Appendix D. Analysis of the case where patients sample $K \geq 1$ anecdotes when estimating a Physician's ability [22]

In this appendix we expand the sample size upon which the consumers base their decision, considering a set of K anecdotes before visiting a given physician. The consumers estimate the ability of some of the physicians who compete in the market through that sample.

To an extent, the market distortions we found hinge on consumers sampling one and only one patient. We are thus interested in understanding how the market behaves when consumers are allowed wider samples. Hence, we let each consumer draw $K > 1$ anecdotes from past patients who visited each physician she is aware of. That is, if three different physicians have treated some members of her family, she will gather K anecdotes for each of them, estimate their respective abilities, and then decide which one to visit.[23]

The sample-processing procedure is slightly altered with respect to the one introduced in this paper's main model. Here we assume that finding a negative anecdote from a physician drives the consumer to discard such physician, no matter if she had previously found some positive anecdotes. A negative anecdote out of the K sampled is equivalent to assigning the physician a zero ability. Hence, in order to consider visiting a given physician the consumer must get exactly K positive anecdotes. A physician from whom she only heard positive anecdotes is attributed an ability of one.

This type of reasoning finds its rationale in the behavioral bias known as *negativity bias*, defined as the tendency for humans to pay more attention or give more weight to negative experiences over neutral or positive counterparts.

According to Sunstein (2003), in the face of negative events people tend to focus on the "badness" of the outcome rather than on its probability. This bias results in what Sunstein calls *probability neglect*. Even when negative experiences are inconsequential or highly improbable, individuals tend to focus on their negative effects rather than their actual probability. It is not far-fetched to imagine a boundedly-rational consumer, suffering an ailment severe enough for her to decide to gather more evidence on a provider, to be prone to a *negativity bias*.

Aside from this change in the sampling procedure, the competitive set-up remains unchaged from this paper's main duopolistic model.

We find that more information, in terms of the physicians' respective visibilities, leads to more differentiation in abilities, with lower average ability values appearing in the equilibrium. That is, for the case of a duopoly, when the visibilities of the physicians are all high, one of them sets the maximum ability level while the other chooses a proportionally lower value. On the other hand, low visibilities across the market lead to an equilibrium where all the physicians set a maximum ability level, granted the choice is costless to them.

---

[22]Full proofs for this appendix are available upon request.

[23]We assume the sample size K to be small enough not to contradict the informational limitations inherent to the market. In simpler words, K will be small enough for each consumer to be able to find such number of anecdotes for all the physicians who have treated someone she knows.

Therefore, allowing consumers to gather larger number of anecdotes leads to higher average ability level in the market. A larger sample size decreases the probability of finding positive anecdotes for low-ability physicians by mere chance. This compels the physicians to choose a higher ability level, particularly when costless. Thus, our result indicating ability differentiation to vanish as the sample size becomes larger, is intuitive. In plain words, irrespective of their visibility a physician will strategically choose a higher level of ability if he knows that consumers take a larger sample of anecdotes.

However, when we include a costly choice of ability, the differentiation result not only is maintained but takes place even when information availability is low.

D.1. Consumer behavior when sampling $K \geq 1$ anecdotes

The consumers follow a sampling procedure to estimate the ability of the physicians they are aware of, before deciding which one to visit. That is, a consumer independently samples $K > 1$ past patients from each of the physicians they observe in the market. More formally, we model the sampling process as if the consumers observe K independent realizations of a Bernoulli distributed random variable with a parameter equal to Physician i's ability (α_i). Therefore, a consumer observes 1 – a positive anecdote – with probability α_i when she samples Physician i.

The consumers build their beliefs on the physicians' abilities based entirely on the anecdotal evidence they gather, following the procedure outlined before. They discard any physician for whom they get a negative anecdote out of their K draws. If the K collected anecdotes are positive the consumer estimates the physician's ability to be 1. All the physicians whose ability is estimated to be maximal by the consumer are included in the *acceptable* set. A consumer considers all the physicians in such set to be equivalent in abilities and thus decides based on her willingness to pay and the fee each physician charges.

Therefore, the probability for a consumer to observe exactly K positive anecdotes for Physician i is: α_i^K. Conversely, $1 - \alpha_i^K$ represents the probability for a consumer to observe at least one negative anecdote in her sample. Thus, the demand Physician 2 faces in the duopolistic setting we study could be written in the following manner:

$$D_2 = \begin{cases} \left[\gamma_2(1-\gamma_1)\alpha_2^K + \gamma_2\gamma_1\alpha_2^K(1-\alpha_1^K) + \gamma_2\gamma_1\alpha_1^K\alpha_2^K\right](1-p_2) & \text{if } p_2 < p_1 \\ \left[\gamma_2(1-\gamma_1)\alpha_2^K + \gamma_2\gamma_1\alpha_2^K(1-\alpha_1^K) + \gamma_2\gamma_1\frac{\alpha_2^K\alpha_1^K}{2}\right](1-p_i) & \text{if } p_2 = p_1 \\ \left[\gamma_2(1-\gamma_1)\alpha_2^K + \gamma_2\gamma_1\alpha_2^K(1-\alpha_1^K)\right](1-p_2) & \text{if } p_2 > p_1 \end{cases}$$

As it was the case in the present paper's main model, the demand for each physician comprises a captive and a contested demand segment.

