Trust Building in Credence Goods Markets

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Abstract

This paper studies trust building in credence goods markets and its impact on a long-lived seller's conduct and market efficiency. In credence goods markets, clients lack expertise to identify the proper treatment for their problems and thus rely on sellers for diagnosis and treatment provision. In the static game, an extreme "lemon problem" develops and there is no trade for the seller's services. We characterize the payoff set of the perfect public equilibria in the repeated game. When the discount factor is sufficiently high, transaction takes place in the most profitable equilibrium. Nevertheless, the most profitable equilibrium either involves undertreatment for the serious problem or overtreatment for the minor problem. As the discount factor approaches to one, the inefficiency approaches to zero. In a competitive market with multiple experts, clients monitor expert honesty by search for second opinion. We find that i) the existence of second opinion may induce more dishonest recommendations, and ii) the industry profit may increase when the market becomes more competitive. When search cost converges to zero, the industry profit in the competitive equilibrium converges to the first best.

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1 Introduction

This paper studies trust building in markets for professional services such as health care, business consulting, various repair services and taxi rides services. In these markets, buyers often lack expertise to identify the appropriate treatments for their problems and hence rely solely on experts for diagnosis and treatment provision. The information asymmetry may prevail even after transaction takes place because buyers often cannot assess the value of the received services. For example, consider that you have a knee injury and your doctor recommends an arthroscopic knee surgery. You can verify whether the pain is relieved after the surgery procedure, but it is hard to tell whether it could have been solved simply by changing your life style. Goods and services with these features are termed "credence goods" by Darby and Karni (1973).

In credence goods markets, sellers' expertise in diagnosing buyers' problems makes them "experts", but also provides them with opportunities to exploit their clients. There is a great deal of documented evidence to demonstrate that expert fraud is very common and costly. CNN reported that a doctor in Michigan made millions of dollars from prescribing cancer treatment drugs to more than 500 patients who don't need it.[1] Auto repair is consistently listed as the number one of the top consumer complaints in the U.S.[2] Blafoutas et al. (2013) and Liu et al. (2017) find empirical evidence that taxi drivers take non locals for unnecessary detours.

When clients are concerned about expert fraud, trust plays an important role in facilitating trade between experts and their clients. It has been documented that patient compliance rates are nearly three times higher in primary care relationships characterized by very high levels of trust.[3] Similarly, homeowners or car owners are more likely to follow recommendations made by handymen or mechanics whom they trust. Despite the fact that trust plays an important role in guiding buyers' decisions when seeking professional services, the mechanism through which a credence good seller builds trust has not been formally studied in the literature

[1] "Patients give horror stories as cancer doctor gets in prison", CNN, July 11, 2015.

[2] "Nation's Top Ten Consumer Complaints", Consumer Federation of America.

[3] Atreja A, Bellam N, Levy SR. Strategies to enhance patient adherence: making it simple.MedGenMed. 2005;7(1):4, Piette JD, Heisler M, Krein S, Kerr EA. The role of patient-physician trust in moderating medication nonadherence due to cost pressures. Arch Intern Med. 2005;165(15):1749-1755

and is not well understood.

The fact that this subject has not received the attention it deserves may be driven by the presumption that trust building mechanism for credence goods is similar to that of experience goods. Nevertheless, we argue that these trust building mechanisms must be quite different. For the seller to be able to build trust, it is important that buyers are able to monitor the seller's previous actions. An experience-good buyer can monitor the quality of the good based on her consumption experience. However, such monitoring technology is ineffective for credence goods because once the buyer has received the services and her problem has been fixed, she cannot tell whether she really needed the service, i.e., whether the expert was honest.

In this paper, we investigate a long-lived expert's trust building in a repeated game and ask the following questions: 1) how do buyers monitor a credence-good expert's honesty? 2) How does the expert's concern for future business shape his pricing and recommendation strategies? 3) Is the efficient treatment attainable when the expert is sufficiently patient? 4) What are the sources of inefficiency when it arises? 5) How does competition influence the trust building mechanism?

In our model, a long-lived expert interacts with a sequence of short-lived clients, each with a problem causing a substantial or a minor loss. We thereafter call the problem serious or minor, respectively. Clients do not know the nature of their problems and rely on the expert for diagnosis and treatment. The expert has one treatment which can fix both types of problem. It is efficient to use the treatment for the serious problem but inefficient to use it for the minor problem.

In each period, the expert posts a price for his treatment. A client arrives in the market. She observes the price and consults the expert for treatment. After diagnosis, the expert learns the nature of the client's problem. Then, he either recommends the treatment at the quoted price or recommends no treatment. If the expert recommends the treatment, the client decides whether or not to accept it. Once the client accepts the treatment, the expert is liable for fixing the client's problem. At the end of the period, the expert's price, his recommendation, the client's acceptance decision as well as her utility from accepting or rejecting the expert's recommendation become public information. In other words, the client shares her experience with others. This assumption is motivated by the flourishing of websites like Angie's list, Yelp, and RateMDs on which consumers actively post and share reviews on experts' services.

We assume the expected loss caused by the problem is lower than the cost of fixing the serious problem. Under this assumption, an extreme "lemon problem" emerges when the expert has no concern for future business. The expert's recommendations cannot credibly convey any information about his clients' problems. In equilibrium, clients always reject the expert's recommendations, and the market for the expert's services collapses. This no-trade equilibrium holds whether the services are credence goods or experience goods because clients' post-consumption experiences do not play any role in the static game.

We characterize the set of perfect public equilibrium payoffs of the repeated game and focus on the most profitable equilibrium, which is referred to as the *optimal equilibrium* thereafter. Despite the complexity of the infinitely repeated game, the expert can obtain the maximum profit using fairly simple strategies. The monitoring technology in the optimal equilibrium is determined endogenously by the expert's pricing and recommendation strategies. The expert's equilibrium profit is weakly increasing in the discount factor but cannot achieve the first best. Specifically, the optimal equilibrium may involve *overtreatment* for the minor problem or *undertreatment* for the serious problem. This stands in sharp contrast with canonical models of experience goods markets wherein the experience goods seller obtains the first best when the discount factor is greater than a threshold.

When the expert is sufficiently patient or the likelihood of the serious problem is low, clients monitor expert honesty through rejection in the optimal equilibrium. We refer to this equilibrium as the *monitoring-by-rejection equilibrium.* In this equilibrium, the expert makes honest recommendations and charges a high price as honesty premium. The price for the treatment is so high that clients sometimes reject the expert's treatment recommendations. When a client rejects the treatment, she can infer from her loss whether the expert has lied. If the expert is caught lying, he loses all future business. Because the client's rejection rate is determined endogenously and is less than one, the equilibrium involves imperfect monitoring. Client rejection keeps the expert honest but also leads to undertreatment for the serious problem.

When the expert is not very patient or the likelihood of the serious problem is high, the optimal equilibrium exhibits a very different feature. The expert posts a low price for his treatment and recommends the treatment for both types of problems. He makes a loss from treating the serious problem but has a gain from fixing the minor problem. Clients always accept the expert' recommendations. This equilibrium is called *one-price-fix-all equilibrium.* In this equilibrium, clients give up monitoring expert honesty. The implicit agreement is that the expert should always fix clients' problems at the quoted price and the expert loses future business once he refuses to treat a client. Since the expert's rejection is perfectly observable, the one-price-fix-all equilibrium involves perfect monitoring. This equilibrium is also inefficient because it involves *overtreatment* for the minor problem.

In a competitive market with N experts, there exists a symmetric equilibrium in which clients monitor expert honesty by searching for second opinion. In the equilibrium, experts recommend the treatment for the serious problem with probability one and for the minor problem with a small positive probability. A client randomizes between accepting the first treatment recommendation and searching for second opinion. If the client searches for second opinion and is recommended the treatment again, she accepts the second treatment recommendation with probability one. If the second opinion recommends no treatment, the expert recommending the treatment on the client's first trip will lose all future business. This competitive equilibrium is sustainable when the discount factor is sufficiently high.

In the competitive equilibrium, the client has a gain from search when the second opinion recommends no treatment. In this case, the client avoids fixing the minor problem. Nevertheless, the client bears a search cost. In equilibrium, the client's gain from search equals the search cost and makes her indifferent between whether or not to search.

The competitive equilibrium has some interesting features. First, the monitoring technology for expert honesty is more efficient than the monopoly market when the search cost is small. Recall that in the monopoly market, clients have to reject the treatment offer with a positive probability in order to keep the expert honest. This results in an efficiency loss from unrepaired serious problems. By contrast, in the competitive market, clients monitor expert honesty by search for second opinion. Although a client may reject the first treatment recommendation, she accepts the second recommendation with probability one. So, the serious problem is is always fixed. When search cost is small enough, the monitoring technology in the competitive market is more efficient than the monopoly market.

Second, the industry profit increases when the search cost is reduced. In other words, the industry profit increases when the market for expert services become more competitive. The intuition is the following. Holding experts' recommendation policy constant, a client is in favor of search when the search cost is reduced. In order to make the client indifferent, her gain from search must also be reduced proportionally. This happens when experts become more honest, which reduces the probability that the client samples two conflicting recommendations. When experts are more honest, clients are willing to pay more for their treatment. As a result, the equilibrium price for the treatment is higher and the industry profit is also higher. In fact, when the search cost converges to zero, the industry profit converges to the first best.

Third, the availability of second opinion may induce more dishonest recommendations. The competitive equilibrium involves small but pervasive cheating among experts. By contrast, in the monopoly market, the expert makes honest recommendations when the discount factor is high enough or when clients' problems are likely to cause the minor loss.

Most of the existing literature on credence goods focuses on a one-time transaction between experts and clients. Contributions to this literature can be broadly classified into two categories. In the first, it is assumed that the expert is liable to fix the client's problem once the expert has charged the client. Papers in this category include Pitchik and Schotter (1987), Wolinsky (1993), Fong (2005), Dulleck et al. (2006), and Liu (2011). In the second category, it is assumed that the repair service provided by the expert is verifiable so the expert cannot provide a service different from the one he promised to deliver. Papers in the second category include Emons (1997, 2001), Dulleck et al. (2006). Alger & Salanie (2006) study a model with partial verifiability. Fong, Liu and Wright (2014) compare market outcomes under liability and verifiability, emphasizing the importance of controlling for consumers' commitment to accept recommended treatments in the comparison. Please also see Dulleck et al. (2006) for a comprehensive review of the early literature.

