Too Much: Misapplying the False Claims Act to Target Overtreatment," Ohio State Law Journal, 74, 463–513.

[8] Buck, I. D. (2015): "Breaking the Fever: A New Construct for Regulating Overtreatment," U. C. Davis Law Review, 48, 1261-1318.

[9] Brown, J. P. (1973): "Toward an Economic Theory of Liability," The Journal of Legal Studies, 2, 323–349.

[10] Brownlee, S. (2008): Overtreated: Why Too Much Medicine is Making Us Sicker and Poorer. New York: Bloomsbury USA.

[11] Chen, Y., and X. Hua (2012): "Ex Ante Investment, Ex Post Remedies, and Product Liability," International Economic Review, 53, 845–866.

[12] Coey, D. (2015): "Physicians' Financial Incentives and Treatment Choices in Heart Attack Management," Quantitative Economics, 6, 703–748.

[13] Danzon, P. M. (1991): "Liability for Medical Malpractice," Journal of Economic Perspectives, 5, 51–69.

[14] Darby, M., and E. Karni (1973): "Free Competition and the Optimal Amount of Fraud," Journal of Law and Economics, 16, 67–88.

[15] Daughety, A. F., and J. F. Reinganum (1995): "Product Safety: Liability, R&D, and Signaling," American Economic Review, 85, 1187–1206.

[16] Daughety, A. F., and J. F. Reinganum (2008): "Product Liability, Signaling, and Disclosure," Journal of Institutional and Theoretical Economics, 164, 106–126.

[17] Dickstein, M. J. (2016): "Physician vs. Patient Incentives in Prescription Drug Choice," Working Paper.

[18] Demougin, D., and C. Fluet (2006): "Preponderance of Evidence," European Economic Review, 50, 963-976.

[19] Demougin, D., and C. Fluet (2008): "Rules of Proof, Courts, and Incentives," Rand Journal of Economics, 39, 20-40.

[20] Dulleck, U., and R. Kerschbamer (2006): "On Doctors, Mechanics, and Computer Specialists: The Economics of Credence Goods," Journal of Economic Literature, 44, 5–42.

[21] Dulleck, U., and R. Kerschbamer (2009): "Experts vs. Discounters: Consumers Free-Riding and Experts Withholding Advice in Markets for Credence Goods," International Journal of Industrial Organization, 27, 15–23.

[22] Emons, W. (1997): "Credence Goods and Fraudulent Experts," Rand Journal of Economics, 28, 107-119.

[23] Emons, W. (2001): "Credence Goods Monopolists," International Journal of Industrial Organization, 19, 375-389.

[24] Fong, Y. (2005): "When do Experts Cheat and Whom do They Target?" Rand Journal of Economics, 36, 113–130.

[25] Fong, Y. and T. Liu (2018): "Liability and Reputation in Credence Goods Markets," Economics Letters, 166, 35–39.

[26] Fong, Y., T. Liu, and D. J. Wright (2014): "On the Role of Verifiability and Commitment in Credence Goods Market," International Journal of Industrial Organization, 37, 118–129.

[27] Gruber, J., and J. Kim, and D. Mayzlin (1999): "Physician Fees and Procedure Intensity: The Case of Cesarean Delivery," Journal of Health Economics, 18, 473–490.

[28] Hua, X. (2011): "Product Recall and Liability," Journal of Law, Economics, & Organization, 27, 113–136.

[29] Liu, T. (2011): "Credence Goods Markets with Conscientious and Selfish Experts," International Economic Review, 52, 227–244.

[30] Shavell, S. (1980): "Strict Liability vs. Negligence," Journal of Legal Studies, 9, 1–25.

[31] Shavell, S. (2007): "Liability for Accidents," Handbook of Law and Economics, Volume 1, edited by A. Mitchell Polinsky and Steven Shavell, Elsevier B.V..

[32] Simon, M. J. (1982): "Diagnoses and Medical Malpractice: A Comparison of Negligence and Strict Liability Systems," Bell Journal of Economics, 13, 170–180.

[33] Spier, K. E. (2011): "Product Safety, Buybacks, and the Post-Sale Duty to Warn," Journal of Law, Economics, & Organization, 27, 515–539.

[34] Taylor, C.R. (1995): "The Economics of Breakdowns, Checkups, and Cures," Journal of Political Economy, 103, 53-74.