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Searching for Treatment*

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Abstract

When experts have superior information on their customers' needs and appropriate treatment/repair/advice is a credence good, there are obvious incentives for opportunistic behavior. What compounds this is that experts regularly make treatment recommendations and price offers only after consumers have approached them, creating additional market power due to search costs. In our model, an expert enjoys monopoly power on diagnosis and major treatments, but has limited market power on minor treatments due to fringe competition. The expert's treatment offer only gets revealed to consumers upon visit, and both searching the expert and fringe firms is costly. For search costs that are not excessively high, in equilibrium the expert inappropriately proposes major treatment to all or a fraction of low-severity consumers, which they respectively accept all or some of the time. Next to wasteful overtreatment, further inefficiencies arise in the latter case, as some high-severity consumers mistakenly leave the expert, and some low-severity consumers incur unnecessary search costs. Total welfare is non-monotonic in search costs and may even be maximized when these are large. Expert competition often does not, or only partly, alleviate market distortions.

Keywords: Expert Service, Credence Goods, Search, Treatment, Overtreatment, Repair, Advice

JEL Classification: D43, D82, D83, L13, L15

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1 Introduction

Most people have incurred problems which need proper diagnosis and expert service to be solved. Examples include medical problems (requiring physician diagnosis and suitable treatment), technical problems (requiring diagnosis and repair by a technical expert, such as a car mechanic for vehicles or an IT specialist for computers), or financial "problems" such as the problem of finding the right investment strategy (requiring advice by a financial professional). In many cases, diagnosis and treatment of such problems are undertaken by the same expert, which may create incentives for experts to offer consumers inappropriate treatment or even to commit fraud. In particular, this is the case when consumers are not even able to assess *ex-post* whether a specific treatment was warranted.[1] In such markets where expert service is therefore a *credence good*,[2] issues with fraud – for example, charging for services which were not conducted – have been widely documented empirically and discussed in the theoretical literature. Also other phenomena, such as providing lower levels of treatment than required to solve a consumer's problem (so-called *undertreatment*), have been studied extensively. Those practices, however, are often already undermined by legal sanctions and liability laws.

On the other hand, expert provision of unnecessary or inefficiently costly services to fix a problem, so-called *overtreatment*, is empirically well documented,[3] can entail similarly

[1]Or even worse, when they may not even observe *which* treatment was conducted, although we do not study this issue in this paper.

[2]The seminal paper on credence goods is by Darby and Karni (1973). Dulleck and Kerschbamer (2006) outline a unifying framework for the theoretical analysis of credence-goods markets and provide a very useful overview of the earlier literature. A comprehensive review of subsequent developments in the field is given by Balafoutas and Kerschbamer (2020)

[3]In a recent field experiment, Gottschalk et al. (2020) find that 28% of the 180 visited dentists recommended unnecessary and highly invasive treatments for a patient with superficial caries lesion, which was especially the case for dentists with low waiting times. Analyzing data from the US Medicare system, Clemens and Gottlieb (2014) find a strong correlation between payments made to physicians and treatment recommendations, indicating the likely presence of overtreatment. Balafoutas et al. (2013) conducted field experiments in the market for taxi services and discovered that 45% of drivers took an unnecessary detour. While Kerschbamer et al. (2019) find mostly fraudulent behavior in the market for computer repair services, there is also evidence of shops unnecessarily exchanging parts which do not need fixing. Data from German car repair services evaluated by Rasch and Waibel (2018) shows that overcharging or overtreating occurs in 4.5% of cases, which decreases under competition. Inderst and Ottaviani (2012) study the impact of commissions paid to financial advisors' recommendations and find that in the presence of monetary incentives for experts, they oftentimes sell products which consumers do not need. Huck et al. (2016) show that in their experimental medical market, overtreatment occurs at a rate of 26.3% when financial gains can be made by recommending a high treatment to a patient with a low-severity problem. This rate increases dramatically to 70.9% when patients are insured. Kerschbamer and Sutter (2017) provide an overview of experimental studies on overtreatment and overcharging in credence-goods markets.

severe welfare distortions, but has received comparatively less attention from the theoretical literature. In this paper, we provide a novel theoretical analysis of expert overtreatment caused by an interplay of consumer search frictions and limited expert market power on basic services.[4]

We argue that limited expert market power is an important driving force of expert overtreatment: One major advantage of visiting an expert, rather than trying to fix a problem oneself (for example, by purchasing and installing only potentially helpful spare parts, or using non-prescribed pharmaceuticals) is that often an accurate diagnosis can be obtained. However, when an expert realizes that a consumer's problem could easily be fixed through a basic treatment widely available at low price, the expert might have an incentive to (try to) trick the consumer into believing that a more sophisticated treatment (which is not as competitively supplied) is required. For example, when a car mechanic finds that a customer's V-belt has snapped, he or she might have an incentive to report a more complex problem, such as a broken engine part. This is because for the former problem, the mechanic knows that no outrageous price can be charged, while his/her market power for a replacement of the (claimed to be) broken part might be considerably higher. As consumers may anticipate such opportunistic behavior, they might in turn be reluctant to (immediately) agree to expensive treatments. It is this tension that we explore in this paper.

Our analysis incorporates three features that are present in many real-world expert markets, but have largely been ignored by previous theoretical work. First, consumers typically *do not* observe experts' price plans before visiting them and obtaining a treatment recommendation, such that they *cannot* perfectly predict in advance whether an expert will be prone to over- or undertreat. Second, due to travel, effort and opportunity costs, consumers find it costly to visit experts (and also alternative treatment providers), which gives experts market power on those consumers who have already arrived at their doors. And third, after diagnosing a consumer's problem, experts usually provide a *single* treatment recommendation at some chosen price – *both specific to that consumer* – which the consumer can either accept or reject. In game-theoretic terms, an important distinction to most previous work is

[4] Other theoretical explanations for expert overtreatment that have been put forward include misaligned incentives caused by regulated prices, commissions or insurance; faulty diagnostics; and capacity constraints. Of course, also expert markets with search frictions have been studied before, though in different setups featuring alternative economic mechanisms and giving rise to different market outcomes. We provide a detailed comparative literature review below.

that we flip the sequence of moves:[5] In our model, consumers first decide whether to visit an expert or not, which they cannot base on *any* observable feature of that expert. Only after a consumer consults an expert, the latter decides upon his/her treatment recommendation and price – which can finally be accepted or rejected by the consumer.

In the precise market we study, each consumer (female in what follows) suffers from one of a number of different *conditions*, and needs effective treatment to get this condition fixed (and thereby, receive some gross surplus). Any given condition can either be of low or high severity, with known ex-ante probabilities. Effective treatment of a problem requires that the correct condition is treated. Moreover, there are two types of treatment, low and high, where high treatment is more costly. As is common in the literature, we assume that low-severity problems can effectively be treated by both low and high treatment, while high-severity problems require high treatment. No consumer initially knows which condition she suffers from and at which severity.

In our main model, consumers may undergo treatment from either a monopolistic expert service provider (male in what follows) who can treat all problems or from competitive fringe firms that can only treat low-severity problems. The expert thus has monopoly power on high treatments.[6] Importantly, we assume that the expert can perfectly and costlessly identify consumers' conditions and severity grades, by which we eliminate mistakes and free-riding problems in diagnosis provision as potential sources of inappropriate treatment. In contrast, each fringe firm is specialized on providing treatment for a single low-severity condition only, has no diagnostic ability and liability (see below), and prices competitively.

Consumers can search sequentially the expert and fringe firms in an arbitrary order, paying a positive cost for every trip they make (including return trips[7]). A consumer that has not yet visited the expert has not received a diagnosis either and can therefore only try her luck by randomly buying low treatments from fringe firms – which however do not bring any benefit when not suitable (i.e., when the consumer suffers from a different condition or has a high-severity problem).

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[5]Compare, e.g., with Dulleck and Kerschbamer (2006).

[6]In an extension, we also study competition between N identical experts. We comment on the differences in outcomes below.

[7]We have also solved the game for costless return trips ("free recall"), for which we find that (a slight variation of) the most interesting (semi-pooling) equilibrium from the main analysis remains an equilibrium under the same set of parameters (and starts to exist for very high search costs). Details are available from the authors upon request.

When a consumer visits the expert, he observes her condition and severity and makes a binding treatment proposal. As we want to focus on the issue of overtreatment, we impose two crucial assumptions, variations of which are commonly employed in the literature: *liability* and *verifiability*.[8] The former means that the expert is liable for the treatment provided, such that he has to pay back the fee to any unsuccessfully treated consumer. The second – stronger – assumption means, in our setting, that the expert cannot recommend treatment for one condition and severity and then undertake treatment of a different condition or severity.[9] Liability makes undertreatment unprofitable, while verifiability rules out overcharging (i.e., proposing high treatment but only conducting low treatment). What verifiability together with liability ensure as well is that the expert cannot find it profitable to leave consumers in the dark about which condition they suffer from: proposing treatment for a wrong condition to (a positive measure of) consumers is a weakly dominated strategy.

Visiting the expert hence enables consumers to *learn* their condition – and also their severity in case low treatment is proposed. In particular for low-treatment recommendations, this learning gives consumers an opportunity to free-ride on the expert's diagnosis by rejecting his offer and purchasing from the fringe. This effectively puts a cap on the markup for low treatments: the maximal markup is given by the additional search friction a consumer would have to incur to visit the fringe. While the expert thus has *some* market power also on low treatments due to consumers' search friction, this market power is limited, such that he might have an incentive to recommend high treatment to (a fraction of) low-severity

[8] See Dulleck and Kerschbamer (2006) for a succinct description of the standard assumptions. Of these, our model also satisfies *homogeneity*: all consumers have the same valuation and suffer from a high-severity problem with the same probability. We however depart from *commitment*, which would mean that consumers are committed to undergo treatment once a recommendation is made by the expert. In our setting, consumers do not observe the expert's price before receiving a treatment recommendation, such that this assumption would make little sense. Interesting tensions arise in our model precisely because consumers have the freedom to reject expert offers.

[9] In many situations, this assumption is arguably satisfied: For instance, a doctor proposing hip surgery (a "high treatment") and accepting payment for it can hardly get away with just giving infusions (a "low treatment") – and likewise, it would be difficult for the doctor to instead treat some seemingly unrelated condition, like a pinched spinal nerve. Similarly, an electrician suggesting to replace a (claimed to be) broken power line at some specific price could hardly succeed in just replacing a defunct wall outlet without (most) customers noticing and complaining – and it would also arise suspicion if he were to instead install a new fuse box. What is crucial is that consumers are able to verify, at least to some extent, the inputs the expert uses for his chosen treatment (see also the related discussions in Alger and Salanié (2006) and Dulleck and Kerschbamer (2006)). Some papers that (explicitly or implicitly) employ similar verifiability assumptions include Emons (1997, 2001), Alger and Salanié (2006), Dulleck and Kerschbamer (2009), Fong et al. (2014), Hilger (2016), Bester and Dahm (2018), and Liu et al. (2020).

consumers. Anticipating this, consumers may in turn reject high-treatment proposals and try their luck at the fringe – potentially returning to the expert if no effective treatment is obtained. It is this struggle which drives many of our results.

We characterize the set of (Perfect Bayesian) equilibria in which all consumers start their search for treatment at the expert. When consumers' search cost is high, this means that the expert enjoys a relatively large market power vis-à-vis visiting consumers even for low treatments. Therefore, the expert has no incentive to propose high treatment to low-severity consumers, such that always appropriate treatment is recommended. Knowing this, consumers immediately accept any expert proposal. This equilibrium only exists if consumers' ex-ante probability from having a high-severity problem is sufficiently low: otherwise, given their high search cost, their participation constraint would be violated.

In contrast, for low and intermediate search costs, the expert's market power on low treatments is relatively low, such that he would prefer to carry out high treatment (at the maximal price compatible with equilibrium) to low-severity consumers, *provided* that they followed his proposal for sure. If, at the same time, consumers' probability of having a high-severity problem is large, then, *even knowing* that the expert always proposes high treatment, they do not find it worthwhile to walk away and try their luck at the respective fringe firm. As a result, the expert always overtreats low-severity consumers in equilibrium.

But otherwise, if consumers are less prone to suffer from a high-severity problem, they *would* find it optimal to leave towards the fringe after consulting an expert that always recommends high treatment. This cannot be part of an equilibrium, however, as the low-severity consumers would never return – such that the expert would prefer to retain them by offering low treatment. In equilibrium, these two forces are balanced by both the expert and consumers randomizing: When the expert faces a low-severity consumer, he inappropriately recommends high treatment *some* of the time. Likewise, when getting offered high treatment, consumers (immediately) accept this proposal only with *some* probability. Indeed, the respective sides' strategies are such that they keep each other indifferent what to do.[10]

[10]One may wonder why the expert would not like to break consumers' indifference to stay or walk away when getting offered high treatment by asking for a marginally lower price. The problem is that consumers should interpret such a deviation to be highly indicative of suffering from a low-severity condition, inducing them to leave anyhow. This is because the expert can guarantee to sell to high-severity consumers already at the equilibrium price, since even when they leave, they will return to him (as they cannot obtain effective treatment at the fringe).

The described tension gives rise to a (to the best of our knowledge) novel and non-trivial combination of welfare losses. First, there is the standard cost inefficiency caused by the expert overtreating (a fraction of) low-severity consumers. Second, as some low-severity consumers who get proposed high treatment (rightly) leave the expert, an unnecessary search friction is incurred by them. Third, and perhaps most interestingly, since a fraction of high-severity consumers incorrectly reject the expert's high-treatment proposal, ineffective low treatments are wastefully bought, and also unnecessary search costs are incurred *twice* (as these consumers ultimately return to the expert). The extreme informational asymmetry in credence-goods markets, combined with expert market power, may thus cause disruptions in consumers' search behavior that have not been pointed out in the literature, with partly severe welfare consequences. Two further welfare results pertain to our model: First, the relative market performance is worst when there is an intermediate fraction of high-severity consumers, such that the degree of asymmetric information between the expert and consumers is large. Second, aggregate welfare is non-monotonic in search costs: while it is often maximized for a negligible search friction, this reverts when the cost of high treatment is large. In this case, a substantial search friction, negating the expert's incentive to overtreat, leads to an absolutely higher welfare.

In an extension, we also consider the effect of competition between N identical experts on market outcomes. Strikingly, due to the assumed unobservability of expert prices before consultation, equilibrium existence is *not* affected across large parts of the parameter space. To start with, both the equilibrium where the expert always proposes appropriate treatment, and the equilibrium where he always overtreats low-severity consumers, remain equilibria even under expert competition (when all experts follow the monopoly strategy). This is because for the considered expert strategies, no consumer can gain from visiting a second expert (or, as before, from going to the fringe). We moreover show that the above-described mixed-strategy equilibrium involving both expert and consumer randomization remains an equilibrium *if consumers' search cost is not too low* (or alternatively, if the incidence of high-severity problems is sufficiently high) – otherwise, it pays off for consumers to visit a second expert, destroying the proposed equilibrium. For somewhat lower levels of search costs such that the original equilibrium cannot be supported, still a qualitatively similar equilibrium exists: There, the experts' equilibrium price for high treatments adjusts downward to avoid direct competition between them. Since in our model with (before search) unobservable prices competition does not necessarily improve welfare, this suggests that policy measures aiming to induce expert entry could well prove fruitless.

The remainder of this paper is structured as follows. In the subsequent paragraph, we discuss the related theoretical literature in detail. Section 2 introduces the model, while Section 3 provides a full equilibrium characterization for the monopoly case. At the end of this section, we also discuss the implications of expert competition. In Section 4, we shed light on the welfare distortions arising in the baseline model. Since search costs can arguably be influenced, we also analyze which levels of search costs maximize aggregate welfare. Some concluding remarks are given in Section 5. Technical proofs are relegated to Appendix A. Finally, Appendix B provides a characterization of an equilibrium that is omitted in the main text.

