Visibly bad: Information availability and ability choice in a market for physicians*

Lara Córdova, Edgardo †   Rodríguez-Camacho, Javier A.‡

June 12, 2017

Abstract

In this paper we study the ability choices and pricing strategies of physicians in a duopolistic market where consumers base their decisions on anecdotal evidence. The consumers are aware of only some of the physicians in the market and estimate their abilities by taking a sample from the patients they have previously treated. Decisions based on anecdotal evidence entail two hindrances, an over-reliance on small samples and the limited availability of information. In this setting, situations arise where physicians have incentives to choose low levels of ability even when it is costless. In particular, more information availability leads to more ability differentiation and a lower average level. When information on the two physicians is readily available, the average ability in the equilibrium is not maximum. Conversely, an equilibrium where both physicians choose a maximum ability level is possible despite the anecdote-based decisions of consumers. This occurs when information on at least one of the physicians is not readily available to consumers. Fixing prices or restricting physicians to operate locally can induce a maximum average ability in the market irrespective of the availability of information level.

Keywords: Anecdotal Reasoning, Ability Choice, Information Availability, Bounded Rationality, Product Differentiation, Healthcare

JEL classification: D03, D40, L13, I11

*We owe a debt of gratitude to our advisors David Pérez-Castrillo and Susanna Esteban, whose kindness, encouragement, and unconditional support were vital to the completion of this project. Committee members and participants in the UAB Micro Lab offered us valuable comments, particularly Francesco Cerigioni, Xavier Martínez-Giralt, Pau Olivella, and Tomás Rodríguez-Barraquer. Financial support from Conacyt, FPI Scholarship, MOVE, and FI AGAUR 2009SGR 00169 is gratefully acknowledged.

†Universitat Autònoma de Barcelona and Barcelona GSE. E-mail: Edgardo.Lara@uab.cat

‡Pontificia Universidad Javeriana in Bogotá. E-mail: rojavier@javeriana.edu.co

1. Introduction

Healthcare markets involve many informational asymmetries. In particular, in their interactions with patients the physicians have superior information concerning several aspects of the relation. In this paper we focus on the physicians' choice of abilities, which despite being crucial to the patients' decisions, are unknown to them. With ability we refer to the probability for a physician to change a patient's health state, to "cure" her. Consumers value being healthy, hence favor visiting the highest-ability physician they can afford. Therefore, each consumer tries to estimate the physicians' abilities resorting to the limited and often hard to process information at her disposal. Deviating from rational behavior, consumers over-rely on small samples to estimate the physicians abilities. Specifically, when deciding which physician to visit a consumer usually ask family members and friends about their experiences, and forms her estimations based on these anecdotes. The information thusly gathered is further undermined by the fact that consumers just have access to anecdotal evidence concerning the physicians their close acquaintances have been treated by.

Health systems where patients can freely visit a physician without the referral of a gatekeeper or can choose between a physician in the public or private sectors are not rare. They can be observed in Germany, Switzerland, Belgium, Taiwan, and some US states where PPOs or FFS are predominant.[1] Therefore, it could be argued that the use of simplifying heuristics like the one described above is pervasive in healthcare markets. According to the "National Survey on Americans as Health Care Consumers: An Update on The Role of Quality Information" (The Kaiser Family Foundation et al., 2000), around 80% of Americans are "very or somewhat" confident that they had enough information to make the right choices the last time they were choosing a doctor. However, the same survey reports that less than 37% of the subjects would go beyond their close network to find information about the quality of such a service. Along a similar line, it has been found that reliance on anecdotal evidence is common among consumers even when comprehensive statistics about medical treatments are available (Fagerlin et al. (2005)).

Decisions based on anecdotal evidence entail two problems: over-reliance on small samples to estimate the physician's abilities and the limited availability of information among the patients a consumer enquires. The first issue directly relates to each physician's ability choice, which determines whether the anecdotal evidence found is positive or not and, thus, if the physician's ability will be over or underestimated. The second issue pertains to the probability for anecdotal evidence on a particular physician to be found, which we denote by visibility and affects the alternatives a consumer contemplates. Not all physicians in a market are equally visible. A physician's visibility can be thought of as how well-known he is across the market. There is a strong exogenous component to visibility, as one can observe in the case of family sagas, where the medical profession is carried over several generations and some "fame" along with it.

The interaction of the physicians' ability choices and the exogenous visibility poses interesting questions, with policy-relevant implications. To untangle these effects we study the behavior of consumers who need to visit a physician and estimate his ability using anecdotal evidence. The limited nature of the consumers' estimations generates a de-

[1] PPO stands for Preferred Provider Organization and FFS for Fee For Service insurance. In both of this health plan schemes consumers have a high degree of freedom to choose the specialist they visit.

mand whose characteristics affect the decisions of the physicians in terms of prices and abilities. Such demand depends on each physician's ability and visibility level, a combination of strategic and exogenous factors. In this paper we try to understand the effect of information availability on the ability-choices of physicians in a market where consumers reason anecdotically. A secondary question involves analyzing the impact of information availability and physician's ability choices on pricing strategies.

We develop a model where consumers have heterogeneous willingness to pay for health and try to learn the physicians' abilities using anecdotal evidence. Each consumer draws a sample from the patients treated by a given physician and takes the outcome as that physician's ability. Each consumer samples from the subset of physicians she is aware of, her consideration set. The composition of such set is determined by the physician's visibility. There are two perfectly-informed and rational physicians in the market, with public fees and abilities not observable by the consumers. Both the price and the ability are strategic variables the physicians set before meeting the consumers. Ability choice is costless for the physicians and taken by both of them simultaneously. We study the behavior of the agents through the equilibria in prices and abilities.

The fact that consumers follow an anecdotal-reasoning procedure induces a demand encompassing two parts for each of the physicians: a contested and a captive segments. The contested demand comprises those consumers who observe both physicians and find positive anecdotal evidence for the two of them. The captive demand includes the consumers who either are aware of only one physician and draw a positive anecdote, or being aware of both physicians gather a positive anecdote about him and a negative for the rival. Two main trade-offs emerge from this demand structure. First, the higher the price a physician sets, the bigger the profits obtained from his captive segment and the smaller his contested demand. The second involves ability choice as a mean to surrender some of the demand in order to push the equilibrium prices up. By lowering his ability a physician increases his rival's captive demand, inducing him to focus on it and thus relaxing competition over the contested segment.

In the light of these trade-offs, the information availability level captured by the physicians' visibilities is found to be a major determinant over the average ability level in equilibrium. We find that more information availability leads to more differentiation, with a lower average ability. When information about both physicians is easy to find, they have incentives to differentiate in abilities: one of them sets the maximum level and the rival chooses a lower value. The rationale behind this derives from the trade-offs discussed above. Higher visibility levels enhance the effect described, making it less costly for the physician who chooses to differentiate, to surrender some of his contested demand in order to relax price competition. Furthermore, physicians with high visibility levels can set high fees even if their ability is low. Other situations arise where the physicians choose abilities such that the average equilibrium ability is maximum. Interestingly, this happens when consumers have access to less information.

Concerning the physicians' pricing decisions, the market has a unique Nash Equilibrium in mixed strategies. In expected terms the physician whose combined visibility and ability are superior, the dominant physician, sets a higher price. Such a physician has incentives to focus on his captive demand, therefore being more likely to set the monopoly price. The more visible the dominant physician becomes, the higher the price he can set. Yet, an increase in the rival's visibility causes the expected price of the dominant physician to decrease. This happens because when information on the two physicians is easy to find, price competition becomes harsher. This analysis follows trough only when we take abilities and visibilities as given, since the interaction between the physicians becomes a pricing game. Nevertheless, in the context of the whole game, the relation between prices and visibilities reinforces the incentives for the physicians to differentiate in abilities.

The demand generated by anecdotally-reasoning consumers creates incentives for the physicians to choose abilities such that the average equilibrium level is not maximum under given circumstances. A planner is interested in avoiding these situations to elevate the market's average ability. We analyze two ability-enhancing measures: regulating the price and restricting physicians to operate locally. When setting a fixed price the planner eliminates the competition-relaxing effect of choosing a low ability. Thus, the physicians compete exclusively in abilities, both setting the maximum level as the choice is costless. By restricting the physicians to operate locally, the planner splits the market in two portions, each aware only of the local physician. This effectively eliminates competition giving incentives to the locally-operating physician to choose a maximum ability level. Situations of this type can be found in health systems where the physicians must practice within local jurisdictions.

The rest of this paper is organized as follows: we first develop a brief survey of the literature, then introduce the model and study the duopoly market proposed, emphasizing on the consumers behavior. We next discuss the prices and abilities equilibria when finding a past-patient depends on the physicians' visibility levels; to finally comment the way these variables change with respect to some of the main modelling parameters, as well as the strategic interactions taking place between the physicians' decisions. All the proofs and a preliminary note on a model with n physician are included in the technical appendix.

2. Related Literature

From the most general perspective, our paper is part of the literature studying markets where the quality of a good or service is hard for the consumers to ascertain. More specifically, we focus on a healthcare market in a setting where consumers follow a $S(1)$ boundedly rational rule to learn the quality of the service being offered. The $S(1)$ procedure is an extreme simplifying heuristics adopted by consumers who base their decisions on a single past experience, often gathered from a third-party. We apply this rule as a departure from the Bayesian reasoning expected from perfectly rational agents. In the manner proposed by Osborne and Rubinstein (1998), consumers in our model estimate the abilities of the physicians using anecdotal evidence drawn from past consumers. In this line we find the work of Gilboa and Schmeidler (2001), who concentrate on the similarity of the evidence being analyzed by the consumers and the analogies they can build before making a decision. However, since our model involves a single illness of unique severity, all cases are assumed to be perfectly similar vis-à-vis the consumers decisions.

The use of small samples to inform consumer decisions is widespread in healthcare markets and leads to non-standard outcomes.[2] Among several others, Rabin (2002) studied the effects of consumer over-reliance on limited-size samples, finding that it induces suboptimal decisions in the consumers, allowing low-skilled competitors to take part in the market. This is a significant issue for our study, since it suggests a connection between market distortions and non-rational sample-based decisions.