While the literature has extensively studied different mechanisms that discipline the expert's behavior in a static game, the role of trust has not been as thoroughly investigated. The paper most closely related to ours is Wolinsky (1993). While Wolinsky investigates the expert's reputation concern in Section 5 of his paper as an extension, there are important differences between our and his work. First, Wolinsky (1993) rules out supergame consideration and considers an overlapping generation model. A consumer lives for two periods and chooses her second period actions based on her interaction with the expert in the first period. By contrast, we allow a consumer to observe the entire public history and choose the strategy based on it. Second, Wolinsky assumes that once a client delegates the treatment decision to the expert, she commits to accepting any recommendation made by the expert. Client commitment takes away the use of rejection and search as a monitoring technology, which is the heart of our paper.

Frankel, Alexander and Michael Schwarz (2009) and Ely, Jeffrey and Juuso Välimäki (2003) investigate a long-lived expert's recommendation strategy when facing a sequence of short-lived consumers. Similar as Wonlinsky (1993), they both assume that clients commit to accepting the chosen expert's recommendations, so they can only use the expert's past recommendation history to monitor his honesty.

Pesendorfer and Wolinsky (2003) consider a model in which experts need to exert a costly and unobservable effort to diagnose a client's problem. They study how competitive sampling of prices and opinions affect experts' effort choices. We assume costless and perfect diagnosis and complement their study by focusing on experts' incentives to make truthful recommendations. In Pesendorfor and Wolinsky, an expert's diagnosis effort has an externality on other experts' returns from their costly efforts. An expert has a reward for making the costly diagnosis effort only when other experts also make such an effort. In our model, an expert's recommendation strategy has an externality on other experts' trust building incentives. When an expert makes a dishonest recommendation for a client, the chance that he is punished and loses all future business depends on the probability that other experts also lie about the client's condition.

2 Model

Environment and Players A risk neutral, long-lived expert interacts with an infinite sequence of risk neutral, short-lived clients. Each period $t \in \{1, 2, ..., \infty\}$ one client arrives with a problem which is either minor or serious. Denote by l_s the loss from the serious problem and l_m the loss from the minor problem, with $0 < l_m < l_s$. We refer to l_s and l_m as substantial and minor losses, respectively. It is common knowledge that the problem is serious with probability $\alpha \in (0, 1)$. The expert can perfectly diagnose the client's problem at zero cost. There is one treatment available for the expert to fix both types of problems. It costs the expert c to apply the treatment on the serious problem and $c - \varepsilon$, for some $\varepsilon > 0$, to apply it on the minor problem [4]. We assume $l_m < c - \varepsilon < c < l_s$, so it is socially efficient to fix the serious problem but inefficient to fix the minor problem. This assumption allows us to study overtreatment, i.e., provision of a treatment whose cost outweighs its benefit to consumers, which is well documented in health care, car repair and legal services markets.

For algebraic simplicity, we assume $E(l) \equiv \alpha l_s + (1 - \alpha) l_m < c$, which implies $\alpha < \widehat{\alpha} \equiv \dfrac{c - l_m}{l_s - l_m}$. Under this condition, there is no trade in the static game. When this condition is violated, both types of problem will be fixed at the the client's expected loss in the static game. Our main results continue to hold in this case but the algebra is more involved because the expert's payoff in the punishment phase is not zero. Following the literature[5], we adopt the assumption the expert is liable for fixing the client's problem once the client has accepted his recommendation. This assumption is termed the *liability assumption* in Dulleck and Kerschbamber (2006). [6]

Payoffs The expert maximizes his expected discounted sum of profit with discount factor $\delta \in (0, 1)$. The expert's profit from treating the serious problem at price p is $p - c$, and that from treating the minor problem is $p - c + \varepsilon$. Each client maximizes her expected payoff. A client's payoff is $u = -l_i$ if she has problem $i \in \{m, s\}$ and the problem is left untreated. The client's payoff is $u = -p$ if the problem is fixed at price p. Note that under the liability assumption, the client receives the same utility once she accepts the treatment.

[4] In many real-life situations, the cost of a treatment depends on the complexity of a client's problem. For example, a cardiac surgeon spends less time on a by pass surgery when a patient's problem is mild than when her condition is serious. Similarly, it requires a tax lawyer less effort to file tax return for a taxpayer with a relatively simple tax situation.

[5] Pitchik and Schotter (1987), Wolinsky (1993), Fong (2005) and Liu (2011), Dulleck and Kerschbamber (2006).

[6] Our results continue to hold qualitatively if we relax the liability assumption. When the expert is not liable for fixing the client's problem, there is still no trade in the static Nash equilibrium. In the repeated game, if the expert charges a client for treatment which is not provided, the client will suffer the loss at the end of the period. Thus, the expert's fraudulent behavior will be perfectly revealed to future clients and trigger the punishment phase. To support the monitoring-by-rejection or the one-price-fix-all equilibrium, we just need to add incentive constraints to ensure the expert does not take the money and run. These conditions are satisifed when the discount factor is high enough.

The client's utility depends on the nature of her problem only when the problem is left untreated and the loss of it is realized. To fix ideas, consider that the client suffers a knee injury, and her doctor recommends a surgical treatment which guarantees a full recovery. If the client chooses to wait and see, she will recover after changing her life style when the problem is minor, but will lose mobility if her problem is serious

Information The client does not know the nature of her problem and has to rely solely on the expert for diagnosis and treatment. The expert learns whether the client's problem is serious or minor after diagnosis. The cost of treatment incurred by the expert is unobservable to the client. At the end of a period, the prices charged by the expert, his recommendation, the client's acceptance decision as well as her utility become public information.

Timeline We summarize our model by describing the timeline of events in period $t = 1, 2, ...$

- Stage 1. The expert posts a price p_t for his treatment.[7]
- Stage 2. A client arrives in the market. Nature draws the loss of her problem according to the prior distribution of problems.
- Stage 3. The client observes the price and consults the expert who either proposes to fix the problem at the quoted price or refuses to treat the client.
- Stage 4. If the expert offers to fix the problem, the client decides whether or not to accept the offer.
- Stage 5. The expert and clients observe the realization of a public randomization device, denoted by x_t.[8]

Strategy and Equilibrium Concept Denote by $R_t \in \{p_t, \emptyset\}$ the recommendation made by the expert in Stage 3, where p_t denotes a recommendation of treatment and $\emptyset$ denotes refusal to treat the client's problem. The expert's recommendation policy is $(\beta_{it}, \varphi_{it})$, $i = m, s$, where β_{it} denotes the probability that

[7] It is without loss of generality to assume that the expert posts a single price for his treatment due to the fact that it is inefficient to fix the minor problem. If the expert posts two different prices for fixing different types of problem, clients will reject the price charged for fixing the minor problem in equilibrium.

[8] The use of public randomization device is common in the liteature. This allows the expert and subsequent clients to publicly randomize at the beginning of the next period and hence will convexify the equilibrium payoff set.

the expert recommends p_t for problem i and φ_{it} denotes the probability that the expert refuses to treat problem i. Denote by $a_t \in \{0,1\}$ the client's acceptance decision, where 0 denotes rejection and 1 denotes acceptance. Let $\gamma_t \in [0,1]$ denote the probability that the client accepts price p_t. Formally, we denote $h_t = \{p_t, R_t, a_t, u_t, x_t\}$ as the public events that happen in period t and $h^t = \{h_n\}_{n=1}^{t-1}$ as a public history path at the beginning of period with $h^1 = \varnothing$. Let $H^t = \{h^t\}$ be the set of public history paths till time t. A public strategy for the expert is a sequence of functions $\{P_t, \beta_{mt}, \beta_{st}, \varphi_{mt}, \varphi_{st}\}_{t=1}^{\infty}$, where $P_t : H^t \to \mathbb{R}_+$ and $(\beta_{mt}, \beta_{st}, \varphi_{mt}, \varphi_{st}) : H^t \cup \mathbb{R}_+ \cup \{m, s\} \to [0,1]^4$. The public strategy of the client is $\gamma_t : H^t \cup p_t \to [0,1]$.

Equilibrium Concept We focus on *Perfect Public Equilibria* (Henceforth PPE) in which the expert and clients use public strategies and the strategies constitute a Nash equilibrium following every public history. It is without loss of generality to restrict attention to public strategies. In our game the expert has private information about clients' problems whereas clients do not have any private information. Hence, it is a game with a product monitoring structure. Mailath and Samuelson (2006) have shown that the every sequential equilibrium outcome is a perfect public equilibrium outcome in this case. So, there is no need to consider private strategies.

3 Static game

We first show that market collapses when the expert has no concerns for future business.

Lemma 1 *There is no trade in the static equilibrium.*

GIven that it is efficient to fix the serious problem but inefficient to fix the minor problem, whenever trade happens the serious problem must be repaired with a positive probability. For the expert to be willing to treat the serious problem, he must charge a price $p \geq c$. However, the client will reject such a price because once she accepts the price with a positive probability, the expert will recommend the treatment for both types of problems. This will yield the client a negative expected payoff given $E(l) < c \leq p$. The assumption $E(l) < c$ imposes an upper bound on the likelihood of the serious problem. Thus, when the client's problem is sufficiently likely to cause the minor loss, an extreme "lemons problem" develops. The expert cannot credibly transmit the information about the client's problem through his recommendation, and the market for the expert's services completely shuts down, causing *undertreatment* of the serious problem.

We close this section by pointing out that the no-trade equilibrium continues to hold even if the expert's service is an experience good. This is true because there are no more moves in the game after the client learns her actual problem, so whether the client learns her actual problem has no bearing on the players' earlier actions.To make this statement precise and also for later reference, we define experience-service expert service as follows:

Experience expert service *We say that the expert's service is an experience good if the client observes at the end of the period what the loss of her problem would have been even if she accepts the expert's treatment.*

4 Repeated game

In this section, we study how the expert's conduct is affected by his concerns for future business. Because the expert is a monopolist who moves first in each period, we restrict attention to the optimal equilibrium which yields the expert the highest profit. To illustrate how the monitoring technology for credence services differ from that for experience services and to explore its implication, we first discuss the optimal equilibrium in experience services markets. The characterization of the optimal equilibrium in credence services markets follows.

4.1 Benchmark: experience service markets

We begin with the experience service markets as defined in the previous section and demonstrate that honesty and efficiency are jointly achieved when the expert is sufficiently patient. To see this, consider the following expert strategy: post price l_s for his treatment and recommend the treatment only for the serious problem. Given the expert's strategy, it is the client's best response to accept the treatment recommendation with probability one. Clients continue to accept the expert's recommendations as long as he has not recommended the treatment for the minor problem in the past. The game reverts to the static Nash equilibrium perpetually, otherwise. Given that the expert is honest every period and the client always accepts the expert's recommendation on the equilibrium path, the expert's average profits is $\alpha\left(l_s - c\right)$. Since this is the surplus from the first best, it is the highest attainable profit for the expert.

