Universitat Autònoma de Barcelona

INFORMATION ACQUISITION, EXPERTISE, AND CONSUMER BEHAVIOR IN MARKETS WITH INFORMATIONAL ASYMMETRIES

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by

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‘However you manipulate, however you try to corner a market, however you expect the value to sort of accelerate, if the core of the art is not real and isn’t there, in the long run it will collapse. For me there’s truth to the auction process—that’s what is actually quite beautiful. It is: Who has the greatest artistic quality? Who as an artist has this enormous discipline to continue to produce interesting works of art? Which pictures do not empty themselves? At the end of the day the truth comes out.’

Tobias Meyer in “Money in the Wall,” Vanity Fair magazine, December 2006

‘The idea of the unrecognized genius slaving away in a garret is a deliciously foolish one. We must credit the life of Vincent van Gogh for really sending that myth into orbit. How many pictures did he sell. One. He couldn’t give them away. Almost no one could bear his work, even among the most modern of his colleagues. (...) He has to be the most modern artist, still. Van Gogh’s don’t crack. But everybody hated them. We’re so ashamed of his life that the rest of art history will be retribution for van Gogh’s neglect. No one wants to be part of a generation that ignores another van Gogh.’

Rene Ricard “The Radient Child,” ARTFORUM magazine, December 1981

‘Well some people try to pick up girls
And get called assholes
This never happened to Pablo Picasso
He could walk down your street
And girls could not resist his stare and
So Pablo Picasso was never called an asshole.’

The Modern Lovers – “Pablo Picasso”

Acknowledgements

If I had to tell the story of how I got my PhD, the first character to feature in it would be David Pérez-Castrillo, my advisor. I have forgotten many other, perhaps more important things but I still remember the day we met to discuss applying to IDEA. It was not long before the Easter break, a March morning in 2010. I had arrived in Barcelona six months earlier to study a Master's in the Science of Economics and Innovation at the Barcelona Graduate School of Economics. I had a class with him that day, so we agreed to meet in the classroom an hour before it started. I always wanted to pursue a career in the academic world and had heard great things about the in-house PhD program. David was a faculty member and a leading expert in economics of information, a field I was already interested in; it made perfect sense to ask him for advice. Both then and now, I feel honored to follow in his footsteps, which made the fact that he agreed to discuss my academic future all the more auspicious. That meeting set the foundation for a relationship that has lasted to this day. More than six years have passed and David has been every bit the role model and mentor I had hoped for. I knew we would get along as I enjoyed his character and banter from our classes, not to mention his intellectual brilliance and research acumen, but I could not have envisioned the amazing level of commitment, guidance, help, patience, encouragement, and support David would offer me. His kindness and wisdom are reflected in this dissertation, and have helped it to materialize despite my evident shortcomings. I will do my best to honor his trust and teachings throughout my life as an academician.

Of course, this story begins a bit earlier than that. My first brush with economics took place as an Industrial Engineering student in Bolivia, around June 2006. Something about the lone six weeks I spent studying the subject made me decide to apply to the MESI program after I graduated, but as I would soon realize, I had little to no idea

about economics at that point. My real gateway to this world was Pedro Rey-Biel, our microeconomics professor and perhaps the main culprit for me not following through with a PhD in political science as originally planned. The enthusiasm and clarity of Pedro's class got me hooked. It did not only come down to understanding how the economic world worked or Pedro's many virtues as a lecturer; here was a guy who in his first class would tell us about the experiments he was running all over the world and how he would get quoted in the second edition of *Freakonomics*. I had never seen anyone so genuinely passionate about research before. To boot, he was a young dude who liked cool music and movies. It's hard not to like someone who explains game theory to you using the Joker as an example. I was sold from that moment on, and have treasured Pedro's friendship – his very valuable academic feedback aside – ever since.

As you can tell, the MESI program was full of inspirational characters. Salvador Barberà, who directed the program that year, was one of them. He was the first professor I met who was doing research of such great import, at the level of the handful of scientists who can claim to have pioneered a field, rubbing shoulders with Nobel laureates and global leaders. Yet, what struck me the most about him was how approachable and good humored he was. Salvador was an enormous scholar, but a fully realized human being above all; research papers were not the be-all-end-all measure of a successful life for him. That just deepened my admiration for him, as I had the privilege to attend his classes and to work as his teaching assistant a few years later. Among the many things he taught me, the meaning of *lletraferit* is the one I will never forget. For all this and more, Salvador came to embody all that I admire from the Catalan culture. There was also Inés Macho-Stadler, an excellent teacher and a leading researcher in her own field, whom we had the fortune to have as our Economics of Information professor. I've enjoyed her class so much that I've taken it three times already, and would give it another go in a heartbeat. There's little doubt that she is the one responsible for steering me away from political economy and into the economics of information. I'm yet to meet someone who can imprint her personality – in Inés' case a deep and warm gentleness – into their academic work as much as she does. Her bulletproof conviviality – I've never seen her annoyed, let

alone a bit angry – underscores her spectacular professional credentials.

Once in IDEA, and into my second year in Barcelona, the inspirational quartet I have mentioned exploded into a constellation. Not to bore the reader with a detailed rundown, at the risk of being unfair I will stick to those who have played the most active parts in the writing of my dissertation. Susanna Esteban merits special credit both as the advisor to my co-author, and thus a crucial actor in the development of this work, and also as the program director through my PhD years. Xavier Martinez-Giralt and Pau Olivella have also greatly contributed to the completion of this thesis, honoring me as members of my dissertation committee several times. Their insights and constant support have helped me grow as a researcher and economist. Tomás Rodríguez-Barraquer, who has organized the MicroLab for the past couple of years, has been the most heroic source of motivation for all of us in the department working on microeconomics. Tomás is the best partner of whom to bounce ideas off, always finding value in them, no matter how wacky those ideas might be, and coming up with amazing suggestions to turn them around. At different points Miguel Angel Ballester, Giaccomo DeGiorgi, and Johannes Gierlinger shared with us their comments on some of the work contained in this thesis, which we greatly appreciate.

Here, a cursory *thank you* to my colleagues would be a disservice to the incredible group I have been a part of. In academic terms, the fact I found my co-author Edgardo Lara-Córdova among my classmates is testament enough to the fruitful bonds we have all cultivated. That Edgardo is now one of my closest friends underlines how important the human side of things was to us all. The same goes for Francesco Cerigioni and Isabel Melguizo-López, who have both shared their friendship and scholarly gifts with us on numerous occasions. Benjamin, Dilan, Alex, Alberto, Franceso, Guillem, Yuliya, Koustuv, David, Iñigo, John, Rita, among several others, were a delight to share a classroom with.

A heartfelt mention goes to Andrés, Vania, Koustuv, Dilan, and my brother Luis, whom I have had the pleasure to share the quotidian side of the past seven years with. I'd be remiss not to mention my family in Bolivia, who kept me supplied with photos of Frank, my cat, and what I miss the most from Cochabamba.

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I wouldn't know how to close this paean to all those who had a hand in getting me to complete my doctoral studies without mentioning the city of Barcelona, where I spent the lion's share of my twenties. I have had a special relationship with the city since I was a child, with family members having lived here and – in hindsight – a great proximity to Catalan culture. Being an art enthusiast, I revered Barcelona as a neural point for Iberoamerican culture, and still it surpassed all of my expectations. I have enjoyed every second I have spent here, cherishing the intoxicating stillness of the light that washes it all in the height of August, witnessing up close the most successful era of Barça's history, spending more money than I should in La Central del Raval, counting the days to Primavera Sound, celebrating La Mercè as if it was my birthday... Not to gloat over the endless good times I have had, I will only highlight three events: Leonard Cohen's concert in September 21 2009, the double bill Galaxie 500 and Spectrum played in November 2009 at Apolo, and the "last" LCD Soundsystem show at Razzmatazz in November 2010. Filmoteca de Catalunya should also be acknowledged, if not for the many hours I spent there then for two movies they screened which profoundly affected me: *Prospero's Books*, which made me fall back in love with cinema, and *Andrey Rublyov*, the film that awakened me to the duties of talent while re-sparking my belief in art and its critique. I will always consider Barcelona my home. I arrived a wide-eyed teenager in search of something I couldn't begin to define, I leave a happier man. Mission accomplished, I suppose.

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Chapter 1

Introduction

For over half a century now, the study of information asymmetries in markets has been of great interest to economists.[1] Among the many shades this situation can take, the most common is for the firm to hold more information on a good or service than the consumer. For instance, the consumers may not be able to observe the quality of a good before they buy it. The study of this type of markets falls into two main categories: when the informational advantage is persistent and when it disappears after consumption takes place. The first case pertains to credence goods, those whose quality is hard to ascertain even after consumption, usually found in settings where a consumer needs a diagnose or treatment, $i.e.$, medical services, technical repairs, education, consulting, etc. A lawyer or a physician always has an edge over the consumers, who will never know if the service offered was really what they needed. The second case is related to experience goods, all those with a quality uncertain to the consumers at the moment they take their participation decision, but which is often learned after consumption, $i.e.$, entertainment and artistic goods, travel and lodging, restaurants, wine, etc.

In this thesis we study both types of markets. First, analyzing the way information asymmetries affect the decisions of physicians competing in prices and the quality of the service they offer. Second, examining the role expert services and user reviews play in a market for experience goods. Therefore, this dissertation is a work of applied microeconomic theory falling under the umbrella of industrial organization, with economics of information as the running thread for the three applications we

[1] Cf. Stigler (1961), Akerlof (1970), Stiglitz (2000).

develop: two of them in health economics and one branching into online markets and cultural economics. Generally speaking, we survey the mechanisms underlying the asymmetries inherent to these markets, analyze their influence on agents' decisions, and discuss ways to deal with them. We also explore the alternatives available for consumers to learn about the uncertain qualities of the goods or services they are considering purchasing. In one case via anecdotal evidence, in the other through product reviews.