The estimation procedure followed by consumers in our model is further limited by the physicians' visibilities, since each consumer can only sample from those physicians she is aware of. It is possible to understand this subset of alternatives as a consumer's consideration set. In our model these sets are constructed reflecting how well-known a physician is and, therefore, how easy it is for a consumer to find anecdotal evidence on him. The literature on consideration sets contemplates cases where these emerge as a result of a firm's promotional efforts (Eliaz and Spiegler (2011)) or due to cognitive biases on the side of the consumers (Manzini and Mariotti (2014)). We assume the physicians' visibilities to be exogenous.

This paper crucially follows the work of Spiegler (2006), who introduced the $S(1)$ rule in a healthcare market analogue to ours. He studies the decisions of consumers who face a finite set of "quacks", who offer no improvement on a costless outside option. The anecdotal reasoning introduced through the $S(1)$ rule allows the market to be active, whereas under perfect information it would not be the case. A handful of additional market failures arise. In particular, the patients' surplus decreases in the number of physicians and in the probability of being cured. However, this surplus-negative effect is non-monotonic. For a large number of "quacks", price competition becomes harsh, driving the prices down. Yet, the welfare loss is robust to high-value competitors ("non-quacks"), who do not manage to expel the "quacks" from the market. The anecdotal evidence-based procedure consumers follow, grants "quacks" a degree of market power, founded on blind luck ($i.e.$ consumers finding a positive anecdote) instead of abilities.

There are important differences between Spiegler (2006) and our study. First, the physicians we consider are not "quacks", instead choosing their abilities strategically. Second, the consumers can only sample from a subset of physicians they are aware of. Spiegler assumed that all the n physicians in the market could be sampled at no cost. We think that it befits the limited nature of the anecdote-based procedure to restrict the set of past-patients available to the consumers so that it includes only a fraction of the physicians in the market. Hence, whether a consumer is able to find one of the physicians' past-patients is determined by the visibility. Finally, where Spiegler consumers had a unique valuation for health, ours are endowed with a uniformly-distributed parameter representing their willingness to pay for healthcare services. This change brings the model closer to the standard way vertically-differentiated markets are analyzed, contrasting the robustness of Spiegler's results in a more general setting.

Despite its proximity with Spiegler (2006), there are other papers our study is closely linked to. Although he does not analyze a healthcare market and works with the information a firm can disclose regarding its products instead of ability levels, Ireland (1993) finds results that resonate with ours. Namely, a small number of firms engage in a two-

[2]For a survey on this issue from a healthcare perspective see Lipkus et al. (2001), Peters et al. (2006) and Reyna et al. (2009). A primer on small-sample effects on economic decisions is found in Tversky and Kahneman (1971).

stage competition, choosing their information provision levels and prices. Ireland (1993) finds an equilibrium where there are incentives for differentiation in information provision. Moreover, non-full disclosure is profitable for the firms despite being costless for them to disclose information.[3] In the case of our model, information disclosure could be interpreted as physicians being able to modify their visibilities strategically. That said, the essential difference with our paper is that for Ireland (1993) the firms' decisions only affect their promotional efforts, not the quality of the service being offered. On the contrary, we let physicians decide over their abilities, which directly affect the anecdotal evidence consumers find when sampling.

The closest precedent to our paper is found in Szech (2011), who extends Spiegler (2006) to include the strategic choice of abilities but keeps the unique valuation for health and the assumption of thorough sampling. She first constructs a unique equilibrium under full information and then uses it to characterize one where the consumers follow the $S(1)$ rule. Szech (2011)'s results are consistent with Spiegler (2006), in that they both find that the market is active when low-skilled physicians operate in it even under strong competition. Furthermore, incentives for the physicians to differentiate in abilities are found by Szech (2011). She finally conducts a welfare analysis, which reveals that the number of physicians diminishes the negative effect of the anecdotal reasoning. This opens a door for the analysis of sampling over restricted sets, as we do in the present paper by including a consideration set.

The core difference between the existing literature and our work lays in that we study the interaction between information availability and the actual quality of the service being offered. In a setting with anecdotically-reasoning consumers, both play a crucial role in the physicians' demand determination. However, they are rarely treated as two separate variables, the way we do in our model. As a matter of fact, we stress the essential distinction between them by letting physicians choose their ability but have no control over their visibility. Moreover, we find the interplay between the variables to be a major factor in the establishment of an equilibrium, driving the trade-off that allows ability differentiation. Actually, Spiegler (2006)'s, Szech (2011)'s, and (to some extent) Ireland (1993)'s results are but a subset of ours, with the equilibria they propose taking place when the physicians are universally known. Given the evidence justifying the limited nature of the information consumers have in healthcare markets, we consider that the case where physicians are not equivalently well-known due to a market variable outside their control, bears some consideration. More so when a policy-relevant outcome where every physician chooses a maximum ability in the equilibrium despite the consumers bounded-rational behavior, or the heterogeneous competitive conditions the physicians display, is attainable.

3. General Setting

We consider a market consisting of two physicians indexed by $i \in \{1, 2\}$, and a mass of consumers indexed by their willingness to pay for healthcare services θ, uniformly distributed over $[0, 1]$. In our setting, health is defined as a binary variable r such that $r = 1$ when the consumer is in full health and $r = 0$ when she suffers an illness unique in type and severity across consumers. Consumers are all initially ill and seek for a physician to

[3] McAfee (1994) finds very similar results studying an advertising game.

treat them. Moreover, consumers do not recover their health unless they visit a physician. Hence, staying out of the market and not recovering from their ailment is the consumers' outside option.

On the one side, physicians are fully rational agents perfectly informed about the market setting. That is, they observe the ability chosen by all the other physicians in the market $\alpha_i \in [0,1]$ for $i \in \{1,2\}$, and set prices to maximize their individual profits. The physicians' abilities represent the probability for a consumer visiting them to be cured, which results in her health state changing from 0 to 1. Thus, a consumer who visits Physician i will be cured with probability α_i. The marginal cost for the physicians to provide the service is zero. The physicians charge a fee $p_i \in (0,1)$ for $i \in \{1,2\}$ for their services, which is publicly known. Ability choice is costless for the physicians.

On the other side, consumers are not perfectly informed and they use a sampling rule to obtain information. That is, a given physician's ability is unknown to the consumers at the moment of taking the participation decision. Instead, they estimate it by gathering anecdotal evidence from their closest acquaintances. In order to do this, consumers follow a $S(1)$ procedure, which we explain in detail in the following section. Moreover, not all physicians in the market are known by the consumers. When sampling, the consumers have access to a limited subset of physicians' past-patients. Thus, they only consider visiting those physicians who they are aware of and can be sampled. We assume $\gamma_i \in (0,1]$ for $i \in \{1,2\}$ to be Physician i's visibility, the probability for him to be considered by any particular consumer. and to be exogenously set. Both visibilities are known by the physicians. Once the sampling process has taken place over all the physicians comprised in each consumer's consideration set, she compares the physicians she is aware of based on the observed outcomes and the fees charged, deciding which one to visit if her willingness to pay so allows her. The aggregation of this individual behavior leads to the demand system physicians face when taking their ability and pricing decisions.

The timing of the game is the following:

1. The physicians choose their abilities independently and simultaneously.
2. The physicians, aware of each other's abilities and visibilities, set a fee.
3. Each consumer takes a size-one sample from each physician in her consideration set.
4. Based on her sampled outcomes, the publicly known fees, and her willingness to pay for healthcare services, each consumer takes the participation decisions.

We proceed our analysis by backwards induction. First we pay attention to the decisions the consumers make when facing a duopoly where the physicians have already established their abilities and fees. Next, we move to the physicians' pricing decisions, which we describe for any pair of given abilities ($\alpha = (\alpha_1, \alpha_2)$). Finally, we consider the ability setting stage, where the physicians decide the ability level with which they will partake in the market. The structure of our model allows us to conduct a multi-layered analysis. Removing all but the last stage leads to a study of the consumers behavior. If we disregard the first stage, we are left with a pricing game where both the abilities and visibilities are exogenously given. We discuss each of these cases in the following sections.

3.1. The Sampling Process

The consumers do not know the abilities of the physicians in the market and estimate them following a $S(1)$ boundedly rational procedure. Therefore, they independently sample a single past-patient from each of the physicians in their consideration sets. These considerations sets represent the fact that consumers might not have access to anecdotal evidence about one or more of the physicians, as their acquaintances may not be aware of each and every physician active in the market. The abilities and visibilities are all independent random variables.

In the duopoly we examine, there are four possible consideration sets: (1) being aware of both physicians, which happens with probability $\gamma_1\gamma_2$, (2) being aware only of Physician 1, with probability $\gamma_1(1-\gamma_2)$, (3) only being aware of Physician 2, with probability $(1-\gamma_1)\gamma_2$, and (4) not being aware of any physician, which happens with probability $(1-\gamma_1)(1-\gamma_2)$. It is reasonable to understand these probabilities as the expected proportion of consumers that have a particular consideration set; hence their being determined by a combination of the physicians' visibilities.

Formally, the sampling process is modeled as if the consumers observe a single realization of a Bernoulli distributed random variable with parameter equal to Physician i's ability α_i. Thus, a consumer observes 1 with probability α_i when she samples Physician i. That is, the patient she sampled recovered after visiting Physician i. Therefore, this probability can be understood as the expected proportion of consumers who observe a positive anecdote from Physician i.

As a result of the consumers following this sampling process, the consumers build their beliefs on physicians' abilities based entirely on anecdotal evidence. If the anecdote is positive (Physician i's past-patient got cured), the consumers think they will also be cured when visiting such a physician. Therefore, the consumers believe Physician i's ability to be maximal: $\alpha_i = 1$. On the contrary, if the outcome is negative (the past-patient sampled was not cured despite visiting i), the consumers believe they will not get cured either. In consequence, they assume Physician i's ability to be null: $\alpha_i = 0$.