Now, consider that the expert recommends the treatment for the minor problem. He receives a profit $l_s - c + \varepsilon$ in the current period but will lose all future business because his fraudulent recommendation will be detected and hence he will be punished from the next period onward. The no lying condition requires

$$\underbrace{\frac{\delta}{1-\delta}}_{\text{future loss}} \alpha\left(l_s - c\right) \geq \underbrace{l_s - c + \varepsilon}_{\text{current gain}}$$

which is satisfied if

$$\delta \geq \underline{\delta}^e(\alpha) \equiv \frac{l_s - c + \varepsilon}{l_s - c + \varepsilon + \alpha(l_s - c)}. \tag{1}$$

So, for a given α, the expert can achieve the first best profit by making honest recommendations when the discount factor is greater than the cutoff $\underline{\delta}^e(\alpha)$. This is a common property of experience good models with two quality levels and perfect monitoring.

4.2 Optimal equilibrium in credence goods markets

Now, we consider the repeated interaction between the expert and his clients in markets for credence services, and we analyze how the expert's concern for future business shapes his conduct and market efficiency. Depending on the discount factor and the likelihood of the serious problem, the expert's conduct in the optimal equilibrium exhibits different features and the sources of market efficiency are different. Specifically, the optimal equilibrium is either the so called "monitoring-by-rejection equilibrium" or the "one-price-fix-all equilibrium". We first characterize these two equilibria. Then, we prove that the expert's profit in any perfect public equilibrium is bounded above by his profit from one of these two equilibria. We also characterize the condition under which the monitoring-by-rejection equilibrium is more profitable than the one-price-fix-all equilibrium.

Monitoring-by-rejection equilibrium We begin by characterizing the monitoring-by-rejection equilibrium. In this equilibrium, clients expect the expert to recommend the treatment only for the serious problem and hence are willing to pay a high price for the expert's honest recommendation. Because the treatment fully repairs both types of problem, clients cannot monitor whether the expert has made an honest recommendation if they always accept the treatment recommendation. The expert's honesty is instead revealed only when clients reject his recommendations, the probability of which is determined endogenously. Thus, the monitoring-by-rejection equilibrium involves imperfect public monitoring and is inefficient because the monitoring technology leads to undertreatment for the serious problem. Because the monitoring-by-rejection equilibrium is stationary, we suppress the subscript t and characterize the equilibrium in the following proposition:

Proposition 1 *In the monitoring-by-rejection equilibrium, the expert posts $p = l_s$ for his treatment; he recommends the treatment for the serious problem and no treatment for the minor problem. Clients accept the treatment recommendation at l_s with probability $\gamma^* = 1 - \frac{1-\delta}{\delta\alpha}\frac{l_s - c + \varepsilon}{l_s - c}$ as long as the expert has not been caught recommending the treatment for the minor problem in the past or recommends no treatment for the serious problem. Otherwise, the game reverts to the static Nash equilibrium perpetually. The average profit of the monitoring-by-rejection equilibrium is*

$$\pi^m \equiv \alpha(l_s - c) - \frac{1-\delta}{\delta}(l_s - c + \varepsilon).$$

This equilibrium is sustainable for $\alpha \in (0, \widehat{\alpha})$ and $\delta \in [\underline{\delta}^m, 1)$, with $\underline{\delta}^m(\alpha) = \underline{\delta}^e(\alpha) \equiv \frac{l_s - c + \varepsilon}{l_s - c + \varepsilon + \alpha(l_s - c)}$.

First, note that although the expert makes honest recommendations on the equilibrium path, it is clients' best response to sometimes reject the treatment offer because the treatment price is so high that they are just indifferent between whether or not to accept the treatment recommendation.

To support the monitoring-by-rejection equilibrium, we have to consider both on-schedule and off-schedule deviations by the expert. The expert can make an off-schedule deviation to a price different from l_s. We assume that clients believe the expert will recommend the treatment for both types of problems at $p' \in [c, l_s)$ and for the minor problem at $p' \in [c - \varepsilon, c)$. Given the clients' off-equilibrium belief, they will reject p' with probability one, yielding the expert zero profit in the current period. Since the off-schedule deviation is perfectly observable, we assume that the game reverts to the static Nash equilibrium perpetually following a price deviation, and hence the expert loses all future profit. Given clients' strategies, the expert does not have a profitable price deviation.

The expert can also make an on-schedule deviation by recommending the treatment for the minor problem. Since clients accept the treatment with a positive probability, the on-schedule deviation is not always detected and punished. Consider that a client has the minor problem. If the expert lies about the client's problem and recommends the treatment, he gains a profit $l_s - c + \varepsilon$ in the current period if his recommendation is accepted. Nevertheless, the expert risks losing all future business if his recommendation is rejected and he is revealed to have lied about the client's problem. Clients' acceptance rate γ^* balances the trade-off the expert is facing and makes him just indifferent between whether or not to recommend the treatment for the minor problem. Hence, it is the expert's best response to recommend no treatment for the minor problem. Specifically, the following no lying condition holds at γ^*:

$$\underbrace{(1-\gamma^*)\frac{\delta}{1-\delta}\alpha(l_s-c)\gamma^*}_{\text{future loss}} = \underbrace{\gamma^*(l_s-c+\varepsilon)}_{\text{current gain}} \tag{2}$$

After canceling one γ^* from both sides of (2), we have:

$$\underbrace{\overbrace{(1-\gamma^*)}^{\text{probability of not getting caught}} \quad \frac{\delta}{1-\delta} \quad \overbrace{\alpha(l_s-c)}^{\text{profit margin in future}}}_{\text{future loss}} = \underbrace{(l_s-c+\varepsilon)}_{\text{profit margin from cheating}}, \tag{3}$$

yielding $\gamma^* = 1 - \frac{(1-\delta)(l_s-c+\varepsilon)}{\delta\alpha(l_s-c)}$.

It is clear that clients' acceptance rate γ^* is increasing in δ and α. So, the inefficiency from undertreatment decreases when the expert has a stronger concern for future business or when the client's problem is more likely to be serious. When the expert cares more about future business, a smaller rejection rate for his recommendation is sufficient to deter him from making dishonest recommendation. As the discount factor approaches to one, γ^* converges to (although never reaching) one and the *monitoring-by-rejection* equilibrium approaches to (although never reaching) full efficiency. To see why γ^* increases in the likelihood of the serious problem, note that the expert's expected equilibrium profit stems from repairing the serious problem and hence increases in the likelihood of the serious problem. So, the expert bears a larger future loss from lying when the likelihood of the serious problem increases. By contrast, the expert's expected gain from lying is made conditional on the problem being minor, and thus is independent of the likelihood of the serious problem. Hence, when clients' problems are more likely to be serious, lying is more costly for the expert and a higher client acceptance rate is sufficient to support the honest recommendation.

Note that when $\delta = 0$ in (3), the expert does not bear any future loss from lying but has a positive current gain. As a result, it is optimal for the expert to always recommend the treatment, which leads to a market breakdown in the static game. When the expert has a sufficiently strong concern for future business, his recommendations can credibly transmit information about clients' problems and hence trade occurs. Even though the expert's reputation concern facilities trade, the serious problem is still left unresolved with a positive probability for δ arbitrarily close to one, which results in undertreatment for the serious problem. The role of rejection in our setting is different from Fong (2005). Fong (2005) studies a static model and assumes that it is efficient to fix both types of problem. In his model, the rejection of the expensive treatment lowers the expected profit of recommending the expensive treatment for the minor problem. Hence, the expert opts for the lower margin of an inexpensive treatment. In our setting, there is only one treatment so if that treatment is accepted with any positive probability, it is optimal for the expert to recommend the treatment whether the problem is minor or serious. Therefore, in our model, clients' rejection cannot support trade in the static game. Instead, it is used to monitor the expert's honesty and will trigger punishment when the expert is caught lying.

Note that the minimum discount factor necessary to sustain the monitoring-by-rejection equilibrium is the same as that required to sustain the honest and efficient equilibrium in experience services markets. So, honesty can be achieved in both markets when $\delta \geq \underline{\delta}^m(\alpha) = \underline{\delta}^e(\alpha)$. Nevertheless, the two equilibria differ in treatment efficiency. Specifically, the first best treatment can be achieved for any $\delta \geq \underline{\delta}^e(\alpha)$ in experience services markets. By contrast, treatment efficiency in the monitoring-by-rejection equilibrium gradually increases in δ for $1 > \delta \geq \underline{\delta}^m(\alpha)$, but is always bounded above by the first best treatment.

The following comparative statics are derived directly from Proposition 1 (proof omitted), and will be used for characterizing the optimal equilibrium.

Corollary 1 *π^m strictly increases in α and δ; the cutoff discount factor $\underline{\delta}^m(\alpha)$ strictly decreases in α.*

The expert's average profit increases in α and δ because clients' acceptance rate γ^* increases in α and δ. To see the minimum discount factor necessary to support the equilibrium decreases in α, note that the expert's equilibrium profit is higher when the problem is more likely to have a substantial loss. So, the expert bears a larger future loss from lying and therefore is willing to make honest recommendations at a lower discount factor.

One-price-fix-all equilibrium We now turn to the one-price-fix-all equilibrium. In this equilibrium, the expert always recommends the treatment irrespective of clients' problems. Therefore, his recommendation does not reveal any information about the nature of his clients' problems. Because it is inefficient to fix the minor problem, clients' expected benefit from the treatment is smaller than in the monitoring-by-rejection equilibrium. As a result, they are willing to pay a lower price. In contrast with the monitoring-by-rejection equilibrium, the one-price-fix-all equilibrium involves *overtreatment* for the minor problem instead of under-treatment for the serious problem.

Define $\alpha' \equiv \dfrac{c-\varepsilon-l_m}{l_s-\varepsilon-l_m}$ and $\underline{\delta}^o(\alpha) \equiv \dfrac{c-E(l)}{(1-\alpha)\varepsilon}$. We characterize below the one-price-fix-all equilibrium which is also stationary:

Proposition 2 *In the one-price-fix-all equilibrium, the expert posts $p = E(l)$ for this treatment and recommends the treatment irrespective of the client's problem. Clients accept the expert's treatment with probability one as long as he recommended the treatment to all previous clients. Otherwise, the game reverts to the static Nash equilibrium perpetually. The average profit of the equilibrium is*

$$\pi^o \equiv \alpha(l_s - c) - (1-\alpha)(c - \varepsilon - l_m).$$

For $\alpha \in (\alpha', \widehat{\alpha})$, the one-price-fix-all equilibrium is sustainable if $\delta \in [\underline{\delta}^o(\alpha), 1)$; it is not sustainable for $\alpha \in (0, \alpha']$.

Because the clients expect the expert to always recommend the treatment, the expert does not have any on-schedule deviation. An off-schedule deviation in price or recommendation strategy is perfectly observed by clients and will be punished from the next period onward.