Related Literature. We contribute to an extensive literature studying experts' incentives to misuse private information, whereby a number of related papers have also examined search frictions as potential driving force. Some early work has focused on experts' incentives to defraud consumers by charging for high-price services which are never conducted, so-called overcharging, rather than to over- or undertreat. In Wolinsky (1993), multiple experts post price menus for low and high treatment. These price menus can serve as commitment device signaling that an expert will abstain from overcharging. Consumers observe all price menus and engage in optimal sequential search. The author argues that for relatively low search costs, the most plausible equilibrium involves vertical separation of experts who then never overcharge.[11] Wolinsky (1995) varies his earlier work by letting consumers make individual price offers to experts (among others). Consumers can visit up to two experts. In equilibrium, experts either always overcharge or they do so with positive probability.[12] In

[11]For higher search costs, low-severity consumers are always overcharged. Wolinsky (1993) also briefly describes a potential equilibrium in which low-severity consumers are only sometimes cheated upon and consumers only sometimes accept high-treatment proposals, reminiscent of our semi-pooling equilibrium. However, the author considers this potential equilibrium to be fragile; it could only exist when there are few experts in the market, although exact conditions for equilibrium existence are not provided.

[12]The result that cheating on consumers probabilistically can be an equilibrium strategy has already appeared in Pitchik and Schotter (1987) for a monopolistic expert with exogenous prices. There, the expert recommends a more profitable high treatment to consumers who have a minor problem with positive probability, which they sometimes reject and leave the market. This follows from the assumption that consumers' expected utility would be negative should the expert cheat with certainty.

the latter case, consumers always inefficiently search a second expert when they cannot obtain an inexpensive treatment immediately.

Pitchik and Schotter (1993) study a model of expert competition with exogenous treatment prices and consumers differing in search costs. In equilibrium, consumers search for a low-price treatment an endogenously-determined maximum number of times, depending on their search cost, and then settle for a high-price treatment. Increasing the measure of consumers without search costs improves market performance. In our work, consumers are homogeneous, while prices are determined endogenously and are only observed after expert consultation. The impact of search costs on welfare is more nuanced, since, *ceteris paribus*, higher search costs would decrease welfare – but they also give the expert(s) more market power on low treatments, reducing the incentive to overtreat.

Pesendorfer and Wolinsky (2003) shift the focus by studying experts' incentive to exert costly but unobservable diagnostic effort in a competitive search market. Consumers only receive positive utility from an expert's service if their correct condition is identified and treated. In equilibrium, price competition and the possibility of consumers looking for second opinions lead to low prices and an inefficiently low diagnostic effort, giving rise to expert mistreatment. In this paper, mistreatment is not a profitable expert strategy due to liability. We moreover rule out diagnosis costs as an incentive to recommend inadequate treatments.

Similar to Pesendorfer and Wolinsky (2003), but closer in spirit to our work, Dulleck and Kerschbamer (2009) also study a setting where experts need to perform costly diagnosis in order to be able to correctly assess consumers' needs. Experts set prices and diagnosis fees. There are also discounters, which offer both high and low treatments but have no diagnostic capabilities.[13] All treatments are verifiable but no liability is imposed, creating the potential for over- and undertreatment. Consumers observe all posted prices and can engage in costly search. The authors find that positive diagnosis fees lead to overtreatment and cannot be part of an equilibrium. Instead, in equilibrium, experts' markups are higher for low treatments in order to induce them to indeed invest in costly diagnosis. No active search takes place in equilibrium. There are several differences to our paper. As mentioned above, we rule out diagnosis costs as a source of opportunistic behavior. Moreover, our model

[13] In contrast to this paper, discounters set prices strategically as well.

features unobservable prices, liability, and it gives rise to active search and overtreatment in equilibrium.

The most closely related paper is Alger and Salanié (2006), which shares our core mechanism that limited market power on basic services may drive overtreatment. At least four experts can diagnose a consumer's problem at weakly positive diagnosis cost. Treatments are (partly) verifiable. There are also non-strategic specialists who can only offer diagnosis (whereas in this paper, the fringe firms do not have any diagnostic abilities) and conduct low treatment. Different from our model, prices are observable. Moreover, experts face diagnosis costs, which they may or may not pass on to consumers, while in our model, consumers directly incur search (or transportation) costs. Depending on market fundamentals, equilibria may involve honest and fraudulent behavior by experts, as well as specialization regarding the offered treatments. In fraudulent equilibria, diagnosis costs are relatively large, so consumers immediately accept recommendations for high treatment, leading to deterministic overtreatment.[14] Compared to their findings, our analysis shows that, when explicit search frictions are present and expert prices are not observable before consultation, substantial further inefficiencies may arise. In equilibrium, stochastic overtreatment can induce consumers to reject expert recommendations and try out low treatments, only to later return if their problem is not solved.

Another closely related contribution is Fong et al. (2014), which contrasts market outcomes in a monopolistic expert market with observable prices, perfect and costless diagnosis, and no consumer commitment to take up the expert's advice. In one scenario, the authors assume that verifiability is intact but liability is violated, while in the other, the exact opposite holds. Different from most concurrent models, the damage prevented from successful treatment can differ between high- and low-severity consumers. For the verifiability setting, Fong et al. show that both deterministic and stochastic over- and undertreatment can occur in the payoff-dominant equilibrium. The overtreatment equilibria are quite similar to our pooling and semi-pooling equilibria, however, a profit-maximizing expert only chooses to induce them (via his choice of prices) if the surplus created by appropriate high treatment

[14] If diagnosis costs are lower, in the resulting specialization equilibrium consumers first visit an expert offering only low treatment in order to learn about their severity and in case a high-severity problem is diagnosed, they visit an expert capable of fixing the major problem. We allow for similar search paths in our model, although they do not occur in the equilibria we study.

(i.e., its damage prevention minus treatment cost) is higher than the surplus created by appropriate low treatment. Since high treatment is more costly, this cannot occur when there is just a single damage to be fixed, like in our paper and most of the literature. Their framework also differs from ours because prices are observable, there is no liability (in the verifiability setting), and there is no scope for search.

In a recent contribution, Fong et al. (2018) study a dynamic model of trust building in credence-goods markets. In an extension related to our work, they introduce competition among experts, where consumers can engage in costly search for a second opinion. Then, all high-severity problems are fixed with probability one, but minor problems are also unnecessarily treated with positive probability. This induces consumers to sometimes leave upon treatment recommendation and look for a conflicting opinion. Competition improves welfare, while in our model inefficiencies are not necessarily alleviated by increasing the number of experts. This indicates that unobservability of prices may have a severe impact on inefficiencies in credence-goods markets.

Several other possible causes for overtreatment have been identified in the literature, many of which stem from either expert or consumer heterogeneity or diagnosis-related issues. For example, Hilger (2016) extends the model of Dulleck and Kerschbamer (2006) by assuming there are two types of experts, with each type having a comparative advantage for one treatment. In Liu et al. (2020), some experts can only offer imprecise diagnoses.[15] In Bester and Dahm (2018), incentives to overtreat arise from the effectiveness of high treatments even without a costly diagnosis.[16] Yet another explanation for overtreatment is provided in Emons (1997), where experts may have an incentive to fill up free capacities.[17]

[15] See also Schneider and Bizer (2017a), where experts differ in their diagnostic ability and can endogenously choose diagnosis effort, and Schneider and Bizer (2017b), in which the authors vary the heterogeneous experts' diagnosis costs. An analysis of experts' heterogeneity as cause for fraud can be found in Liu (2011) and Heinzel (2019a), where some experts have social preferences, as well as in Heinzel (2019b), where prices are fixed, experts vary in their costs for low treatments, and consumers may search for second opinions. Fong (2005) shows that heterogeneity of consumers' valuations for receiving high treatments can lead to expert cheating in equilibrium without price discrimination.

[16] The authors show that in their framework, inefficiencies can be eliminated by expanding the contract space by either allowing up-front payments entailing equal markups over expected treatment costs or separating diagnosis from treatment when no additional search costs arise. The result that expanding the contract space can correct market outcomes is also shown in Taylor (1995).

[17] Inefficiencies are largely eliminated if free market entry is given. See also Emons (2001), where a credence-goods monopolist chooses capacity endogenously.

2 Model Setup

We consider the following setting. There is a unit mass of consumers (female) who each have one of a number $K \geq 1$ of possible *conditions* $k \in \mathcal{K} = \{1, \ldots, K\}$. For simplicity, we assume that all of these conditions are equally likely ex-ante.[18] Each consumer requires treatment of her specific, initially unknown condition k to obtain a gross surplus of $v > 0$. For any given condition k, consumers have one of two different *severity* grades $x \in \mathcal{X} = \{H, L\}$, high ($x = H$) and low ($x = L$). A consumer's type is denoted by $\tau = (k, x) \in \mathcal{K} \times \mathcal{X}$. We assume that without any market interaction, a consumer cannot infer her own type. It is however common knowledge that irrespective of the specific condition k, a fraction $\alpha \in (0, 1)$ of consumers with this condition are high-severity subtypes with $x = H$, while the remaining fraction $1 - \alpha$ are low-severity subtypes with $x = L$. As will be explained in more detail below, through the market a consumer may undergo different treatments $t = (k', x') \in \mathcal{K} \times \mathcal{X}$.

We say that a treatment t is *effective* for any given consumer if it lets the consumer enjoy the gross surplus of v when undergoing it, which always requires that the consumer's correct condition is treated: $k' = k$. An *ineffective* treatment (or no treatment at all) does not generate any gross surplus for consumers. We assume that the only effective treatment for any high subtypes (k, H) (with a severe form of their condition) is $t = (k, H)$. In contrast, an effective treatment for any low subtypes (k, L) (with a mild form of their condition) is both given by $t = (k, L)$ and $t = (k, H)$.

There is a monopolist expert service provider (called expert; male). We take the (strong) assumption that once a consumer visits the expert, the latter can perfectly and costlessly diagnose the consumer's type τ, such that provision of effective (and also appropriate; see below) treatment will always be possible. This assumption ensures that any inefficiencies arising in the market do not stem from erroneous or costly expert diagnosis.

For any given consumer arriving at the expert, the expert observes the consumer's type τ, and, based on that, makes a committing proposal to provide some treatment t at fee p. We assume that the expert is fully *liable* in the sense that if any ineffective treatment is proposed and the consumer undergoes the treatment, the expert needs to fully compensate the

[18] This assumption does not drive any of our results and is mainly chosen for analytical convenience. In particular, it allows us to provide sharp bounds for existence of the equilibria to be characterized.

consumer by paying back the fee. Moreover, the expert can not later on alter his treatment proposal.

For each treated condition $k' \in \mathcal{K}$, the expert incurs a marginal cost of $c_H < v$ when carrying out high treatment, $t = (k', H)$, and a marginal cost of $c_L \in (0, c_H)$ when carrying out low treatment, $t = (k', L)$. This implies that when a consumer of type $\tau = (k, x)$ accepts treatment $t = (k', x')$ for fee p, the expert's payoff from this consumer is given by

$$\pi((k',x');(k,x)) = \begin{cases} -c_{x'} & \text{if } k' \neq k, \text{ or } k' = k \text{ and } x' = L \neq x \\ p - c_{x'} & \text{else.} \end{cases}$$

Since the expert can provide effective treatment to low-severity consumers both when choosing low treatment and high treatment, but low treatment is less costly, we say that a treatment is *appropriate* if and only if $t = \tau$.

Next to the expert, there are competitive fringe firms which each supply *only* the low treatment for some specific condition $k \in \mathcal{K}$ at marginal cost c_L. This marginal cost is equal to the expert's marginal cost of providing low treatment. We assume that the competitive fringe firms have no diagnostic ability, are not liable, and each sell a single treatment $t_f = (k, L) \in \mathcal{K} \times \{L\}$ at fee c_L if so requested by a consumer.

As final but crucial element, we assume that the consumers incur a search/travel cost $s \in (0, v - c_H)$ for *every* visit they make to a firm (be it to the expert or to any single fringe firm), implying that recall is *costly*.[19] It should be noted that s does indeed constitute a search (and not only) travel friction when visiting the expert for the first time, as no consumer can observe the expert's fee before visiting him and obtaining a treatment proposal. The assumption that $s < v - c_H$ implies that the expert finds it strictly profitable to treat high-severity consumers at price $v - s$,[20] and that from society's perspective, high-severity consumers should be treated by the expert.

We look for Perfect Bayesian equilibria (PBEs[21]) with the following structure: (1) if a consumer with type $\tau = (k, H)$ visits the expert, she is always offered treatment $t = (k, H)$

[19] Hence, if, for example, a consumer were to first visit the expert, then reject the expert's treatment proposal and visit a fringe firm, but subsequently return to the expert to take up his initial offer, the total search cost incurred would be $3s$. Costly recall is however not necessary to drive our most interesting results (compare with Footnote 7).

[20] As will be shown in the equilibrium analysis below, the price $v - s$ for high treatments is often an important threshold, such that the assumption that $v - s - c_H > 0$ helps to avoid cumbersome case distinctions.

[21] For ease of exposition, we will refer to a single Perfect Bayesian equilibrium as PBE and to several (or an indefinite number of) Perfect Bayesian equilibria as PBEs.

at price p_H^*; (2) if a consumer with type $\tau = (k, L)$ visits the expert, she is offered treatment $t = (k, H)$ at price p_H^* with probability $q_H^* \in [0, 1]$ and treatment $t = (k, L)$ at price p_L^* with probability $1 - q_H^*$; (3) all consumers search and purchase optimally, given the proposed expert equilibrium strategy, updating their beliefs (about their own type) according to Bayes' rule whenever possible; (4) the consumers find it optimal to start their search at the expert, rather than at any of the fringe firms or staying out of the market; (5) the expert's strategy is optimal, given consumers' search behavior.[22] In what follows, we will refer to Perfect Bayesian equilibria that satisfy conditions (1) to (5) as *Expert PBEs*.[23]

3 Equilibrium Analysis

Preliminaries. It may first be noted that given our assumptions that the expert (1) can perfectly and costlessly observe each arriving consumer's type, (2) is committed to carry out any proposed treatment (if so desired by the respective consumer), (3) is fully liable, and (4) cannot later on adapt his treatment proposals, it is a weakly dominated strategy for him to propose ineffective treatments to (a positive measure of) consumers. This is because by doing so, the expert can at best make zero profit with these consumers (if none of them buy; otherwise, he makes a loss with these consumers), while he could guarantee to make a non-negative profit with these consumers buy offering them effective treatment at a price above the respective treatment cost.

In what follows, we want to avoid having to deal with (potential) equilibria in which the expert plays such a weakly dominated strategy. Likewise, we want to bypass the technicalities stemming from having to rule out (implausible) consumer off-equilibrium beliefs that put positive probability mass on the expert proposing ineffective treatment (playing a weakly dominated strategy). We will therefore impose the following assumption.

[22] Throughout, we employ the following tie-breaking assumptions regarding consumers' search behavior: (i) If a consumer is indifferent between starting her search at the expert and staying out of the market (or starting at a fringe firm), she searches the expert, (ii) if a consumer visits the expert and receives a treatment recommendation such that continued search can never strictly improve her current payoff, she follows the expert's recommendation, and (iii) if a consumer has already obtained an offer from the expert, subsequently searched the fringe, and is then indifferent between taking up the expert's offer or leaving the market, she takes up the offer.

[23] What is not reflected in this terminology (but still in the equilibrium description) is that we only consider single-price-per-treatment equilibria in which all low (high) treatments are offered at the same price p_L^* (p_H^*).