Both major applications look at markets where the lack of symmetric information is essential. In the case of the healthcare market, we study the behavior of patients who need to visit a physician whose ability they do not know, instead building an estimate using anecdotes gathered from close acquaintances. We then concentrate on the effect these estimates have on the ability and pricing strategies of the physicians. Regarding the market for experience goods, we examine the effect of freely available reviews on experts' behavior. The fact that experts must compete with costless user-generated content, though arguably of a lesser quality, undermines the informational advantage central to the service they provide, influencing their pricing strategies. These research lines combine topics from health economics, behavioral economics, and media studies.

In chapter 2 we study the effect of information availability on the ability and pricing strategies of physicians in a duopolistic market where patients reason anecdotically. The patients are aware of only some of the physicians in the market and estimate their abilities before deciding which one to visit. With ability we refer to the probability of a physician to improve a patient's health state. Each patient in the market estimates these abilities by drawing anecdotes from friends and family members who have previously been treated by the physicians. The patient takes the anecdotal evidence as fully representative of a physician's ability: a positive anecdote will lead her to believe that she, too, will be cured when visiting such a physician. Not all physicians are equally visible in the market, irrespective of their abilities. For instance, think of the inherited *fame* we observe in family sagas where the medical profession is carried over across generations. It is easier for a consumer to find anecdotes on a more visible physician. We take the visibility as the exogenous component of a physician's information, with ability representing the strategic part of it.

We find that more information availability leads to more differentiation in abilities and a lower average value. When information on both physicians is readily available, one of them sets the maximum level while the rival chooses a lower value. Conversely, an equilibrium where both physicians choose a maximum ability level occurs when information on at least one of them is not widely available. Our result is novel for two reasons: First, because it characterizes an equilibrium where all the physicians in a market set maximum ability levels despite the anecdote-based procedure followed by patients. Second, because we are able to find conditions under which physicians who compete with heterogeneous visibilities set homogeneous ability choices in equilibrium. We believe this result to have policy-relevant implications, particularly in a market where providing an outstanding service is paramount.

Chapter 3 presents an extension of the healthcare market model discussed in the preceding chapter. We consider a setup where a pair of physicians simultaneously and independently compete in prices and abilities over a market of consumers who use anecdotal evidence to estimate each physician's ability. However, we now consider the ability choice to have a marginal cost for the physicians. If a costless ability choice leads to an equilibrium where both physicians set the maximum ability level, it is interesting to examine how such an equilibrium is affected by an ability cost. We find that the relative size of the physicians' visibilities determines the abilities they set in the equilibrium. Ability differentiation appears at all visibility levels. In particular, the physician with a higher visibility tends to set a high ability the lower the rival's visibility is. However, if the visibility levels are not far apart, two robust equilibria in abilities are found. The ability cost is the main driver for low-ability decisions in the equilibrium. That is, the costlier it is for a physician to choose a high ability, the lower the average equilibrium ability found in the market. A planner might be interested in noting that when the ability is costly there is no equilibrium where the two physicians set the same ability level. Nevertheless, the two physicians' abilities increase in their visibilities. Hence, there is room to consider the quality-enforcing nature of information in a market where the physicians' ability choices are costly.

We present this dissertation's the second application in chapter 4, where we analyze the role of expert services and user reviews in experience goods markets. We begin by developing a model for a market of horizontally and vertically differentiated goods where the consumers know how much their type aligns with the good's but cannot observe the quality. An expert is present in the market and offers to reveal the quality in exchange for a fee. We find expert services to increase the consumers' welfare, although no demand-attraction effect takes place. An intermediate market arises between the expert and the consumers, and which is bigger than the demand faced by the firm. This happens because low-valuation consumers participate in the market for expert services, some of whom would not have considered buying the good if making the decision based only on their priors. On the other hand, consumers with high valuations who overestimated the quality of the good now dropout of the market after learning the quality from the expert. However, a relatively small segment of consumers consult the expert before buying the good, which along the linear utility assumed causes the firm to be indifferent to the presence on an expert in the market in the equilibrium.

Next we introduce free-to-access user reviews in the market. User reviews are a competing source of information for the expert, for they are costless to the consumers and offer them a refinement on their beliefs despite being of lesser informational quality than expert services. We model this through a binary reporting mechanism where user reviews are either positive or negative. The bent of these reviews has an effect on the type of consumers who buy the good, with higher-valuation ones buying when the review is negative and low-valuation consumers entering the market when it is positive. User reviews increase the consumer's surplus, though the firm remains indifferent. Hence, both expert services and user reviews increase consumers' welfare with respect to a benchmark where such agents decide based exclusively on their priors.

Expert services are sensitive to competing sources of information, serving a smaller demand, charging a lower fee, and obtaining less profits when user reviews become available. The firm is indifferent to the increase in information, charging the same price and obtaining identical profits in all the informational scenarios. User reviews grant the consumers a superior surplus than expert services alone, despite offering less accurate information on the good's quality. When both are available simultaneously, the social welfare significantly improves. We can therefore say that more information is beneficial to the consumers in a market for experience goods. We discuss this market using the film industry as an illustration. Technical appendices including proofs for all the propositions appear at the end of each chapter. A list with all the works referenced through this thesis closes the volume.

Chapter 2

Information availability and ability choice in a market for physicians

2.1 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 of a physician changing a patient's health state – to *cure* her. Consumers value being healthy and hence favor visiting the highest-ability physician they can afford. Therefore, each consumer tries to estimate the physicians' abilities by 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 asks 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 have access only 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, Foundation, and Henry J. Kaiser Family Foundation 2000), around 80% of Americans are "very or somewhat" confident that they had enough information to make the right choices the last time they had to choose a doctor. However, the same survey reports that less than 37% of the subjects would go beyond their close network to find information on 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, Wang, and Ubel 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 is over or underestimated. The second issue pertains to the probability of finding anecdotal evidence on a particular physician, which we denote by visibility and which 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

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

using anecdotal evidence. The limited nature of the consumers' estimations generates a demand 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 ability choices on the physicians' 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. This sample comes from the subset of physicians a consumer is aware of – her consideration set. The composition of such a set is determined by the physicians' visibilities. The easier it is to find anecdotes about them, the more consumers will have them in their consideration sets. 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 which the physicians set before meeting the consumers. Ability choice is costless for the physicians and is 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 are either aware of only one physician and draw a positive anecdote, or being aware of both physicians gather a positive anecdote about one and a negative for the rival. Two main trade-offs emerge from this demand structure. First, the higher the price a physician sets, the larger 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 and ultimately driving the market to higher equilibrium prices.

In light of these trade-offs, information availability – captured by the physicians' visibilities – is found to be a major determinant over the average ability level observed in equilibrium. We find that more information 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 make 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 less access to information. In other words, the average ability in the equilibrium is highest for small visibilities.

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 and is therefore 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 through only when we take abilities and visibilities as given, since in such a case the interaction between the physicians becomes a pricing game exclusively. 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 in order 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, with both of them 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, with an emphasis on the consumers' behavior. Next, we discuss the prices and abilities equilibria when finding a past-patient depends on the physicians' visibility levels. Finally, we comment on the way these variables change with respect to some of the main modeling parameters, also paying attention to the strategic interactions taking place between the physicians' decisions. All the proofs are included in the technical appendix.

2.2 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 an $S(1)$ 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. Along 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 them to suboptimal decisions, 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

[2] For a survey on this issue, from a healthcare perspective, see Lipkus, Samsa, and Rimer (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).

option. The anecdotal reasoning modeled through the $S(1)$ rule allows the market to be active, whereas under perfect information that 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 that 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 in which vertically-differentiated markets are analyzed, contrasting the robustness of Spiegler's results in a more general setting.

Despite its proximity to 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-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 the physicians being able to strategically modify their visibilities. 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 on 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. The results in Szech (2011) 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 work.

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, though they have no control over their visibility. Moreover, we find that the interplay between these variables is a major factor in the establishment of an equilibrium, driving the trade-off that allows ability differentiation. Actually, the results

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

presented in Spiegler (2006), Szech (2011), and (to some extent) Ireland (1993) 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 an outcome as policy-relevant as the one 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.

2.3 The 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 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 hand, physicians are fully rational agents that are 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 of 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 their services, which is publicly known. Ability choice is costless for the physicians.

On the other hand, 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 an $S(1)$ 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 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 with 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. Similarly, 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.

2.3.1 The Sampling Process

The consumers do not know the abilities of the physicians in the market and estimate them following an $S(1)$ boundedly-rational procedure. Therefore, they independently sample a single past-patient from each of the physicians in their consideration sets. These consideration sets represent the fact that consumers might not have access to anecdotal evidence on 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 out of the whole mass, a segment which is hence 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 a parameter equal to Physician i's ability α_i. Thus, a consumer observes a positive anecdote ($i.e.$, an outcome with value 1) with probability α_i when she samples Physician i. That is, the patient she sampled recovered after visiting Physician i with probability α_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 following this sampling process, the consumers build their beliefs on physicians' abilities based entirely on anecdotal evidence. If the anecdote is positive the consumers think they will also be cured when visiting the same physician. Therefore, the consumers believe Physician i's ability to be maximal: $\widehat{\alpha_i} = 1$, where $\widehat{\alpha_i}$ denotes the value of the estimation. On the contrary, if the outcome is negative (the past-patient sampled was not cured despite visiting i), the consumers believe they will not be cured either. As a consequence, they assume Physician i's ability to be null: $\widehat{\alpha_i} = 0$.