The condition $\alpha' < \alpha$ ensures that the equilibrium price $E(l)$ is greater than the average cost of fixing the problem so that the expert can earn a positive profit. It also follows that $E(l)$ is greater than the cost of fixing the minor problem. Nevertheless, given the assumption $E(l) < c$, the price is too low to cover the expert's cost of repairing the serious problem. So, the expert has an incentive to cherry-pick the clients with the minor problem and refuse to treat those with the serious problem. When the discount factor is greater than the cutoff $\underline{\delta}^o(\alpha)$, the expert's current gain from dumping a client with the serious problem is outweighed by his loss from losing all future business, and the equilibrium is sustainable.

The comparative statics follow (proof omitted):

Corollary 2 *π^o strictly increases in α and remains constant in δ. When $\alpha \in (\alpha', \widehat{\alpha})$, the cutoff discount factor $\underline{\delta}^o(\alpha)$ strictly decreases in α.*

Given that it is efficient to fix the serious problem but inefficient to fix the minor problem, the surplus from trade increases in the likelihood of the serious problem. As the expert fully extracts the surplus from trade, his expected profit increases in α. It can be verified that the derivative

$$\frac{\partial \underline{\delta}^o(\alpha)}{\partial \alpha} = -\frac{l_s - c}{(1-\alpha)^2 \varepsilon} < 0.$$

So, it is easier to sustain the one-price-fix-all equilibrium when the likelihood of the serious problem is higher. To see this, when the problem is more likely to cause a substantial loss, clients are willing to pay more for the treatment. As a result, the expert bears a smaller loss from repairing the serious problem and hence has a smaller gain from dumping clients with the serious problem. On the other hand, as α increases, the expert's average profit π^o also increases, so the expert has more to lose when his rejection triggers the punishment phase. .

The next proposition shows the optimal equilibrium is either the monitoring-by-rejection or the one-price-fix-all equilibrium.

Proposition 3 *For each $\alpha \in (0, \widehat{\alpha})$, the expert's average profit in any Perfect Public equilibrium is bounded above by* $\max\{\pi^m, \pi^o\}$.

We characterize the perfect public equilibrium payoff set for the expert and show that the upper bound of the payoff set is either π^m or π^o. In doing so, we adopt the approach pioneered by Abreu, Pearce and Stacchetti (1990). There are five public outcomes in our game: 1) the expert recommends no treatment to a client and the client suffers a minor loss, 2) the expert recommends no treatment and the client suffers a substantial loss, 3) the expert recommends the treatment, the client accepts the treatment and receives utility $-p$, 4) the expert recommends the treatment, the client rejects it and suffers a minor loss, and 5) the expert recommends the treatment, the client rejects it and suffers a substantial loss. The set of public outcomes is denoted by Y.

An action profile $\sigma = (p, \beta_m, \beta_s, \varphi_m, \varphi_s, \gamma)$ determines the probability distribution over the public outcomes $f(y|\sigma)$, $y \in Y$. The action profile $\sigma \in \mathbf{\Sigma}$ is enforceable on a payoff set W if there exists a mapping $\nu : Y \to W$ such that for each player i and $\sigma_i' \in \Sigma_i$,

$$\begin{aligned} u_i(\sigma, \nu) &= (1-\delta)u_i(\sigma) + \delta \sum_{y \in Y} \nu(y) f(y|\sigma) \\ &\geq (1-\delta)u_i(\sigma_i', \sigma_{-i}) + \delta \sum_{y \in Y} \nu(y) f(y|\sigma_i', \sigma_{-i}). \end{aligned}$$

In other words, player i's action maximizes his/her payoff given other players' actions and the continuation payoff $\nu(y)$. In our model, clients are all short lived and therefore their continuation payoffs are zero. The payoff set W is self generating if for every element $w \in W$, there exists an action profile $\sigma \in \mathbf{\Sigma}$, enforced by ν on W, such that $w_i = u_i(\sigma, v)$. The set of perfect public equilibrium payoff is the maximum self-generating set. (See Chapters 7 and 8 in Mailath and Samulson 2006). Hence, we characterize the maximum self-generating set and shows that the upper bound of is $\max\{\pi^m, \pi^o\}$. The proof is relegated to Appendix B.

Next, we characterize the optimal equilibrium for all parameter configurations. Recall that when $\alpha \leq \alpha'$, the one-price-fix-all equilibrium is not sustainable for any $\delta < 1$ and hence the monitoring-by-rejection equilibrium is the most profitable equilibrium when the expert is sufficiently patient. If $\alpha \in (\alpha', \widehat{\alpha})$, both the monitoring-by-rejection and the one-price-fix-all equilibria are sustainable when the discount factor is sufficiently high. In the following analysis, we characterize the condition under which the monitoring-by-rejection equilibrium dominates the one-price-fix-all equilibrium. To begin, we first compare the minimum discount factors necessary to support each type of equilibrium.

Lemma 2 *There exists a unique cutoff likelihood* $\overline{\alpha} \in (\alpha', \widehat{\alpha})$ *such that* $0 \leq \underline{\delta}^m(\alpha) \leq \underline{\delta}^o(\alpha) \leq 1$ *for* $\alpha \in (\alpha', \overline{\alpha}]$ *and* $0 \leq \underline{\delta}^o(\alpha) < \underline{\delta}^m(\alpha) \leq 1$ *for* $\alpha \in (\overline{\alpha}, \widehat{\alpha})$.

By Corollaries 1 and 2, the cutoff discount factors $\underline{\delta}^m(\alpha)$ and $\underline{\delta}^o(\alpha)$ are both decreasing in α and are illustrated in Figure 1. It is best to understand the comparison by considering the two extreme cases: α is at α' and at $\widehat{\alpha}$. First, consider that clients are likely to have the minor problem (α is at α'). By Proposition 2, clients' maximum willingness to pay in the *one-price-fix-for-all* equilibrium is at most the average cost from repairing the problem. Without a positive profit, the expert bears no future loss from refusing to fix the serious problem, so the *one-price-fix-for-all* equilibrium is not sustainable for all $\delta < 1$. By contrast, the monitoring-by-rejection equilibrium is sustainable as long as δ is sufficiently close to one. This can be seen in Figure 1 that $\underline{\delta}^m(\alpha)$ lies strictly below 1 for all $\alpha > 0$. In the monitoring-by-rejection equilibrium, the expert's profit becomes smaller when the likelihood of the minor problem becomes higher. But as long as the expert's concerns for future business increase proportionally, it will balance off his incentive to recommend the treatment for the minor problem.

As α approaches to $\widehat{\alpha}$, it is easier to support the one-price-fix-for-all equilibrium. Note that in Figure 1, $\underline{\delta}^o(\widehat{\alpha}) = 0$. This is because when $\alpha = \widehat{\alpha}$, clients' average loss $E(l)$ equals the treatment cost for the serious problem. Hence, it is optimal for the expert to repair the serious problem even when he has no concern for future business. By contrast, in order to support the monitoring-by-rejection equilibrium, the expert's discount factor must be positive. If the expert has no concern for future business, he would strictly prefer to recommend the treatment for the minor problem because he has a positive gain in the current period but bears no future loss from lying.

By Lemma 2, both the monitoring-by-rejection and the one-price-fix-all equilibria are sustainable for $\alpha \in (\alpha', \widehat{\alpha})$ and $\delta > \max\{\underline{\delta}^o(\alpha), \underline{\delta}^m(\alpha)\}$ (refer to Figure 1). In this case, the most profitable equilibrium depends on the comparison between π^m and π^o. For a fixed α, define $\delta_1(\alpha) \equiv \frac{l_s - c + \varepsilon}{l_s - c + \varepsilon + (1-\alpha)(c - \varepsilon - l_m)}$ which is solved from $\pi^m = \pi^o$. Next, we characterize the expert's optimal profit for all configurations of (α, δ) with $\alpha \in (0, \widehat{\alpha})$ and $\delta \in (0, 1)$.

Proposition 4 *There exists a unique cutoff* $\alpha^* \in (0, \widehat{\alpha})$ *such that*

i) $\forall\ \alpha \in (0, \alpha^*]$, *the maximum average profit is* π^m *for* $\delta \in [\underline{\delta}^m(\alpha), 1)$ *and zero, otherwise;*

ii) $\forall\ \alpha \in (\alpha^*, \overline{\alpha}]$, *the maximum average profit is* π^m *for* $\delta \in [\underline{\delta}^m(\alpha), \underline{\delta}^o(\alpha)] \cup [\delta_1(\alpha), 1)$, π^o *for* $\delta \in (\underline{\delta}^o(\alpha), \delta_1(\alpha))$ *and zero, otherwise;*

iii) $\forall \alpha \in (\,\overline{\alpha}, \widehat{\alpha})$, *the maximum average profit is* π^o *for* $\delta \in [\underline{\delta}^o(\alpha), \delta_1(\alpha))$, π^m *for* $\delta \in [\delta_1(\alpha), 1)$ *and zero, otherwise.*

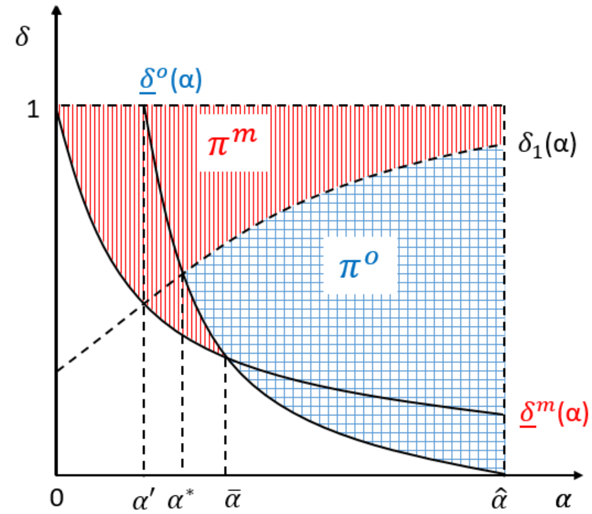

Figure 1

We illustrated the maximum attainable average profit in Figure 1. For any $\alpha \in (0, \widehat{\alpha})$, π^m is sustainable if and only if $\delta \geq \underline{\delta}^m(\alpha)$. Similarly, π^o is sustainable if and only if $\delta \geq \underline{\delta}^o(\alpha)$. For $\alpha \in (\alpha', \widehat{\alpha})$, both π^m and π^o are attainable if $\delta \geq \max\{\underline{\delta}^m(\alpha), \underline{\delta}^o(\alpha)\}$, and $\pi^m \geq \pi^o$ if and only if $\delta \geq \delta_1(\alpha)$. So, the expert's maximum attainable average profit is π^m in the striped area and is π^o in the shaded area with squares. It is zero for the remaining area.