Assumption 1. *The expert may only propose* <u>*effective*</u> *treatments to any arriving consumer (at a freely chosen price). That is, the expert may only propose $t = (k,H)$ when a consumer's type is $\tau = (k,H)$, while he may only propose $t = (k,L)$ or $t = (k,H)$ when a consumer's type is $\tau = (k,L)$, for any $k \in \mathcal{K}$.*

Assumption 1 greatly facilitates the exposition without eliminating any analytical insights.[24] In particular, given this assumption, it is now clear that whenever the expert offers some low treatment $t = (k,L)$ to a consumer, she can deduce that she has the low-severity type $\tau = (k,L)$ for sure. If instead the expert offers some high treatment $t = (k,H)$ to a consumer, she does not know whether she really suffers from a high-severity condition or not, but at least she can deduce that she suffers from condition k for sure. To streamline the notation, we will subsequently suppress the (necessarily correct) condition the expert offers to treat for each arriving consumer: when we say that the expert offers low treatment $t = L$ (high treatment $t = H$) to a consumer, we mean that the expert offers $t = (k,L)$ ($t = (k,H)$) to a consumer suffering from condition $k \in \mathcal{K}$.

General equilibrium properties.

□ *Equilibrium prices.* Assumption 1 ensures that if the expert offers low treatment (to low-severity consumers) with positive probability in any Expert PBE, the corresponding equilibrium price must be $p_L^* = c_L + s$ (where $p_L^* < v$ due to $s < v - c_H$). This is because by Assumption 1, the consumers always learn perfectly about their condition k and their (low) severity when getting offered $t = L$. Hence, for $p_L^* > c_L + s$, the consumers getting offered $t = L$ would optimally leave and purchase at the respective fringe firm, such that it would be profitable for the expert to reduce p_L to $c_L + s$ and stop these consumers from leaving. Likewise, for $p_L^* < c_L + s$, the expert could profitably increase p_L to $c_L + s$, which would not cause these consumers to leave.

Further, there exists no Expert PBE in which the expert offers high treatment at a price $p_H^* < v - s$. This is because, by increasing p_H to $v - s$ for those consumers with $x = H$, even if these consumers were to deterministically leave towards the corresponding fringe

[24]Moreover, fixing consumers' off-equilibrium beliefs (i.e., when, after an expert deviation, consumers still put zero probability mass on the possibility that their condition differs from the one proposed to be treated by the expert), all of the to-be-characterized Expert PBEs would still exist if Assumption 1 was relaxed. This is because the expert would always lose money by deviating and offering ineffective treatment to (a positive measure of) consumers.

firms in response to this deviation, they would not receive effective treatments there (since fringe firms can only treat $x = L$) and find it optimal to return to the expert, increasing his profit. Hence, in any equilibrium, it must hold that $p_H^* \geq v - s$ (where $p_H^* - c_H > 0$ due to $p_H^* \geq v - s$ and $s < v - c_H$).

Combining these two findings, a consumer that starts her search at the expert can, at best (when always appropriate treatment is offered at the lowest possible equilibrium price), get an expected surplus of $\alpha[v-(v-s)]+(1-\alpha)[v-(c_L+s)]-s = (1-\alpha)(v-c_L-2s)$.[25] This falls short of the consumer's (outside) option of not engaging in any treatment for $s > \frac{v-c_L}{2}$, implying that no Expert PBE can exist in this case. A crucial condition for the expert to be active in equilibrium is therefore that consumers' search cost is not too large. We summarize these findings in the following lemma.

Lemma 1. *Suppose that Assumption 1 holds. Then, in any Expert PBE, it must hold that $p_L^* = c_L + s$ and $p_H^* \geq v - s$. An Expert PBE may only exist for*

$$s \leq \frac{v - c_L}{2}. \tag{1}$$

We assume in the remainder of this paper that Assumption 1 and inequality (1) hold.

□ *Consumers' optimal search behavior.* Given the outlined setting, a candidate Expert PBE may only exist if the consumers indeed find it optimal to first search the expert, thereby perfectly learning about their conditions (and severity, if getting offered $t = L$) and optimally proceeding from there. Denoting the expected consumer surplus in any such candidate Expert PBE by CS_E, it thus clearly needs to hold that $CS_E \geq 0$ in order for the consumers not to prefer to stay out of the market.

As each condition is equally probable ex ante, the only alternative search strategy, given $CS_E \geq 0$, is to first search randomly through $l \in \{1, \ldots, K\}$ fringe firms, buying low treatments without diagnosis and only stopping when an effective treatment is found. If no effective treatment is obtained from any of the l sampled fringe firms, the consumer then either chooses to leave the market, or (if this yields a higher expected surplus) to visit the

[25]Note that $p_L^* = c_L + s$ exceeds the minimal possible expert equilibrium price p_H^* for high treatment, that is, $v - s$, for $s > \frac{v-c_L}{2}$. This implies that for $s > \frac{v-c_L}{2}$, a consumer with $x = L$ would prefer to receive high treatment at the lowest possible expert equilibrium price $p_H^* = v - s$ for high treatment over receiving low treatment at the corresponding expert equilibrium price $p_L^* = c_L + s$. Given that high treatment is more costly for the expert, it is clear that low-severity consumers could not hope for such a benevolent overtreatment.

expert, learn perfectly about her condition (but not necessarily, her severity) and proceed optimally from there. The associated expected consumer surplus of this strategy, also nesting $CS_E = CS(0)$, is given by

$$CS(l) = \frac{(1-\alpha)l}{K}v - \sum_{k=1}^{l} \frac{1-\alpha}{K}k(c_L+s) - \left(1 - \frac{(1-\alpha)l}{K}\right) l(c_L+s)$$
$$+ \max\left\{\frac{\alpha l}{K}(v - p_H^* - s) + \left(1 - \frac{l}{K}\right) CS_E, 0\right\}. \quad (2)$$

Equation (2) can be understood as follows. The first term is the expected gross surplus a consumer makes from sampling (up to) l fringe firms, as with probability $\frac{(1-\alpha)l}{K}$, an effective treatment providing gross surplus v is found at one of these firms. The second and third term give the expected cost of searching through the fringe firms. With probability $\frac{1-\alpha}{K}$, the k'th fringe firm ($k = 1, \ldots, l$) provides effective treatment, such that the total cost incurred is $k(c_L + s)$ (second term). With probability $1 - \frac{(1-\alpha)l}{K}$, none of the first l sampled fringe firms provides effective treatment, such that the total cost incurred is $l(c_L + s)$ (third term). The term in the second line gives the expected continuation value of (the better of) searching the expert or leaving the market, conditional on that all l searched fringe firms have not provided effective treatment. In this case, when searching the expert, the consumer knows that two possibilities remain. First, with conditional probability $\frac{\alpha l}{K}$, the expert will offer high treatment for one of the conditions $k = 1, \ldots, l$ that the consumer already tried to get fixed by one of the sampled fringe firms (and failed). Then, the consumer would know that the offered treatment is appropriate, and accept it for a continuation surplus (including the additional search cost) of $v - p_H^* - s$.[26] Second, with conditional probability $1 - \frac{l}{K}$, the expert will offer *some* treatment for one of the remaining conditions $k = (l+1), \ldots, K$ that the consumer has not sampled so far, following his equilibrium strategy. But then, the consumer's search through the l fringe firms would not have provided any useful information, and her expected continuation surplus would simply be CS_E.

Since all terms apart from the two cost terms in the first line are linear in l, using that $\sum_{k=1}^{l} \frac{1-\alpha}{K}k(c_L+s) = \frac{1-\alpha}{K}(c_L+s)\frac{l^2+l}{2}$, it is easy to see that $CS(l)$ is strictly convex in l. This shows that only one of two search paths can be optimal from consumers' point of view: It

[26] Note that at this point, the consumer would accept the expert's offer, as the additionally incurred search cost would already be sunk, and $p_H^* \leq v$.

either has $l = 0$, for an expected surplus of $CS(0) = CS_E$, or $l = K$, for an expected surplus of $CS(K)$. Noting that $v - p_H^* - s \leq 0$ due to Lemma 1, we can thus state the following.

Lemma 2. *Any given candidate Expert PBE with associated consumer surplus CS_E may only exist if $CS_E \geq \max\{CS_f, 0\}$, where*

$$CS_f \equiv CS(K) = (1-\alpha)v - (c_L + s)\left(\frac{1-\alpha}{2} + \frac{1+\alpha}{2}K\right). \tag{3}$$

Clearly, the attractiveness of randomly searching through fringe firms and conducting speculative minor treatments is low if the number of possible conditions one may suffer from (K) is large. For K sufficiently large, Expert PBEs are therefore never jeopardized by consumers wishing to start their search at fringe firms. Indeed, the equilibrium analysis below reveals that in the considered setting, having three or more equally probable conditions is always sufficient to deter consumers from doing this. It should moreover be stressed that equal probabilities are not needed to drive this result: it is intuitive that consumers are deterred from randomly searching through (a subset of) fringe firms if the most probable condition is sufficiently unlikely. In our setting, if the most probable condition occurs with a probability of less than one third, consumers are never willing to start their search at the corresponding fringe firm (or any other). We now turn to the equilibrium characterization.

Existence of separating equilibria. We call an *Expert Separating PBE* an Expert PBE in which $q_H^* = 0$, such that every consumer with $x = L$ is offered $t = L$ at price $p_L^* = c_L + s$ by the expert, while every consumer with $x = H$ is offered $t = H$ at some price $p_H^* \in [v-s, v]$ by the expert (compare with Lemma 1 above). Given the candidate equilibrium strategy, a consumer visiting the expert and getting offered $t = H$ at p_H^* would correctly deduce that she has the high severity for sure, such that she would optimally buy (and of course, likewise for a consumer getting offered $t = L$ at $p_L^* = c_L + s$).

Naturally, such a separating equilibrium with honest expert advice can only exist if the expert has no incentive to fool low-severity consumers into thinking that they suffer from a high-severity condition. This requires that the markup on high treatments, $p_H^* - c_H$, does not exceed the markup on low treatments, $p_L^* - c_L = s$. Hence, it is necessary that $p_H^* \leq c_H + s$. This is only compatible with the general equilibrium result that $p_H^* \geq v - s$ (see Lemma 1) if $s \geq \frac{v-c_H}{2}$, such that consumers' search friction needs to be sufficiently large. Intuitively, this is true since the search friction s directly influences the maximal markup the expert can set for low treatments. If this is too small, the expert cannot be induced to always truthfully reveal a low-severity condition to consumers.

As it turns out, for $s > \frac{v-c_H}{2}$, a continuum of Expert Separating PBEs exist, provided that the number of conditions K is sufficiently large to make consumers willing to start their search at the expert. All of these equilibria require that consumers' off-equilibrium beliefs when getting offered $t = H$ at an off-equilibrium price $p_H > p_H^*$ make them sufficiently optimistic about suffering from a low-severity condition, such that they would leave the expert (and therefore, never return, as $v - p_H^* - s \leq 0$ for $p_H^* \geq v - s$). However, it may be observed that all putative Expert Separating PBEs that do not entail equal markups – and hence, by the previous results, have $p_H^* < c_H + s$ – do not survive the well-known *Intuitive Criterion* (Cho and Kreps (1987); IC in what follows) as equilibrium refinement. To see this, note that such equilibria would require consumers to put sufficiently much probability on having low severity after getting offered $t = H$ at an off-equilibrium price $p_H \in (p_H^*, c_H + s)$ – otherwise, they would not leave towards the fringe in face of such a deviation, rendering it profitable. Such off-equilibrium beliefs are implausible, however: as the expert can guarantee a profit of $s > p_H - c_H$ with low-severity consumers by sticking to the equilibrium schedule, such a deviation could only make sense for high-severity consumers.

Hence, the only candidate Expert Separating PBE that remains has $p_L^* = c_L + s$ and $p_H^* = c_H + s$. But this can clearly only constitute an Expert PBE if consumers' participation constraint is not violated, which requires that $CS_{sep} = \alpha(v - p_H^*) + (1 - \alpha)(v - p_L^*) - s \geq 0$, that is, $\alpha \leq \frac{v-c_L-2s}{c_H-c_L}$. If this holds and also K is sufficiently large, the candidate PBE indeed exists if consumers' off-equilibrium beliefs facing $t = H$ at $p_H > p_H^*$ put sufficiently much probability on suffering from a low-severity condition, such that they would optimally leave towards the fringe. Letting these beliefs be denoted by $\mu_L(p_H)$, we thus need that $\mu_L(p_H)v - c_L - s > v - p_H$, that is, $\mu_L(p_H) > \frac{v+c_L+s-p_H}{v}$. Proposition 1 provides the formal statement.

Proposition 1. *Suppose that $s \in [\frac{v-c_H}{2}, \frac{v-c_L}{2}]$*[27] *and that K is sufficiently large.*[28] *Then, for $\alpha > \hat{\alpha}(s) \equiv \frac{v-c_L-2s}{c_H-c_L} \in [0,1]$, no Expert PBE surviving IC exits. For $\alpha \leq \hat{\alpha}(s)$, there exists a unique Expert Separating PBE surviving IC with the following structure:*

- *Each consumer with $x = L$ that visits the expert gets offered $t = L$ at price $p_L^* = c_L + s$.*
- *Each consumer with $x = H$ that visits the expert gets offered $t = H$ at price $p_H^* = c_H + s$.*
- *Each consumer optimally starts her search at the expert and buys immediately when receiving an equilibrium recommendation.*
- *When receiving an off-equilibrium treatment proposal $t = H$, $p_H > p_H^*$, the consumers' off-equilibrium beliefs of having low severity, $\mu_L(p_H)$, satisfy*[29]

$$\mu_L(p_H) \in (\underline{\mu}_L(p_H), 1], \tag{4}$$

where

$$\underline{\mu}_L(p_H) \equiv \frac{v + c_L + s - p_H}{v} \in (1 - \frac{c_H - c_L}{v}, 1). \tag{5}$$

The expert's equilibrium profit is $\pi_{sep} = s$.

Proof. See Appendix A. □

A further remark on consumers' off-equilibrium beliefs is due. Starting from the characterized equilibrium but with unspecified off-equilibrium beliefs, no matter whether the expert faces a high- or low-severity consumer, his incentive to deviate to an off-equilibrium price $p_H > p_H^*$ is exactly the same: he either gains $p_H - (c_H + s)$, if the consumer still takes up his recommendation, or loses s, if the consumer does not. It is thus, a priori, unclear why consumers should put strictly *more* probability weight on suffering from a low-severity condition than their prior probability $1-\alpha$ when facing such a deviation. If we were to fix $\mu_L(p_H) = 1-\alpha$ for $p_H > p_H^*$ following this argument, the set of parameter values supporting the equilibrium would further be restricted. Indeed, the condition $\mu_L(p_H) = 1-\alpha > \frac{v+c_L+s-p_H}{v}$ could then only be sustained for all $p_H > p_H^*$ if $\alpha \leq \frac{c_H-c_L}{v}$.

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[27] And, by assumption, $s < v - c_H$.

[28] Precisely, it needs to hold that $K \geq \underline{K}_{sep} \equiv \frac{-2\alpha v + 2\alpha c_H + (1-\alpha)c_L + (3+\alpha)s}{(1+\alpha)(c_L+s)} \in (0,3)$. To see that $\underline{K}_{sep} < 3$, note that $\frac{\partial}{\partial\alpha}\underline{K}_{sep} = -\frac{2(v-c_H+c_L+s)}{(1+\alpha)^2(c_L+s)} < 0$, such that $\underline{K}_{sep}(\alpha)$ is largest for $\alpha = 0$, with $\underline{K}_{sep}(0) = \frac{c_L+3s}{c_L+s} < 3$.

[29] Note that no restriction on consumers' off-equilibrium beliefs for deviation prices $p_H < p_H^*$ is needed.

On the other hand, consumers updating their priors towards $x = L$ when getting offered $t = H$ at $p_H > p_H^*$ can also be rationalized. Suppose, for example, that next to his own profit, the expert also cares for consumers, in a lexicographic manner. Suppose, moreover, that he believes that when deviating to $p_H > p_H^*$, a fraction of consumers would leave towards the fringe. But then, compared to their equilibrium payoffs, leaving high-severity consumers would be harmed, while leaving low-severity consumers would remain unaffected (the former would lose $v - (c_H + s) + (c_L + s)$, while the latter would still obtain a net surplus of $v - c_L - 2s$, same as on the equilibrium path). Hence, if consumers think that the expert also cares for them, they could consider a deviation price $p_H > p_H^*$ as an indicator that they suffer from a low-severity condition. Since this and other reasons are conceivable as to why consumers may put more weight on suffering from a low-severity condition after getting offered $t = H$ at $p_H > p_H^*$, we will not impose any restrictions other than IC on consumers' off-path beliefs throughout the analysis.