2.4 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 one of the physicians 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 about whom she has heard positive anecdotes. 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 the 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 of being 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 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,

[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 $\widehat{\alpha_i} = 1$ 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 $1 - p_i$.

by setting a price closer to the monopoly level the physician would lose demand in 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 between the physicians. These cases are given by the third term in the first and second lines of the demand function above.

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, established through the 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 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 that is 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 that 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 determining which demand a given 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. A physician's demand increases the more visible he is.

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 exclusively depend on these products because: as being included in a consumer's consideration set and the 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 his being 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 the physician's ability and its potential influence over the market outcomes, which we indeed study here.

The physicians are fully rational and perfectly 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.

2.5 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 section 2.6. Nevertheless, we can already grasp some of the effects this interaction has on the price competition stage, as discussed in the current section.

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 found a positive anecdote concerning him and a negative one from the competitor – his captive demand. 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 when playing such strategies.

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,

[5] As in this paper's case, the $S(1)$ rule; though in Spiegler (2006) there are no restrictions on what

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 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

past-patients the consumers can sample.

[6]We talk about a relative dominance because our assumption does not imply that the physician has either a superior ability or visibility. Instead, it claims that the combination of both parameters

2's relative superiority. Thus, the probability for him to price in the upper bound decreases as the gap between abilities and visibilities disappears. More simply put, as his relative dominance is weakened.

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.*, when the gap in visibilities and abilities diminishes and the dominant physician's advantage becomes smaller. 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 larger 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, would take place under such a scenario.

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.

Both physicians' 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 for both physicians is smaller. Thus, 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, 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:

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

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.

[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 inverse scenario still holds.

We have so far discussed 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 move to the preceding stage, where the physicians choose their ability level. We analyze these decisions in the following section.

2.6 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 that the consumers reason anecdotically, such a decision resonates in the demand the physicians face. Among the physicians included in the consideration set, the ability determines the probability of a consumer finding 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 in which consumers form their beliefs, as seen in Ireland (1993) and Szech (2011). Yet, unlike what those two studies postulate, the availability of information on the physicians must also be taken into account in our equilibrium, represented in our setup by the physicians' 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 than a well-known competitor with a lower ability level. Therefore, the trade-off between ability and

[8] This is particularly true for the case we are currently analyzing, 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.

visibility becomes crucial for the physicians' decisions.

Two equilibria in abilities are possible in the market setting we analyze, depending on the physicians' visibilities. How high or low these visibilities 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 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. 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 may be, the higher the ability is, the more likely it is for them to come by positive anecdotal evidence. Thus, if a physician is endowed with a low γ_i – $i.e.$, he has unfavorable initial conditions 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 will report a positive experience.

In this equilibrium the better-known physician is in a relatively advantageous position given his superior visibility, $\gamma_2 \geq \gamma_1$. Thus, Physician 2 sets a higher price and obtains bigger profits 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:

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

The profits for both Physician 1 and 2 positively depend on their respective visibilities, when these have values of one half or less. 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 a 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 vice-versa. 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 of each physician's demand, 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 case 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 obtain are given by:

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

The better-known physician prices more highly, serves a bigger demand, and obtains superior profits to those of 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, itself a function of γ_1. On the other hand, Physician 2's profits increase with his visibility.

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

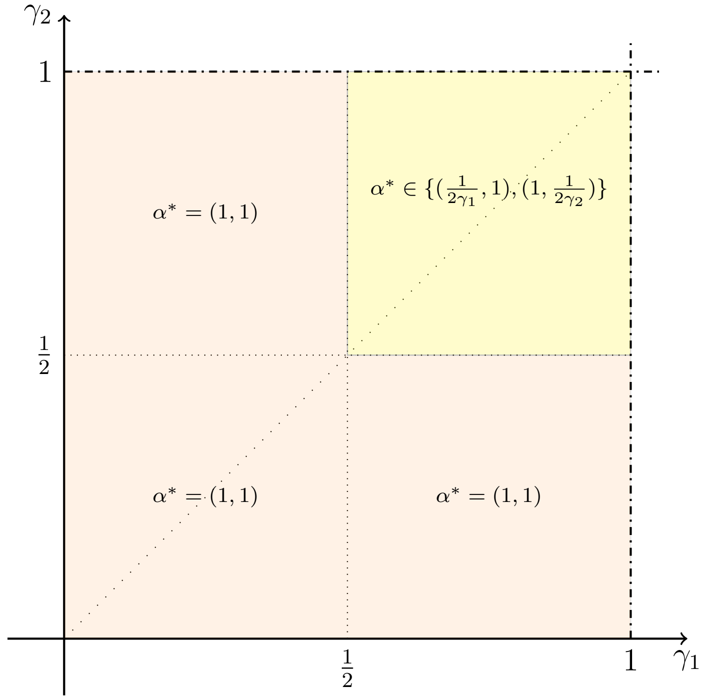


Figure 2.1: **Ability equilibria as a function of visibilities (γ_1, γ_2)**

Figure 2.1 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. 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 section 2.5 is relatively small. The two physicians will very rarely compete in prices, hence the incentives to reduce the intensity of price competition by setting a below-maximal ability level.

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 by all intents 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 and 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 that is proportionally smaller than that of 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 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 an 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 continue to price above his rival irrespective of how we denote its identity.

2.7 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 market settings of this ilk. 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 that 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, 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 equilibrium where one of the physicians chooses a lower ability level, as established in the literature, only when both physicians have high visibilities. Our setup allows for an equilibrium where all physicians in the market set the maximum ability level, in contrast to 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 might 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 operating 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 fixed fee for the physicians' services, which would induce them to focus on ability competition and lead them to the highest ability level since the decision is costless.

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 analyzing the interaction between visibility and ability choice in greater depth. In this chapter 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 depends on the number of patients he has 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 findings 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, plays an increasingly critical role. An examination of a similar market where ability choice is costly is presented in the next chapter.

Technical Appendix

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 we 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 physicians 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 will assign 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 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 about 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 to 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 $(\alpha_1 = \frac{1}{2\gamma_1}, \alpha_2 = 1)$.

■

Chapter 3

Costly ability choice in a healthcare market where consumers base their decisions on anecdotal evidence

3.1 Introduction

In chapter 2 we studied the role of information availability in a market for physicians. Typically, the consumers have limited access to information when deciding which physician to visit (Dulleck and Kerschbamer 2006). An average consumer does not know the quality of a healthcare service before she has been treated or she might not even be aware of the existence of the service at all. If she sprains her ankle, the consumer may not know if a private traumatologist is better than a public one or which of the many working in private practice is her best option. Thus, consumers in healthcare markets often base their decisions on the anecdotal evidence they obtain from family members and friends (The Kaiser Family Foundation 2001, Tu and Lauer 2008, Freed et al. 2010, Mostaghimi, Crotty, and Landon 2010, Azu, Lilley, and Kolli 2012). If an acquaintance recovered from her illness after visiting a physician, the consumers take this as an indicator of the physican's ability and use it to inform their decisions (Spiegler 2006).

Information in this context is modeled through the product of an exogenous and a strategic variable, respectively denoting a physician's visibility and ability. The former captures how well-known a physician is, $i.e.$, if it is easy for a consumer to find a family member whom the physician has treated. The latter is a measure of the physician's quality, representing the probability of his being able to cure a patient. A consumer who visits a physician with a high ability has a higher probability of recovering. However, a high-ability physician is not necessarily more visible than a low-ability rival. A high-visibility physician simply has treated many patients in the past, though not all of them may have recovered. In chapter 2 we find that more information leads to more differentiation in abilities, with lower average values appearing in the equilibrium. That is, 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. And while low visibilities lead to an equilibrium where all the physicians set a maximum ability level, differentiation appears even when the ability choice is costless for the physicians.

Indeed, it is interesting to examine to what extent these results are driven by the costless ability. Particularly the equilibrium where all physicians choose the maximum ability level, which takes place when the visibilities are not high, and despite the heterogeneity in the physicians' visibilities and the limited information available to the consumers. In general, the sampling-based nature of the procedure the consumers follow to decide which physician to visit allows low-ability agents to participate in the market (Spiegler 2006, Szech 2011, chapter 2 of this dissertation). It might be that they can also operate when visibilities are low, leading to outcomes where both physicians choose lower equilibrium abilities if the ability is costly. We introduce a convex cost for the abilities in order to capture the investment physicians make when setting a high ability level. This separates our model from preceding works, which either did not consider the abilities as a strategic variable or took it as a costless choice.

We find that the two physicians differentiate in abilities for any combination of visibilities in the support. That is, while in chapter 2 they both set the same ability level as long as at least one of their visibilities was small enough, here the relatively-dominant physician will always choose a higher equilibrium ability, no matter the specific size of the visibilities. These continue to be taken as exogenous, although the relatively-dominant physician will be the one who has a superior visibility. The relatively-dominant player is in an advantageous situation with respect to his competitor, for he charges a higher fee, serves a bigger demand, and obtains more profits than the rival.

Both physicians' equilibrium abilities decrease in the cost. Thus, the costlier it is for a physician to offer a high-quality service, the further down the overall market standard is pushed. Similarly, the difference between the equilibrium abilities diminishes as the non-dominant physician's visibility increases, thus reducing the dominant player's advantage.