When does the monitoring-by-rejection equilibrium dominate the one-price-fix-all equilibrium? Because the expert extracts the entire surplus from trade in both equilibria, the monitoring-by-rejection equilibrium is more profitable when it is more efficient than one-price-fix-all equilibrium. While the monitoring-by-rejection equilibrium involves *undertreatment* for the serious problem, the one-price-fix-all equilibrium involves *overtreatment* for the minor problem. The efficiency comparison depends on the likelihood of the serious problem as well as the expert's discount factor.

When clients' problems are most likely to be minor (the parameter range $\alpha \in (0, \alpha^*]$), *overtreatment* for the minor problem is more costly than *undertreatment* for the serious problem. Consequently, the monitoring-by-rejection equilibrium dominates the one-price-fix-all equilibrium both in efficiency and profit.

Now, consider that the likelihood of the serious problem is relatively high (the parameter range $\alpha \in (\overline{\alpha}, \widehat{\alpha})$). When $\delta \geq \delta_1(\alpha)$, $\pi^m \geq \pi^o$. This is because as δ converges to one, clients' acceptance rate converges to one in the monitoring-by-rejection equilibrium, and hence the expert's profit converges to the first best. By contrast, the minor problem is always repaired with probability one in the one-price-fix-all equilibrium, yielding π^o dominated by π^m. As δ keeps decreasing, a larger rejection rate is necessary to discipline the expert to make honest recommendations, and the monitoring-by-rejection equilibrium becomes less efficient. As a result, when δ falls below $\delta_1(\alpha)$, the one-price-fix-all equilibrium dominates the monitoring-by-rejection equilibrium in efficiency and profit.

Finally, when α is in the intermediate range $(\alpha^*, \overline{\alpha}]$, something unusual happens. As δ falls below $\delta_1(\alpha)$, the one-price-fix-all equilibrium dominates the monitoring-by-rejection equilibrium in efficiency. However, as δ continues to fall below $\underline{\delta}^m(\alpha)$, the expert is no longer willing to fix the serious problem at a loss, causing the one-price-fix-all equilibrium to collapse. By contrast, the monitoring-by-rejection equilibrium is still sustainable, although giving the expert a lower profit.

When information asymmetry is severe enough to lead to a market break down in the static game, the expert's concern for future business facilitates trade in both experience goods and credence goods market. Nevertheless, the most profitable equilibrium in credence goods markets stand in sharp contrast to that in experience goods markets. While the efficient treatment is attainable in experience goods markets when the expert is sufficiently patient, it is never attainable in credence goods markets. Undertreatment for the serious problem is likely to arises when the expert is very patient or when the likelihood of the serious problem is very low, and overtreatment is likely to occur when the expert is less patient or when clients' are more likely to have the serious problem.

5 Competitive market

In this section we consider a market with $N \geq 2$ experts and investigate how the trust building mechanism is affected by competition. In the monopoly expert market, clients monitor the expert's honesty by rejecting the expert's treatment offers but they have to bear the loss from unresolved serious problem. When there are multiple experts in the marketplace, clients can monitor an expert's honesty by seeking for second opinion. When an expert recommends the treatment for a client with the minor problem, he risks losing all future business if the client seeks for second opinion and the second opinion recommends no treatment. Hence, consumer search makes experts' trust building mechanism interdependent because the likelihood of an expert being punished for lying depends on the likelihood that other experts also lie about clients' problems. We explore this idea in this section.

We make minimal modifications to the monopoly model and continue to adopt its key elements with two added features. First, consumers pay a small search cost k per visit except for their first visit. The assumption of no search cost for the first visit is inessential[9] and allows us to make a fair comparison with the monopoly market which does not involve a cost of entry. We assume that consumers bear a search cost because search in credence goods markets often involves delay which is costly. Second, we allow entry and exit to maintain a stable pool of experts in market in each period. Specifically, when an expert exits the market, he is replaced by a new expert. Allowing entry and exit is realistic and makes our model tractable. Third, we assume that an expert cannot identify whether a client has any search experience

Events in period t unfold as follows: Experts first simultaneously post prices for their treatment. A client arrives in the market and observes all the prices. She then consults an expert. If the expert recommends no treatment, the client exits the market. Otherwise, the client either accepts the treatment offer or go on to consult another expert. At the end of the period, experts' prices, the client's utility and the recommendations made by all the experts she has visited become public information. If an expert exits the market, he is replaced by a new expert.

We first show that the optimal equilibrium in the monopoly market continue to exist when the discount factor is sufficiently high.

Lemma 3 *The optimal equilibrium in the monopoly market continues to hold in a market with multiple experts.*

[9] Suppose the client pays a search cost for the first visit, then ...

Proposition 3 has shown that the optimal equilibrium in monopoly market is either the monitoring-by-rejection equilibrium or the one-price-fix-all equilibrium. First, consider that all experts adopt the strategy in the monitoring-by-rejection equilibrium in Proposition 1. When a client arrives in the market, she randomly visits an expert. If the expert is revealed to have recommended the treatment for the minor problem, he loses all future clients and is replaced by a new entrant. To see this constitutes an equilibrium, note that because experts are all making honest recommendations, clients do not search for second opinion in the presence of a positive search cost. Since experts have local monopoly, by the same argument for the monitoring-by-rejection equilibrium, experts' recommendation strategies and clients' acceptance decisions are mutually best response. The proof is omitted to avoid repetition.

To support this equilibrium, we need to construct clients' off-equilibrium belief so that experts do not have a profitable deviation in price. Consider the following off-equilibrium belief: If an expert posts a price $p^{'} \neq l_s$, clients believe that the expert will recommend the treatment for both types of problem when $p^{'} \geq c$ and for the minor problem exclusively when $l_m < p^{'} < c$. Given this belief, clients will not visit the deviant because their expected loss conditional on the deviant's treatment recommendation is lower than the price posted by the deviant. Consequently, experts do not have a profitable deviation in price.

There also exists an equilibrium in which all experts adopt the strategies in the one-price-fix-all equilibrium in Proposition 2. Clients randomly visit an expert. If the expert refuses to treat a client, he loses all future business and is replaced by a new entrant. Given that experts make the same recommendations, clients will not search for second opinion. Using the same argument above, experts and clients' strategies constitute an equilibrium.

If consumers do not search, the monitoring technology is the same as the monopoly market. Nevertheless, when search cost is small, there exists another equilibrium in which consumers search and use second opinion to monitor expert honesty.

Proposition 5 *When* $k < \dfrac{(1-\alpha)(l_s - l_m)}{4}$*, there exists a symmetric equilibrium which involves consumer search. Experts' equilibrium strategies are stationary. In each period, experts post price* $p^*(k) \in [c, l_s)$*. They recommend the treatment for the serious problem with probability one and for the minor problem with* *probability $\beta_m^*(k) \in (0,1)$. A client randomly visits an expert when arriving at the marketplace. The client accepts the treatment recommendation with probability $\gamma^*(k|\delta, n) \in (0,1)$ on her first visit, and searches for second opinion with the complementary probability. If recommended the treatment again on her second visit, the client accepts the recommendation with probability one. If the second opinion recommends no treatment, the expert who recommends the treatment on the client's first visit loses all future business and exits the market. This equilibrium is sustainable for $\delta \geq \underline{\delta}(k|n)$.*

To understand the equilibrium, we first analyze a client's incentives to search for second opinion. When all of the experts lie with positive probabilities, the client may receive different recommendations from different experts and hence has incentives to search for second opinion. If the client accepts the treatment on her first visit, her problem will be fixed and she receives a payoff $-p$. Alternatively, the client can go on to search for second opinion. If the second opinion recommends no treatment, the client must have the minor problem and will bear the loss l_m. So, the client has a net benefit of $p - l_m$ from search when the second opinion contradicts the first opinion. The search condition requires that the client's expected net benefit from search equals her search cost k, which gives

$$\Pr(\emptyset|p)(p - l_m) = k, \tag{4}$$

where $\Pr(\emptyset|p)$ is the probability that the second opinion recommends no treatment conditional on the first opinion recommending the treatment. When (4) holds, the client strictly prefers accepting the second treatment recommendation to searching for third opinion. This is because the likelihood that the third opinion recommends no treatment is smaller, and hence the expected net benefit from search is strictly less than the search cost.

For the client to be willing to accept the treatment on her first visit, her expected loss must be at least the price. So, the participation constraint is

$$p \leq \Pr(l_s|p)l_s + \Pr(l_m|p)l_m, \tag{5}$$

where $\Pr(l_i|p)$, $i = m, s$, is the probability that the client's problem is i conditional on a treatment recommendation. Clearly, if the second opinion also recommends the treatment, the client updates her belief of having the serious problem upward and expects a greater loss from the problem. So, the participation constraint (5) implies that the client has a positive surplus from accepting the treatment on her second visit.

Now, we turn to analyze experts' recommendation strategies. An expert is indifferent between whether or not to recommend the treatment for the minor problem when the following condition holds:

$$\overbrace{\frac{\delta\overline{\pi}}{1-\delta}\underbrace{(1-\Pr(\mathrm{e}|l_m))}_{\substack{\text{inexperienced}\\ \text{clients}}}\underbrace{(1-\gamma)(1-\beta_m)}_{\substack{\text{the client receives an}\\ \text{honest 2nd opinion}}}}^{\text{future loss}} = \overbrace{(p-c+\varepsilon)\underbrace{[\Pr(\mathrm{e}|l_m)+(1-\Pr(\mathrm{e}|l_m))\gamma]}_{\substack{\text{prob of acceptance}\\ \text{of the treatment}}}}^{\text{current gain}}, \tag{6}$$

where $\Pr(\mathrm{e}|l_m) \equiv \dfrac{\beta_m(1-\gamma)}{1+\beta_m(1-\gamma)}$ is the probability that an client is on her second visit conditional on her problem being minor and $\overline{\pi}$ is the expert's expected stage game payoff when he is not caught lying. When an expert recommends the treatment for a client with the minor problem, the treatment is accepted if the client is on her second visit or if she is on her first visit and chooses not to search for second opinion, which occurs with probability γ. The expert's profit margin from fixing the minor problem is $p - c + \varepsilon$. So, the expert's expected current gain from recommending the treatment for the minor problem is on the right-hand side of (6). On the other hand, the expert risks losing all future business if he is revealed to have lied. This happens when the client is on her first visit and decides to seek for second opinion which turns out to be honest. The expert's discounted expected future loss from lying is therefore given by the left-hand side of (6). When (6) holds, it is the expert's best response to randomize between whether or not to recommend the treatment for the minor problem.

Similar as in the monopoly case, experts have no profitable price deviation given clients' off-equilibrium belief that an expert will recommend the treatment for both types of problem if he deviates to a price $p' > c$ and recommends the treatment only for the minor problem for $p' < c$. Under this off-equilibrium belief, clients' expected loss from the problem is less than p', and hence the deviant will not attract any clients.