Existence of pooling equilibria. We call an *Expert Pooling PBE* an Expert PBE in which $q_H^* = 1$, such that every consumer, irrespective of the severity of her condition, always gets offered $t = H$ at price p_H^* by the expert. From Lemma 1 above, we already know that for every such candidate equilibrium, it must hold that $p_H^* \geq v - s$. Further, potentially two sorts of Expert Pooling PBE could exist.

The first is an Expert Pooling PBE where the consumers visit the expert and then, upon getting offered the equilibrium proposal $t = H$ for p_H^*, buy immediately. Given $p_H^* \geq v - s$, it is clear that the only possible equilibrium of this sort has $p_H^* = v - s$, as otherwise, the consumers would not find it optimal to visit the expert in the first place.

The second sort of Expert Pooling PBE could have the consumers visiting the expert, and then, upon getting offered the equilibrium proposal $t = H$ for p_H^* and thereby learning about their condition, leaving towards the fringe (potentially returning to the expert if no effective treatment is found at the fringe, and the expert's price is sufficiently low). However, it is easy to see that this second type of Expert Pooling PBE cannot exist: since no leaving consumer with low severity would return to the expert, he would have a profitable deviation of offering these consumers $t = L$ at $p_L = c_L + s$ and selling to them.

We are thus left with the first equilibrium candidate with $p_H^* = v - s$ and all consumers taking up the expert's equilibrium proposal. For this to be an equilibrium, the expert needs to weakly prefer to treat low-severity consumers with $t = H$ at price $p_H^* = v - s$ than to treat them appropriately with $t = L$ at the maximal possible price $p_L = c_L + s$. This requires that $v - s - c_H \geq (c_L + s) - c_L$, that is, $s \leq \frac{v - c_H}{2}$. Moreover, upon visiting the expert and receiving the equilibrium treatment recommendation $t = H$ at $p_H^* = v - s$, the consumers should not want to leave towards the fringe. Since the expert's pooling strategy does not reveal anything about a consumer's severity type, this requires that $v - (v - s) \geq (1 - \alpha)v - c_L - s$,[30] such that

$$\alpha \geq \overline{\alpha}(s) \equiv 1 - \frac{c_L + 2s}{v} \tag{6}$$

is necessary for this equilibrium to exist. As for the Expert Separating PBE discussed above, equilibrium existence further requires that the number of conditions K consumers may suffer from is not too small, and that their beliefs $\mu_L(p_H)$ of suffering from a low-severity condition after getting offered $t = H$ at an off-equilibrium price $p_H > p_H^*$ must be sufficiently optimistic. Proposition 2 summarizes our result.

Proposition 2. *Suppose that $s < \frac{v - c_H}{2}$,[31] $\alpha > \overline{\alpha}(s)$,[32] and that K is sufficiently large.[33] Then there exists a unique Expert PBE (an Expert Pooling PBE) according to which:*

- *Each consumer that visits the expert gets offered $t = H$ at a price $p_H^* = v - s$.*
- *Each consumer optimally starts her search at the expert and buys immediately when receiving the equilibrium recommendation.*

[30] Note that given $p_H^* = v - s$, a consumer obtains zero continuation surplus from returning to the expert after getting ineffective treatment at the fringe.

[31] For $s = \frac{v - c_H}{2}$, the outlined Expert Pooling PBE also exists, but is not the unique Expert PBE anymore: it then coincides with the corresponding Expert Separating PBE of Proposition 1.

[32] For $\alpha = \overline{\alpha}(s)$, the outlined Expert Pooling PBE also exists, but it is not the unique Expert PBE anymore. In this case, there is actually a continuum of Expert Pooling PBEs featuring the same expert pricing strategy, which however differ in the frequency with which consumers accept high-treatment proposals. This frequency, r, must satisfy $r \in [\frac{s}{v - s - c_H}, 1]$.

[33] Precisely, it needs to hold that $K \geq \underline{K}_{pool} \equiv \frac{(1-\alpha)(2v - s - c_L)}{(1+\alpha)(c_L + s)} \in (0, 3)$. To see that $\underline{K}_{pool} < 3$, note that this is equivalent to $\alpha > \frac{v - 2c_L - 2s}{v + c_L + s}$, which is implied by $\alpha \geq \overline{\alpha}(s)$, as is necessary to support the considered Expert Pooling PBE.

- *When receiving an off-equilibrium treatment proposal $t = H$, $p_H > p_H^*$, the consumers' off-equilibrium beliefs of having low severity, $\mu_L(p_H)$, satisfy*[34] $\mu_L(p_H) \in (\underline{\mu}_L(p_H), 1]$, *where $\underline{\mu}_L(p_H)$ is specified in equation (5).*

The expert's equilibrium profit is $\pi_{pool} \equiv v - s - c_H$.

Proof. See Appendix A. □

If consumers' search friction is not too large and the ex-ante probability of suffering from a high-severity condition is high, we thus observe an extreme form of overtreatment in the unique Expert PBE: the expert always proposes high treatment, and all consumers accept this. Even though the consumers get informed precisely about their conditions through the expert's treatment proposal, they do not find it worthwhile to walk away and try their luck by purchasing low treatment at the corresponding fringe firm: relative to the cost of doing so, their success probability is too low.

Interestingly, the expert market does not break down despite the usual hold-up problem in markets with unobservable prices and costly first search (Diamond (1971)): this is because the expert is disciplined by the need to truthfully disclose consumers' conditions to make profit and the existence of the competitive fringe. What is required for this, however, is that the consumers become sufficiently optimistic to suffer from a low-severity condition when getting offered an off-equilibrium price $p_H > p_H^*$. For $\alpha = \overline{\alpha}(s)$, it is enough if their beliefs of having $x = L$ remain at the prior probability when facing such a deviation, but as α increases, the updating of beliefs towards this must become increasingly drastic to support the equilibrium. This suggests that the characterized Expert Pooling PBE is most plausible to be played for not too high values of α.

Existence of semi-pooling equilibria: overview. We call an *Expert Semi-pooling PBE* an Expert PBE in which $q_H^* \in (0, 1)$, such that low-severity consumers are sometimes offered $t = L$ at $p_L^* = c_L + s$ and sometimes $t = H$ at some $p_H^* \geq v - s$ (compare with Lemma 1). High-severity consumers are always offered $t = H$ at p_H^*. Given the candidate equilibrium

[34] Again, no restriction on consumers' off-equilibrium beliefs for deviation prices $p_H < p_H^*$ is needed.

strategy for yet unknown q_H, a consumer visiting the expert and getting offered $t = H$ at p_H^* would then reason via Bayes' rule that her probability of having a low-severity condition is

$$\Pr\{x = L | t = H; p_H^*\} = \frac{(1-\alpha)q_H}{(1-\alpha)q_H + \alpha} \equiv \mu_L(p_H^* | q_H). \tag{7}$$

In what follows, we will characterize the unique Expert Semi-pooling PBE for $s < \frac{v-c_H}{2}$, which happens to be the unique Expert PBE whenever it exists. For $s \geq \frac{v-c_H}{2}$ and α sufficiently low, it turns out that a continuum of Expert Semi-pooling PBEs exist, next to the unique Expert Separating PBE (surviving IC) of Proposition 1. These equilibria all give rise to the same expected profit as the coexisting Expert Separating PBE, but generate lower total welfare. We relegate a characterization of these equilibria to Appendix B.

Expert Semi-pooling PBE for $\mathbf{s} < \frac{\mathbf{v}-\mathbf{c_H}}{\mathbf{2}}$. We start by arguing that for $s < \frac{v-c_H}{2}$, there exists no Expert Semi-pooling PBE with $p_H^* > v - s$. Suppose to the contrary that this was the case. Then, since in an Expert Semi-pooling PBE the expert randomizes whether to offer $t = L$ at price $p_L^* = c_L + s$ or to offer $t = H$ at price p_H^* to low-severity consumers, he must be indifferent between these two options when facing a low-severity consumer. As $p_H^* - c_H > p_L^* - c_L = s$ due to $p_H^* > v - s$ and $s < \frac{v-c_H}{2}$, this is only possible if just a fraction of consumers buy when facing $t = H$ at price p_H^*.

Let the fraction of consumers who buy given $t = H$ and price p_H^* be denoted by r. Then, the value of r that makes the expert indifferent between offering $t = L$ at price $p_L^* = c_L + s$ and offering $t = H$ at price p_H^* to low-severity consumers solves $r(p_H^* - c_H) = s$, that is, it is given by

$$r^*(p_H^*) \equiv \frac{s}{p_H^* - c_H} \in (0,1).^{35} \tag{8}$$

The above means that in the specified candidate equilibrium, a fraction $1 - r^*$ of consumers who are offered $t = H$ at price p_H^* would have to leave the firm. Moreover, they would clearly never return, as $p_H^* > v - s$. But this would be true for both low-severity *and* high-severity consumers, such that the profit per high-severity consumer would also be given by s. This cannot be an equilibrium, however, as by deviating and offering $p_H = v - s < p_H^*$ to all high-severity consumers, all of these consumers would (eventually) buy at the expert (as even if they all left towards the fringe in face of this deviation, no effective treatment

[35] Note that $r^*(p_H^*) < 1$ since by assumption $p_H^* > v - s$ and $s < \frac{v-c_H}{2}$.

could be obtained from the fringe, such that they would find it optimal to return to the expert). The profit per high-severity consumer would then increase to $v-s-c_H > s$, rendering the deviation profitable.

We can thus conclude that for $s < \frac{v-c_H}{2}$, the only possible Expert Semi-pooling PBE has $p_H^* = v-s$ and thereby, via equation (8),

$$r^* \equiv \frac{s}{v-s-c_H} \in (0,1). \tag{9}$$

Since in this candidate equilibrium, when getting offered $t=H$ at price p_H^*, consumers randomize between buying immediately from the expert and leaving towards the fringe, it must hold that

$$v-(v-s) = \Pr\{x=L|t=H;p_H^*\}v - c_L - s.$$

Inserting $\Pr\{x=L|t=H;p_H^*\}$ from equation (7) and solving for q_H, this implies that in the candidate equilibrium, we must have that

$$q_H^* \equiv \frac{\alpha(c_L+2s)}{(1-\alpha)(v-c_L-2s)}. \tag{10}$$

Plugging back (10) into (7), we also obtain consumers' updated beliefs of suffering from a low-severity condition after getting offered $t=H$ at $p_H^* = v-s$ in the candidate equilibrium: they are given by

$$\mu_L^* \equiv \mu_L(p_H^*|q_H^*) = \frac{c_L+2s}{v}. \tag{11}$$

Note that $q_H^* > 0$ due to $s < \frac{v-c_H}{2}$. However, the candidate equilibrium is only well-defined when $q_H^* < 1$, which implies that $\alpha < 1 - \frac{c_L+2s}{v} = \overline{\alpha}(s)$ is necessary for equilibrium existence. As for the Expert Separating PBE and Expert Pooling PBE above, it is further required that the number of conditions K is sufficiently large, such that the consumers wish to start their search at the expert.

Lastly, consumers' off-equilibrium beliefs when getting offered $t=H$ at some $p_H \neq p_H^*$ again need to put sufficiently much weight on having a low-severity condition, such that they would respond by leaving towards the fringe. Due to consumers' on-path indifference between going to the fringe and buying directly at the expert when getting offered $t=H$ at $p_H^* = v-s$, for deviations to some $p_H > p_H^*$, it is clearly sufficient that the consumers do not start to put *more* weight on having the high-severity condition than on the equilibrium path.[36] For downward deviations, it likewise needs to hold that consumers' beliefs of having low-severity are sufficiently high. But this is very natural, as the expert can guarantee to sell to high-severity consumers at the equilibrium price p_H^* (as even those consumers who leave return to the expert), so the considered downward deviation is equilibrium-dominated when facing high-severity consumers (but not when facing low-severity ones). Proposition 3 provides our formal result.

Proposition 3. *Suppose that $s < \frac{v-c_H}{2}$, $\alpha < \overline{\alpha}(s)$ and that K is sufficiently large.*[37] *Then there exists a unique Expert PBE (an Expert Semi-pooling PBE) according to which*

- *Each consumer with $x = H$ that visits the expert gets offered $t = H$ at price $p_H^* = v - s$.*
- *Each consumer with $x = L$ that visits the expert gets offered $t = H$ at $p_H^* = v - s$ with probability $q_H^* \in (0,1)$, while she gets offered $t = L$ at $p_L^* = c_L + s$ with probability $1 - q_H^*$, where q_H^* is specified in (10).*
- *Each consumer optimally starts her search at the expert. Then, on the equilibrium path, a consumer's optimal search and purchase behavior is as follows. When she gets offered $t = L$ at $p_L^* = c_L + s$, she buys immediately. When she gets offered $t = H$ at price $p_H^* = v - s$, she buys with probability $r^* \in (0,1)$ and leaves towards the fringe with probability $1 - r^*$, where r^* is specified in (9). If, after getting offered $t = H$ at price $p_H^* = v - s$, she leaves towards the fringe, but receives no effective treatment there, she returns to buy from the expert.*
- *When receiving an off-equilibrium treatment proposal $t = H$, $p_H \neq p_H^*$, the consumers' off-equilibrium beliefs of having low severity, $\mu_L(p_H)$, satisfy*[38] *$\mu_L(p_H) \in (\underline{\mu}_L(p_H), 1]$ for all $p_H \in (c_H + s, p_H^*) \cup (p_H^*, v]$, where $\underline{\mu}_L(p_H)$ is specified in equation (5).*

The expert's equilibrium profit is given by $\pi_{sem} \equiv \alpha(v - s - c_H) + (1 - \alpha)s$.

Proof. See Appendix A. □

[36] Hence, a sufficient condition on consumers' off-equilibrium beliefs to make upward deviations unprofitable is that $\mu_L(p_H) \geq \mu_L^* = \frac{c_L+2s}{v}$ for $p_H > p_H^*$.

[37] Precisely, it needs to hold that $K \geq \underline{K}_{sem} \equiv 1 + \frac{2s}{(1+\alpha)(s+c_L)} \in (1,3)$.

[38] No restriction on consumers' off-equilibrium beliefs for deviation prices $p_H \leq c_H + s$ is needed.

In the characterized Expert Semi-pooling PBE, the expert and consumers keep each other in check: If the consumers bought for sure when getting offered $t = H$ at p^*_H, the expert would find it optimal to always recommend high treatment. But given this, since consumers' probability of suffering from a high-severity condition is now relatively low with $\alpha < \overline{\alpha}(s)$, they would find it optimal to walk aways towards the fringe. This cannot be part of an equilibrium, however, as then the expert would like to retain low-severity consumers by offering them low treatment. The only way to stabilize incentives is for both parties to randomize: The expert overtreats low-severity consumers with positive probability, which makes consumers, unknowing about the severity of their conditions, exactly indifferent between accepting a high-treatment recommendation and visiting the fringe. At the same time, the fraction of consumers leaving towards the fringe after a high-treatment recommendation is exactly such to make the expert indifferent between recommending low and high treatment to low-severity consumers. A similar equilibrium configuration arises in Pitchik and Schotter (1987) with *exogenous* (and thereby, known) treatment prices. We show that a limitation of expert market power due to competition from non-expert suppliers of low treatments can yield this outcome even with endogenous and, before search, *unobservable* expert pricing.

We also want to stress that the showcased equilibrium features two characteristics that are indeed observed in many real-world expert markets: experts *sometimes* propose and carry out unnecessarily costly treatments, while consumers *sometimes* reject experts' treatment recommendations and try to fix their problems through different means, such as purchasing spare parts from a discount store. Of course, this strategy sometimes fails, which may then force consumers to return to the initially consulted expert. A detailed analysis of the various inefficiencies occurring in the described equilibrium will be provided in Section 4.