4. Consumer Behavior

We begin our analysis by studying the decisions of any consumer as a function of the anecdotal evidence they gather and the fees charged by the physicians. Under perfect information a consumer who visits Physician $i \in \{1, 2\}$ gets an expected utility given by:

$$\theta u(r = 1)\alpha_i + \theta u(r = 0)(1 - \alpha_i) - p_i.$$

We further assume that $u(r = 1) = 1$ and $u(r = 0) = 0$. Then, the utility under perfect information would be:

$$\theta\alpha_i - p_i.$$

This is not the case in a setting where consumers take anecdote-based decisions. Once the anecdotal evidence is gathered, each consumer decides whether to visit any physician she has sampled. A consumer would visit Physician i if he was included in the consumer's consideration set, a positive anecdote was found and: $\theta - p_i \geq 0$ and $p_i < p_j$, for each physician $j \neq i$ she is aware of. That is, she decides to visit Physician i if he offers her the best price among all those physicians she is aware of and has found positive anecdotes on. The expected utility for a consumer who found a positive anecdote for Physician i is: $\theta - p_i$. On the contrary, if no positive anecdotal evidence is found, she discards the idea of visiting i.

The anecdotal evidence observed by each consumer depends on the ability chosen by physicians and on their respective visibilities. This implies that such decisions are, to some extent, determined by the composition of each consumer's consideration set. Per our assumption on the physicians' visibilities, both have a positive probability to be included in such a set. From the side of the abilities, α_1 and α_2 represent the probability that any one consumer would observe a positive anecdote subject to each physician being in her consideration set. Given the form of their utility function, among all the consumers who would in principle demand the services from a particular physician after observing the samples, only the ones with a high-enough willingness to pay end up visiting the physician. In particular, from all those who observe a positive anecdote for i and a negative one for the rival, only the consumers with a willingness to pay at least as big as Physician i's fee, will visit him.[4] An analogue reasoning applies when two positive anecdotes are sampled. With this in mind, we build the demand Physician i faces, for $i, j \in \{1, 2\} : i \neq j$:

$$D_i = \begin{cases} \gamma_i(1-\gamma_j)\alpha_i(1-p_i) + \gamma_i\gamma_j\alpha_i(1-\alpha_j)(1-p_i) + \gamma_i\gamma_j\alpha_i\alpha_j(1-p_i) & \text{if } p_i < p_j \\ \gamma_i(1-\gamma_j)\alpha_i(1-p_i) + \gamma_i\gamma_j\alpha_i(1-\alpha_j)(1-p_i) + \gamma_i\gamma_j\frac{\alpha_i\alpha_j}{2}(1-p_i) & \text{if } p_i = p_j \\ \gamma_i(1-\gamma_j)\alpha_i(1-p_i) + \gamma_i\gamma_j\alpha_i(1-\alpha_j)(1-p_i) & \text{if } p_i > p_j \end{cases}$$

The nature of the sampling process followed by the consumers to make their participation decisions, induces a demand for each physician comprising two parts: a captive and a contested demand segment. If a consumer observes positive anecdotal evidence about Physician i while being unaware of Physician j, or observes a positive anecdote for i and a negative one for his competitor, then in both cases i becomes her only alternative. Physician i's captive demand segment comprises all such consumers. This portion of the demand is given by the first two terms in the function above, irrespective of the relationship between the prices. Physician i could act as a monopolist over this segment of the demand, for these consumers know no other physician or estimate him to be inferior. Naturally, by doing so the physician would lose demand on the remaining demand segment.

The contested demand segment includes all the consumers who while being aware of the two physicians, simultaneously found positive anecdotal evidence about them. Then, the main deciding factor for each consumer becomes the fees charged by the physicians. Thus, direct price competition takes place between the physicians over this segment of the demand. In case the prices are tied, the contested demand is evenly split by the physicians. These cases are given by the third term in the first and second lines of the demand function above.

[4] The expected utility for a consumer with willingness to pay θ, who observes a positive anecdote for i and a negative one for the rival, is given by: $\theta\alpha_i - p_i$. Since $\alpha_i = 1$, then the consumer will demand Physician i's services if and only if $\theta \geq p_i$. Hence, the demand for Physician i in such a scenario would be given by: $1 - p_i$.

Since we restrict our analysis to uniform non-discriminatory prices, the main trade-offs regarding the decisions of the Physicians emerge from these demand structures. First, keeping the competitor's price and both physicians' abilities and visibilities fixed, a higher price allows a Physician to obtain bigger profits from his captive demand while diminishing his contested demand segment. The size of the captive and contested demand a physician serves depends not only on his ability, but also on that of the rival. Therefore the trade-off just discussed becomes more interesting when the abilities are strategic variables. For instance, a physician may choose to set a low ability to increase the rival's captive demand, inducing him to set a fee closer to the monopoly price. The interplay between the captive and the contested demand, through ability choices, could therefore be seen as a way for a physician to soften price competition.

Physician i's demand can be rewritten as follows:

$$D_i = \begin{cases} \alpha_i\gamma_i(1-p_i) & \text{if } p_i < p_j \\ \alpha_i\gamma_i(1-\frac{\alpha_j\gamma_j}{2})(1-p_i) & \text{if } p_i = p_j \\ \alpha_i\gamma_i(1-\alpha_j\gamma_j)(1-p_i) & \text{if } p_i > p_j. \end{cases}$$

Evidently, the demands for the physicians negatively depend on their respective prices. This effect is reinforced by the fact that, when i's own price increases, only consumers with higher willingness to pay parameters will demand Physician i's services. This is captured in the demand expression above, by multiplying every portion of the expected demand by $(1 - p_i)$. In effect, only those consumers who have a willingness to pay high enough to afford visiting the physicians they have sampled, will do so. The participation cut-off, given the form of the consumers' utility function and the fact they estimate the ability of the physicians to be maximal upon finding positive anecdotal evidence, is simply given by Physician i's fee.

It is possible to see that both the visibility and the ability level chosen are key to determine which demand a give physician faces. The demand for the physician whose ability is estimated to be superior, expands as the ability difference between the physicians enlarges. The same applies to the visibility gap.

When writing the physicians' demands in this way, one highlights the strategic interaction between visibility and ability, represented by the product $\alpha_i\gamma_i$ $\forall i \in \{1, 2\}$. The demand expressions now exclusively depend on these products because: as being included in a consumer's consideration set and such consumer observing a positive anecdote for a physician, are independent events, then $\gamma_i\alpha_i$ represents the probability of observing a positive anecdote from Physician 1 conditional on having him in the consideration set. We are most interested in making this interaction as explicit as possible, for it stresses the relationship between information availability and physician's ability and its potential influence over the market outcomes, which we study here.

The physicians are perfectly rational and informed, thus aware of their potential demands. They maximize their profits, contingent to such demands, when solving the pricing game. We discuss these decisions in the upcoming sections.

5. Price Competition with Exogenous Abilities

For the analysis of the physicians' competitive behavior, we assume *without loss of generality* that $\alpha_2 \geq \frac{\gamma_1}{\gamma_2}\alpha_1$. This assumption simply underlines the fact that there may be interacting effects between how easy it is to find a given physician's past-patients, and the intensity of the competition in abilities. The analysis of the interdependence between visibility and ability is undertaken in the ability competition section of the paper. Nevertheless, we can already grasp some of the effects this interaction has on the price competition stage.

First, unlike what is observed in standard models of price competition with vertical differentiation, there is no Nash Equilibrium in pure strategies for the game. This happens because, regardless of the rival's pricing strategy, a physician will always serve a positive portion of the demand, even if being undercut by the competitor. A physician who faces a low-pricing rival still serves the consumers that got a positive anecdote concerning him, and a negative one from the competitor. Thus, undercutting cannot be carried out to the point where both prices reach the marginal cost –which is zero in our case. Setting a price equal to a null marginal cost would yield zero profits for both physicians, and they would thus rather set any positive price. A positive price, no matter its size relative to the competitor's, would give the physician positive profits from serving his captive market segment. Hence, setting a price equal to marginal cost does not constitute a Nash Equilibrium in pure strategies. Neither does both physicians setting a unique positive price, since there are incentives to undercut the rival.

Therefore, it is possible to see that anecdotal reasoning, via the captive market it generates for each of the physicians, provokes the impossibility of a pure strategies Nash Equilibrium in the pricing stage. This result aligns with Spiegler (2006), who similarly found the non-existence of a pricing Nash Equilibrium in pure strategies when consumers followed an analogous belief-formation process.[5]. Proposition 1, presented below, formally describes this result.

Proposition 1. *In the price competition stage of the game, with two physicians active in the market, given their abilities α_1, α_2, and visibilities $\gamma_1, \gamma_2 \in (0, 1]$, such that $\alpha_2 \geq \frac{\gamma_1}{\gamma_2}\alpha_1$, there is a unique Nash Equilibrium in mixed strategies characterized by the following c.d.f.s:*

$$F_1(p_1) = \frac{1}{\alpha_1\gamma_1}\left[1 - \frac{1-\alpha_1\gamma_1}{4p_1(1-p_1)}\right] \; \forall p_1 \in \left(\frac{1-\sqrt{\alpha_1\gamma_1}}{2}, \frac{1}{2}\right],$$
$$F_2(p_2) = \frac{1}{\alpha_2\gamma_2}\left[1 - \frac{1-\alpha_1\gamma_1}{4p_2(1-p_2)}\right] \; \forall p_2 \in \left(\frac{1-\sqrt{\alpha_1\gamma_1}}{2}, \frac{1}{2}\right),$$

and $F(2)$ has a mass point at $p_2 = \frac{1}{2}$, occurring with probability $M_2 = \frac{\gamma_2\alpha_2 - \gamma_1\alpha_1}{\alpha_2\gamma_2}$.

In the equilibrium, the asymmetry created by the visibility/ability relationship we hypothesized generates a strategic interaction in the physicians' mixed pricing strategies reported in Proposition 1. These rely on distribution functions with support over a range of fees comprised between: what the physicians would charge if they were alone in the

[5] As in this paper's case, the $S(1)$ rule; though in Spiegler (2006) there are no restrictions to what past-patients the consumers can sample.

market, and the lowest price that allows them to keep obtaining the profits level they would get if focusing on their captive market segment. The lowest pricing boundary for these distributions is a function of the physician with the smallest ability/visibility combination ($\alpha_1\gamma_1$). Naturally, this neglects any room for undercutting.