The rest of this paper is organized as follows: we develop a model for a duopoly where the physicians compete in prices and costly abilities. Next, we discuss the pricing competition equilibrium as examined in chapter 2. A section comprising the ability competition stage follows. We close the paper with a short note outlining a dynamic analysis of the market, where visibilities are carried over time as a measure of a physician's market share. That is, today's physicians' visibilities are given by the market share of the past-generation's physicians. All the proofs are included in a technical appendix.

3.2 The Model

The healthcare market we study comprises two physicians, denoted by $i \in \{1, 2\}$, and a mass of consumers indexed by their uniformly-distributed willingness to pay for healthcare services, $\theta \sim U(0, 1)$.

We define health as a binary variable $r \in \{0,1\}$, where $r = 0$ when the consumer is ill and $r = 1$ if she is in full health. All the consumers are initially ill, suffering a condition unique in its severity and type. That is, they all have a sprained ankle or a mild stomach flu.

The consumers search for a physician to treat them, since only a physician can change a consumer's health state. A consumer who visits Physician i may or may not recover from her ailment after being treated, but would certainly remain ill if she decided to stay out of the market.

The physicians are fully rational and perfectly informed agents who compete in prices and abilities: p_i and α_i for $i \in \{1,2\}$. By ability we simply refer to the probability of a physician changing a consumer's health state. A consumer who visits Physician i will be cured with probability $\alpha_i \in [0,1]$, her health state changing from 0 to 1. The physicians simultaneously and independently set their ability levels before meeting the consumers. The ability choice cost for Physician i is described by the following function: $C(\alpha_i) = \frac{1}{2}c\alpha_i^2$, where $c > 0$. Providing the healthcare service is otherwise costless for the physicians.

The two physicians observe the ability chosen by their rival and then set the fees they will charge for their services $p_i \in (0,1)$. Each physician is endowed with a visibility $\gamma_i \in (0,1]$. A physician's visibility captures how well-known he is, how easy it is to find patients he has treated in the past, his *fame* level. We assume the visibilities to be non-strategic and independent of the ability, since they come to represent whether a physician is part of a family saga in the medical profession and has thus inherited some name recognition irrespective of his specific ability level, or if he might have gone to a more prestigious medical school than his average peer.

Unlike the physicians, the consumers are not perfectly informed and base their decisions on information gathered through a sampling procedure. In particular, the consumers know the physicians' fees but only estimate their abilities. In order to do that, each consumer asks a family member or friend if they know a physician who could treat her. We denote the information thus disclosed as an anecdote. If the past-patient recovered after visiting the physician, the anecdote is considered positive and the consumer believes she will also be cured when visiting such a physician. On the contrary, a negative anecdote means that the consumer will believe she would not be cured by the physician either, thus deciding not to visit him. This decision procedure is well established in the literature, known as the $S(1)$ rule and analyzed in a similar healthcare market in chapter 2.

When drawing the sample they use to estimate a physician's ability the consumers are limited to the set of those physicians who have treated someone they know. We can therefore see γ_i as the exogenously given probability for Physician i to be considered by a particular consumer, $i.e.$, a patient who visited Physician i will be sampled by a γ_i portion of the consumer mass. Physician i is unknown to the remaining $1 - \gamma_i$ mass of consumers. The physicians know both their own and the rival's visibilities.

Each consumer draws a single anecdote for every physician they know and use it to estimate their abilities. After building their beliefs on the physicians' abilities, the consumers compare them based on the observed outcomes and the fees charged, deciding which one to visit according to their expected health value.

We assume the consumers derive no utility from being sick. Thus, a consumer with willingness to pay θ who visits Physician i obtains the following expected utility:

$$U(\theta, \widehat{\alpha_i}) = \theta\widehat{\alpha_i} - p_i,$$

where $\widehat{\alpha_i}$ is Physician i's ability as estimated by the consumer from her sample. This estimate is also a binary variable, $\widehat{\alpha_i} \in \{0, 1\}$, taking value 1 if the anecdote found by the consumer is positive. A consumer never visits a physicians whose anecdote was negative.

The timing of the game is:

1. The physicians simultaneously and independently choose their abilities.
2. Aware of the rival's abilities and visibilities, both physicians set a fee.
3. Every consumer takes a size-one sample from the physician in her consideration set.
4. Based on the sampled outcomes, the fees, and her willingness to pay for health-care services, the consumer takes the participation decisions.

Closely following chapter 2 we solve the game by backwards induction. The analysis of the price competition stage is not changed by the fact that ability choice is now costly for the physicians. Thus, in section 3.3 we briefly comment the equilibrium pricing strategies adopted by the physicians as presented in chapter 2. Next, we consider the ability setting stage in section 3.4, where the physicians strategically choose their ability level.

3.3 Price Competition Stage

In this section we briefly review the equilibrium behavior of the consumers and the pricing strategies of the physicians. A more detailed analysis is presented in chapter 2, where consumers also base their decisions on anecdotes and the physicians in the duopoly compete in prices and abilities, although the latter is a costless choice for them. In the current chapter we deem the ability costly, bringing our setup – and the ability as a strategic variable itself – closer to representing a physician's diagnose effort.

The consumers follow a boundedly rational $S(1)$ procedure to estimate the ability of the physicians in the market. From an independent, random size-one sample drawn from the patients who Physician i had treated in the past, each consumer estimates

$\widehat{\alpha_i}$. Thus, if a consumer knows a friend who visited Physician i and recovered after the treatment, she believes $\widehat{\alpha_i} = 1$. On the contrary, she will estimate $\widehat{\alpha_i} = 0$ if the friend did not recover despite visiting Physician i. Thus, she will decide to visit Physician i if she finds a positive anecdote and $p_i \leq \theta$. In case the consumer is aware of both physicians and finds positive anecdotes simultaneously for the two of them, she will visit the one whose fee is the smallest.

This estimation procedure induces a demand comprising two segments for each physician: a captive and a contested demand segments. The captive demand segment includes all the consumers who are either aware of only one of the physicians, or find a positive anecdote for one of them and a negative for the other. The contested demand segment comprises all the consumers who find positive anecdotes for the two physicians at the same time. A Physician i is the only option for the consumers in his captive segment to consider visiting. He competes in prices with his rival over the contested segment, as such consumers consider the two physicians to be equivalent in abilities. A complete discussion of the demand system is included in section 2.5.

The physicians set their prices once their abilities have been chosen. Thus, we first look at their pricing strategies while taking the abilities as given. This entails that the costly ability choice has no real influence on their strategies. That is, the equilibrium pricing strategies will be completely equivalent to those found when the ability choice had no cost for the physicians. Therefore, as seen in chapter 2, there is no Nash Equilibrium in pure strategies for the pricing game. Proposition 1 formally presents 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* $\alpha_1 \geq \frac{\gamma_2}{\gamma_1}\alpha_2$*, there is a unique Nash Equilibrium in mixed strategies characterized by the following c.d.f.s:*

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

and $F(1)$ *has a mass point at* $p_1 = \frac{1}{2}$*, occurring with probability* $M_1 = \frac{\gamma_1\alpha_1 - \gamma_2\alpha_2}{\alpha_1\gamma_1}$.

The presence of a captive demand segment is what makes the existence of a Nash Equilibrium in pure strategies impossible, for it gives the physicians incentives to set a price above their marginal cost. Similarly, the random nature of the sampling procedure allows low-ability physicians to participate in the market. A consumer might find the proverbial patient who from sheer luck was cured after visiting a very lousy physician, overestimate his ability and then decide to visit the *bad* physician herself. These two effects of anecdote-based reasoning in the healthcare market align with Spiegler's (2006) and Szech's (2011) findings, as discussed in chapter 2.

We can also see that the relatively dominant physician, $i.e.$, the one whose information is more plentiful, charges a higher fee in expected terms. The extent of this dominance is captured by the atom found in the relatively-dominant physician's $C.D.F.$, which we presented in the pricing equilibrium stage. In Proposition 1 we assume without loss of generality that Physician 1 is the relatively dominant player. Hence, in the equilibrium $\alpha_1 \geq \frac{\gamma_2}{\gamma_1}\alpha_2$ implies that Physician 1 sets a price closer to the one he would charge as a monopolist. The relatively dominant physician is also able to serve a bigger demand segment and obtain higher profits. How much *better-known* the relatively dominant physician is – the size of the atom – will determine the pervasiveness of the price differential. Moreover, when information becomes more plentiful, the competition in prices turns tougher, with the equilibrium prices converging to the marginal cost as both $\gamma_1\alpha_1$ and $\gamma_2\alpha_2$ approach 1, meaning that the two physicians and their abilities are universally known.

Two main trade-offs emerge from the physicians' equilibrium pricing strategies. First, they can decide to focus on their captive demand, charging a higher price but becoming less competitive over the contested segment of the market. Second, they can surrender some of their captive demand to make the rival focus on his own captive demand, pushing up the equilibrium price throughout the whole market. In simpler words, the non-dominant physician can set a higher equilibrium price by inducing his rival to focus on his own captive demand. We can already see the mechanism behind this interaction in the $C.D.F.$ of the relatively dominant physician's pricing strategies, since it is a decreasing function of the rival's ability. Hence, the non-dominant player is able to steer the dominant physician's pricing strategies through his own ability decision. We explore this interaction, as well as the potential incentives for the physicians to differentiate in abilities, in the following section.

3.4 Ability Competition Stage

We now move on to discuss the equilibrium ability choices. In this stage of the game the physicians independently set the value of α_i. The ability level determines not only the probability of a consumer recovering after visiting a physician, but also of her finding a positive anecdote for a given physician. In this stage of the game the physicians maximize their profits knowing that they will next compete in prices. We obtain the physicians' respective expected demand functions from Proposition 1 and present them in the following corollary.