Multiple Experts. We will briefly outline under which circumstances the Expert PBEs from Propositions 1 to 3 continue to exist when there are multiple experts in the market.[39] Suppose hence that there are $N \geq 2$ identical experts in the market. We assume that the

[39]To simplify the exposition, we will not discuss any necessary restrictions on consumers' out-of-equilibrium beliefs in what follows. Throughout, it is sufficient if they satisfy the same conditions as in Propositions 1 to 3, with the (natural) additional assumption that consumers' off-equilibrium beliefs are passive with respect to not-yet-visited experts' strategies.

consumers randomize with equal probability which expert to visit first if it is optimal to visit any expert, which is however inconsequential for the subsequent results. It is then immediate that the Expert Separating PBE of Proposition 1 and the Expert Pooling PBE of Proposition 2 remain PBEs when $N \geq 2$ experts follow the respective expert equilibrium strategy for $N = 1$. This is because, given these strategies, a consumer getting offered $t = H$ at p_H^* at the first visited expert can only lose when visiting any other expert, as she expects to receive an identical offer with certainty. Likewise, there is clearly no reason to visit another expert when getting offered $t = L$ at $p_L^* = c_L + s$. Therefore, the experts are not constrained by each other, and the equilibria for $N = 1$ remain equilibria for arbitrary N.

In contrast, equilibrium existence under expert competition is more subtle in the case of the Expert Semi-pooling PBE of Proposition 3. Consider a candidate equilibrium in which each expert follows the strategy outlined in this proposition. Moreover, same as in the monopoly case, each consumer who gets offered $t = H$ at p_H^* leaves towards the fringe with probability $1 - r^*$ (as specified in (9)), and returns to the *same* expert in case no effective treatment is obtained.[40] Then, given the candidate expert strategies, we know from equation (11) that consumers' updated beliefs of suffering from a low-severity condition when getting offered $t = H$ at $p_H^* = v - s$ are $\mu_L^* = \frac{c_L + 2s}{v}$, where $\mu_L^* < 1 - \alpha$ due to $\alpha < \overline{\alpha}(s)$. Therefore, on the (candidate) equilibrium path, consumers become less optimistic about suffering from a low-severity condition after getting offered high treatment. Moreover, by Assumption 1, they get revealed their true condition (albeit not their severity) already through the first treatment recommendation.

Yet, consumers might still find it optimal to visit another expert after getting offered $t = H$ at p_H^* by the first visited expert (rather than purchasing there or visiting the fringe[41]), upsetting the equilibrium. Noting that the first incurred search cost is sunk at this point,

[40] Of course, given the assumed expert strategies, a consumer who has received ineffective treatment at the fringe is actually indifferent between returning to her initial expert and visiting any other (or alternatively, leaving the market). However, it is arguably her best (and definitely, safest) strategy to return to the first consulted expert: he has already made a committing offer to treat her (high-severity) problem at $p_H^* = v - s$, while there is a chance that another expert would try to exploit her by asking for a higher price (for example, if he would find out about her search history). In any case, consumers' on-path indifference which expert to visit after an unsuccessful fringe treatment can be broken at will when considering existence of a specific equilibrium (here, an equilibrium where all consumers return to the initially visited expert).

[41] Recall that consumers are indifferent between these two options by construction.

and taking into account consumers' updated beliefs, the expected immediate gain of visiting another expert is

$$\Delta \equiv \mu_L^*(1-q_H^*)(v-c_L-2s)-s.$$[42]

Since q_H^* is strictly increasing in α, with $\lim_{\alpha\to\overline{\alpha}(s)} q_H^* = 1$, it is clear that for α sufficiently close to $\overline{\alpha}(s)$ (where Δ is therefore close to $-s$), searching a second expert is not worthwhile. Solving $\Delta = 0$ for α, the exact lower bound on α to make searching a second expert not worthwhile is given by

$$\tilde{\alpha}_N(s) \equiv 1-\frac{(c_L+2s)^2}{v(c_L+s)} < \overline{\alpha}(s). \tag{12}$$

Now, given the candidate equilibrium strategies, searching new experts clearly gets worse and worse the more experts have already been sampled who have offered $t = H$ at p_H^* (as consumers become more and more pessimistic about suffering from a low-severity condition). It is hence immediate that the original Expert Semi-pooling PBE prevails if and only if $\alpha \geq \tilde{\alpha}_N(s)$. As $\tilde{\alpha}_N(s)$ is strictly decreasing in s, this condition gets relaxed as s increases – and may even be satisfied for any value of α if s is sufficiently large (as then $\tilde{\alpha}_N(s) \leq 0$).

We have thus shown that also the Expert Semi-pooling PBE of Proposition 3 survives expert competition, given that α (or s) is sufficiently large. Intuitively, for α close to $\overline{\alpha}(s)$, the candidate equilibrium strategy is such that experts almost always recommend high treatment. Hence, even though it is optimal for consumers to visit one expert as this reveals their condition (provided that K is sufficiently large), searching a second expert after having received a high-treatment proposal is not. Similarly, for a large search cost s, experts' propensity to overtreat, q_H^*, is large as well – while at the same time, accepting $t = H$ at $p_H^* = v-s$ entails a comparatively large surplus (of s), and searching on is costly.

Naturally, one may wonder whether a similar type of Expert Semi-pooling PBE surviving expert competition can also be supported for $\alpha < \tilde{\alpha}_N(s)$. Indeed, the answer is often affirmative: provided that α (or s) is not too low, the experts can coordinate on an equilibrium with lower high-treatment price $p_H^{**} \in (c_H+s, v-s)$ which still avoids direct competition between themselves. Consider such a candidate equilibrium where every expert overtreats low-severity consumers with some probability $q_H^{**} \in (0,1)$, proposing a price

[42]This is because, with posterior probability μ_L^*, the consumer suffers from a low-severity condition, in which case with probability $1-q_H^*$, the next visited expert will offer $t = L$ at $p_L^* = c_L+s$. This would entail a price saving of $p_H^*-p_L^* = v-c_L-2s$. With remaining probability $1-\mu_L^*(1-q_H^*)$, the same price p_H^* will be offered, such that no pricing saving would be achieved. The cost of searching another expert is s.

$p_H^{**} \in (c_H + s, v - s)$ such that also $r^* < 1$ (compare with equation (8)). Then, consumers do not find it worthwhile to visit a second expert after initially getting offered $t = H$ at p_H^{**} if and only if

$$\mu_L(p_H^{**}|q_H^{**})(1 - q_H^{**})(p_H^{**} - (c_L + s)) - s \leq 0, \tag{13}$$

where $\mu_L(p_H^{**}|q_H^{**}) = \frac{(1-\alpha)q_H^{**}}{(1-\alpha)q_H^{**}+\alpha}$ is the (on the candidate equilibrium path) posterior probability of suffering from a low-severity condition (compare with equation (7)). Clearly, for any given q_H^{**}, the maximal price that satisfies (13), giving rise to the highest equilibrium payoff, makes this condition binding.

The candidate equilibrium moreover requires that consumers are indifferent between purchasing immediately and visiting the fringe after getting offered $t = H$ at p_H^{**}. This requires that

$$\mu_L(p_H^{**}|q_H^{**})(p_H^{**} - c_L - s) + (1 - \mu_L(p_H^{**}|q_H^{**}))(-c_L - 2s) = 0, \tag{14}$$

as with probability $\mu_L(p_H^{**}|q_H^{**})$, effective treatment at price c_L is found at the fringe (giving rise to a gain in surplus of $p_H^{**} - c_L - s$), while with remaining probability $1 - \mu_L(p_H^{**}|q_H^{**})$, additional costs of $c_L + 2s$ are unnecessarily incurred. Simultaneously solving the binding version of (13) together with (14), the (payoff-dominant) candidate equilibrium has

$$q_H^{**} = \frac{\alpha(c_L + s)}{\alpha(c_L + s) + s} \in (0, 1) \tag{15}$$

and

$$p_H^{**} = \frac{(c_L + 2s)^2}{(1 - \alpha)(c_L + s)} - s. \tag{16}$$

This candidate equilibrium indeed exists (under suitable off-equilibrium beliefs) if $p_H^{**} \in (c_H + s, v - s)$, which is equivalent to

$$1 - \frac{(c_L + 2s)^2}{(c_H + 2s)(c_L + s)} \equiv \underline{\alpha}_N(s) < \alpha < \tilde{\alpha}_N(s).^{43} \tag{17}$$

While we have thus shown that Expert Semi-pooling PBEs giving rise to equilibrium overtreatment can often be sustained under expert competition, it also straightforward to see that these equilibria are not unique. Consider, for example, an Expert Separating PBE with

[43] The equilibrium also exists for $\alpha = \underline{\alpha}_N(s)$, where then $p_H^{**} = c_H + s$. However, in this case, the experts have no strict incentive to overtreat anymore, such that a payoff-equivalent Expert Separating PBE could alternatively be played. For $\alpha = \tilde{\alpha}_N(s)$, it holds that $p_H^{**} = v - s$ and $q_H^{**} = q_H^*$, hence there is a smooth transition to the original Expert Semi-pooling PBE existing for $\alpha \in [\tilde{\alpha}_N(s), \overline{\alpha}(s))$.

$p_L^* = c_L + s$ and $p_H^* = c_H + s$. Provided that deviation prices $p_H > p_H^*$ make consumers sufficiently optimistic to suffer from a low-severity condition such that they would leave towards the fringe or another expert, such deviations would indeed not be profitable. This is because, in contrast to the monopoly setting, even high-severity consumers would never return. Yet, we conjecture that under expert competition, the just characterized Expert Semi-pooling PBE for $\alpha \in (\underline{\alpha}_N(s), \tilde{\alpha}_N(s))$, as well as the still existing original Expert Semi-pooling PBE for $\alpha \in [\tilde{\alpha}_N(s), \overline{\alpha}(s))$, constitute the payoff-dominant Expert PBEs, such that experts might be prone to coordinate on them.

Summary of Equilibria. Figure 1 showcases the various equilibrium regions arising from Propositions 1 to 3 in (s, α)-space, assuming that the number of conditions K is sufficiently large[44] such that the characterized Expert PBEs exist. For $s \in [\frac{v-c_H}{2}, \frac{v-c_L}{2}]$ and $\alpha \leq \hat{\alpha}(s)$, the Expert Separating PBE of Proposition 1 is the unique Expert Separating PBE satisfying IC. Moreover, we show in Appendix B that also a continuum of Expert Semi-pooling PBEs exist for $s \in [\frac{v-c_H}{2}, \frac{v-c_L}{2})$ and $\alpha < \overline{\alpha}(s)$, where $\overline{\alpha}(s) < \hat{\alpha}(s)$. For $s < \frac{v-c_H}{2}$, the line $\overline{\alpha}(s)$ divides the parameter space into the region where the (pure) pooling equilibrium of Proposition 2 is the unique Expert PBE[45] (for $\alpha > \overline{\alpha}(s)$) and the region where the semi-pooling equilibrium of Proposition 3 is the unique Expert PBE (for $\alpha < \overline{\alpha}(s)$). The Expert PBEs of Propositions 1 and 2 also exist when $N \geq 2$ experts compete in the market, while the Expert Semi-pooling PBE of Proposition 3 only exists if $\alpha \geq \tilde{\alpha}_N(s)$. Still, for $\alpha \in (\underline{\alpha}_N(s), \tilde{\alpha}_N(s))$, a similar Expert Semi-pooling PBE with $p_H^* \in (c_H + s, v - s)$ can be supported under competition.[46] Finally, for $\alpha > \hat{\alpha}(s)$, no Expert PBE surviving IC exists.[47]

Figure 2 considers a slightly different parameter combination, $v = 1$, $c_H = 0.4$, $c_L = 0.1$,[48] and showcases in (s, α)-space the minimum number of (equally probable) conditions K that is necessary to support the unique Expert Pooling PBE, the unique Expert Semi-

[44] Recall that $K \geq 3$ is sufficient for this.

[45] It is also an equilibrium for $s = \frac{v-c_H}{2}$, although it then coexists with the corresponding Expert Separating PBE of Proposition 1.

[46] One may wonder why an Expert Semi-pooling PBE involving overtreatment may exist even for $s = 0$ (as is evident from Figure 1 for α high). The reason is that, perhaps surprisingly, the experts' propensities to (attempt to) overtreat low-severity consumers in the considered equilibrium, q_H^{**}, tends to one as s goes to zero. Because of this, visiting a second expert is not worthwhile for $s = 0$, even though it is free.

[47] For $s > \frac{v-c_L}{2}$, no Expert PBE exists at all, even ignoring IC (see Lemma 1).

[48] A very similar picture is obtained when considering the parameter combination employed for Figure 1, $v = 1$, $c_H = 0.4$, $c_L = 0.2$. However, in this case, $K \geq 2$ is always sufficient to support the Expert Pooling PBE, such that the red region above $\overline{\alpha}(s)$ (for s close below $\frac{v-c_H}{2}$) disappears.

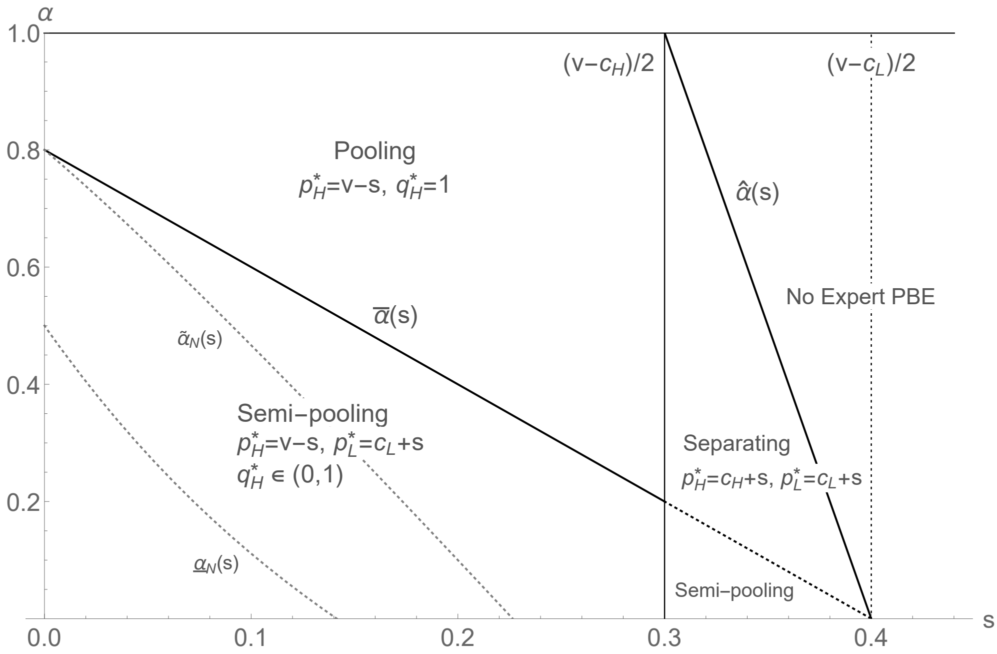

Figure 1: Depiction of the model's equilibrium regions for $v = 1$, $c_H = 0.4$, $c_L = 0.2$, K sufficiently large.

pooling PBE for $s < \frac{v-c_H}{2}$, and the unique Expert Separating PBE surviving IC for $s \geq \frac{v-c_H}{2}$. As is already known from Propositions 1 to 3, $K \geq 3$ is always sufficient to guarantee existence of the respective Expert PBE. It can moreover be seen that the Expert Separating PBE of Proposition 1 and the Expert Pooling PBE of Proposition 2 can even be supported for a single condition in parts of the parameter space. In contrast, the Expert Semi-pooling PBE of Proposition 3 requires at least two different conditions, $K \geq 2$.

4 Welfare

In this section, we will discuss the welfare distortions arising from the documented expert overtreatment – and consumers' induced search behavior – as well as how aggregate welfare depends on the model parameter that seems most susceptible for policy intervention, consumers' search friction s.