Due to the assumption over Physician 2's ability and visibility, the cumulative distribution function characterizing his pricing behavior does not comprise the upper bound. Furthermore, the function includes a mass point for such a price level, meaning Physician 2 is more likely to set a fee equal to the upper pricing bound. The relative dominance implied by the assumption allows Physician 2 to attract consumers even when setting higher prices, given that his captive market segment is relatively bigger than Physician 1's. [6] The size of the mass point reflects the extent of Physician 2's relative superiority. Thus, the probability for him to price in the upper bound decreases as the gap between abilities and visibilities disappears.

In the equilibrium, the prices the physicians are expected to set, are given by the following expressions:

$$Ep_1 = \frac{1-\gamma_1\alpha_1}{4\gamma_1\alpha_1}\left[ln\left(\frac{1+\sqrt{\gamma_1\alpha_1}}{1-\sqrt{\gamma_1\alpha_1}}\right) - \left(\frac{2\sqrt{\gamma_1\alpha_1}}{1+\sqrt{\gamma_1\alpha_1}}\right)\right].$$

$$Ep_2 = \frac{\gamma_2\alpha_2-\gamma_1\alpha_1}{2\gamma_2\alpha_2} + \frac{1-\gamma_1\alpha_1}{4\gamma_2\alpha_2}\left[ln\left(\frac{1+\sqrt{\gamma_1\alpha_1}}{1-\sqrt{\gamma_1\alpha_1}}\right) - \left(\frac{2\sqrt{\gamma_1\alpha_1}}{1+\sqrt{\gamma_1\alpha_1}}\right)\right].$$

We can see that Physician 2's expected price is above the competitor's. The expected price Physician 1 sets depends exclusively on his own ability and visibility. Unsurprisingly, Physician 2 can charge a higher price the bigger his ability is. On the contrary, Physician 2's expected price decreases as either α_1 or γ_1 grow. Moreover, both expected prices negatively depend on these variables. In effect, though it is true that Physician 2 charges a higher fee in expected terms, both p_2 and p_1 converge when $\alpha_1\gamma_1$ tends to $\alpha_2\gamma_2$ –$i.e.$ the gap in visibilities and abilities diminishes. When positive anecdotes conditional on the physicians being known by the consumers, are similarly easy to come by for both physicians, the price competition becomes more fierce, taking place over a bigger segment of the market. Furthermore, when $\alpha_1\gamma_1 = \alpha_2\gamma_2 = 1$, the physicians' captive markets disappear altogether, and with them the incentives to set a positive price irrespective of the threat of being undercut. Indeed, a Bertrand equilibrium where both physicians set a fee equal to the marginal cost, takes place under such a scenario.

Both physician's expected prices decrease in α_1. Naturally, Physician 2 feels the competitive pressure generated by the rival's ability improvement, and thus pushes his price down. But Physician 1 endures this effect as well, since a higher α_1 implies that price competition will be established over a wider market segment. In the opposite case, when $\gamma_1\alpha_1$ tends to zero, Physician 2 is able to operate uncontested over a larger portion of the market. That is, while neither Physician 2's ability or visibility change, the segment of consumers who find positive anecdotal evidence about both physicians is smaller. Thus,

[6] We talk about a relative dominance because our assumption neither implies that the physician has a superior ability or visibility. Instead, it claims that the combination of both parameters is bigger. Hence, it could be the case that a lower ability physician who is better known than his higher-ability-though-lesser-known competitor, satisfies our assumption.

Physician 2's expected price tends to $\frac{1}{2}$, while the competitor's approaches zero.[7] Then again, the fact that Physician 1's price decreases in his own ability hints at the incentives to differentiate from Physician 2. Namely, Physician 2 will always want to choose a maximum ability level, whereas Physician 1 could benefit from setting a lower ability. Hence, it is possible to say that Physician 1 by choosing an ability below Physician 2's, indirectly softens the competition. By doing this Physician 1 induces 2 to focus on his captive market, and therefore allowing himself to set a higher expected price in the portion of the market where both compete.

Finally, we look at the profits the physicians expect to obtain from playing the strategies described in Proposition 1. Taking the abilities and visibilities as given, the profits the physicians expect to obtain are:

$$\Pi_1 = \frac{\alpha_1\gamma_1(1-\alpha_1\gamma_1)}{4},$$
$$\Pi_2 = \frac{\alpha_2\gamma_2(1-\alpha_1\gamma_1)}{4}.$$

The physicians' expected profits depend on their abilities and visibilities. Physician 2 always gets bigger profits than his rival. As expected, Physician 2's profits depend negatively on the competitor's ability, and positively on his own. Interestingly, despite being smaller in magnitude, Physician 1's profits do not depend on the rival's ability. This further amplifies the incentives for Physician 1 to differentiate in the ability-setting stage.

We have so far discussed at length the pricing stage of the competitive game taking place between two physicians in a market where consumers reason anecdotically. What we obtain, aside from expressions concerning the pricing equilibrium in mixed strategies, is a first glance at the incentives for ability differentiation between the physicians. As we are solving the game by backwards induction, we next move to the preceding stage, where the physicians choose their ability level. We analyze these decisions in the following section.

6. Ability Choice

In the ability choice stage of the game, the physicians strategically set a value for their respective α_i. More simply put, they decide the probability with which a patient who visits them will be cured. Since we have assumed the consumers to reason anecdotically, such decision resonates in the demand the physicians face. Among the physicians included in the consideration set, the ability determines the probability for a consumer to find positive anecdotal evidence when asking past-patients about a certain physician.[8] We can thus expect the ability decision to involve the interactions described in the price-setting stage. In particular, there might be incentives for the physicians to differentiate in abilities, owing to the manner consumers form their beliefs, as seen in Ireland (1993) and Szech (2011). Yet, unlike what those two studies postulate, the availability of information on

[7]When it is $\gamma_2\alpha_2$ that tends to zero, by our assumption $\gamma_2\alpha_2 \geq \gamma_1\alpha_1$, it must be that $\alpha_1\gamma_1$ approaches zero even faster. Hence, the analysis of the reverse scenario still holds.

[8]This is particularly true for the case we currently analyze, given that we take the probability of finding a past patient ($\gamma_i\ \forall i \in \{1,2\}$) to be exogenous and positive. Hence, a bigger alpha *ceteris paribus* increases the probability that a consumer will find a positive anecdote on a specific physician.

the physicians must also be taken into account in our equilibrium, represented as it is by the pysician's visibilities.

This is the first stage of the game which, according to the timeline described, means that the physicians choose their ability knowing that in the next stage they will compete in prices. Generally speaking, a high-ability physician whose past-patients are hard to find, will in all likelihood have a smaller captive market that a well-known competitor with a lower ability level. Therefore, the trade-off between ability and visibility becomes crucial for the physicians' decisions. Ability choice is costless for the physicians and taken simultaneously.

Two equilibria in abilities are possible in the market setting we analyze, depending on the physicians' visibilities. How high or low these are will determine whether ability differentiation is observed or not. In particular, the physician in a relatively weaker competitive position, given his being lesser-known, will have to decide whether to pool with the better-known rival by choosing a high ability level; or to set a lower ability level that forgoes competition over patients outside his captive market. The better-known physician, regardless of the size of his visibility (γ_i), always chooses the maximum ability level. We formally present the first of these results in the following proposition.

Proposition 2. *If at least one of the physicians' visibility is below one half, that is* $\gamma_1 < \frac{1}{2}$, $\gamma_2 < \frac{1}{2}$ *or both, then the physicians do not differentiate in abilities, choosing* $\alpha_1 = \alpha_2 = 1$ *in equilibrium.*

If a physician's visibility is low, then only a small portion of the population is aware of his presence in the market. Naturally, by choosing a high ability the physician increases the size of the patients' mass that could potentially demand his services. Out of those who have the physician in their consideration sets, however few they maybe, the higher the ability is, the more likely such consumers will be to come by positive anecdotal evidence. Thus, if a physician is endowed with a low γ_i, $i.e.$ he has unfavorable initial conditions ($e.g.$ not being part of a family saga in the medical profession) the best he can do is choose as high an ability as possible. In doing this the physician maximizes the probability that when one of his past-patients is actually found, she has had a positive experience.

In this equilibrium the better-known physician is on a relatively advantageous position given his superior visibility, $\gamma_2 \geq \gamma_1$. Thus, Physician 2 sets a higher price and obtains bigger profits by also choosing the highest possible ability, $\alpha_2 = 1$. Therefore, both physicians set the maximum ability level to maximize their profits. According to *Proposition 2*, the equilibrium profits are given by:

$$\Pi_1 = \frac{\gamma_1(1-\gamma_1)}{4} \quad \text{and} \quad \Pi_2 = \frac{\gamma_2(1-\gamma_1)}{4}.$$

Both the profits for Physician 1 and 2 positively depend on their respective visibilities for visibility values of one half. Being known by a bigger portion of the population entails a potentially larger demand for the physicians, both in their captive market as well as in the segment they compete over. The profits Physician 2 obtains, decrease as the rival's visibility grows. Nonetheless, this effect is proportional to the physician's own visibility.

The second type of equilibrium we need to consider takes place when both physicians' visibilities are above one half. In such case, ability differentiation occurs: one of the physicians chooses a lower ability than the rival, who continues to set the highest ability level possible, and viceversa. We formally present this result in the following proposition.

Proposition 3. *If both physicians' visibilities are above one half, $\gamma_1 \geq \frac{1}{2}$ and $\gamma_2 \geq \frac{1}{2}$, two equilibria where ability differentiation is observed are possible:*

$$\alpha_1 = \frac{1}{2\gamma_1}\,,\ \alpha_2 = 1;$$

and

$$\alpha_1 = 1\,,\ \alpha_2 = \frac{1}{2\gamma_2}.$$

We can see that the physicians differentiate in abilities if the visibility of both is above one half. In each of the possible equilibria one of them chooses to be a low-ability physician, while the rival chooses to be high-ability. The equilibrium level chosen by the low-ability physician is proportional to his own visibility. The rationale driving these choices has to do with the form each physician's demand has, comprising captive and contested segments. A low ability entails a small captive demand for the physician who chooses it, and a larger one for the rival. In this type of equilibrium it pays off for the low-ability physician to differentiate despite this trade-off. By choosing a non-maximum level the low-ability physician surrenders some of his demand in order to induce the rival to focus on his own captive demand. This pushes the high-ability physician to play a pricing strategy skewing toward the monopoly price. Hence, the equilibrium prices over the whole market rise in expected terms, effectively softening the competition.