The demand Physician 2 faces can be rewritten as:

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

We restrict our analysis to uniform, non-discriminatory prices. Thus, the main trade-offs regarding the decisions of the physicians originate from the demand structure.

D.2. Competition in prices when sampling $K \geq 1$ anecdotes

Due to the demand structure there is no Nash Equilibrium in pure strategies for this stage. There is a unique mixed strategies Nash equilibrium, as reported in Proposition 7.

Proposition 7. *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:*

$$F_1(p_1) = \frac{1}{\alpha_1^K \gamma_1}\left[1 - \frac{1 - \alpha_1^K \gamma_1}{4p_1(1-p_1)}\right] \ \forall p_1 \in \left(\frac{1 - \sqrt{\alpha_1^K \gamma_1}}{2}, \frac{1}{2}\right],$$

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

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

The mixed strategies Nash Equilibrum we found aligns with the one introduced in this paper's main model. Nevertheless, there are some interesting implications deriving from the increase in sample size.

First, the domain of the mixed equilibrium price strategies shrinks towards $\frac{1}{2}$ as the sample size increases. Second, the $c.d.f$s characterizing the equilibrium are increasing functions of the sample size K. In sum, higher expected average prices appear in the market when consumers are allowed to collect a larger number of anecdotes before deciding to visit a physician.

The way in which consumers process the larger amount of information gathered modifies the sizes of the demand segments, making setting lower fees lees profitable for the physicians. This occurs because the consumers do not construct a more accurate estimator of physicians abilities with the greater quantity of information they gather.

One important consequence of the sample-size increase is that both segments of the demand become smaller for each physician. Therefore, as the sample size grows the trade-off between the two segments of the demand becomes less relevant for the physicians' pricing strategy.

The larger the sample is, the lower each physician's profits will become. This being largely a side effect of the demand-decreasing effect of a sample expansion. The fact that a consumer only visits a physician for whom she has observed K positive anecdotes causes that, the lower visibilities and abilities are, the lower a physician's profits level as long as $\alpha_i < 1$ for all $i \in \{1, 2\}$.

We now move to the analysis of the ability competition stage.

D.3. Competition in abilities when sampling $K \geq 1$ anecdotes

We address two different scenarios: one where ability is costless for the physicians, and another where the physicians choose their respective ability at some cost.

Costless ability choice:

Two equilibria in abilities are possible, depending on physician 1's visibility.[24] These equilibria are reported in Proposition 8.

Proposition 8. *In the ability choice stage of the game, and assuming $\gamma_2 \geq \gamma_1$, two equilibria are possible:*

- *If $\gamma_1 < \frac{1}{2}$, then the physicians do not differentiate in abilities, both of them choosing $\alpha_1 = \alpha_2 = 1$.*

- *If both physicians' visibilities are above one half, equilibrium abilities are $\alpha_1 = \left(\frac{1}{2\gamma_1}\right)^{\frac{1}{K}}$ and $\alpha_2 = 1$.*

If the visibility of the dominated physician is below one half, there is no differentiation in abilities. However, when the visibilities of both physicians are above one half, ability differentiation emerges.

The ability equilibrium level chosen by the low-ability physician is proportional to his own visibility, and increases with the size of the sample, as we can see in the following graph.