Corollary 1. *The equilibrium expected demands for the physicians are:*

$$ED_1 = \frac{\alpha_1\gamma_1(1-\alpha_2\gamma_2)}{4p_1} \quad \textit{and} \quad ED_2 = \frac{\alpha_2\gamma_2(1-\alpha_2\gamma_2)}{4p_2}.$$

Recall that Proposition 1 is written assuming without loss of generality that Physician 1 is the relatively-dominant player. Since the ability is taken as exogenous in that stage of the game, the equilibrium in pricing strategies will be symmetric in case the rival is the relatively-dominant physician. Thus, more generally speaking, the maximization problem Physician i faces if he is the relatively-dominant player, is the following:

$$\begin{aligned} &\max_{\alpha_i} \quad \frac{\alpha_i\gamma_i(1-\alpha_j\gamma_j)}{4} - \frac{1}{2}c\alpha_i^2 \\ &\text{st.} \quad \alpha_i \geq \frac{\gamma_j}{\gamma_i}\alpha_j, \end{aligned}$$

where $i, j \in \{1, 2\} : i \neq j$. Physician j's maximization problem is only different in that his demand is a function of his own ability and visibility, not the rival's. Hence, the non-dominant physician's maximization problem is the following:

$$\begin{aligned} &\max_{\alpha_j} \quad \frac{\alpha_j\gamma_j(1-\alpha_j\gamma_j)}{4} - \frac{1}{2}c\alpha_j^2 \\ &\text{st.} \quad \alpha_j \leq \frac{\gamma_i}{\gamma_j}\alpha_i. \end{aligned}$$

Notice that the problem the two physicians solve includes the cost of the ability, which crucially differentiates this stage of the competitive game and the one studied in section 2.6. The convex cost function $C(\alpha_i) = \frac{1}{2}c\alpha_i^2$ captures the fact that a physician's incentives to set a high alpha, so that he is able to attract many consumers from both the captive and contested demand segments, are counterbalanced by how costly it is for him to increase his ability level. If in the costless ability choice setting we modeled in chapter 2 this choice represented the diagnose technology or professional preparation a physician decided to acquire before entering the market, when the decision is costly we move closer to a setting where the physician decides his performance standards during a specific market period.

From solving the respective maximization problems we find that there are two possible equilibria in the ability competition stage, which will be adopted by the physicians depending on the relative size of their visibilities. We denote these equilibria as follows:

$$(\widetilde{\alpha_1}, \widetilde{\alpha_2}) = \left(\frac{\gamma_1(4c+\gamma_2^2)}{8c(2c+\gamma_2^2)}, \frac{\gamma_2}{4c+2\gamma_2^2} \right) \quad \text{and} \quad (\widetilde{\alpha_1}', \widetilde{\alpha_2}') = \left(\frac{\gamma_1}{4c+2\gamma_1^2}, \frac{\gamma_2(4c+\gamma_1^2)}{8c(2c+\gamma_1^2)} \right).$$

In which case either of these will be the equilibrium strategy played by the physicians is determined by the following visibility levels:

$$\gamma_1^A(\gamma_2) \equiv \frac{2\gamma_2\sqrt{2c(2c+\gamma_2^2)}}{4c+\gamma_2^2} \text{ and } \gamma_1^B(\gamma_2) \equiv \sqrt{\frac{4c\gamma_2^2}{2(c+\sqrt{c(c+\gamma_2^2)})-\gamma_2^2}},$$

where $\gamma_1^B(\gamma_2) > \gamma_2 > \gamma_1^A(\gamma_2)$. These cut-off levels define three regions in the physicians' visibility space. In these regions the equilibrium decisions of the physicians will either be $(\widetilde{\alpha_1}, \widetilde{\alpha_2})$, $(\widetilde{\alpha_1}', \widetilde{\alpha_2}')$ or both.

Thus, the equilibria found when the physicians compete in abilities depends on the region their visibilities fall into. We formally describe the result in the following proposition.

Proposition 2. *In the ability competition stage of the game, with two physicians active in the market and given the visibilities $\gamma_i \in (0,1)$ for $i \in \{1,2\}$, the set of Nash Equilibria is the following:*

a. $\{(\widetilde{\alpha_1}, \widetilde{\alpha_2})\}$ *if* $\gamma_1 > \gamma_1^B(\gamma_2)$.

b. $\{(\widetilde{\alpha_1}, \widetilde{\alpha_2}), (\widetilde{\alpha_1}', \widetilde{\alpha_2}')\}$ *if* $\gamma_1 \in [\gamma_1^A(\gamma_2), \gamma_1^B(\gamma_2)]$.

c. $\{(\widetilde{\alpha_1}', \widetilde{\alpha_2}')\}$ *if* $\gamma_1 < \gamma_1^A(\gamma_2)$.

We can see that a unique Nash Equilibrium in abilities is found when the physician's visibilities are such that they fall either in regions $a.$ or $c.$ On the other hand, if the visibilities are in region $b.$, there are two Nash Equilibria in abilities. In region $b.$, Physician 1 either sets a high or low ability level, with $\widetilde{\alpha_1}$ being the superior ability if $\gamma_1 \in [\gamma_2, \gamma_1^B]$. For the rival, $\widetilde{\alpha_2}'$ is the superior ability when $\gamma_1 \in [\gamma_1^A, \gamma_2]$. However, $\widetilde{\alpha_1}'$ and $\widetilde{\alpha_2}$ are also equilibrium strategies in those regions for the respective physician.

In the case where γ_1 falls in regions $a.$ or $c.$ the relatively-dominant physician always sets the highest ability level. Thus, Physician 1 is the relatively-dominant player in region $a.$ and so is Physician 2 in region $c.$

The equilibrium abilities in the three regions are functions of the physicians' visibilities and the cost. Regardless of who the dominant player is, the relative size of the visibilities largely affects the ability levels observed in the equilibrium. We discuss the comparative statics of these abilities in the following corollary.

Corollary 2. *In any of the Nash Equilibria presented in Proposition 2 the physicians' abilities increase in their own visibilities and decrease in that of the rival's. Both physicians' equilibrium abilities negatively depend on the ability cost.*

As expected, the physicians' abilities in the three regions decrease as the cost rises. Compared to the result in section 2.6 where if both visibilities were close to zero, the two physicians would choose the maximum ability level, here any small but positive cost would imply a lower average equilibrium level in abilities for low visibility values. Which is to say, if both visibilities are smaller than $\frac{1}{2}$ and there is an ability cost, the two equilibrium abilities are smaller than those set by the physicians when the choice was costless. This, however, does not imply an increase in the difference between the two abilities. The average ability is lower the higher the cost gets, but $\widetilde{\alpha_1}$ and $\widetilde{\alpha_2}'$ continue to be superior to the rival's in regions $a.$ and $c.$ That is, both abilities decrease in the cost but none more so than the other, neither to the point where the relatively-dominant physician ceases to be so.

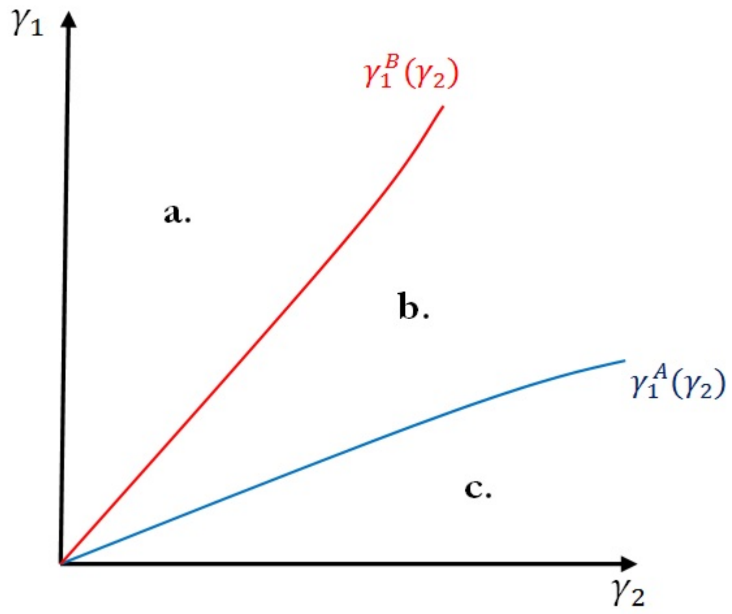
In terms of visibilities we find that $\widetilde{\alpha_1}$ negatively depends on Physician 2's visibility. Similarly, $\widetilde{\alpha_2}'$ decreases in γ_1. We can therefore say that the relatively-dominant physician's ability decreases in the rival's visibility. This suggests that when a physician's dominant position is weakened, he has fewer incentives to set a high ability in the equilibrium. Moreover, the equilibrium fee a physician sets also decreases in the rival's visibility. An increase in the rival's visibility entails a fiercer price competition over a larger portion of the market, leading the relatively-dominant physician to a less profitable position.

The equilibrium abilities for both the dominant and non-dominant physicians in regions $a.$, $b.$, and $c.$ are increasing functions of their own visibility. When more consumers are aware of a physician and can find positive anecdotes easily, such a physician not only serves a bigger demand, but also charges a higher fee for his services. As a consequence, when the rival is more visible a consumer is more likely to find two positive anecdotes simultaneously. This implies a higher probability that consumers will consider the physicians equivalent in abilities, basing their decision to visit one of them on the price. Setting a high ability level while charging a lower fee is not attractive for the relatively-dominant physician, given the negative relationship between $\widetilde{\alpha_1}$ and γ_2, and $\widetilde{\alpha_2}'$ and γ_1.