To analyze the profits levels obtained by each physician and the interactions between them in the equilibrium, we take the example of a market where Physician 2 is the better-known of the pair: $\gamma_2 \geq \gamma_1 > \frac{1}{2}$. The equilibrium abilities are: $\alpha_2 = 1$ and $\alpha_1 = \frac{1}{2\gamma_1}$. The profits each of the physicians in our example obtain are given by:

$$\Pi_1 = \frac{1}{16} \quad \text{and} \quad \Pi_2 = \frac{\gamma_2}{8}.$$

The better-known physician prices higher, serves a bigger demand, and obtains superior profits than his rival. Actually, Physician 1's profits do not depend on any variable, given that they come from the maximization of the physician's captive segment. On the other hand, Physician 2's profits increase with his visibility.

A summary of the equilibria presented in Propositions 2 and 3, as a function of the two physicians' visibilities, is presented in the following graph:

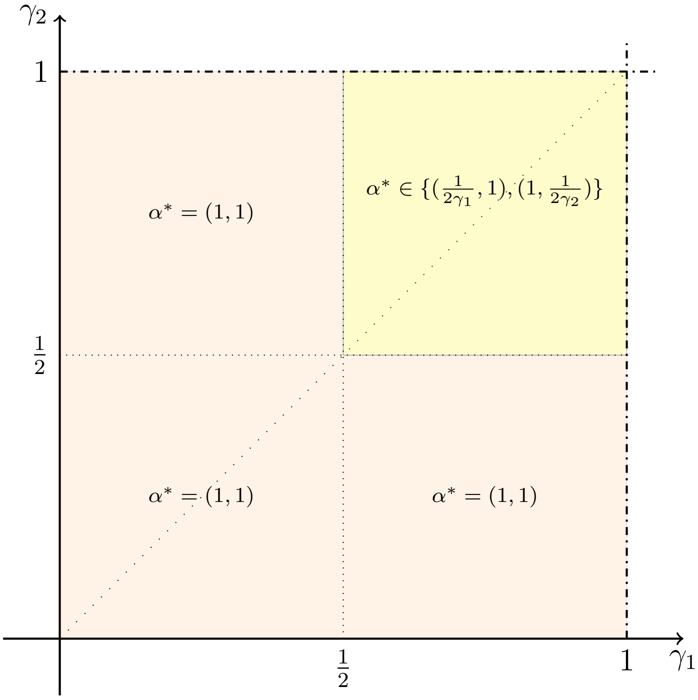

Figure 1: **Ability equilibria as a function of visibilities** (γ_1, γ_2)

Figure 1 illustrates the trade-off established in the ability-competition stage, between ability differentiation and information availability. Considering the physicians' visibilities as a measure of how plentiful information about the physicians is, we can see that ability differentiation does not take place when both values of γ_i are smaller than $\frac{1}{2}$. For what we call *low visibilities*, both physicians set a maximum ability level. This decision comes from the fact that both the physicians' captive market and the segment of consumers over which they compete, are small. Their past-patients are hard to find, and the physicians are included in a reduced number of consideration sets, for few consumers are aware of them. By choosing a maximum ability level, the physicians make sure that whenever a rare past-patient of theirs is sampled, her experience with the treatment was positive. Also, the proportion of consumers who have both physicians in their consideration set at the same time, is quite small. Thus, the price-diminishing effect of setting a high ability that we described in the previous section, is relatively small. The two physicians very rarely will compete in prices, hence the incentives to reduce the intensity of price competition by setting a below-maximal ability level, are insignificant.

We can also note that the result remains for as long as the lesser-known physician's visibility is below one half. Thus, ability differentiation is not observed in the equilibrium either when the two physicians are little-known, or just when the lesser-known of the two's visibility is below one half. In the latter case, the limited competitive presence of the lesser-known physician exerts little pressure on the superior-visibility rival, who for all effects and purposes acts as a monopolist over a large portion of the market, setting a maximum ability level since it is costless for him do to so. Then, to summarize, no ability differentiation is observed in the equilibrium when both of the physicians' market segments are small of the visibility-gap between them quite large.

For higher visibility values, $i.e.$ when the lesser-known physician's visibility is above one half, ability differentiation is observed in the equilibrium. Furthermore, it is always the relatively lesser-known physician who differentiates by setting an ability level proportionally smaller than his rival. How much smaller the chosen ability is, depends on the lesser-known physician's visibility. The differentiated ability will move away from the maximum level as the physician's visibility grows. As a matter of fact, when both visibilities are equal to one, we get the Spiegler (2006) and Szech (2011) results, in what could be called maximal ability differentiation, with one of the physicians setting an ability level of one and the other choosing one half.

We have discussed the reasons behind the differentiation decision throughout this section, and how it is motivated by the lesser-known physician's desire to give-up some of his demand in order to downplay price competition over the whole market, so that he can set a higher fee for his captive segment. Another way of seeing this mechanism, would be to focus on the effect the low-visibility physician's ability has on the mass point the better-known rival assigns to the upper pricing bound: the higher such ability, the more likely the superior-visibility competitor is to price close to one half. Lastly, it is interesting to see that the non-generality-impairing nature of our assumption on the sizes of the abilities and visibilities, is confirmed, since all the equilibria in abilities are symmetric, with no result hinging on the identity of any of the physicians. Moreover, the pricing stage equilibrium is also symmetric, granted one considers that the change in the direction of the assumption will imply a change in the relation of the equilibrium-prices set. That is, the relatively dominant physician will remain to price above his rival.

7. Concluding Remarks

In this paper we study the role of asymmetric information in a market for physicians where consumers base their decisions on anecdotal evidence. We closely follow Spiegler (2006) and Szech (2011). However, we introduce a crucial distinction: separating the exogenous and strategic components underlying the physicians' strategies in this market settings. In order to do this, we restrict consumers' samples to consideration sets whose composition is determined by an exogenous factor we call visibility. A physician's visibility reflects how well-known he is, thus influencing his competitive decisions.

The novelty of our approach resides in analyzing the interactions between the strategic choice of physician's abilities and the exogenous factor captured by their visibility. The non-existence of a pricing equilibrium in pure strategies and the incentives to differentiate in abilities we find, heavily depend on the complementarity of these two features. A clear interdependence between ability choices and visibilities is established, to the point that whether ability differentiation is observed in the equilibrium or not, depends on the physicians' visibilities. To be precise, more ability differentiation is observed when information on the physicians is more readily available.

In the equilibria we characterize, ability differentiation does not always take place when anecdotal-reasoning consumers are involved. We find an equilibirum where one of the physicians chooses a lower ability level, as established in the literature, only when both physicians have high visibilities. Our set-up allows for an equilibrium where all physicians in the market set the maximum ability level, unlike what the existing literature shows. Namely, when at least one of the physicians visibilities is low the two physicians set an ability equal to one. This is a result that carries valuable policy insights for a planner.

From a normative perspective, the interesting question to ask is how to achieve an equilibrium where ability attains its maximum level despite the consumers' bounded rationality and the heterogeneity in the physicians visibilities. Interestingly, introducing a maximum ability physician in the way of a high-value competitor, does not induce such an equilibrium. Similarly, forcing information on the physicians to be freely available would only work to the extent that it included an actual record of the physicians' abilities. Otherwise, it would just amplify the distorting effects of anecdotal-reasoning, potentially leading to the maximum ability-differentiation equilibrium one observes when all physicians in the market are equally visible but their ability remains private.

Achieving a high average ability in equilibrium seems to require information to be "less plentiful" for at least one of the physicians involved in the market. There are some ways for a planner to implement this. A regulator may intervene by restricting physicians to act in local parcels, which effectively eliminates competition by creating local monopolies where each physician is interested in choosing the highest ability possible. An alternative intervention would be to set a fix fee for the physicians' services, which induces them to focus on ability competition and leads them to the highest ability level since the decision is costless for the physicians.

Though our results are novel to the literature and potentially interesting for a regulator, a healthcare market is one of the type requiring further research before finer policy recommendations are made. In particular, it would be worthwhile to analyze the interaction between visibility and ability choice with greater depth. In this paper we have focused on a static game in which visibilities are completely exogenous. Yet, it is natural to think that the analysis could be pushed to a dynamic setting in which the present visibility of a physician depended on the number of patients he treated in the past (his market share) or his success rate (a function of the ability itself). This could lead to a deeper comprehension of the rise and development of family sagas, as observed in the medical profession, and the effect these have on market abilities and prices. Nevertheless, we believe that our paper offers some early insights concerning the impact of information availability on the decisions of physicians in a healthcare market. Thus, we hope it can set a path for future research, ultimately leading to policy considerations regarding a market where information, its access and reliability, play an increasingly critical role.

References

Eliaz, K and R Spiegler (2011) "On the strategic use of attention grabbers," *Theoretical Economics*, Vol. 6, No. 1, pp. 127–155.

Fagerlin, Angela, Catharine Wang, and Peter A Ubel (2005) "Reducing the influence of anecdotal reasoning on people's health care decisions: is a picture worth a thousand statistics?" *Medical decision making*, Vol. 25, No. 4, pp. 398–405.

Gilboa, Itzhak and David Schmeidler (2001) "A Theory of Case-Based Decisions."

Ireland, Norman J (1993) "The provision of information in a Bertrand oligopoly," *The Journal of Industrial Economics*, Vol. 41, No. 1, pp. 61–76.

Lipkus, Isaac M, Greg Samsa, and Barbara K Rimer (2001) “General performance on a numeracy scale among highly educated samples,” *Medical Decision Making*, Vol. 21, No. 1, pp. 37–44.

Manzini, Paola and Marco Mariotti (2014) “Stochastic choice and consideration sets,” *Econometrica*, Vol. 82, No. 3, pp. 1153–1176.