For this, we may first note that given our parameter restriction of $v - c_H - s > 0$, welfare is maximized if and only if every consumer visits the expert, the expert offers appropriate

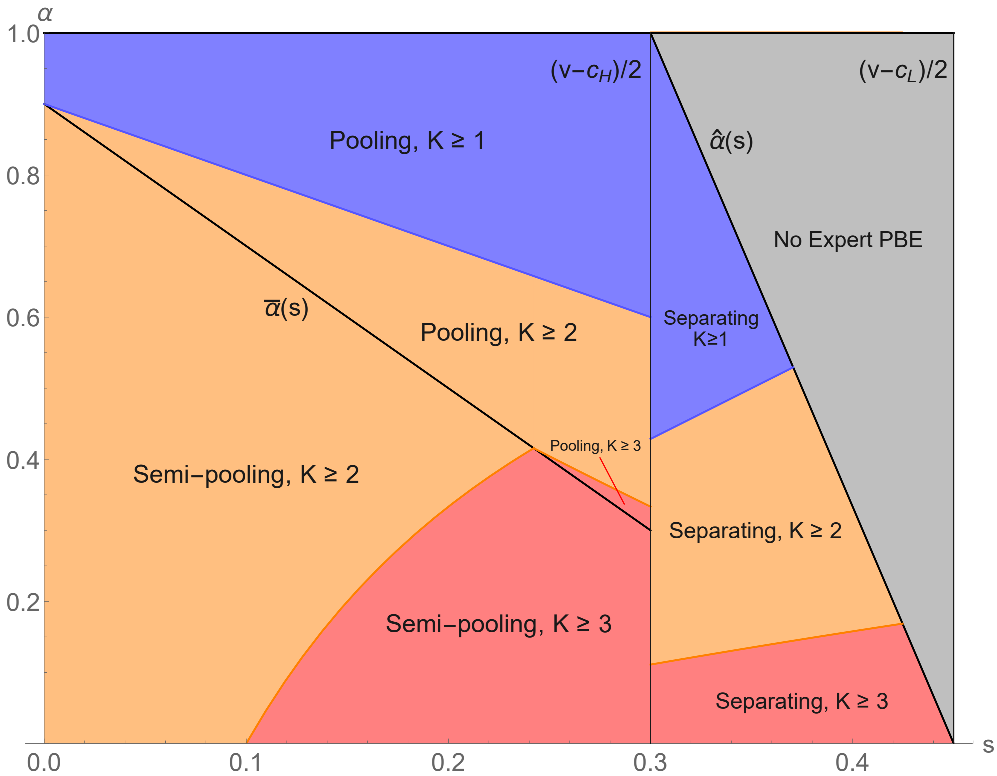

Figure 2: Illustration of the minimum number of (equally probable) conditions K that is necessary to support the Expert PBEs of Propositions 1 to 3, for $v = 1$, $c_H = 0.4$, $c_L = 0.1$.

treatment to every arriving consumer, and every consumer takes up the expert's offer. The maximal welfare that can be achieved for any given parameter combination is thus

$$W_{max} \equiv v - \alpha c_H - (1-\alpha)c_L - s, \tag{18}$$

which clearly coincides with the welfare that is achieved in the Expert Separating PBE of Proposition 1. It thus holds that for s relatively large ($s \in [\frac{v-c_H}{2}, \frac{v-c_L}{2})$) and α sufficiently low ($\alpha \leq \hat{\alpha}(s)$), no welfare distortion occurs in equilibrium.[49] In contrast, for any $s < \frac{v-c_H}{2}$, no Expert Separating PBE exists, such that welfare distortions must necessarily arise. We start by discussing the distortion arising in the (unique) Expert Pooling PBE for $s < \frac{v-c_H}{2}$ and $\alpha \geq \overline{\alpha}(s)$ (compare with Proposition 2), before turning to the most interesting distortions that emerge in the (unique) Expert Semi-pooling PBE of Proposition 3.

[49]In what follows, we assume that the Expert Separating PBE is played when either the Expert Pooling PBE of Proposition 2 coexists (for $s = \frac{v-c_H}{2}$ and $\alpha \geq \overline{\alpha}(s)$) or the Expert Semi-pooling PBEs characterized in Appendix B coexist (for $s \in [\frac{v-c_H}{2}, \frac{v-c_L}{2})$ and $\alpha < \overline{\alpha}(s)$).

Welfare distortion in the Expert Pooling PBE. In the Expert Pooling PBE of Proposition 2, all consumers first visit the expert; all of them, irrespective of the severity of their condition, get offered $t = H$ at price $p_H^* = v - s$; and all of them immediately take up this offer. Clearly, the consumers make zero surplus in this equilibrium, and total social welfare is simply equal to the expert's equilibrium profit, that is,

$$W_{pool} \equiv v - s - c_H.^{50} \tag{19}$$

Compared to the first best, we thus have a welfare loss of $W_{pool}^{loss} \equiv (1-\alpha)(c_H - c_L)$, as for the mass $1-\alpha$ of consumers that only suffer from a low-severity condition, high treatment rather than low treatment (at an excess cost of $c_H - c_L$ per consumer) is inefficiently conducted. Naturally, this welfare loss is larger the more consumers are inefficiently treated (the higher $1-\alpha$) and the higher the additional cost $c_H - c_L$ per inefficient treatment. Consumers' search friction s does no affect the absolute level of welfare loss in this equilibrium, but it one-to-one reduces the total welfare in the market, as it becomes more costly for the consumers to visit the expert.

Welfare distortion in the Expert Semi-pooling PBE. In the Expert Semi-pooling PBE of Proposition 3, all consumers first visit the expert; a fraction $q_H^* \in (0,1)$ of visiting low-severity consumers inappropriately get offered $t = H$ at $p_H^* = v - s$; a fraction $r^* \in (0,1)$ of consumers who get offered $t = H$ accept this treatment, while a fraction $1 - r^*$ try their luck by buying low treatment from their relevant fringe firm; finally, those high-severity consumers who have left the expert return to purchase from him.

It may hence be observed that three different types of welfare losses occur when the Expert Semi-pooling PBE is played. First, a fraction $q_H^* r^*$ of the mass $1-\alpha$ of low-severity consumers get offered $t = H$ and accept this offer. This amounts to a welfare loss of

$$W_{sem}^{loss,1} \equiv (1-\alpha) q_H^* r^* (c_H - c_L) = \frac{\alpha(c_L + 2s)}{v - c_L - 2s} \left(\frac{s}{v - s - c_H} \right) (c_H - c_L), \tag{20}$$

as the additional cost for high treatment, $c_H - c_L$, is wasted per served low-severity consumer. Second, a fraction $q_H^*(1 - r^*)$ of the mass $1-\alpha$ of low-severity consumers get

[50] This expression indeed equals the total surplus created in the market: for every consumer, a gross surplus of v is created through effective treatment; the conducted high treatment costs c_H per consumer, and each consumer has to pay the search cost s to visit the expert.

offered $t = H$ and leave towards their relevant fringe firm, where these consumers indeed get effective treatment of their condition. The resulting welfare loss is

$$W_{sem}^{loss,2} \equiv (1-\alpha)q_H^*(1-r^*)s = \frac{\alpha(c_L+2s)}{v-c_L-2s}\left(1-\frac{s}{v-s-c_H}\right)s, \tag{21}$$

as an additional search cost s is unnecessarily incurred from society's perspective. Third, a fraction $1-r^*$ of high-severity consumers, who all get offered $t = H$ by the expert, erroneously leave the expert towards a fringe firm; doing so, they buy ineffective treatment at social cost c_L, and, as they then return to the expert, a total additional search friction of $2s$ is created. The welfare loss stemming from this group of consumers is therefore

$$W_{sem}^{loss,3} \equiv \alpha(1-r^*)(c_L+2s) = \alpha\left(1-\frac{s}{v-s-c_H}\right)(c_L+2s). \tag{22}$$

Each of these individual welfare losses strictly increases in the fraction α of consumers with a high-severity condition, and partly depends in a complex manner on the other model parameters, in particular, on consumers' search friction s. However, when aggregating the three welfare losses, a surprisingly simple expression for the total loss of welfare in the market emerges: it is given by

$$W_{sem}^{loss} \equiv \alpha(c_L+2s), \tag{23}$$

which strictly increases in α, c_L and s. Note that this total loss of welfare could alternatively (and more easily) be obtained by first summing up the expert's equilibrium profit $\pi_{sem} = \alpha(v-s-c_H)+(1-\alpha)s$ and consumers' aggregate surplus

$$CS_{sem} \equiv (1-\alpha)(1-q_H^*)(v-c_L-2s) = (1-\alpha)v-c_L-2s \tag{24}$$

in the given Expert Semi-pooling PBE, which directly gives the total social welfare in the considered equilibrium:

$$W_{sem} \equiv v-\alpha c_H-c_L-s(1+2\alpha). \tag{25}$$

Computing $W_{max}-W_{sem}$ then shows that the welfare loss is indeed W_{sem}^{loss} in the Expert Semi-pooling PBE.

Relative welfare. The model's parameters, with the possible exception of s, are rather "deep" consumer and technological parameters that can hardly be influenced by policymakers – arguably, it is difficult to change the fraction of consumers suffering from high-severity conditions, or to reduce the costs of various treatments. Therefore, rather than studying the welfare comparative statics with respect to these parameters, it seems most important to analyze *which* market configurations are particularly prone to market failure, such that policymakers can appropriately respond by adapting the regulatory framework. For example, in markets where large relative welfare losses seem likely, policymakers may want to separate expert diagnosis from treatment, introduce regular expert inspections and fines for misbehavior, empower third-party quality certifiers, and so on.

As mentioned above, welfare losses only occur for $s < \frac{v-c_H}{2}$, such that we will focus on this parameter region. Compared to the maximal welfare W_{max} that could be achieved in the market, the relative market performance is then given by $W^{rel}_{pool} \equiv W_{pool}/W_{max}$ in the Expert Pooling PBE for $\alpha \geq \overline{\alpha}(s)$, and by $W^{rel}_{sem} \equiv W_{sem}/W_{max}$ in the Expert Semi-pooling PBE for $\alpha < \overline{\alpha}(s)$. Examining these expressions, it is now straightforward to establish the following.

Proposition 4. *Suppose that $s < \frac{v-c_H}{2}$ such that there is a welfare distortion in the market. Then, the attained welfare relative to the first best is non-monotonic in the fraction α of high-severity consumers: it is strictly decreasing in α for $\alpha < \overline{\alpha}(s)$ and strictly increasing in α for $\alpha \geq \overline{\alpha}(s)$, reaching its lowest level as $\alpha \uparrow \overline{\alpha}(s)$. When transitioning from the Expert Semi-pooling PBE to the Expert Pooling PBE, total social welfare discontinuously jumps up.*

Proof. See Appendix A. □

Thus, particularly large relative welfare losses are to be expected when consumers face high uncertainty regarding the severity of their conditions (α is intermediate). Intuitively, for α close to zero, the expert almost always has to recommend the appropriate treatment to low-severity consumers in equilibrium, as otherwise, they would find it optimal to leave when getting recommended high treatment, which cannot be part of an equilibrium. This means that for α low, the primary welfare loss stems from high-severity consumers inefficiently leaving in face of an (appropriate) high-treatment recommendation, which, since these consumers are scarce, is however negligible.[51]

As α increases, the consumers become less wary when getting offered high treatment, such that the equilibrium frequency of overtreatment q^*_H increases. The net effect of this is

[51]Note that for $s < \frac{v-c_H}{2}$ and α low, the consumers *must* mix between accepting and rejecting a high-treatment recommendation in any Expert PBE.

to increase the absolute welfare loss in the market,[52] decreasing the relative market performance. This trend continues until for α close below $\overline{\alpha}(s)$, the expert almost always offers inappropriate high treatment to low-severity consumers in equilibrium, which they accept with a probability that is bounded away from one. When α then increases slightly more to reach $\overline{\alpha}(s)$, the nature of equilibrium changes: the expert now always recommends high treatment, and the consumers never reject the expert's offer. This leads to a discontinuous increase of welfare: this is because, from society's perspective, even with sure overtreatment, consumers should not search when getting offered high treatment by the expert for α close below $\overline{\alpha}(s)$.

Once the Expert Pooling PBE is played for $\alpha \geq \overline{\alpha}(s)$, the absolute welfare level remains constant in α, at $v - c_H - s$. Because the maximal attainable welfare decreases in α, the relative welfare performance then increases in α, giving rise to the documented non-monotonicity of relative welfare. Ultimately, as α tends to one, equilibrium overtreatment vanishes (as almost every consumer suffers from a high-severity condition anyway), such that the maximal welfare is achieved again.

Figure 3 showcases a contour plot of the market' relative welfare performance in (s, α)-space for the interesting parameter range where $s < \frac{v-c_H}{2}$ (with the other parameters set to $v = 1$, $c_H = 0.4$, $c_L = 0.2$). The darker an area in the plot, the lower is the welfare achieved in the market, relative to the first-best outcome. It can clearly be seen that the relative welfare performance is non-monotonic in α, first decreasing for $\alpha < \overline{\alpha}(s)$ and then increasing for $\alpha > \overline{\alpha}(s)$, jumping up at the boundary. For the considered parameters, we find that the welfare performance is worst for α and s intermediate,[53] with a major welfare loss of around 45% in the most affected parameter region.

Total social welfare as a function of s. In some cases, policymakers – or certain other market players – may have the possibility to influence consumers' search cost parameter s, at least to some extent. For example, a reduction of s could be achieved by facilitating

[52] This is true even though from consumers' perspective, they correctly reject high-treatment recommendations more often in equilibrium as α increases.

[53] However, it is easy to check numerically that also $s = 0$ or $s \approx \frac{v-c_H}{2}$, together with $\alpha \approx \overline{\alpha}(s)$, can lead to the worst relative welfare performance, depending on v, c_H and c_L.

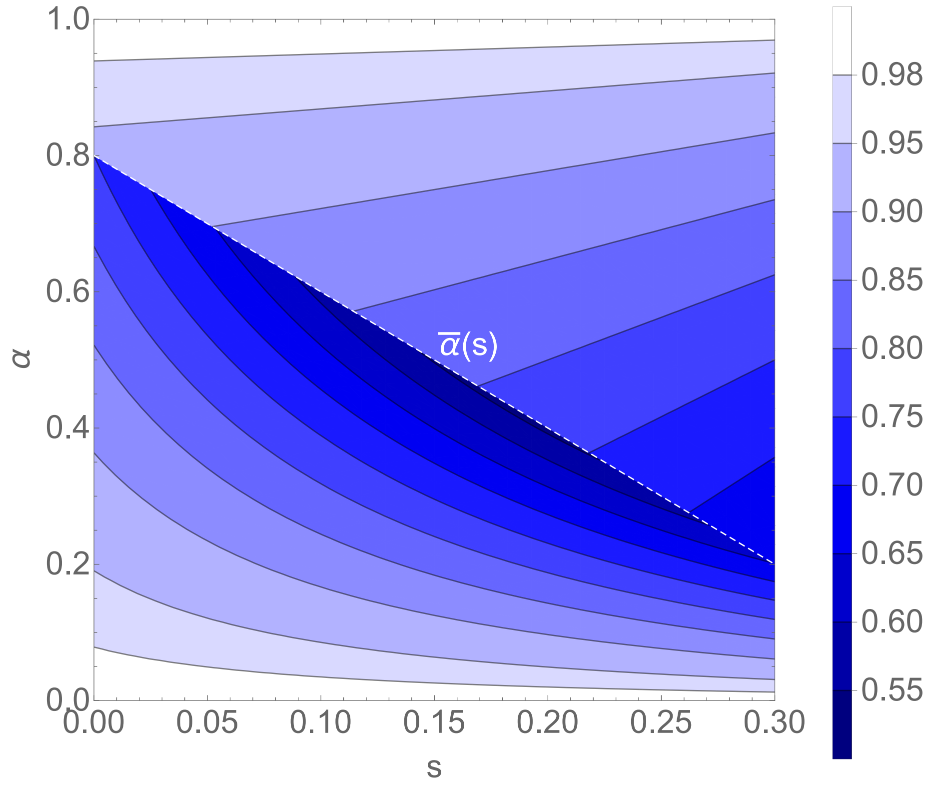

Figure 3: Contour plot of the market's relative welfare performance for $v = 1$, $c_H = 0.4$, $c_L = 0.2$, $s \leq \frac{v-c_H}{2}$, K sufficiently large.

consumers' access to industry information (e.g., by creating online business directories such as electronic "Yellow Pages").