Therefore, more information becoming available to the consumers in the form of easier-to-find anecdotes might lead to smaller fees, but it will also lower the average ability levels in some equilibria, particularly when the relatively-dominant physician's visibility remains unchanged with respect to an increase in the rival's. This result is consistent with our findings in chapter 2, where low average ability levels appeared when the two physicians' visibilities were above $\frac{1}{2}$. On the contrary, if both visibilities increase simultaneously, with the dominant physician's advantage being only narrowly affected, both physicians might have incentives to increase their ability level if the marginal cost of doing so is small enough. That is, a low cost and low visibilities might lead to higher equilibrium abilities in our model than high visibilities and a low cost do.

In the following graph we present the three equilibria described in Proposition 2 and the visibility combinations determining the regions where they will be found. Each region is denoted with the corresponding equilibria set, as detailed in Proposition 2.

Figure 3.1: **Nash Equilibria in the Ability Competition Stage**



It is easy to identify the relatively dominant player in the regions where only one Nash Equilibrium exists. In region $a.$, Physician 1 is the relatively-dominant player, setting a higher ability level and serving a bigger demand. On the other hand, Physician 2 is the relatively dominant player in region $c.$

Both regions $a.$ and $c.$ expand when the ability choice becomes more costly. Naturally, a costlier ability choice makes it less attractive for a non-dominant physician to set a high ability level in the equilibrium. For instance, if the cost c is high and $\gamma_1 \in [\gamma_1^B, 1]$, Physician 1 is more likely to choose $\widetilde{\alpha_1}$ in the equilibrium. That is, the region where $\widetilde{\alpha_1}$ and $\widetilde{\alpha_1}'$ are equilibria for him, becomes smaller. In Figure 1 this would amount to region $b.$ becoming smaller as the ability cost rises.

All things equal, a higher ability allows the relatively-dominant physician to charge a higher fee, since his captive demand segment enlarges. A higher equilibrium fee is an evident reply to a higher ability cost. Region $a.$ also expands in γ_2, which means that when the relatively-dominant physician's advantage becomes less strong, he has incentives to set a high ability in the equilibrium, provided the cost is not too high. If the mass point included in his equilibrium pricing strategies' $C.D.F.$ becomes smaller, then the dominant physician's captive demand segment is diminished. Hence, the physician has incentives to be more competitive over the contested demand segment, and the way for him to do so is through a high ability level. In other words, the two responses the relatively-dominant physician has to counter an increase in the rival's visibility are to set a high ability level or lower his fee.

An analysis of the equilibrium profits the physicians obtain in each region reveals that the relatively-dominant player is in an advantageous position. That is, he obtains higher profits than his rival. In each of the regions defined in Proposition 2 the physician's profits are given by:

a. $\left\{\widetilde{\Pi_1} = \frac{\gamma_1^2\left(\gamma_2^2+4c\right)^2}{128c\left(\gamma_2^2+2c\right)^2}, \ \widetilde{\Pi_2} = \frac{\gamma_2^2}{16\gamma_2^2+32c}\right\}$,

b. $\left\{\widetilde{\Pi_1} = \frac{\gamma_1^2\left(\gamma_2^2+4c\right)^2}{128c\left(\gamma_2^2+2c\right)^2}, \ \widetilde{\Pi_2} = \frac{\gamma_2^2}{16\gamma_2^2+32c}\right\}$ or $\left\{\widetilde{\Pi_1}' = \frac{\gamma_1^2}{16\gamma_1^2+32c}, \ \widetilde{\Pi_2}' = \frac{\gamma_2^2\left(\gamma_1^2+4c\right)^2}{128c\left(\gamma_1^2+2c\right)^2}\right\}$,

c. $\left\{\widetilde{\Pi_1}' = \frac{\gamma_1^2}{16\gamma_1^2+32c}, \ \widetilde{\Pi_2}' = \frac{\gamma_2^2\left(\gamma_1^2+4c\right)^2}{128c\left(\gamma_1^2+2c\right)^2}\right\}$.

In all cases a Physician's profit levels increase in his visibility. That is, he is able to attract more consumers, has incentives to set a higher ability level, and can charge a higher fee. This is true for both the dominant and the non-dominant players, though the effect is somewhat amplified for the dominant physician. On the other hand, a costlier ability diminishes the profits level for the two physicians. A higher cost causes the physicians' captive demands to shrink, forcing them to compete in prices.

Looking at region $b.$ we find that although both equilibria are robust we can rank them in terms of the total industry profits. The total profits obtained by the two physicians are always higher when the relatively dominant physician chooses a high ability. That is $\widetilde{\Pi_1} + \widetilde{\Pi_2} \geq \widetilde{\Pi_1}' + \widetilde{\Pi_2}'$ in region $a.$, where Physician 1 is the relatively-dominant player, but also in the portion of region $b.$ where $\gamma_1 \in \left[\gamma_2, \gamma_1^B\right]$. The same argument applies for Physician 2 and the region determined by $\gamma_1 \in (0, \gamma_2)$. We formally present this result in the following proposition.

Proposition 3. *The strategies $\{\widetilde{\alpha_1}, \widetilde{\alpha_2}\}$ lead to higher total profits for the physicians than $\{\widetilde{\alpha_1}', \widetilde{\alpha_2}'\}$ if and only if $\gamma_1 \geq \gamma_2$.*

Given the equilibrium allocations found in Proposition 2, we know that both physicians will always choose different ability levels leading to one leader and a follower. Proposition 3 describes a scenario in which we can argue that the Pareto efficiency of the equilibrium where the relatively-dominant physician sets the highest ability level is superior, even when more than one equilibria exists. In the terms discussed in Proposition 2 this implies that in region b. the strategies $\{\widetilde{\alpha_1}, \widetilde{\alpha_2}\}$ establish a more efficient equilibrium from the perspective of total industry profits than $\{\widetilde{\alpha_1}', \widetilde{\alpha_2}'\}$ when $\gamma_1 > \gamma_2$. By symmetry, the same happens for $\{\widetilde{\alpha_1}', \widetilde{\alpha_2}'\}$ when $\gamma_1 < \gamma_2$.

Following this argument we can say that Physician 1 will be the relatively-dominant player when $\gamma_1 \geq \gamma_2$, with the physicians setting the equilibrium abilities corresponding to Proposition 2's region a. By symmetry, Physician 2 is the relatively-dominant player when $\gamma_2 > \gamma_1$ and the equilibrium is the one defined in Proposition 2's region c. Under this frame of analysis, where a total efficiency argument would take precedence, the dominant physician would always be the one who has the higher visibility level.[1]

The ability cost is what ultimately determines whether the non-dominant physician will set a higher equilibrium ability the more visible he is. That is, both physicians' ability choices decrease in the cost. However, if this cost is high enough the non-dominant physician may have incentives to set a higher ability in the equilibrium the higher his visibility is. The rationale for this being that the non-dominant physician can catch-up quickly to his rival, since both the ability cost and the increase in the

[1]This hints at the importance of family sagas and inherited advantages as captured by the visibilities in our model, a particularly interesting implication in the analysis of a dynamic setting. That said, the existence of more than one Nash Equilibria in one portion of the visibility space somewhat complicates this analysis, as we are unaware of refinements that could weed-out either of them.

non-dominant physician's visibility undermine the dominant player's advantage.

A higher ability increases the non-dominant player's competitiveness and his potential demand, thus being a fitting strategic response. On the other hand, if the ability cost is low or very close to zero, the non-dominant physician's equilibrium ability decreases in his visibility. This happens because the non-dominant physician decides to focus on his captive demand, charging a higher fee. The low ability cost also means that the dominant physician will choose a high ability, becoming a tougher competitor over the contested segment of the demand. This outcome is very close to what we found in chapter 2 when the ability choice was costless for the physicians. Moreover, high visibility levels and a low ability cost would lead to an outcome where the differentiation is maximum, as found in section 2.6.

The fact that the relatively-dominant physician chooses the superior ability level implies that he will also serve a bigger demand in the equilibrium, charging a higher fee and obtaining more profits than the rival. The dominant player's profits increase in his visibility, indicating that as his advantage becomes more important, so does his dominance over the market. This is captured by the atom present in his pricing strategies' $C.D.F.$, as discussed in Proposition 1. The bigger this atom turns, the more likely the dominant physician is to set a price close to the monopoly level. As a consequence, his captive demand comprises a larger segment of the market. Moreover, his superior ability will also make him a strong competitor over the contested segment as well.

An increase in the ability cost diminishes the equilibrium profits for the two physicians, again per the convex nature assumed when modeling the cost of choosing an ability level. That is, the two equilibrium abilities decrease in the cost as seen in Corollary 2, whereas the pricing strategies are not adjusted, leading to a reduction in the physicians' profits.

The non-dominant physician's profits rise as he becomes more visible. This makes the non-dominant agent more competitive, relative to a dominant player whose advantageous position is weakened. As a result, the contested demand segment expands, leading the two physicians to lower equilibrium fees.

3.5 Conclusions and Extensions

In this paper we study costly ability choices in a market for physicians where the consumers base their decisions on anecdotal evidence. To a large degree, that constitutes an extension of chapter 2, where a pair of physicians simultaneously and independently competed in prices and abilities over a market of consumers who used anecdotal evidence to estimate each physician's ability. We found that more information leads to more differentiation in abilities, with the physicians choosing low ability levels in the equilibrium even when such a decision was costless for them.