McAfee, R Preston (1994) “Endogenous Availability, Cartels, and Merger in an Equilibrium Price Dispersion,” *Journal of Economic Theory*, Vol. 62, No. 1, pp. 24–47.

Osborne, MJ and Ariel Rubinstein (1998) “Games with procedurally rational players,” *American Economic Review*, Vol. 88, No. 4, pp. 834–847.

Peters, Ellen, Daniel Västfjäll, Paul Slovic, CK Mertz, Ketti Mazzocco, and Stephan Dickert (2006) “Numeracy and decision making,” *Psychological science*, Vol. 17, No. 5, pp. 407–413.

Rabin, Matthew (2002) “Inference by believers in the law of small numbers,” *The Quarterly Journal of Economics*, No. August.

Reyna, Valerie F, Wendy L Nelson, Paul K Han, and Nathan F Dieckmann (2009) “How numeracy influences risk comprehension and medical decision making.,” *Psychological bulletin*, Vol. 135, No. 6, p. 943.

Spiegler, R (2006) “The market for quacks,” *The Review of Economic Studies*, Vol. 73, No. 4, pp. 1113–1131.

Szech, Nora (2011) “Welfare in Markets where Consumers Rely on Word of Mouth,” No. April.

The Kaiser Family Foundation, Foundation, and Henry J. Kaiser Family Foundation (2000) “National Survey on Americans as Health Care Consumers: An Update on The Role of Quality Information,” No. December.

Tversky, Amos and Daniel Kahneman (1971) “Belief in the law of small numbers.,” *Psychological bulletin*, Vol. 76, No. 2, p. 105.

Appendix A. Proofs

Proof of Proposition 1. We first compute the equilibrium prices taking the abilities as given (α_1, α_2). We start by showing that there is no pure strategies equilibrium, and then find the actual Nash Equilibrium in mixed strategies for the price competition stage of the game.

Step 1: *There is no equilibrium in pure strategies*

Physician 2's demand, given his ability α_2, is the following:

$$D_2 = \begin{cases} \alpha_2\gamma_2(1-p_2) & \text{if } p_2 < p_1 \\ \alpha_2\gamma_2(1-\frac{\alpha_1\gamma_1}{2})(1-p_2) & \text{if } p_2 = p_1 \\ \alpha_2\gamma_2(1-\alpha_1\gamma_1)(1-p_2) & \text{if } p_2 > p_1 \end{cases}$$

The demand for Physician 1 is symmetric. Thus, physician k's profits will be given by:

$$\Pi_k = p_k D_k \quad \forall k = \{1, 2\}.$$

First, in a pure strategies equilibrium, none of the physicians would ever set a price above $\frac{1}{2}$. If the rival has a price bigger than one half, the optimal price for the physician is to set a price equal to one half. If the rival undercuts the physician in prices, then the best strategy is to set a price strictly smaller than one half. Therefore, we can discard any price larger than $\frac{1}{2}$ as being part of an equilibrium in pure strategies.

Second, $p_1 = p_2 = \frac{1}{2}$ cannot be an equilibrium either. Assume, by contradiction that these pricing strategies constitute a Nash Equilibrium in pure strategies. The profits for Physician 2 in such a case are given by:

$$\pi_2 = \frac{1}{4}\alpha_2\gamma_2\left(1 - \frac{\alpha_1\gamma_1}{2}\right).$$

If Physician 2 undercuts Physician 1 by setting $p_2^d < \frac{1}{2}$, his profits are given by:

$$\pi_2^d = p_2^d(1-p_2^d)\alpha_2\gamma_2.$$

Equating these two expressions to find the minimum price that yields the same profits for Physician 2, we get:

$$p_2' = \frac{1}{2} \pm \frac{1}{4}\sqrt{2\alpha_1\gamma_1}.$$

Therefore, any price $p_2^d \in \left(\frac{1}{2} - \frac{1}{4}\sqrt{2\alpha_1\gamma_1}, \frac{1}{2}\right)$ constitutes a profitable deviation for Physician 2. Moreover, a similar argument follows through for any pricing situation such that: $p_1 = p_2 \; \forall \, p_1, p_2 \in (0, \frac{1}{2})$. That is, no positive price in the interval, simultaneously set by both physicians, is a Nash Equilibrium in pure strategies.

Finally, $p_1 = p_2 = 0$ is not an equilibrium either. Assume, by contradiction that it is an equilibrium. Clearly, both physician have incentives to deviate. Since these prices yield them zero profits, any positive price would constitute a profitable deviation, considering that it would yield positive profits for the physician, no matter how small the price, from serving his captive market segment.

Therefore, there is no equilibrium in pure strategies for the pricing game. Let us consequently assume there exists a Nash Equilibrium in mixed strategies for the game, which induces a $c.d.f.$ F_i with support over $[p_i^L, p_i^H]$ for all $i \in \{1, 2\}$, where $p_i^H = \frac{1}{2}$ (obtained from the maximization of i's captive market segment), and p_i^L is the lowest price that lets Physician i obtain the same profits level that p_i^H.

Step 2: *Show that the mixed strategies Nash equilibrium does not include mass points in any price $p^* < p_i^H$*
It is necessary to comment on the possibility that there may exist one (or several) mass points at any price p^* below the upper bound of Physician i's $c.d.f.$ support. This is useful for our proof because, if there are no spikes in the mixed strategies, then the measure of the set of prices for which there might be pricing ties is negligible, and we can rule out all such cases.

First, we need to show that the physicians never assign a mass point to the same price in their action domain. This is true because, if physician 1 has an atom on p, then physician 2 would never set an atom on the same p in equilibrium. Because, by moving the atom to a price just below p physician 2 would obtain higher profits, constituting a profitable deviation.

Now we show that none of the physicians would individually assign a mass point to a price lower than the upper bound of their action domain. Which we show next.

Assume, by contradiction, that Physician 1 plays in the equilibrium a mixed strategy that assigns a measurable probability to some price $p^* < p_1^H$, $i.e.$ F_1 has a discontinuity at p^*. Then, it would not be optimal for Physician 2 to play p^* with a measurable probability, since by playing any price below p^* he would undercut his rival, obtaining higher profits. Furthermore, it would be profitable for Physician 2 to reduce any positive density above p^*, and place a mass point at a price just below p^*. In fact, Physician 2 would never play any price above p^*. Thus, Physician 1 would like to redistribute its own mass point over the whole pricing interval, to increase the expected price and enhance the expected demand. Therefore, we conclude that a mass point cannot occur in equilibrium at any price below p_1^H and, more importantly, both physicians will never select the same mass point. Hence, the only possibility is that only one of the physicians assigns a mass point to the upper boundary of the $c.d.f.$'s support. In the next step we show that this is indeed the case for the high physician whose ability satisfies $\alpha_i \geq \frac{\gamma_j}{\gamma_i}\alpha_j$ where $i, j \in \{1, 2\} : i \neq j$.

Step 3: *Find the upper and lower bounds for the mixed strategies c.d.f.s' support*
Recall that, *without loss of generality* we assume that $\alpha_2 \geq \frac{\gamma_1}{\gamma_2}\alpha_1$. Since we have ruled out the probability of ties, then we know that for every possible price p_2, the expected demand of Physician 2, given the mixed strategy of his rival, is:

$$D_2 = \gamma_1\gamma_2\alpha_2(1 - \alpha_1 F_1(p_2))(1 - p_2) + \gamma_2(1 - \gamma_1)\alpha_2(1 - p_2)$$

Where $F_1(p_2)$ is the probability that p_1 is smaller or equal than the price p_2. Using the expression above we can write Physician 2's expected profits function as follows:

$$E\Pi_2 = E_{p_2}[\gamma_1\gamma_2\alpha_2(1 - \alpha_1 F_1(p_2))(1 - p_2)p_2 + \gamma_2(1 - \gamma_1)\alpha_2(1 - p_2)p_2]$$

The expressions for the expected profits and demand of Physician 1 are symmetric. We use them to find the upper and lower bounds for the mixed strategies of the physicians.

Let p_1^L and p_1^H represent F_1's lower and upper bounds. First, the upper bound will be the maximum price to which any physician would assign a positive probability, so that $F_i(p_i^H) = 1$ and $F_i(p) < 1\ \forall p < p_i^H$. This price is the one that maximizes Physician 1's profits when the rival is undercutting his price. Thus, this is the price that yields the *maxmin* profits. Notice that when physician i is being undercut he will only serve the portion of patients that sampled both physicians and got a positive from i and a negative from its rival, plus the portion of patients that sampled only physician i but not his rival, and found a positive anecdote from him –$i.e.$ Physician i's captive market segment. Notice that this upper bound price coincides for both physicians, $p_i^H = \frac{1}{2}\ \forall\, i \in \{1, 2\}$.

Second, the lower bound is the minimum price to which any physician i would assign a positive probability, so that $F_i(p_i^L) = 0$ and $F_i(p) = 0\ \forall p < p_i^L$. Due to the fact that the expected profits are strictly increasing for any price in the $[0, \frac{1}{2}]$ interval, the lower bound corresponds to price p_i', which –even if undercutting the rival's– would yield the same expected profits level than setting the price that yields the *maxmin* profits.

$$p_i'\alpha_i\gamma_i\left(1-\alpha_j\gamma_j F_1(p_i')\right)(1-p_i') = \frac{1}{4}\alpha_i\gamma_i(1-\alpha_j\gamma_j) \iff$$
$$p_i' = \frac{1 \pm \sqrt{\alpha_j\gamma_j}}{2}.$$

Where j indexes the variables corresponding to physician i's rival. Thus, Physician i will never set a price below $\frac{1-\sqrt{\alpha_j\gamma_j}}{2}$, guaranteeing a profits level at least equal to what he would get by following his *maxmin* strategy. Carrying out these computations for both physicians we get: $p_1' = \frac{1-\sqrt{\alpha_2\gamma_2}}{2}$ and $p_2' = \frac{1-\sqrt{\alpha_1\gamma_1}}{2}$.