Ability of Physician 1 (γ_1)
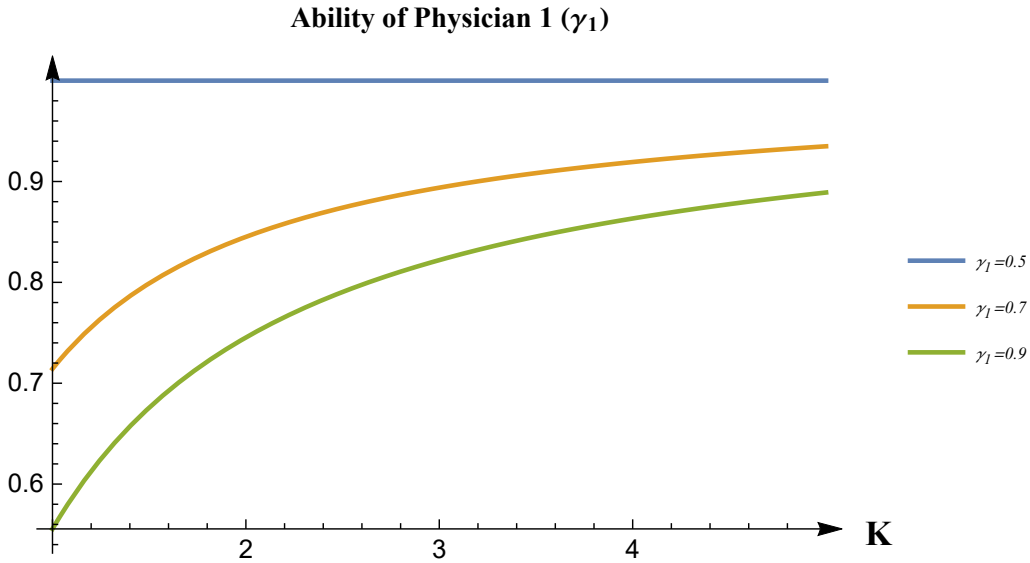
Both physicians' abilities converge to the maximal level in equilibrium as the number of anecdotes gathered by the consumers grows. Moreover, visibility becomes irrelevant when the sampling process is thorough (a large enough K). In consequence, it does not matter that a consumer is aware of a limited subset of the physicians in the market, since all of them will choose the maximal ability level given a large K sample and a costless choice.

Indeed, we see that as K grows, regardless of the visibility levels, the ability choice of physicians tends to be closer to 1. This implies that a larger sample leads to less ability differentiation and a higher average ability level in the duopolistic market.

---

[24]According to our assumption $\gamma_2 \alpha_2^K \geq \gamma_1 \alpha_1^K$.

It is interesting to note that captive demands do not disappear, which opens the question of how the equilibrium would change if the ability choice were costly. A matter we discuss next.

Costly ability choice:
We are interested in how the tendency to choose higher abilities due to the expanded sample sizes is affected by the introduction of a costly choice of abilities. We perform this exercise by introducing a costly choice of ability.

Assume that attaining an ability level of α comes at a cost $c(\alpha)$ for the physician, where $c(\cdot)$ is a continuously differentiable, increasing and convex function, with $c(0) = 0$, $c'(0) = 0$ and $c'(1) = \infty$. The convexity of the cost function captures the fact that a physician's incentives to set a high ability, so that he can attract many consumers to both his captive and contested demand segments, are counterbalanced by how costly it is for him to increase his ability level.

Taking into account the cost function introduced above, we can rewrite the profits functions found for the price competition stage:

$$\Pi_1 = \frac{1}{4}\gamma_1\alpha_1^K \left(1 - \gamma_1\alpha_1^K\right) - c(\alpha_1)$$

and

$$\Pi_2 = \frac{1}{4}\gamma_2\alpha_2^K \left(1 - \gamma_1\alpha_1^K\right) - c(\alpha_2)$$

The equilibrium outcomes reported in proposition 9 show that when ability choice is costly, physician 1 sets an ability level that is bounded from above by the ability level he would choose if ability were costless. That is $\left(\frac{1}{2\gamma_1}\right)^{\frac{1}{K}}$ whenever $\gamma_1 > \frac{1}{2}$. On the other hand, physician 2 sets an ability which is bounded from below by the ability set by Physician 1.

Proposition 9. *If the choice of ability level α_i generates a cost $c(\alpha_i)$ to physician i, then there exists an equilibrium where:*

- *Physician 1 chooses an ability level $\underline{\alpha_1} \in \left(0, \left(\frac{1}{2\gamma_1}\right)^{\frac{1}{K}}\right) \subseteq (0,1)$ that solves*

$$\frac{1}{4}K\gamma_1\underline{\alpha}_1^{K-1}(1 - 2\gamma_1\underline{\alpha}_1^K) = c'(\underline{\alpha}_1)$$

- *Physician 2 chooses an ability level $\overline{\alpha}_2 \in (\underline{\alpha}_1, 1)$ that solves*

$$\frac{1}{4}K\gamma_2\overline{\alpha}_2^{K-1}(1 - \gamma_1\underline{\alpha}_1^K) = c'(\underline{\alpha}_2)$$

This result is interesting to the extent that it entails the relatively dominant physicians to be the one who "sets the competitive standards" for the market. While it is entirely expected for the costless equilibrium choices to set the upper bound for the non-dominant physician, who always sets an ability level below that of the dominant player.

Furthermore, notice that the ability levels in the equilibrium are further limited by the cost function. While, in the costless ability scenario, $\gamma_1 \leq \frac{1}{2}$ implied that both physicians

would choose an ability level equal to the maximum, in the costly ability scenario the implication depends on the cost function. Moreover, Physician 2 will always choose a superior or equal ability to his rival, though it will not always be the at the maximal level.

Thus, discussing both the costly and costless ability choice equilibria in relation to the present paper's main model induces several worthwile research questions we intend to explore in the future.