Acknowledging this possibility, we will conclude our welfare discussion by analyzing how the total social welfare in the market is influenced by changes in s. Using the above results on total social welfare in the different equilibrium regions (see equations (18), (19) and (25)), we may observe that welfare is always strictly decreasing *within* each equilibrium region. Interestingly, however, total social welfare discontinuously jumps *up* when an increase in s leads to a transition from the Expert Semi-pooling PBE of Proposition 3 to the Expert Pooling PBE of Proposition 2,[54] or, no matter which of these two equilibria is played before, when s reaches the critical threshold $\frac{v-c_H}{2}$ such that the Expert Separating PBE is played – compare also with Figures 1 and 3 above.

[54]The critical value of s where this happens can be found by rearranging the inequality $\alpha \geq \overline{\alpha}(s)$ for s, which gives $s \geq \frac{(1-\alpha)v-c_L}{2}$.

These observations imply that for any given combination of parameters (v, c_H, c_L, α), only three values of s can be potential maximizers of total social welfare: $s = 0$, such that there is no search friction in the market, and either the Expert Pooling PBE of Proposition 2 or the Expert Semi-pooling PBE of Proposition 3 is played; $s = \frac{v-c_H}{2}$, which is the lowest search cost for which the Expert Separating PBE of Proposition 1 without any welfare distortion is played; and finally, provided that $\alpha \in (\frac{c_H-c_L}{v}, 1-\frac{c_L}{v})$, it may also be given by $s = \frac{(1-\alpha)v-c_L}{2} \in (0, \frac{v-c_H}{2})$, which is then the unique, interior value of s where the Expert Semi-pooling PBE of Proposition 3 transitions to the Expert Pooling PBE Proposition 2, with an upward jump of welfare. The respective welfare comparison then yields the following proposition.

Proposition 5. *Fix any $v > 0$ and $c_L \in (0, v)$ and let*

$$\alpha_1 \equiv \frac{v-c_L}{v+2c_L} \tag{26}$$

$$\alpha_2 \equiv \frac{3v+4c_L-\sqrt{9v^2-24vc_L+64c_L^2}}{8c_L} \tag{27}$$

$$\alpha_3 \equiv \overline{\alpha}(0) = 1-\frac{c_L}{v}, \tag{28}$$

where $0 < \alpha_1 < \alpha_2 < \alpha_3 < 1$, as well as

$$c_H^1(\alpha) \equiv v - 2\alpha c_L \tag{29}$$

$$c_H^2(\alpha) \equiv \frac{3c_L-(1-\alpha)v}{2(1-\alpha)} \tag{30}$$

$$c_H^3(\alpha) \equiv \frac{\alpha v+(3-2\alpha)c_L}{3-2\alpha} \tag{31}$$

$$c_H^4(\alpha) \equiv \frac{v+2(1-\alpha)c_L}{3-2\alpha}. \tag{32}$$

Then, for α small, $\alpha \in (0, \alpha_1]$, total social welfare is maximized for $s = 0$ if $c_H \leq c_H^1(\alpha)$, and for $s = \frac{v-c_H}{2}$ if $c_H \geq c_H^1(\alpha)$.

For α moderately low, $\alpha \in (\alpha_1, \alpha_2]$, total social welfare is maximized for $s = \frac{(1-\alpha)v-c_L}{2}$ if $c_H \leq c_H^2(\alpha)$, for $s = 0$ if $c_H \in [c_H^2(\alpha), c_H^1(\alpha)]$, and for $s = \frac{v-c_H}{2}$ if $c_H \geq c_H^1(\alpha)$.

For α moderately high, $\alpha \in [\alpha_2, \alpha_3)$, total social welfare is maximized for $s = \frac{(1-\alpha)v-c_L}{2}$ if $c_H \leq c_H^3(\alpha)$, and for $s = \frac{v-c_H}{2}$ if $c_H \geq c_H^3(\alpha)$.

Finally, for α large, $\alpha \geq \alpha_3$, total social welfare is maximized for $s = 0$ if $c_H \leq c_H^4(\alpha)$, and for $s = \frac{v-c_H}{2}$ if $c_H \geq c_H^4(\alpha)$.

Proof. See Appendix A. □

Figure 4 illustrates Proposition 5 graphically. In particular, it may be noted that for the showcased parameters ($v = 1$ and $c_L = 0.2$), a substantial part of the depicted (α, c_H)-space has $s = 0$ as welfare-maximizing search cost. This is no coincidence: Proposition 5 establishes that whenever $\alpha \leq \alpha_1$ or $\alpha \geq \alpha_3$, it is sufficient that the cost of high treatment c_H is not too large ($c_H \leq c_H^1(\alpha)$ in the former case and $c_H \leq c_H^4(\alpha)$ in the latter) for $s = 0$ to be welfare-maximizing. Economically, this is the case because, for α close to zero or one, there are almost no welfare distortions in the corresponding Expert PBE (as established in the discussion of relative welfare above). But then, the total welfare in the market is close to the maximal welfare of $W_{max} = v - \alpha c_H - (1-\alpha)c_L - s$, which is clearly highest for $s = 0$.

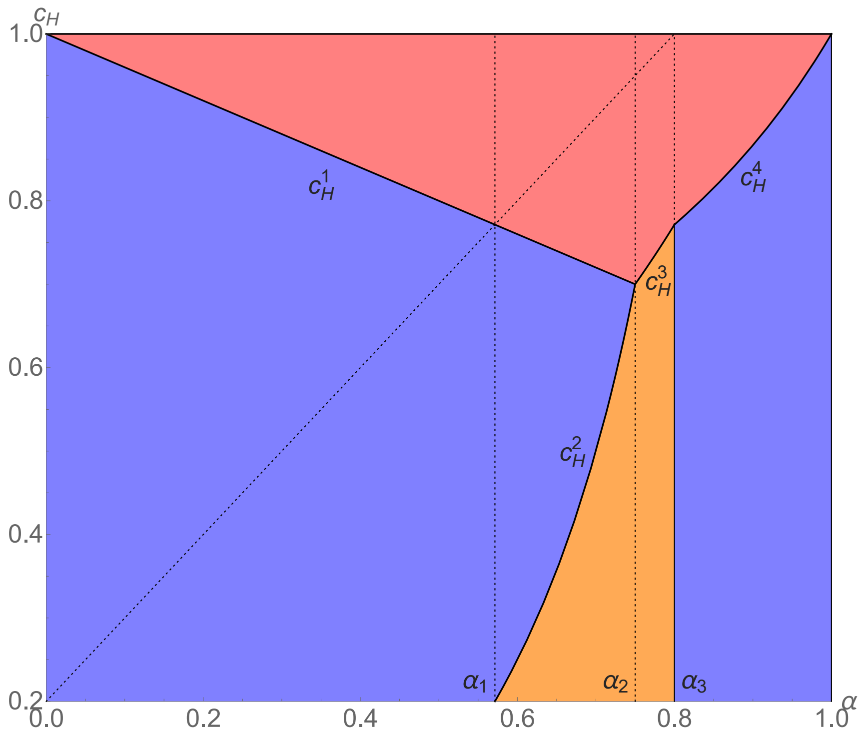

Figure 4: Illustration of the regions in (α, c_H)-space where the different values of the search cost s are welfare-maximizing, given $v = 1$ and $c_L = 0.2$. Blue: $s = 0$; orange: $s = \frac{(1-\alpha)v - c_L}{2}$; red: $s = \frac{v - c_H}{2}$ is welfare-maximizing.

On the other hand, it may be seen from Proposition 5 that for any combination of parameters (v, c_L), there is a range of high-severity probabilities α such that $s = 0$ is either never optimal (for $\alpha \in (\alpha_2, \alpha_3)$), or only optimal for intermediate costs of high treatment (for $\alpha \in (\alpha_1, \alpha_2]$, where it is required that $c_H \in [c_H^2, c_H^1]$). Moreover, irrespective of α, minimizing the search cost is never welfare-maximizing when the cost of high treatment is very large relative to consumers' valuation, as then the optimal search cost is given by the minimal level which gives rise to the Expert Separating PBE of Proposition 1. In particular the latter is economically intuitive: When c_H is large – that is, close to v – the minimal search cost required for the Expert Separating PBE without any welfare distortion to be played, $s = \frac{v-c_H}{2}$, is low. But then, it is better from society's point of view when this equilibrium is played at small but positive search cost, rather than the Expert Semi-pooling PBE or Expert Pooling PBE at zero search cost, but with a significant welfare distortion.

5 Conclusion

In markets for expert service, such as for medical treatments and technical repairs, experts often face incentives to use their superior information on clients' needs at the latter's detriment. A common problem is overtreatment, the prescription of unnecessarily costly treatments. An important channel driving this inefficiency are search frictions, which make it costly for consumers to find out about appropriate treatments for their problems, and to compare different offerings.

In this paper, we point out a non-trivial and so-far overlooked interaction between search frictions and experts' incentives to carry out proper treatment. In particular, our model features a monopolistic expert with perfect diagnostic ability that has full market power on costly high treatments, but limited market power on low treatments due to the presence of competitively-priced (fringe) discount stores. The expert is liable for ineffective treatment, while the fringe firms are not. Consumers need to engage in costly search to find out about the expert's treatment recommendation and price, or to try out the fringe firms' offers. A higher search friction – which is, *per se*, not desirable – now also gives the expert a higher market power on low treatments, conditional on being visited. This partly corrects his incentive to fool consumers into purchasing unnecessarily costly high treatment, rendering the overall impact of search costs on market outcomes ambiguous.

We find that, provided that the expert's diagnostic ability is sufficiently valuable to make consumers willing to visit him first, various qualitatively different market outcomes can emerge. For a relatively large search friction, the expert's market power on low treatments is large, such that he has no incentive to overtreat consumers. For low to moderate search costs, however, no equilibrium where the expert always recommends appropriate treatment exists, and he either sometimes or always attempts (and succeeds) to overtreat arriving consumers. In the most interesting (and robust) equilibrium, the expert inappropriately offers high treatment with positive probability to low-severity consumers, while consumers discipline the expert by only sometimes accepting high-treatment proposals. This induces various inefficiencies: some low-severity consumers accept unnecessary high treatment; some low-severity consumers incur an extra search cost obtaining effective treatment from a discount firm; and some high-severity consumers buy ineffective low treatment and incur an additional search friction twice after rejecting the expert's treatment proposal. Hence, expert market power on high treatments, combined with consumer search frictions, may lead to severe market distortions.

Interestingly, given the assumed unobservability of expert prices before consultation, the described inefficiencies do not necessarily disappear when multiple experts compete in the market. Indeed, even with an arbitrarily large numbers of experts, the above mixed-strategy equilibrium prevails if consumers' probability of suffering from a high-severity condition is sufficiently large. This is because, by the experts' corresponding high propensities to recommend high treatment to low-severity consumers, consumers never find it worthwhile to visit a second expert, essentially shielding experts from competition between themselves. One implication is that promoting expert entry may not be sufficient to mitigate inefficient opportunistic behavior in expert markets – rather, structural reforms, such as the separation of expert diagnosis and treatment, or the introduction of third-party monitoring, may be necessary. This is particularly true when consumers find it difficult and costly to compare different experts' offerings, as is the case in many real markets.

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Appendix A: Technical Proofs

Proof of Proposition 1. Existence (non-existence) of the characterized Expert Separating PBE for $\alpha \leq \hat{\alpha}(s)$ ($\alpha > \hat{\alpha}(s)$) follows almost immediately from the discussion preceding the proposition. The precise condition on K provided in Footnote 28 is obtained by applying Lemma 2 and rearranging the condition $CS_{sep} \geq CS_f$ for K, where $CS_{sep} = v - 2s - \alpha c_H - (1-\alpha)c_L$. That no condition on consumers' off-equilibrium beliefs for deviation prices $p_H < p_H^*$ needs to be imposed (see Footnote 29) is obvious, as the expert already sells for sure when offering $t = H$ at p_H^*. It remains to show that no other type of Expert PBE can exist for $\alpha > \hat{\alpha}(s)$ (which requires that $s > \frac{v-c_H}{2}$). This stems from the facts that (i) no Expert Pooling PBE can exist for $s > \frac{v-c_H}{2}$ (see the argument before Proposition 2) and (ii) no Expert Semi-pooling PBE can exist for $\alpha \geq \overline{\alpha}(s)$ (see the argument before Proposition 3 and the proof of Proposition 6 in Appendix B), which is implied by $\alpha > \hat{\alpha}(s)$ and $s \leq \frac{v-c_L}{2}$. □

Proof of Proposition 2. Again, existence of the characterized Expert Pooling PBE follows almost immediately from the discussion preceding the proposition. The precise condition on K provided in Footnote 33 is obtained by applying Lemma 2 and rearranging the condition $CS_{pool} = 0 \geq CS_f$ for K. The condition on consumers' off-equilibrium beliefs for $p_H > p_H^*$ comes from the same consideration as for existence of the Expert Separating PBE of Proposition 1, see the discussion preceding it. That no condition on consumers' off-equilibrium beliefs for deviation prices $p_H < p_H^*$ needs to be imposed (see Footnote 34) is again obvious, as the expert already sells for sure when offering $t = H$ at p_H^*. It remains to show that no other type of Expert PBE can exist for $s < \frac{v-c_H}{2}$ and $\alpha > \overline{\alpha}(s)$. This stems from the facts that (i) no Expert Separating PBE can exist for $s < \frac{v-c_H}{2}$ (see the argument before Proposition 1) and (ii) no Expert Semi-pooling PBE can exist for $\alpha \geq \overline{\alpha}(s)$ and $s < \frac{v-c_H}{2}$ (see the arguments before Proposition 3). □

Proof of Proposition 3. Once more, existence of the characterized Expert Semi-pooling PBE follows almost immediately from the discussion preceding the proposition. The precise condition on K provided in Footnote 37 is obtained by applying Lemma 2 and rearranging the condition $CS_{sem} \geq CS_f$ for K, where $CS_{sem} = (1-q_H^*)(1-\alpha)(v-c_L-2s) = (1-\alpha)v - c_L - 2s$. The condition on consumers' off-equilibrium beliefs for $p_H \neq p_H^*$, $p_H > c_H + s$ comes from the same consideration as for existence of the Expert Separating PBE of Proposition 1, see the discussion preceding it. That no condition on consumers' off-equilibrium beliefs for deviation prices $p_H \leq c_H + s$ needs to be imposed (see Footnote 38) follows from the fact that even if all consumers bough for sure when facing such a deviation price, the expert could not increase his profit. It remains to show that no other type of Expert PBE can exist for $s < \frac{v-c_H}{2}$ and $\alpha < \overline{\alpha}(s)$. This stems from the facts that (i) no Expert Separating PBE can exist for $s < \frac{v-c_H}{2}$ (see the argument before Proposition 1) and (ii) no Expert Pooling PBE can exist for $\alpha < \overline{\alpha}(s)$ (see the argument before Proposition 2). □