Since every result up to now is symmetric for both physicians, we can assume without loss of generality that $\gamma_2\alpha_2 > \gamma_1\alpha_1$. This implies that $p_1' < p_2'$. Let us assume that these prices represent the lower bound of the corresponding pricing strategies, in the equilibrium. Then, Physician 1 would be assigning a positive probability to the range $[p_1', p_2')$. However this is not an equilibrium because Physician 1 would be better off by redistributing this positive probability over the remaining interval of the pricing region: $[p_2', \frac{1}{2}]$. Thus, the lower bound of the domain of the $c.d.f$ of both physicians are equal, $p_1^L = p_2^L = \frac{1-\sqrt{\alpha_1\gamma_1}}{2}$.

Step 4: *We find the expressions of the c.d.f.s induced by the Nash Equilibrium strategies.*

We know that for all prices in the $[\frac{1-\sqrt{\alpha_1\gamma_1}}{2}, \frac{1}{2}]$ interval, function $F_1(p_2)$ must be such that Physician 2 is indifferent when playing any price in its action space. Therefore,

$$v_2 = p_2\alpha_2\gamma_1\gamma_2(1-\alpha_1 F_1(p_2))(1-p_2) + \gamma_2(1-\gamma_1)\alpha_2 p_2(1-p_2),$$

must be the same for every p_2 in the interval. In particular, this must be the case for p_1^L and $F_2(p_1^L) = 0$. Thus, we can plug this in the preceding profits equation, in order to compute the value of v_2:

$$v_2 = \frac{\alpha_2\gamma_2(1-\alpha_1\gamma_1)}{4}.$$

Substituting v_2 back in the equation, and isolating the $c.d.f.$, we get:

$$F_2(p_2) = \frac{1}{\alpha_2\gamma_2}\left(1 - \frac{1-\alpha_1\gamma_1}{4p_2(1-p_2)}\right).$$

Following the same procedure for the other physician, we get the corresponding $c.d.f.$:

$$F_1(p_1) = \frac{1}{\alpha_1\gamma_1}\left(1 - \frac{1-\alpha_1\gamma_1}{4p_1(1-p_1)}\right).$$

Step 5: *We compute the size of the mass point Physician 2 assigns to $p_2 = \frac{1}{2}$.*
It is easy to see that $F_2(\frac{1}{2})$ is lower than one. Moreover, substituting $p_2 = \frac{1}{2}$ in the Nash Equilibrium $c.d.f.$ just computed, we get:

$$F_2\left(\frac{1}{2}\right) = \frac{\gamma_1\alpha_1}{\gamma_2\alpha_2},$$

and thus, the mass point ability Physician 2 assigns to the upper pricing bound is:

$$M_2 = 1 - F_2\left(\frac{1}{2}\right) = 1 - \frac{\gamma_1\alpha_1}{\gamma_2\alpha_2} = \frac{\gamma_2\alpha_2 - \gamma_1\alpha_1}{\gamma_2\alpha_2}.$$

■

Proof of Propositions 2 and 3. Once the equilibrium prices are found, we go back one stage in the game, when physician's abilities are chosen. As found in the proof of Proposition 1, the physicians profits given the abilities are:

$$\pi_1 = \begin{cases} \frac{\alpha_1\gamma_1(1-\alpha_2\gamma_2)}{4} & if\ \alpha_1 \geq \alpha_2 \\ \frac{\alpha_1\gamma_1(1-\alpha_1\gamma_1)}{4} & if\ \alpha_1 \leq \alpha_2 \end{cases}$$

and

$$\pi_2 = \begin{cases} \frac{\alpha_2\gamma_2(1-\alpha_1\gamma_1)}{4} & if\ \alpha_2 \geq \alpha_1 \\ \frac{\alpha_2\gamma_2(1-\alpha_2\gamma_2)}{4} & if\ \alpha_2 \leq \alpha_1 \end{cases}$$

Thus, the equilibrium abilities would be given by:

$$\alpha_1^* = \begin{cases} 1 & if\ \alpha_1 \geq \alpha_2 \\ \frac{1}{2\gamma_1} & if\ \alpha_1 \leq \alpha_2 \end{cases}$$

and

$$\alpha_2^* = \begin{cases} 1 & if\ \alpha_2 \geq \alpha_1 \\ \frac{1}{2\gamma_2} & if\ \alpha_2 \leq \alpha_1 \end{cases}$$

However, we need to check which of these strategies are Nash equilibria. The profits level each physician would obtain when setting a given ability level are:

$$\pi_1^* = \begin{cases} \frac{\gamma_1}{8} & if\ \alpha_1 \geq \alpha_2 \\ \frac{1}{16} & if\ \alpha_1 \leq \alpha_2 \end{cases}$$

and

$$\pi_2^* = \begin{cases} \frac{\gamma_2}{8} & if\ \alpha_2 \geq \alpha_1 \\ \frac{1}{16} & if\ \alpha_2 \leq \alpha_1 \end{cases}$$

We can see that:

$$\frac{\gamma_1}{8} > \frac{1}{16} \iff \gamma_1 \in \left(\frac{1}{2}, 1\right].$$

Therefore, we face the following combinations:

$$\text{If } \gamma_1 \in \left(0, \frac{1}{2}\right] \quad \text{then} \quad \alpha_1 = \frac{1}{2\gamma_1}, \alpha_2 = 1 \quad \text{and,}$$
$$\text{if } \gamma_1 \in \left(\frac{1}{2}, 1\right) \quad \text{then} \quad \alpha_1 = 1, \alpha_2 = \frac{1}{2\gamma_1}.$$

These are all possible equilibria, with their symmetric equivalents. Nevertheless, there is only one profitable deviation for each physician: if Physician 1 sets an ability level $\alpha_1 = 1$ when $\gamma_1 \in \left(0, \frac{1}{2}\right]$, the profits he obtains are $\frac{\gamma_1(1-\gamma_2)}{4}$. Moreover: $\frac{\gamma_1(1-\gamma_2)}{4} \geq \frac{\gamma_1}{8} \iff \frac{1}{2} \geq \gamma_2$.

Thus, if one or both of the visibilities are smaller than $\frac{1}{2}$, the two physicians set a maximum ability level: $\alpha_1 = \alpha_2 = 1$. On the other hand, if both visibilities are above $\frac{1}{2}$, two equilibria are feasible: $(\alpha_1 = 1, \alpha_2 = \frac{1}{2\gamma_2})$ and $(\alpha_1 = \frac{1}{2\gamma_1}, \alpha_2 = 1)$.

■

Appendix B. The n Physicians Case

- Let N be the set of physicians present in the market, with cardinality n.
- Let $\alpha_i \in [0,1] \quad \forall i \in N$ be each physician i's probability to cure any patient that visits him. Physicians have the capacity to cure the patients, but they may differ in their ability to cure them. That is, given physicians $i, j \in N : i \neq j$ with abilities $\alpha_i > \alpha_j$, a patient who visits Physician i has a higher probability of being cured than one who visits Physician j.
- Let $\gamma_i \in [0,1] \quad \forall i \in N$ be the probability that physician i is considered by any patient in the market. This implies that, $\prod_{i \in N} \gamma_i$ denotes the segment of consumers that consider all the physicians active in the market at a given time. That is, a consumer in such a segment of the market, will have access all the physicians active therein. Similarly, $\prod_{i \in N \setminus j} \gamma_i (1 - \gamma_j)$ denotes the segment of consumers that consider every physician active in the market, except for physician j.
- The physicians strategically choose their abilities and the fee they charge for their services: $\alpha_i, p_i \quad \forall i \in N$.
- At the time of choosing their prices, the physicians have perfect information on the abilities of their competitors. The probability for a Physician to be considered by the consumers ($\gamma_i \quad \forall i \in N$) is public information.
- There is a continuum of consumers who are initially ill and look for the services of physicians.[9]
- Consumers are uniformly distributed on the $[0,1]$ interval, indexed by their willingness to pay for healthcare service, θ.
- The consumers have no prior information regarding the physicians' abilities, estimating them by following a boundedly-rational $S(1)$ rule. Thus, they sample a single past-patient from each of the physicians they consider, and if the anecdote found is positive, believe visiting the physician will have identical results for them. The sampling procedure follows the same logic as in the duopoly case.
- The timing of the game is identical to the duopoly scenario's.
- The demand for any Physician i will comprise only those consumers for whom such physician is in their consideration set, and who have found a positive anecdote about him. Hence, Physician i's demand should encompass the consumers who have any possible consideration set including Physician i.
- For example, if $n = 4$ the demand for Physician 1 would be the following:

[9] All consumers in the market are initially ill, and suffer the same disease, with unique severity.

$$
\begin{aligned}
&\gamma_1\alpha_1\left[\gamma_2\gamma_3\gamma_4(1-\alpha_2F_2(p_1))(1-\alpha_3F_3(p_1))(1-\alpha_4F_4(p_1))+\right.\\
&\gamma_2\gamma_3(1-\gamma_4)(1-\alpha_2F_2(p_1))(1-\alpha_3F_3(p_1))+\\
&\gamma_2(1-\gamma_3)\gamma_4(1-\alpha_2F_2(p_1))(1-\alpha_4F_4(p_1))+\\
&(1-\gamma_2)\gamma_3\gamma_4(1-\alpha_3F_3(p_1))(1-\alpha_4F_4(p_1))+\\
&\gamma_2(1-\gamma_3)(1-\gamma_4)(1-\alpha_2F_2(p_1))+\\
&(1-\gamma_2)\gamma_3(1-\gamma_4)(1-\alpha_3F_3(p_1))+\\
&(1-\gamma_2)(1-\gamma_3)\gamma_4(1-\alpha_4F_4(p_1))+\\
&\left.(1-\gamma_2)(1-\gamma_3)(1-\gamma_4)\right](1-p_1)\,,
\end{aligned}
$$

In the expression above, each term represents the proportion of consumers that face one particular consideration set. That is, the first term represents those consumers that consider all the physicians, the second those consumers who consider all but Physician 4, so on and so forth. Finally, the last line represent the segment of consumers whose consideration set only includes Physician 1.