Consumers in this chapter follow the same reasoning procedure as in chapter 2. The main difference lies in that the competing duopoly now face a costly ability choice. We find that the relative size of the physicians' visibilities will determine the abilities they choose in the equilibrium. Thus, the physicians differentiate when the difference in visibilities is large, with the relatively-dominant player setting a higher ability level than his rival. Moreover, in many cases the relatively-dominant physician is also the one who has a higher visibility. On the other hand, if the visibility levels are not too far apart, two robust equilibria in abilities are found. In each of them, one of the physicians sets a higher ability than the competitor, though the relationship between the visibility level and the equilibrium ability of each one is not as clear.

From a policy perspective it is interesting that the total healthcare profits are bigger when the relatively-dominant physician is the one who sets the highest ability in the equilibrium. The dominant player serves the largest demand and charges the higher fee for his services, obtaining the most profits as well. These results align with the ones discussed in chapter 2, although there are many other important differences that deserve to be mentioned. First, when the ability is costly there is no equilibrium where the two physicians set the maximum ability. Actually, neither is there one where the competitors choose the same ability level. The two physicians differentiate in abilities for all visibilities as long as the choice carries a cost. Moreover, the costlier the ability decision is, the lower the equilibrium average ability found in the market.

The two physicians' abilities increase in their visibilities, with the dominant player's position becoming stronger as his visibility increases. The easier it is for a consumer to find an anecdote for a given physician, the more incentives he has to set a high ability. This result somewhat contradicts our findings in chapter 2, since in our current framework the equilibrium where both visibilities are equal to one does not lead to the maximum differentiation in abilities. Instead, this suggests to us several future research questions regarding the evolution of the physician's ability decisions over time.

If a physician's visibility were a function of his past performance, we could hypothesize that the relatively-dominant physician will continue to set a higher ability in the equilibrium, thus reasserting his dominance. In other words, a relatively-dominant physician in our framework is often the one with a higher visibility, which lets them set a higher ability and serve a bigger demand in the equilibrium. Next period, given that his visibility is tied to his preceding demand, the physician would also be the dominant one, since he remains to be the one with the highest visibility. From the perspective of a family saga this entails a double effect: those who start in an advantageous position tend to keep it in a hypothetical steady state, but also that those agents who are part of a saga have incentives to consistently choose a high ability level. It would be interesting to analyze the rival's response to this and the effect that might have on the average ability found in the market.

A more nuanced analysis of the welfare implications stemming from this intergenerational saga-effect would have to consider the cost of the ability choice as well. Looking back at an equilibrium where the ability is costless and the two physicians set the maximum level, we can imagine that a low-enough cost could allow the non-dominant rival to fight back by setting as high an ability level as possible. This could slowly erode the dominant saga's advantage, eventually equalizing the demand segments each physician serves; therefore, countering – in an eventual steady state – the advantage of being part of a family saga. What these scenarios mean for the consumers and the market at large is one of the questions we hope to tackle in the future research projects to originate from the present work.

Technical Appendix

Proof of Proposition 1. See chapter 2. ■

Proof of Proposition 2. The physicians' profits are given by:

$$\pi_1 = \begin{cases} \frac{\alpha_1\gamma_1(1-\alpha_2\gamma_2)}{4} - \frac{1}{2}c\alpha_1^2 & if\ \gamma_1\alpha_1 \geq \gamma_2\alpha_2 \\ \frac{\alpha_1\gamma_1(1-\alpha_1\gamma_1)}{4} - \frac{1}{2}c\alpha_1^2 & if\ \gamma_1\alpha_1 \leq \gamma_2\alpha_2 \end{cases}$$

and

$$\pi_2 = \begin{cases} \frac{\alpha_2\gamma_2(1-\alpha_1\gamma_1)}{4} - \frac{1}{2}c\alpha_2^2 & if\ \gamma_2\alpha_2 \geq \gamma_1\alpha_1 \\ \frac{\alpha_2\gamma_2(1-\alpha_2\gamma_2)}{4} - \frac{1}{2}c\alpha_2^2 & if\ \gamma_2\alpha_2 \leq \gamma_1\alpha_1. \end{cases}$$

We first find the candidates to be Nash Equilibria (NE) assuming that $\gamma_1\alpha_1 \geq \gamma_2\alpha_2$.
Physician 1's maximization problem is:

$$\begin{aligned} \max_{\alpha_1} \quad & \frac{\alpha_1\gamma_1(1-\alpha_2\gamma_2)}{4} - \frac{1}{2}c\alpha_1^2 \\ \text{st.} \quad & \alpha_1 \geq \frac{\gamma_2}{\gamma_1}\alpha_2. \end{aligned}$$

And Physician 2's:

$$\begin{aligned} \max_{\alpha_2} \quad & \frac{\alpha_2\gamma_2(1-\alpha_2\gamma_2)}{4} - \frac{1}{2}c\alpha_2^2 \\ \text{st.} \quad & \alpha_2 \leq \frac{\gamma_1}{\gamma_2}\alpha_1. \end{aligned}$$

From solving each physician's respective maximization problem we find:

$$\widetilde{\alpha_1} = \frac{\gamma_1(4c+\gamma_2^2)}{8c(2c+\gamma_2^2)} \quad \text{and} \quad \widetilde{\alpha_2} = \frac{\gamma_2}{4c+2\gamma_2^2}.$$

Which indeed satisfy our hypothesis $\widetilde{\alpha_1}\gamma_1 \geq \widetilde{\alpha_2}\gamma_2$ if:

a. $\gamma_1 \geq \gamma_2$, or

b. $\gamma_1 < \gamma_2$ and $\gamma_1 > \overline{\gamma_1} \equiv \sqrt{\frac{4c\gamma_2^2}{\gamma_2^2+4c}}$.

The profits the physicians would obtain if the above were indeed an NE are:

$$\widetilde{\Pi_1} = \frac{\gamma_1^2(4c+\gamma_2^2)^2}{128c(2c+\gamma_2^2)^2} \quad \text{and} \quad \widetilde{\Pi_2} = \frac{\gamma_2^2}{16(2c+\gamma_2^2)}.$$

Next we check when $\widetilde{\alpha_1}$ is optimal. That is, when Physician 1 has no incentives to deviate to a different candidate solution. In order to do this, we look at his maximization problem when $\alpha_1\gamma_1 \leq \gamma_2\widetilde{\alpha_2}$, where $\widetilde{\alpha_2} = \frac{\gamma_2}{4c+2\gamma_2^2}$.

Thus, Physician 1 solves:

$$\max_{\alpha_1} \quad \frac{\alpha_1\gamma_1(1-\alpha_1\gamma_1)}{4} - \frac{1}{2}c\alpha_1^2$$
$$\text{st.} \quad \alpha_1 \leq \frac{\gamma_2}{\gamma_1}\widetilde{\alpha_2}.$$

We find Physician 1's best response against $\widetilde{\alpha_2}$ to be:

$$\overline{\alpha_1} \equiv \frac{\gamma_1}{4c+2\gamma_1^2}.$$

Looking at the restriction:

$$\overline{\alpha_1}\gamma_1 \leq \widetilde{\alpha_2}\gamma_2 \iff \gamma_1 < \gamma_2.$$

Thus, for $\gamma_1 \in [\gamma_2, \overline{\gamma_1}]$ we have two potential best responses to $\widetilde{\alpha_2}:$ $\widetilde{\alpha_1}$ and $\overline{\alpha_1}$.

However, we can see that $\widetilde{\alpha_1}$ dominates $\overline{\alpha_1}$ for some values of the physicians' visibilities. Namely:

$$\widetilde{\Pi_1} > \overline{\Pi_1} \iff \frac{\gamma_1^2(4c+\gamma_2^2)^2}{128c(2c+\gamma_2^2)^2} > \frac{\gamma_1^2}{16\gamma_1^2+32c}$$
$$\iff \gamma_1 > \overline{\overline{\gamma_1}} \equiv \frac{\gamma_2\sqrt{2c(8c+3\gamma_2^2)}}{4c+\gamma_2^2}.$$

Therefore, given that $\gamma_2 > \overline{\overline{\gamma_1}} > \overline{\gamma_1}$ for all values of c and γ_2 , $\widetilde{\alpha_1}$ is optimal for Physician 1 if $\gamma_1 \in [\overline{\overline{\gamma_1}}, 1]$.

To learn whether $(\widetilde{\alpha_1}, \widetilde{\alpha_2})$ is indeed a Nash Equilibria, we now look at the equilibrium strategies of Physician 2. We need to find the conditions under which $\widetilde{\alpha_2}$ is optimal if Physician 1 chooses $\widetilde{\alpha_1}$. Thus, we look at Physician 2's maximization problem when $\alpha_2\gamma_2 \geq \gamma_1\widetilde{\alpha_1}$, $\gamma_1 \in [\overline{\overline{\gamma_1}}, 1]$, and $\widetilde{\alpha_1} = \frac{\gamma_1(4c+\gamma_2^2)}{8c(2c+\gamma_2^2)}$.

Physician 2 solves:

$$\max_{\alpha_2} \quad \frac{\alpha_2\gamma_2(1-\alpha_1\gamma_1)}{4} - \frac{1}{2}c\alpha_2^2$$
$$\text{st.} \quad \alpha_2 \geq \frac{\gamma_1}{\gamma_2}\widetilde{\alpha_1}.$$

We find Physician 2's best response against $\widetilde{\alpha_1}$ to be: $\overline{\alpha_2} = \frac{\gamma_2\left(8c\left(\gamma_2^2+2c\right)-\gamma_1^2\left(\gamma_2^2+4c\right)\right)}{32c^2\left(\gamma_2^2+2c\right)}$.