When k is small enough and $\delta \geq \underline{\delta}(k|n)$, there exists a search equilibrium which satisfies the condition (4), (5) and (6) The search equilibrium is sustainable when the discount factor is greater than a threshold. To see this, note that if the discount factor is zero, the expert does not bear any future loss from lying. Nevertheless, he has a current gain from lying because there is a positive probability that the client is on her second visit and will accept the treatment recommendation with probability one. So, the expert will lie with probability one when he does not have enough concern for future business.

This search equilibrium has two interesting features. First, the availability of second opinion may induce more dishonest recommendations. The search equilibrium involves small but pervasive cheating among experts. By contrast, the monopoly expert will make honest recommendations when his discount factor is sufficiently high or the likelihood of the serious problem is sufficiently low. Second, when the search cost is sufficiently low, the search equilibrium is more efficient than the monopoly equilibrium. The conventional wisdom suggests that competition improve efficiency through price effect. In our model, the efficiency gain from competition is due to the more efficient monitoring technology. Recall that in the monopoly market, clients monitor expert honesty by sometimes rejecting his treatment offer even when the expert is making honest recommendation. In other words, it is necessary for clients to burn the surplus from repairing the serious problem to keep the expert honest. When there are competing experts, clients can monitor expert honesty by seeking for second opinion and identify cheaters from conflicting recommendations. The search equilibrium is more efficient because the serious problem is repaired with probability one. Although the search equilibrium still has overtreatment for the minor problem, it only occurs when clients sample two fraudulent recommendations which happens with a small probability.

Lemma 4 *$\beta_m^*(k)$ increases in k and $p^*(k)$ decreases in k.*

Lemma 4 says that when search cost is reduced, experts' lying probability decreases whereas the equilibrium price for their treatments increases. To see this, note that the search condition (4) requires a client to be indifferent between taking the first treatment recommendation and searching for second opinion. When the search cost is reduced, the client's benefit from search must also be reduced proportionally for the indifference condition (4) to hold. This requires experts to be more honest so that the client is less likely to draw two conflicting recommendations. When experts' recommendations are more honest, the client is willing to pay more for the treatment. As a result, the equilibrium treatment price increases as the search cost decreases. An interesting observation is that the equilibrium price increases as the competition becomes more intense.

When the search cost converges to zero, the search equilibrium is more efficient than the optimal monopoly equilibrium. We show the limiting case in the following proposition.

Proposition 6 *For a given (δ, n), when $k \to 0$, $p^*(k) \to l_s$, $\beta_m^*(k) \to 0$, $\gamma^*(k|\delta, n) \to \frac{\delta\alpha(l_s-c)}{\delta\alpha(l_s-c)+n(l_s-c+\varepsilon)(1-\delta)}$, $\underline{\delta}(k|n) \to 0$, and the industry profit converges to the first best surplus $\alpha(l_s - c)$.*

The limiting case $p^*(k) \to l_s$, $\beta_m^*(k) \to 0$ as $k \to 0$ follows from Lemma 4. Moreover, Proposition 6 says that it is easier to sustain the search equilibrium when the search cost converges to zero. This is because when the search cost is very small, an expert's current gain from lying is very small relative to his future loss from lying. As a result, the indifference condition (6) holds even when the expert has a small concern for future business. To see this, first note that when the search cost converges to zero, experts' lying probability also converges to zero. This implies that condition on a client having the minor problem, she is more likely to be on her first visit instead of the second visit. Hence, if the expert recommends the treatment, the client will reject the treatment with a very large probability. So, the expert's gain from lying is small. On the other hand, the expert's future loss from lying is very large when search cost converges to zero. This is because once the client searches for second opinion, she will sample an honest recommendation with a probability close to one. Thus, the expert's dishonest recommendation will be detected almost surely, which makes it very risky for the expert to cheat.

Finally, when the search cost converges to zero, the industry profit in the search equilibrium converges to the first best surplus. This is because the probability of overtreatment for the minor problem converges to zero, so the equilibrium outcome approaches to the first best. Because consumer surplus is zero, the industry profit is approximately the first best.

6 Concluding remarks

This paper studies trust building in professional service markets. In these markets, clients cannot assess the value of the services provided by experts due to the lack of expertise, and hence they cannot monitor expert honesty by consumption. This stand in sharp contrast with experience goods markets in which consumers learn and monitor the quality of experience goods by consumption.

We show that although experts' concern for future business facilitates trade, the most profitable equilibrium in monopoly market always involves inefficiency. When the monopoly expert is sufficiently patient or the likelihood of the serious problem is small, he makes honest recommendations and charges a high price as honest premium. Consumers sometimes reject the expert's recommendation and monitor his honesty through rejection. Nevertheless, consumer rejection results in undertreatment for the serious problem. By contrast, when the expert is less patient or the likelihood of the serious problem is high, the expert always recommends the treatment and charges a relatively low price for his treatment. Clients give up monitoring expert honesty. They always accept the expert's treatment recommendation as long as the expert never refuses to treat anyone in the past. The equilibrium involves overtreatment for the minor problem.

When the market has multiple experts and the search cost is low, there exists an equilibrium in which consumers actively search for second opinion to monitor expert honesty. The search equilibrium involves small but pervasive cheating. Although competition does not necessarily improve honesty, it makes consumers' monitoring technology more efficient than the monopoly market. As a result, the industry can achieve a higher profit relative to the monopoly market when search cost is sufficiently small.

Appendix A

Proof for Lemma 1: We confine the analysis to the case $p \geq c - \varepsilon$ because it is weakly dominated for the expert to recommend a treatment at $p < c - \varepsilon$. Suppose that trade happens with a positive probability, then p must be at least c. To see this, if $p < c$, the expert will recommend the treatment only when the client has the minor problem. Since $l_m < c - \varepsilon \leq p$, the client's best response is to reject p with probability one. Now, consider $c \leq p$. If p is accepted with a positive probability, the expert will recommend p for the minor problem with probability one. This implies $E(l|p) \leq E(l)$, where $E(l|p)$ is the client's expected loss from the problem, conditional on being recommended the treatment p. But then it is the client's best response to reject p with probability one because $E(l|p) \leq E(l) < c \leq p$. A contradiction. Q.E.D.

Proof for Proposition 1: Given the expert's strategy, a client's expected loss from her problem is l_s upon a treatment recommendation. So, the client is indifferent between accepting or rejecting the treatment offer and therefore it is her best response to accept the treatment offer with probability γ^*. Assume that the game reverts to the static Nash equilibrium perpetually following one of the following histories: i) the expert is revealed to have recommended the treatment for the minor problem, ii) the expert recommends no treatment to a client and the client suffers a substantial loss, and iii) the expert posts a price different from l_s.

Given price $p = l_s$, the expert does not have a profitable deviation in his recommendation strategy. The expert will make a positive profit from recommending the treatment for the serious problem but will make zero profit if she recommends no treatment to the problem. Hence, the expert does not have an incentive to refuse to treat the serious problem. Consider that the client has the minor problem. The condition (2) holds at γ^*, which makes the expert just indifferent between whether or not to recommend the treatment. So, it is the expert's best response to recommend no treatment for the minor problem. Last, for $\gamma^* \geq 0$, it is necessary to have $\delta \geq \underline{\delta}^m$.

Finally, the expert does not have a profitable price deviation. A price deviation outside the range $[c-\varepsilon, l_s)$ is not profitable because the expert will make a loss from repairing a problem at $p' < c - \varepsilon$ and the client will reject a price $p' > l_s$ irrespective of her belief about her problem. Clients will reject a price deviation in the range of $[c - \varepsilon, l_s)$, given the off-equilibrium belief specified for Proposition 1 in the main text. Hence, any price deviation leads to zero profit because the expert's recommendation will be rejected in the current period and the deviation will trigger the reversion to the punishment path from the next period onward. Q.E.D.

Proof for Proposition 2: Clients' maximum willingness to pay in a one-price-fix-all equilibrium is $E(l)$. Hence, it is clients' best response to accept the expert's treatment offer with probability one. The game reverts to the static Nash equilibrium perpetually if the expert refuses to treat a client or deviates to a price different from $E(l)$.

First, consider the expert's incentives to deviate in the recommendation strategy. The expert's profit from fixing the serious problem is

$$E(l) - c + \frac{\delta\pi}{1-\delta},$$

where $\pi = E(l) - c + (1-\alpha)\varepsilon$. The expert receives zero profit if he refuses to fix the client's problem because all players revert to the static Nash equilibrium from the next period onward. So, the no deviation condition requires

$$
\begin{aligned}
E(l) - c + \frac{\delta\pi}{1-\delta} &\geq 0 \qquad (7) \\
\delta &\geq \underline{\delta}^o \equiv \frac{c - E(l)}{(1-\alpha)\varepsilon}.
\end{aligned}
$$

The cutoff $\underline{\delta}^o$ is positive given the assumption $E(l) < c$. It can be verified that $\underline{\delta}^o < 1$ if and only if $\alpha \geq \alpha'$. Now consider the expert's no deviation incentives when the client's problem is minor:

$$
E(l) - c + \varepsilon + \frac{\delta\pi}{1-\delta} \geq 0, \qquad (8)
$$

where the left hand side of (8) is the expert's payoff from repairing the minor problem. Condition (7) implies (8) because it is less costly to repair the minor problem than the serious problem. As a result, the expert does not have a profitable deviation in his recommendation strategy when $\delta \geq \underline{\delta}^o$.

Finally, assume that clients hold the same off-equilibrium belief following a price deviation as in the proof for Proposition 1. Given this off-equilibrium belief, a price different from $E(l)$ will be rejected in the current period and result in zero future profit. Thus, the expert does not have a profitable deviation in price. Q.E.D.

Proof for Lemma 2: Substitute $\underline{\delta}^m(\alpha)$ and $\underline{\delta}^o(\alpha)$ defined in Propositions 1 and 2 and take the difference:

$$
\underline{\delta}^o(\alpha) - \underline{\delta}^m(\alpha) = \frac{-\alpha^2(l_s - l_m)(l_s - c) - \alpha[(c - \varepsilon - l_m)\varepsilon + (l_s - c)^2] + (c - \varepsilon - l_m)(l_s - c + \varepsilon)}{(1-\alpha)[\varepsilon + (1+\alpha)(l_s - c)]\varepsilon}.
$$

Since the denominator is positive, the sign of $\underline{\delta}^o(\alpha) - \underline{\delta}^m(\alpha)$ is determined by the numerator which we denote by $f(\alpha)$. The derivatives of $f(\alpha)$ is

$$
f'(\alpha) = -2\alpha(l_s - l_m)(l_s - c) - [(c - \varepsilon - l_m)\varepsilon + (l_s - c)^2] < 0.
$$

So, $f(\alpha)$ is strictly decreasing in the range of $(\alpha', \widehat{\alpha})$.