- When rewritten, this expression reduces to:

$$\gamma_1\alpha_1(1-\alpha_2\gamma_2F_2)(1-\alpha_3\gamma_3F_3)(1-\alpha_4\gamma_4F_4)\,(1-p_1)$$

- Thus, the demand for a Physician i's services, where $i \in N$, is:

$$\gamma_i\alpha_i\prod_{j\neq i}(1-\alpha_j\gamma_jF_j)\,(1-p_i)$$

The pricing game's Nash equilibrium in mixed strategies is described in the following proposition:

Proposition 4. *In the price competition stage of the game, with n physicians active in the market, given their abilities $\alpha_1 \leq \alpha_2 \leq \cdots \leq \alpha_{n-1} \leq \alpha_n$, and exogenous probabilities of being considered $\gamma_i \in (0,1] \quad \forall i \in N$, such that $\gamma_n\alpha_n \geq \gamma_i\alpha_i \quad \forall i \in N$, there is a Nash equilibrium in mixed strategies characterized by the following c.d.f.:*

$$
\begin{aligned}
F_n(p) &= \frac{1}{\alpha_n\gamma_n}\left[1-\left(\frac{\prod_{j\neq n}(1-\alpha_j\gamma_j)}{4p(1-p)}\right)^{\frac{1}{n-1}}\right] \;\forall p \in \left(p^L,\frac{1}{2}\right]\\
F_i(p) &= \frac{1}{\alpha_i\gamma_i}\left[1-\left(\frac{\prod_{j\neq n}(1-\alpha_j\gamma_j)}{4p(1-p)}\right)^{\frac{1}{n-1}}\right] \;\forall p \in \left(p^L,\frac{1}{2}\right]
\end{aligned}
$$

where $p^L = \frac{1-\sqrt{1-\prod_{j\neq n}(1-\alpha_j\gamma_j)}}{2}$ *and* $F_n(\frac{1}{2}) = 1$.

Proof of proposition 4. In the pricing stage the Nash equilibrium in prices is computed taking the abilities as given. We first show that there is no pure strategies equilibrium, and then find the actual equilibrium in mixed strategies for the price competition stage of the game.

Step 1: *There is no equilibrium in pure strategies.*
Due to the fact that abilities are taken as given, and are deterministic, there is no pure strategies Nash equilibrium. On the one hand, every physician chooses a price strictly larger than zero, because (as $\alpha_i\gamma_i > 0$ for all $i \in N$) there is always a positive probability that physician i being the only physician with a positive anecdote or the only physician considered. ON the other hand, there is always the incentives to undercut the prices of the rivals. These two factors cause the impossibility that pure strategies constitute a Nash equilibrium of the pricing game.

Step 2: *$F_i(p)$ is a continuous function over the strategy support $[p_i^L, p_i^H] \subseteq [0,1]$*
To prove continuity of F_i in equilibrium we use the fact that it will only be continuous on the strategy support $[p_i^L, p_i^H]$ if f_i contains no probability atoms on such interval. This will allows us to disregard the case of ties in prices for the rest of the proof, as this cases would happens with probability zero.

By contradiction assume f_i contains an atom on some price $p < p_i^H$. There can be three cases:(i) $p = 0$, (ii) $p \in (0, p_i^H)$ and (iii) $p = p_i^H$.

(i) Suppose $p = 0$
The physician i would be assigning a positive measure to a price that is yielding zero profits. as there is a positive probability of being the only recommended physician, by charging a price $p' > 0$ physician would get positive profits regardless of the prices set by any of the rivals. Thus, p' constitutes a profitable deviation and in equilibrium there cannot be a mass point on $p = 0$.

(ii) Suppose $p \in (0, p_i^H)$

- Suppose none of the rivals assigns positive probability to the interval $(p, p+\varepsilon)$ for $\varepsilon > 0$. Then physician i could profitably deviate by moving the positive measure he has assigned to p to, for instance, $p + \frac{\varepsilon}{2}$. Thus constituting a profitable deviation.
- Suppose at least one of the rivals assigns a positive probability to the interval $(p, p+\varepsilon)$. Then hysician i could profitably deviate by switching the positive measure originally assigned to p to $p - \delta$ for $\delta > 0$ small enough. Thus constituting a profitable deviation.

(iii) The only remaining possibility s to have an atom on $p = p_i^H$. If physician i has an atom on p, then no other physician j would set an atom on p. As any physician j would profitably deviate by moving this mass point slightly downwards.

This implies that F_i is continuous on the strategy support $[0, p_i^H)$ for all $i \in N$.

Step 3: *The upper bound of the strategy support is equal for all physicians $p_i^H = p^H = \frac{1}{2}$.*

- Assume by contradiction that in equilibrium $p_i^H < \frac{1}{2}$. As we have established in the previous step, there can be only one physician with a mass point on p_i^H, therefore $F_j(p_i^H) = 1$, and the profits when setting p_i^H with probability 1 for physician i are smaller than the profits he would get if he were being undercut by every rival and setting price one half, given by the following expression:

$$p_i^H(1-p_i^H)\prod_{j\neq i}(1-\alpha_j) < \frac{1}{4}\alpha_i\prod_{j\neq i}(1-\alpha_j)$$

Then it would be profitable to assign a positive probability to the interval $(p_i^H, \frac{1}{2})$ which is a profitable deviation, which is a contradiction.

- Assume by contradiction $p_i^H > \frac{1}{2}$. By exactly the same reasoning as the point above,

$$p_i^H(1-p_i^H)\prod_{j\neq i}(1-\alpha_j) < \frac{1}{4}\alpha_i\prod_{j\neq i}(1-\alpha_j)$$

  Thus, it would be profitable to move any positive probability assigned to the interval $(\frac{1}{2}, p_i^H)$ to one half, even if physician i is being undercut by his rivals.

Thus, $p_i^H = \frac{1}{2} \quad \forall i \in N$.

Step 4: *The "higher" ability physician's lower bound of strategy support in equilibrium is* $p_n'' = \frac{1-\sqrt{1-\prod_{j\neq n}(1-\alpha_j)}}{2}$

Without loss of generality, let us assume that abilities of the physicians present in the market are such that $\alpha_1 \leq \alpha_2 \leq \cdots \leq \alpha_{n-1} \leq \alpha_n$. In such case, physician n will not set a lesser price than the one that yields the maxmin payoff.

- The maxmin payoff of physician n: is the one physician n gets by maximizing his profits when all rivals are undercutting him in prices, this is $Fj(p_n^M) = 1$ where p_n^M is the price that maximizes profits given that every rival is setting prices such that physician n finds himself in the worst situation possible. The profits function in such case of physician n is given by the following expression:

$$\pi_n = p_n^M(1-p_n^M)\prod_{j\neq n}(1-\alpha_j)$$

  This function is maximized in $p_n^M = \frac{1}{2}$ and the maxmin value is $\pi_n = \frac{1}{4}\prod_{j\neq n}(1-\alpha_j)$

We use the previous result to find the lower bound on the mixed strategy of physician n. Call this price p_n''. Price p_n'' is the price that equates the profits of the best case scenario for physician n, that is physician n by setting p_n'' is undercutting all his rivals ($F_j(p'') = 0 \qquad \forall j \neq n$), with the maxmin value. This condition is formally described in the following expression:

$$p_n''(1-p_n'')\alpha_n = \frac{1}{4}\alpha_n\prod_{j\neq n}$$

We find the price:

$$p_n'' = \frac{1-\sqrt{1-\prod_{j\neq n}(1-\alpha_j)}}{2}$$

Step 5: *The support of the c.d.f. describing the mixed strategies is the same for every physician in the market,* $p_i^L = p_n^L \quad \forall i \in N$. Of course the same logic as the one in the previous step can be followed for every physician present in the market, in such case given the assumption we have made on the ranking of magnitudes of the physicians abilities, these prices are ordered in the following manner: $p_1'' \leq p_2'' \leq \cdots \leq p_{n-1}'' \leq p_n''$

Step 6: *Profits in equilibrium.* The expected profits for physician i for all $i \in N$ are given by the following expression:

$$E_{p_i}\Pi_i = \left[p_i(1-p_i)\alpha_i \prod_{j\neq i}(1-\alpha_j F_j(p_i)) \right]$$

in equilibrium

$$v_i = p_i(1-p_i)\alpha_i \prod_{j\neq i}(1-\alpha_j F_j(p_i)),$$

should be constant for all p_i in the strategy support, in particular this should be the case for p^L, which implies $F_j(p^L) = 0$ for all $j \neq i$. using this condition and the fact that we know p^L we get to the profits every physician gets in equilibrium:

$$\pi_i = \frac{1}{4}\alpha_i \prod_{j\neq n}(1-\alpha_j) \qquad \forall i \in N$$

Step 7: *The particular form of the mixed strategies in equilibrium.* Using the result we obtained in the previous step we get:

$$\frac{\pi_i}{\alpha_i} = \frac{1}{4}\prod_{j\neq n}(1-\alpha_j)$$

which is equal for all i, and

$$\frac{\pi_i}{\alpha_i} = p(1-p)\prod_{j\neq i}(1-\alpha_j F_j(p))$$

for a particular price in the strategy support:

$$\frac{\pi_i}{\alpha_i} = p(1-p)(1-\alpha_j F_j(p)) \prod_{k\neq i,j}(1-\alpha_k F_k(p))$$

$$\frac{\pi_j}{\alpha_j} = p(1-p)(1-\alpha_i F_i(p)) \prod_{k\neq i,j}(1-\alpha_k F_k(p))$$

Doing the ratio:

$$\frac{\pi_j}{\alpha_j}(1-\alpha_j F_j(p)) = \frac{\pi_i}{\alpha_i}(1-\alpha_i F_i(p))$$
$$(1-\alpha_j F_j(p)) = (1-\alpha_i F_i(p))$$

Replacing back this result we get:

$$\frac{\pi_i}{\alpha_i} = p(1-p)(1-\alpha_i F_i(p))^{n-1}$$

and

$$\frac{\pi_i}{\alpha_i} = \frac{1}{4}\prod_{j\neq n}(1-\alpha_j)$$

Thus,

$$F_i(p) = \frac{1}{\alpha_i}\left[1 - \left(\frac{\prod_{j\neq n}(1-\alpha_j)}{4p(1-p)}\right)^{\frac{1}{1-n}}\right]$$

For all $i \in N$. ■