Proof of Proposition 4. The comparative-statics results are trivial to obtain via direct inspection or differentiation. At the boundary between the two equilibria, it holds that $\alpha = \overline{\alpha}(s) = 1 - \frac{c_L+2s}{v}$. Hence, the absolute welfare loss in the Expert Pooling PBE at the boundary is $W_{pool}^{loss}(\overline{\alpha}(s)) = (1-\overline{\alpha}(s))(c_H - c_L)$, while the absolute welfare loss in the Expert Semi-pooling PBE at the boundary is $W_{sem}^{loss}(\overline{\alpha}(s)) = \overline{\alpha}(s)(c_L + 2s)$. The latter is indeed strictly larger, giving rise to the outlined discontinuity, if and only if

$$\overline{\alpha}(s) = 1 - \frac{c_L + 2s}{v} > \frac{c_H - c_L}{c_H + 2s}.$$

The LHS of the above inequality strictly increases in v, such that the inequality is hardest to satisfy for v low. Since in the considered parameter region it holds that $s < \frac{v-c_H}{2}$, a lower bound for v is $v = c_H + 2s$. The inequality thus certainly holds if $1 - \frac{c_L+2s}{v}\Big|_{v=c_H+2s} \geq \frac{c_H-c_L}{c_H+2s}$, which is true. □

Proof of Proposition 5. From the argument in the main text, we know that there are only three possible values of s that may maximize social welfare: $s_1 \equiv 0$, $s_3 \equiv \frac{v-c_H}{2}$, and, for $\alpha \in (\frac{c_H-c_L}{v}, \alpha_3)$, also $s_2 \equiv \frac{(1-\alpha)v-c_L}{2} \in (s_1, s_3)$. If, for $s = 0$, the Expert Semi-pooling PBE is played (which requires that $\alpha < \alpha_3$), the corresponding welfare is $W_{sem}(s_1) = v - \alpha c_H - c_L$. In contrast, if, for $s = 0$, the Expert Pooling PBE is played (which requires that $\alpha \geq \alpha_3$), the corresponding welfare is $W_{pool}(s_1) = v - c_H$. For $s = s_3$, the welfare in the corresponding Expert Separating PBE is

$$W_{sep}(s_3) = v - \alpha c_H - (1-\alpha)c_L - \frac{v - c_H}{2}.$$

Finally, for $\alpha \in (\frac{c_H - c_L}{v}, \alpha_3)$ and $s = s_2$, the welfare in the corresponding Expert Pooling PBE is

$$W_{pool}(s_2) = v - c_H - \frac{(1-\alpha)v - c_L}{2}.$$

Consider now first the simpler cases where (a) $\alpha \in (0, \frac{c_H - c_L}{v}]$ and (b) $\alpha \in [\alpha_3, 1)$. For (a), where the Expert Semi-pooling PBE is played for all $s \in [0, \frac{v - c_H}{2})$, we only need to compare $W_{sem}(s_1)$ with $W_{sep}(s_3)$. Rearranging $W_{sem}(s_1) \geq W_{sep}(s_3)$ for c_H, it is then easy to check that this is satisfied if and only if $c_H \leq c_H^1(\alpha)$, with $c_H^1(\alpha)$ as specified in the proposition. Next, for (b), where the Expert Pooling PBE is played for all $s \in [0, \frac{v - c_H}{2})$, we only need to compare $W_{pool}(s_1)$ with $W_{sep}(s_3)$. Rearranging $W_{pool}(s_1) \geq W_{sep}(s_3)$ for c_H, it is again easy to check that this is satisfied if and only if $c_H \leq c_H^4(\alpha)$, with $c_H^4(\alpha)$ as specified in the proposition.

In the more nuanced intermediate case (c) where $\alpha \in (\frac{c_H - c_L}{v}, \alpha_3)$, all of s_1, s_2 and s_3 may potentially maximize social welfare. First, for optimality of s_1, it is required that $W_{sem}(s_1) \geq W_{pool}(s_2)$ and $W_{sem}(s_1) \geq W_{sep}(s_3)$. Rearranging these conditions for c_H, it is straightforward to find that they are equivalent to $c_H \in [c_H^2(\alpha), c_H^1(\alpha)]$, with $c_H^2(\alpha)$ as specified in the proposition. Note now that for $\alpha \leq \frac{v - c_L}{v + 2c_L} = \alpha_1$, this is automatically satisfied, as then $c_H \geq c_H^2(\alpha)$ due to $c_H^2(\alpha) \leq c_L$, while $c_H \leq c_H^1(\alpha)$ is implied by $\alpha > \frac{c_H - c_L}{v}$ (that is, by $c_H < \alpha v + c_L$). Note next that the condition $c_H \in [c_H^2(\alpha), c_H^1(\alpha)]$ can clearly only be satisfied if $c_H^1(\alpha) \geq c_H^2(\alpha)$, which reduces to the following quadratic inequality in α:

$$f(\alpha) \equiv \alpha^2 - \alpha\left(\frac{3v}{4c_L} + 1\right) + \left(\frac{3v}{4c_L} - \frac{3}{4}\right) \geq 0. \tag{33}$$

Since $f(\alpha)$ is strictly convex, $f(1) = -\frac{3}{4} < 0$ and $\lim_{\alpha \to \infty} = +\infty$, it can be concluded that α should not exceed the lower root of $f(\alpha)$ in order for $c_H^1(\alpha) \geq c_H^2(\alpha)$ to hold. Hence, we need that

$$\begin{aligned}
\alpha &\leq \frac{3v}{8c_L} + \frac{1}{2} - \sqrt{\left(\frac{3v}{8c_L} + \frac{1}{2}\right)^2 - \frac{3v}{4c_L} + \frac{3}{4}} \\
&= \frac{3v}{8c_L} + \frac{1}{2} - \sqrt{\left(\frac{3v}{8c_L}\right)^2 - \frac{3v}{8c_L} + 1} \\
&= \alpha_2,
\end{aligned}$$

with α_2 as specified in the proposition. Straightforward (but somewhat tedious) algebra further reveals that $\alpha_2 \in (\alpha_1, \alpha_3)$ for all $v > c_L > 0$.[55] Combining the parameter regions (a), (b), (c) and sorting by α and c_H, we thus find that the search cost $s_1 = 0$ is optimal if and only if $\alpha \in (0, \alpha_1]$ and $c_H \leq c_H^1(\alpha)$, or $\alpha \in (\alpha_1, \alpha_2]$ and $c_H \in [c_H^2(\alpha), c_H^1(\alpha)]$, or $\alpha \geq \alpha_3$ and $c_H \leq c_H^4(\alpha)$.

Second, optimality of s_2 requires that $W_{pool}(s_2) \geq W_{sem}(s_1)$ and $W_{pool}(s_2) \geq W_{sep}(s_3)$, which is equivalent to $c_H \leq \min\{c_H^2(\alpha), c_H^3(\alpha)\}$, with $c_H^3(\alpha)$ as specified in the proposition. Since $c_L < c_H$, this condition can only be satisfied for $c_L < c_H \leq c_H^2(\alpha)$, which, after rearranging for α, gives the condition

$$\alpha > \frac{v - c_L}{v + 2c_L} = \alpha_1.$$

Moreover, it may be checked that $c_H^2(\alpha) \leq c_H^3(\alpha)$ can be reduced to the same quadratic inequality in α as given in (33). By the above argument, it therefore holds that $\min\{c_H^2(\alpha), c_H^3(\alpha)\} = c_H^2(\alpha)$ for $\alpha \leq \alpha_2$ and $\min\{c_H^2(\alpha), c_H^3(\alpha)\} = c_H^3(\alpha)$ for $\alpha > \alpha_2$. Summing up, the search cost s_2 is therefore optimal if and only if $\alpha \in (\alpha_1, \alpha_2]$ and $c_H \leq c_H^2(\alpha)$, or $\alpha \in (\alpha_2, \alpha_3)$ and $c_H \leq c_H^3(\alpha)$.

Third, optimality of s_3 requires that $W_{sep}(s_3) \geq W_{sem}(s_1)$ and $W_{sep}(s_3) \geq W_{pool}(s_2)$, which is equivalent to $c_H \geq \max\{c_H^1(\alpha), c_H^3(\alpha)\}$. As in the above cases, it can once more be checked that $c_H^1(\alpha) \geq c_H^3(\alpha)$ reduces to inequality (33), which implies that $\max\{c_H^1(\alpha), c_H^3(\alpha)\} = c_H^1(\alpha)$ for $\alpha \leq \alpha_2$ and that $\max\{c_H^1(\alpha), c_H^3(\alpha)\} = c_H^3(\alpha)$ for $\alpha > \alpha_2$. Combining the parameter regions (a), (b), (c) and sorting by α and c_H, we thus find that the search cost s_3 is optimal if and only if $\alpha \in (0, \alpha_2]$ and $c_H \geq c_H^1(\alpha)$, or $\alpha \in [\alpha_2, \alpha_3)$ and $c_H \geq c_H^3(\alpha)$, or $\alpha \in [\alpha_3, 1)$ and $c_H \geq c_H^4(\alpha)$. This completes the proof. $\square$

Appendix B: Expert Semi-pooling PBEs for $s \geq \frac{v - c_H}{2}$

For $s \geq \frac{v - c_H}{2}$, we cannot use the argument preceding Proposition 3 to rule out Expert Semi-pooling PBEs with $p_H^* > v - s$. It is however still clear that in any Expert Semi-pooling PBE (where the expert is indifferent between offering $t = L$ at $p_L^* = c_L + s$ and offering $t = H$ at $p_H^* \geq v - s$ to low-severity consumers), it must hold that $p_H^* - c_H \geq s$. Moreover, for $p_H^* - c_H > s$, the probability $r^*(p_H^*)$ that a consumer buys who is offered $t = H$ at p_H^*

[55] A proof is available from the authors upon request.

must be less than one (see equation (8)). We will restrict attention to the latter type of Expert Semi-pooling PBEs, leaving aside the existence of Expert Semi-pooling PBEs where with $p_H^* = c_H + s \geq v - s$, all consumers would have to buy when offered $t = H$ at p_H^*.[56] Proposition 6 provides a full characterization of the set of Expert Semi-pooling PBEs with $p_H^* - c_H > s$, for $s \geq \frac{v - c_H}{2}$.

Proposition 6. *Suppose that $s \geq \frac{v-c_H}{2}$ and that K is sufficiently large.*[57] *For $\alpha \geq \overline{\alpha}(s)$, no Expert Semi-pooling PBE exists. For $\alpha < \overline{\alpha}(s)$, there exist a continuum of Expert Semi-pooling PBEs according to which*

- *Each consumer with $x = H$ that visits the expert gets offered $t = H$ at price $p_H^* \in (c_H + s, v]$.*
- *Each consumer with $x = L$ that visits the expert gets offered $t = H$ at p_H^* with probability $q_H^*(p_H^*)$, while she gets offered $t = L$ at $p_L^* = c_L + s$ with probability $1 - q_H^*(p_H^*)$, where*
$$q_H^*(p_H^*) \equiv \frac{\alpha(v + c_L + s - p_H^*)}{(1-\alpha)(p_H^* - c_L - s)}.$$
- *Each consumer optimally starts her search at the expert. Then, on the equilibrium path, a consumer's optimal search and purchase behavior is as follows. When she gets offered $t = L$ at $p_L^* = c_L + s$, she buys immediately. When she gets offered $t = H$ at price p_H^*, she buys with probability $r^*(p_H^*) \in (0,1)$ and leaves towards the fringe with probability $1 - r^*(p_H^*)$, where $r^*(p_H^*)$ is specified in (8). If, after getting offered $t = H$ at price p_H^*, she leaves towards the fringe, but receives no effective treatment there, she leaves the market.*
- *When receiving an off-equilibrium treatment proposal $t = H$, $p_H \neq p_H^*$, the consumers' off-equilibrium beliefs of having low severity, $\mu_L(p_H)$, satisfy*[58] *$\mu_L(p_H) \in (\underline{\mu}_L(p_H), 1]$ for all $p_H \in (c_H + s, p_H^*) \cup (p_H^*, v]$, where $\underline{\mu}_L(p_H)$ is specified in equation (5).*

[56]Such equilibria exist and simply require that the expert does not inappropriately offer high treatment with too high frequency (which is never an issue, as the expert is indifferent between offering $t = L$ at $p_L^* = c_L + s$ and $t = H$ at $p_H^* = c_H + s$, given that all consumers buy when offered $t = H$). Details are available from the authors upon request.

[57]Like for the Expert Semi-pooling PBE when $s < \frac{v-c_H}{2}$, the precise condition on K is that $K \geq \underline{K}_{sem} \in (1,3)$.

[58]No restriction on consumers' off-equilibrium beliefs for deviation prices $p_H \leq c_H + s$ is needed.

The expert's equilibrium profit is given by $\tilde{\pi}_{sem} \equiv s$.

Proof. Since in the candidate equilibrium the consumers must be indifferent between accepting $t = H$ at price p_H^* and searching the fringe (never returning in the latter case due to $p_H^* > v - s$), it needs to hold that

$$v - p_H^* = \Pr\{x = L | t = H; p_H^*\} v - c_L - s.$$

Inserting $\Pr\{x = L | t = H; p_H^*\}$ from equation (7) and solving for q_H^*, this indeed implies the expression for $q_H^*(p_H^*)$ as specified in the proposition. It may easily be checked that $q_H^*(p_H^*) > 0$ and that $q_H^*(p_H^*) < 1$ if and only if $\alpha < \overline{\alpha}(s)$ as given in (6). We thus need that $\alpha < \overline{\alpha}(s)$ for equilibrium existence.

Next, given that the consumers take up $t = H$ at price p_H^* with probability $r^*(p_H^*)$, the expert is indeed indifferent between offering $t = L$ at $p_L^* = c_L + s$ and $t = H$ at p_H^* to low-severity consumers.

Regarding off-equilibrium beliefs, basically the same considerations as for the Expert Semi-pooling PBE of Proposition 3 apply (replacing the previous $p_H^* = v - s$ with an arbitrary $p_H^* \in (c_H + s, v]$).[59] What is different is that it could be worthwhile for the expert to deviate by offering $p_H = v - s < p_H^*$ to high-severity consumers, as this would eventually enable the firm to sell to all of them, rather than to only a fraction $r^*(p_H^*) < 1$. However, this is not profitable, as the corresponding profit per high-severity consumer, $v - s - c_H$, never exceeds the equilibrium candidate profit of s per high-severity consumer, given the assumed $s \geq \frac{v - c_H}{2}$.

The final requirement for equilibrium existence is that the consumers must find it optimal to first search the expert, rather than to stay out of the market or optimally search through the fringe firms. Now, given a candidate equilibrium with high-treatment price p_H^*, a consumer's expected surplus of first searching the expert is

$$\begin{aligned} CS_{sem,2} &= (1-\alpha)(1-q_H^*(p_H^*))(v - c_L - s) + [1 - (1-\alpha)(1-q_H^*(p_H^*))](v - p_H^*) - s \\ &= (1-\alpha)v - c_L - 2s = CS_{sem}. \end{aligned} \tag{34}$$

This coincides with consumers' expected surplus in the Expert Semi-pooling PBE of Proposition 3, giving rise to the same condition on K. Consumers' participation constraint $CS_{sem,2} \geq 0$ is finally equivalent to $\alpha \leq \overline{\alpha}(s)$, which holds by assumption. □

[59]The remark that for deviation prices $p_H < p_H^*$, consumers should be inclined to believe that they suffer from a low-severity condition no longer holds.

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Searching for Treatment

Abstract
When experts have superior information on their customers' needs and appropriate treatment/repair/advice is a credence good, there are obvious incentives for opportunistic behavior. What compounds this is that experts regularly make treatment recommendations and price offers only after consumers have approached them, creating additional market power due to search costs. In our model, an expert enjoys monopoly power on diagnosis and major treatments, but has limited market power on minor treatments due to fringe competition. The expert's treatment offer only gets revealed to consumers upon visit, and both searching the expert and fringe firms is costly. For search costs that are not excessively high, in equilibrium the expert inappropriately proposes major treatment to all or a fraction of low-severity consumers, which they respectively accept all or some of the time. Next to wasteful overtreatment, further inefficiencies arise in the latter case, as some high-severity consumers mistakenly leave the expert, and some low-severity consumers incur unnecessary search costs. Total welfare is non-monotonic in search costs and may even be maximized when these are large. Expert competition often does not, or only partly, alleviate market distortions.

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