Next, we show $f(\alpha') > 0$. To see this, note that $\underline{\delta}^o(\alpha') = 1$ and $\underline{\delta}^m(0) = 1$. By Corollary 1, $\underline{\delta}^m(\alpha)$ is strictly decreasing in α, and hence

$$
\underline{\delta}^m(\alpha') < \underline{\delta}^o(\alpha') = 1.
$$

Now, we evaluate $f(\alpha)$ at $\alpha = \widehat{\alpha} \equiv \dfrac{c - l_m}{l_s - l_m}$ and obtain $f(\widehat{\alpha}) = \dfrac{-(l_s - c)(l_s - c + \varepsilon)\varepsilon}{l_s - l_m} < 0$. Given that $f(\alpha)$ is continuous and decreasing and that $f(\alpha') > 0$ and $f(\widehat{\alpha}) < 0$, there exists a unique $\overline{\alpha} \in (\alpha', \widehat{\alpha})$, such that $\underline{\delta}^o \geq \underline{\delta}^m$ for $\alpha \in (\alpha', \overline{\alpha}]$ and $\underline{\delta}^o < \underline{\delta}^m$ for $\alpha \in (\overline{\alpha}, \widehat{\alpha})$. Q.E.D.

Proof for Proposition 4: The proof is divided into 4 steps. Step 1 defines α^* and characterizes properties of α^* and $\delta_1(\alpha)$, which will be used for the subsequent steps. Steps 2, 3 and 4 prove cases i), ii) and iii) in the Proposition, respectively. Figure 1 will facilitate the understanding of the proof.

Step 1. Define α^* as the value which solves $\delta_1(\alpha) = \underline{\delta}^o(\alpha)$. We show that there exists a unique $\alpha^* \in (\alpha', \overline{\alpha})$. To begin, we first prove that there exists a unique $\alpha^* \in (\alpha', \widehat{\alpha})$. Evaluate $\delta_1(\alpha)$ and $\underline{\delta}^o(\alpha)$ at $\alpha = \alpha'$ and $\alpha = \widehat{\alpha}$, respectively. We have

$$\delta_1(\alpha') = \frac{l_s - c + \varepsilon}{l_s - c + \varepsilon + (1-\alpha')(c - \varepsilon - l_m)} < 1 = \underline{\delta}^o(\alpha') \tag{9}$$

$$\delta_1(\widehat{\alpha}) = \frac{l_s - c + \varepsilon}{l_s - c + \varepsilon + (1-\widehat{\alpha})(c - \varepsilon - l_m)} > 0 = \underline{\delta}^o(\widehat{\alpha}). \tag{10}$$

Note that $\delta_1(\alpha)$ and $\underline{\delta}^o(\alpha)$ are continuous in the range of $(\alpha', \widehat{\alpha})$ and $\delta_1(\alpha)$ is strictly increasing while $\underline{\delta}^o(\alpha)$ is strictly decreasing (Corollary 2). As a result, conditions (9) and (10) implies that there is a unique $\alpha^* \in (\alpha', \widehat{\alpha})$ such that $\delta_1(\alpha) > \underline{\delta}^o(\alpha)$ for $\alpha > \alpha^*$ and $\delta_1(\alpha) \leq \underline{\delta}^o(\alpha)$ for $\alpha \leq \alpha^*$.

Next, we show $\alpha^* < \overline{\alpha}$ by contradiction. Suppose $\alpha^* \geq \overline{\alpha}$. Then, it follows that

$$\underline{\delta}^m(\overline{\alpha}) = \underline{\delta}^o(\overline{\alpha}) \geq \underline{\delta}^o(\alpha^*) = \delta_1(\alpha^*) \geq \delta_1(\overline{\alpha}). \tag{11}$$

The equalities follows from the definitions of $\overline{\alpha}$ and α^*, respectively. The first inequality holds because $\underline{\delta}^o(\alpha)$ strictly decreases in α and the second inequality holds because $\delta_1(\alpha)$ strictly increases in α. Furthermore, it can be verified that $\underline{\delta}^m(\alpha') = \delta_1(\alpha')$. Since $\underline{\delta}^m(\alpha)$ strictly decreases in α while $\delta_1(\alpha)$ strictly increases in α, $\underline{\delta}^m(\alpha) < \delta_1(\alpha)$ for all $\alpha > \alpha'$, which contradicts (11) given $\overline{\alpha} > \alpha'$.

Step 2. Consider $\alpha \in (0, \alpha^*]$. By Step 1, $\alpha^* < \overline{\alpha}$, so $\underline{\delta}^m(\alpha) < \underline{\delta}^o(\alpha)$ for $\alpha \in (0, \alpha^*]$. The *one-price-fix-for-all* equilibrium is not sustainable if $\underline{\delta}^m(\alpha) \leq \delta < \underline{\delta}^o(\alpha)$ by Proposition 2. So, the *monitoring-by-rejection* equilibrium yields the expert the highest profit. Next, consider $\underline{\delta}^o(\alpha) \leq \delta < 1$. By Step 1, $\delta_1(\alpha) \leq \underline{\delta}^o(\alpha)$ for $\alpha \leq \alpha^*$. Consequently, $\pi^o \leq \pi^m$ for $\delta_1(\alpha) \leq \underline{\delta}^o(\alpha) \leq \delta$ by the definition of $\delta_1(\alpha)$.

Step 3. Consider $\alpha \in (\alpha^*, \overline{\alpha}]$. By Lemma 2, $\underline{\delta}^m(\alpha) < \underline{\delta}^o(\alpha)$ for $\alpha < \overline{\alpha}$ and therefore the maximum average profit is π^m for $\underline{\delta}^m(\alpha) \leq \delta \leq \underline{\delta}^o(\alpha)$. Now, consider $\underline{\delta}^o(\alpha) < \delta$. By Step 1, $\delta_1(\alpha) > \underline{\delta}^o(\alpha)$ for $\alpha \in (\alpha^*, \overline{\alpha}]$. It follows that $\pi^m \leq \pi^o$ for $\underline{\delta}^o(\alpha) \leq \delta < \delta_1(\alpha)$ and $\pi^m > \pi^o$ for $\delta_1(\alpha) \leq \delta < 1$.

Step 4. Consider $\alpha \in (\overline{\alpha}, \widehat{\alpha}]$. By Lemma 2, $\underline{\delta}^o(\alpha) < \underline{\delta}^m(\alpha)$ for $\overline{\alpha} < \alpha$. So, the maximum average profit is

π^o for $\underline{\delta}^o(\alpha) \leq \delta < \underline{\delta}^m(\alpha)$. Both π^m and π^o can be supported for $\underline{\delta}^m(\alpha) \leq \delta < 1$. Since $\underline{\delta}^m(\alpha) < \delta_1(\alpha)$ for $\alpha \in (\overline{\alpha}, \widehat{\alpha})$, by Step 1, $\pi^m \geq \pi^o$ for $\delta_1(\alpha) \leq \delta < 1$ and $\pi^m < \pi^o$ for $\underline{\delta}^m(\alpha) \leq \delta < \delta_1(\alpha)$. Q.E.D.

Proof for Proposition 5 Define

$$\beta_m^*(k) \equiv \frac{1}{2} \times \frac{\Delta l - 2k - \sqrt[2]{(\Delta l - 2k)^2 - 4k[k + \Delta l \alpha/(1-\alpha)]}}{\Delta l + k(1-\alpha)/\alpha}, \tag{12}$$

$$p^*(k) \equiv \frac{\alpha l_s + (1-\alpha)\beta_m^*(k) l_m}{\alpha + (1-\alpha)\beta_m^*(k)}, \tag{13}$$

where $\Delta l \equiv l_s - l_m$, and

$$\underline{\delta}(k|n) \equiv \frac{n(p^*(k) - c + \varepsilon)\beta_m^*(k)}{n(p^*(k) - c + \varepsilon)\beta_m^*(k) + [\alpha(p^*(k) - c) + (p^*(k) - c + \varepsilon)(1-\alpha)(\beta_m^*(k))^2](1 - \beta_m^*(k))}. \tag{14}$$

First, we show that clients' strategy is a best response given experts' strategies. When a client receives a treatment recommendation on her first visit, the probability that the second opinion recommends no treatment is $\Pr(\emptyset|p) = \frac{(1-\alpha)\beta_m(1-\beta_m)}{\alpha + (1-\alpha)\beta_m}$. Substitute $\Pr(\emptyset|p)$ into the search condition (4), it becomes

$$\frac{(1-\alpha)\beta_m(1-\beta_m)(p - l_m)}{\alpha + (1-\alpha)\beta_m} = k. \tag{15}$$

Next, consider the client's participation constraint (5). Substitute $\Pr(l_s|p) = \frac{\alpha}{\alpha+(1-\alpha)\beta_m}$ and $\Pr(l_m|p) = \frac{(1-\alpha)\beta_m}{\alpha+(1-\alpha)\beta_m}$ into (5) and let the constraint binds. We obtain

$$p = \frac{\alpha l_s + (1-\alpha)\beta_m l_m}{\alpha + (1-\alpha)\beta_m}. \tag{16}$$

Substitute p defined in (16) into (15) and (15) boils down the the following quadratic equation:

$$(1-\alpha)\left[(1-\alpha)k + \alpha\Delta l\right](\beta_m)^2 + \alpha(1-\alpha)(2k - \Delta l)\beta_m + k\alpha^2 = 0.$$

It can be verified that $\beta_m^*(k)$ is the smaller root of the quadratic equation and $\beta_m^*(k) \in [0,1]$ for $k < \frac{(1-\alpha)(l_s - l_m)}{4}$. So, $\beta_m^*(k)$ and $p^*(k)$ jointly solve (15) and (16). We conclude that given $\beta_m^*(k)$ and $p^*(k)$, it is the client's best response to randomize between accepting the treatment on her first visit and searching for second opinion.

Next, we show that it is the client's best response to accept the second treatment recommendation with probability one. The probability that the third opinion recommends no treatment conditional on the first two opinions recommending the treatment is denoted by $\Pr(\emptyset|pp) = \frac{(1-\alpha)(\beta_m)^2(1-\beta_m)}{\alpha + (1-\alpha)(\beta_m)^2}$. Because

$\Pr(\emptyset|pp) < \Pr(\emptyset|p)$, it follows that $\Pr(\emptyset|pp)(p - l_m) < k$ and hence the client strictly prefer accepting the second treatment recommendation to searching for the third opinion. Finally, the participation constraint (16) is satisfied when the client receives the second treatment recommendation. Hence, it is the client 's best response to accept the second treatment recommendation with probability one.

Now, we show that experts' strategies are their best response. We first show that experts have no profitable deviation in their recommendation strategies. To proceed, we show that there exists a unique $\gamma^*(k|\delta, n) \in (0, 1)$ which solves (6). So, $\beta_m^*(k) \in [0, 1]$ is a best response. When the expert diagnoses that a client has the minor problem, the probability that she is on her second visit is

$$\Pr(\mathrm{e}|l_m) = \frac{(1-\alpha)\frac{1}{n}\beta_m(1-\gamma)}{(1-\alpha)[\frac{1}{n} + \frac{1}{n}\beta_m(1-\gamma)]} = \frac{\beta_m(1-\gamma)}{1+\beta_m(1-\gamma)}. \tag{17}$$

If the expert is active in the market, his profit is $\frac{1}{n}$ of the industry profit in that period, which is

$$\overline{\pi} = \frac{1}{n}\left[\alpha(p-c) + (1-\alpha)(p-c+\varepsilon)(\gamma\beta_m + (1-\gamma)(\beta_m)^2)\right]. \tag{18}$$

The item in the square bracket is the industry profit. Since the serious problem is fixed with probability one, the expected industry profit from treating the serious problem is $\alpha(p - c)$. The minor problem is fixed with probability $\gamma\beta_m + (1 - \gamma)(\beta_m)^2$, where $\gamma\beta_m$ is the probability that the minor problem is fixed on the client's first visit and $(1 - \gamma)(\beta_m)^2$ is the probability that it is fixed on her second visit. So, the expected industry profit from fixing the minor problem is the second item in the square bracket. Substitute $\Pr(\mathrm{e}|l_m)$ and $\overline{\pi}$ into (6), it follows that

$$\begin{aligned} & \frac{\delta}{n(1-\delta)}(1-\gamma)(1-\beta_m)\left\{\alpha(p-c) + (1-\alpha)(p-c+\varepsilon)(\gamma(1-\beta_m)\beta_m + \beta_m^2)\right\} \\ = \; & \gamma(1-\beta_m)(p-c+\varepsilon) + \beta_m(p-c+\varepsilon). \end{aligned} \tag{19}$$

The left hand side of equation (19) can be written as a concave function in γ: $L(\gamma) \equiv -A\gamma^2 + B\gamma + C$, where

$$\begin{aligned} A &= \frac{\beta_m(1-\beta_m)^2(1-\alpha)(p-c+\varepsilon)\delta}{(1-\delta)n} > 0 \\ B &= [\beta_m(1-2\beta_m)(1-\alpha)(p-c+\varepsilon) - \alpha(p-c)]\frac{\delta(1-\beta_m)}{(1-\delta)n} \\ C &= [\alpha(p-c) + (p-c+\varepsilon)(1-\alpha)(\beta_m)^2]\frac{\delta(1-\beta_m)}{(1-\delta)n} > 0. \end{aligned} \tag{20}$$

Note that $L(0) = C > 0$ and $L(1) = 0$. The right hand side of (19) is a linear function increasing in γ and is denoted by $R(\gamma)$. In addition, $R(0) = \beta_m(p - c + \varepsilon) > 0$ and $R(1) = p - c + \varepsilon > 0$. Because both $L(\gamma)$ and $R(\gamma)$ are continuous and $L(1) < R(1)$, there exists a unique $\gamma^* \in (0, 1)$ which solves (19) if

$$\begin{aligned}
R(0) &< L(0) \\
\beta_m(p - c + \varepsilon) &< [\alpha(p - c) + (p - c + \varepsilon)(1 - \alpha)(\beta_m)^2]\frac{\delta(1 - \beta_m)}{(1 - \delta)n} \\
\delta &> \frac{n(p - c + \varepsilon)\beta_m}{n(p - c + \varepsilon)\beta_m + [\alpha(p - c) + (p - c + \varepsilon)(1 - \alpha)(\beta_m)^2](1 - \beta_m)} \\
&\equiv \underline{\delta}(p, \beta_m|n) \in (0, 1).
\end{aligned}$$

Substitute $\beta_m^*(k)$ and $p^*(k)$ into $\underline{\delta}(p, \beta_m|n)$, we have $\underline{\delta}(p^*(k), \beta_m^*(k)|n) = \underline{\delta}(k|n)$. So, when $\delta > \underline{\delta}(k|n)$, there exists a $\gamma^* \in (0, 1)$ such that it is optimal for the expert to randomize between whether or not to recommend the treatment for the minor problem when other experts lie with probability $\beta_m^*(k)$. Therefore, lying with probability $\beta_m^*(k)$ is a best response.

Lastly, given the off-equilibrium belief specified for Proposition 5, clients will not be attracted to an expert who posts a price different from $p^*(k)$. Therefore, there is no profitable price deviation. Q.E.D.

Proof for Lemma 4: We first prove $\frac{d\beta_m^*(k)}{dk} > 0$. To simplify notation, define $\Delta l \equiv l_s - l_m$. Taking the derivative of (12) with respect to k, it follows that

$$\frac{d\beta_m^*(k)}{dk} = \frac{g'(k)\left(\Delta l + k(1 - \alpha)/\alpha\right) - g(k)(1 - \alpha)/\alpha}{2\left[\Delta l + k(1 - \alpha)/\alpha\right]^2}, \tag{21}$$

where

$$g(k) = \Delta l - 2k - M^{1/2}, \text{ and } g'(k) = -2 + \frac{2\Delta l}{1 - \alpha}M^{-1/2},$$

with $M \equiv (\Delta l)^2 - \frac{4k\Delta l}{1-\alpha}$. Given $k < \frac{(1 - \alpha)\Delta l}{4}$, $M > 0$. The sign of $\frac{d\beta_m^*(k)}{dk}$ is determined by the numerator of (21). We can simplify the numerator of (21) as the following:

$$\begin{aligned}
& \left\{-2+\frac{2\Delta l}{1-\alpha}M^{-1/2}\right\}\{\Delta l + k(1-\alpha)/\alpha\} - \left\{\Delta l - 2k - M^{1/2}\right\}\left\{\frac{1-\alpha}{\alpha}\right\} \\
= \; & 2\Delta l\left(\frac{\Delta l}{1-\alpha}+\frac{k}{\alpha}\right)M^{-1/2} - \frac{(1+\alpha)\Delta l}{\alpha} + \frac{(1-\alpha)M^{1/2}}{\alpha} \\
= \; & M^{-1/2}\left\{\frac{(1+\alpha^2)(\Delta l)^2}{\alpha(1-\alpha)} - \frac{2k\Delta l}{\alpha}\right\} - \frac{(1+\alpha)\Delta l}{\alpha} \\
= \; & M^{-1/2}\left\{\frac{(1+\alpha^2)(\Delta l)^2}{\alpha(1-\alpha)} - \frac{2k\Delta l}{\alpha} - \frac{(1+\alpha)\Delta l M^{1/2}}{\alpha}\right\} \\
= \; & \frac{M^{-1/2}(1+\alpha)\Delta l}{\alpha}\left\{\frac{(1+\alpha^2)\Delta l}{(1-\alpha)(1+\alpha)} - \frac{2k}{1+\alpha} - M^{1/2}\right\}. \qquad (22)
\end{aligned}$$

So, the sign of (22) is determined by the item in the curly bracket $\Gamma \equiv \frac{(1+\alpha^2)\Delta l}{(1-\alpha)(1+\alpha)} - \frac{2k}{1+\alpha} - M^{1/2}$. Given $k < \frac{(1-\alpha)\Delta l}{4}$, $\frac{(1+\alpha^2)\Delta l}{(1-\alpha)(1+\alpha)} - \frac{2k}{1+\alpha} > 0$. So, the sign of Γ is the same as the sign of

$$\widehat{\Gamma} \equiv \left(\frac{(1+\alpha^2)\Delta l}{(1-\alpha)(1+\alpha)} - \frac{2k}{1+\alpha} - M^{1/2}\right)\left(\frac{(1+\alpha^2)\Delta l}{(1-\alpha)(1+\alpha)} - \frac{2k}{1+\alpha} + M^{1/2}\right)$$

because the second item in the bracket is positive. We can simplify $\widehat{\Gamma}$ as

$$\begin{aligned}
\widehat{\Gamma} &= \left(\frac{(1+\alpha^2)\Delta l}{(1-\alpha)(1+\alpha)} - \frac{2k}{1+\alpha}\right)^2 - M \\
&= \frac{4\alpha^2}{(1-\alpha^2)^2}(\Delta l)^2 + \frac{8k\alpha}{(1-\alpha)(1+\alpha)^2}\Delta l + \frac{4k^2}{(1+\alpha)^2} \\
&= \left(\frac{2\alpha\Delta l}{1-\alpha^2} + \frac{2k}{1+\alpha}\right)^2 > 0,
\end{aligned}$$

where the second equality follows by substituting M. Since $\widehat{\Gamma} > 0$, (22)> 0 and hence $\frac{d\beta_m^*(k)}{dk} > 0$.

Next, we show $p^*(k)$ defined in (13) decreases in k. Take the derivative

$$\begin{aligned}
\frac{dp^*(k)}{dk} &= \frac{[(1-\alpha)l_m(\alpha + (1-\alpha)\beta_m^*(k)) - (\alpha l_s + (1-\alpha)\beta_m^*(k)l_m)(1-\alpha)]}{(\alpha + (1-\alpha)\beta_m^*(k))^2}\frac{d\beta_m^*(k)}{dk} \\
&= \frac{-\alpha(1-\alpha)\Delta l}{(\alpha + (1-\alpha)\beta_m^*(k))^2}\frac{d\beta_m^*(k)}{dk} < 0.
\end{aligned}$$

The inequality follows from $\frac{d\beta_m^*(k)}{dk} > 0$. Q.E.D.

Proof for Proposition 6: Using (12), (13) and (14), it can be verified that as $k \to 0$,

$$\begin{aligned}
\beta_m^*(k) &\to \frac{1}{2} \times \frac{\Delta l - \Delta l}{\Delta l} = 0, \\
p^*(k) &\to \frac{\alpha l_s}{\alpha} = l_s, \\
\underline{\delta}(k|n) &\to \frac{0}{0 + [\alpha(p-c)]} = 0.
\end{aligned}$$

The industry profit is $n\overline{\pi}$ which converges to $\alpha(l_s - c)$

Lastly, as $k \to 0$, the function $L(\gamma)$ defined in the proof for Proposition 5 converges to $L'(\gamma) \equiv \frac{\delta\alpha(l_s - c)}{(1-\delta)n}(1-\gamma)$ and the function $R(\gamma)$ converges to $R'(\gamma) \equiv \gamma(l_s - c + \varepsilon)$. Thus, by (19), the equilibrium acceptance rate γ^* converges to $\frac{\alpha(l_s - c)\delta}{\alpha(l_s - c)\delta + (l_s - c + \varepsilon)n(1-\delta)}$. Q.E.D.

Appendix B

To be added....

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