Looking at the restriction:

$$\overline{\alpha_2}\gamma_2 \geq \widetilde{\alpha_1}\gamma_1 \iff \gamma_1 < \gamma_1^A(\gamma_2) \equiv \frac{2\gamma_2\sqrt{2c(2c+\gamma_2^2)}}{4c+\gamma_2^2}.$$

Notice that $\gamma_1^A(\gamma_2) > \overline{\overline{\gamma_1}}$ for any value of c and γ_2. Therefore, there is a region where either $\overline{\alpha_2}$ and $\widetilde{\alpha_2}$ could be optimal for Physician 2. Namely, when $\gamma_1 \in \left[\overline{\overline{\gamma_1}}, \gamma_1^A(\gamma_2)\right]$.

We compare the profits level Physician 2 would obtain if setting each of the ability levels in the equilibrium:

$$\widetilde{\Pi_2} > \overline{\Pi_2} \iff \frac{\gamma_2^2}{16(2c+\gamma_2^2)} > \frac{\gamma_2^2\left(\gamma_1^2\left(\gamma_2^2+4c\right)-8c\left(\gamma_2^2+2c\right)\right)^2}{2048c^3\left(\gamma_2^2+2c\right)^2}$$
$$\iff \gamma_1 > \gamma_1^X \equiv \sqrt{\frac{\sqrt{128c^3\left(\gamma_2^2+2c\right)}+8c\left(\gamma_2^2+2c\right)}{\gamma_2^2+4c}}.$$

However, we can see that:

$$\gamma_2 > \gamma_1^A(\gamma_2) > \overline{\overline{\gamma_1}} > \overline{\gamma_1}, \text{ and } \gamma_1^X > \gamma_1^A(\gamma_2) > \overline{\overline{\gamma_1}},$$

for any values of c and γ_2.

Therefore, $(\widetilde{\alpha_1}, \widetilde{\alpha_2})$ is a Nash Equilibrium if $\gamma_1 \geq \gamma_1^A(\gamma_2)$.

By symmetry, we also know that $(\widetilde{\alpha_1}', \widetilde{\alpha_2}')$ is a NE when $\gamma_2\alpha_2 \geq \gamma_1\alpha_1$ if: $\gamma_2 \geq \overline{\overline{\overline{\gamma_2}}}$.

Where: $\widetilde{\alpha_1}' = \frac{\gamma_1}{4c+2\gamma_1^2}$, $\widetilde{\alpha_2}' = \frac{\gamma_1(4c+\gamma_2^2)}{8c(2c+\gamma_2^2)}$, with $\overline{\overline{\overline{\gamma_2}}} \equiv \frac{2\gamma_1\sqrt{2c(2c+\gamma_1^2)}}{4c+\gamma_2^2}$.

We rewrite the latter condition as a function of γ_2: $\gamma_1^B(\gamma_2) \equiv \sqrt{\frac{4c\gamma_2^2}{2(c+\sqrt{c(c+\gamma_2^2)})-\gamma_2^2}}$.

Thus, $(\widetilde{\alpha_1}', \widetilde{\alpha_2}')$ is a NE when $\gamma_1 < \gamma_1^B(\gamma_2)$.

Furthermore, when $\gamma_2\alpha_2 = \gamma_1\alpha_1$ no Nash Equilibrium is feasible.

We can prove this by contradiction. Assume (α_1^*, α_2^*) is a Nash Equilibrium.

First, $\alpha_1^* = \alpha_2^* = 0$ cannot be a Nash Equilibrium because the right-hand derivative $\left.\frac{\partial \Pi_1}{\partial \alpha_1}\right|_+ = \frac{\gamma_1(1-\alpha_2\gamma_2)-4c\alpha_1}{4}$ is positive if $\alpha_1^* = \alpha_2^* = 0$.

Second, if $\alpha_1^* > 0$ and $\alpha_2 = \frac{\gamma_1}{\gamma_2}\alpha_1$ the following condition holds:

$$\left.\frac{\partial \Pi_1}{\partial \alpha_1}\right|_- (\alpha_1^* = \frac{\gamma_2}{\gamma_1}\alpha_2) < \left.\frac{\partial \Pi_1}{\partial \alpha_1}\right|_+ (\alpha_1^* = \frac{\gamma_2}{\gamma_1}\alpha_2).$$

Thus, either $\left.\frac{\partial \Pi_1}{\partial \alpha_1}\right|_- (\alpha_1^* = \frac{\gamma_2}{\gamma_1}\alpha_2^*) < 0$ or $\left.\frac{\partial \Pi_1}{\partial \alpha_1}\right|_+ (\alpha_1^* = \frac{\gamma_2}{\gamma_1}\alpha_2^*) > 0$. This implies the existence of a $\alpha_1 = \alpha_1^* + \epsilon$ that dominates α_1^* as an equilibrium for all $\epsilon > 0$, when $\left.\frac{\partial \Pi_1}{\partial \alpha_1}\right|_- (\alpha_1^* = \frac{\gamma_2}{\gamma_1}\alpha_2) < 0$.

The same is true for the converse case, $\left.\frac{\partial \Pi_1}{\partial \alpha_1}\right|_+ (\alpha_1^* = \frac{\gamma_2}{\gamma_1}\alpha_2) > 0$.

Therefore, no Nash Equilibria exist when $\gamma_1\alpha_1 = \gamma_2\alpha_2$.

Finally, by looking at the region where γ_1 falls we have that: $(\widetilde{\alpha_1}, \widetilde{\alpha_2})$ if a NE if $\gamma_1 > \gamma_1^A$, and $(\widetilde{\alpha_1}', \widetilde{\alpha_2}')$ if $\gamma_1 < \gamma_1^B$. From which three regions and their associated NE are defined:

$(\widetilde{\alpha_1}, \widetilde{\alpha_2})$ if $\gamma_1 \in [\gamma_1^B(\gamma_2), 1]$, $(\widetilde{\alpha_1}, \widetilde{\alpha_2})$ or $(\widetilde{\alpha_1}', \widetilde{\alpha_2}')$ if $\gamma_1 \in (\gamma_1^A(\gamma_2), \gamma_1^B(\gamma_2))$, and $(\widetilde{\alpha_1}', \widetilde{\alpha_2}')$ if $\gamma_1 \in [0, \gamma_1^A(\gamma_2)]$.

■

Proof of Proposition 3. We compare the profits level the two physicians would obtain in each of the Nash Equilibria.

$$\widetilde{\Pi_1} + \widetilde{\Pi_2} \geq \widetilde{\Pi_1}' + \widetilde{\Pi_2}' \iff \gamma_1 \geq \gamma_2.$$

Therefore, we can discard the coexistence of the equilibria in region $b.$, as described in the proof of Proposition 2, for all the values of γ_1 bigger or equal than γ_2. Moreover, $(\widetilde{\alpha_1}, \widetilde{\alpha_2})$ is the only NE for values of γ_1 above γ_2.

By symmetry, we can apply the same reasoning for $\gamma_1 < \gamma_2$.

■

Chapter 4

Expert services and user reviews in a market for experience goods

4.1 Introduction

Expert services play an important role in markets where the consumers are uncertain about a good's quality (Eliashberg and Shugan 1997, Basuroy, Chatterjee, and Ravid 2003, Chen and Xie 2005, Friberg and Grönqvist 2012). Faced with the decision to buy a good whose quality is difficult to observe, consumers are known to rely on the opinions of others. An expert mediates between the firm and the consumers, offering to reveal information on the good's quality in exchange for a fee. Within the frame of this interaction the experts are third-party agents who provide an assessment of a good without being directly involved in its sale; in effect, they initiate an information exchange with the consumers that is not controlled by the firm. This is the case of professional critics who write reviews that consumers can access through paid outlets like magazines, consumer guides, subscription-based websites or newspapers. Think of a literary critic reviewing an upcoming novel, a financial analyst surveying a company's assets for clients interested in buying their stock, or a personal trainer recommending a new workout app.

Experience goods are precisely the ones for which the informational asymmetry between the firm and the consumers is essential. In the frame of our analysis we understand experience goods as those with a quality unknown to the consumers prior to their purchase, but which is learned once consumption takes place (Nelson 1970). The entertainment, art, and culture industry is a prime example of an experience goods market, although many other consumer goods are also subject to critical review (automobiles, electronics, wine, food, commodities, luxury items, and the travel and hospitality sector). Reviews about movies, restaurants or video cameras are commonplace in this type of market, since the experts operating in them provide both the consumers and the firm a valuable service. Indeed, the literature suggests that expert services play a positive role in experience goods markets, inducing more demand for the firm and leading to higher profits while decreasing the consumers' uncertainty (Sawhney and Eliashberg 1996, Reinstein and Snyder 2005, Dellarocas, Zhang, and Awad 2007).

Our first objective in the application presented in this chapter is to develop a theoretical framework to study the role expert services play in a market for experience goods. We model an environment where a firm sells a good of unobservable quality to a mass of consumers with idiosyncratic types. Aside from the type-specific bonus, all consumers derive more utility from the good the higher its quality is. The consumers know how well the good's type matches their own, obtaining a higher utility the closer the match is. We use this design to examine the film industry. Thus, in our setup a comedy fan might enjoy a high-quality drama more than a lousy comedy, though in general he would favor the latter film genre. There is an expert in the market, who observes the quality of the good and reports it to the consumers in exchange for a fee.

We find expert services to increase the consumers' welfare, allowing low-type consumers to participate in the market. That is, comedy lovers who have a very low tolerance for dramas consider watching a drama when an expert is available to ask him about the film's quality before deciding to go to the cinema. The expert serves some of those consumers but also others who would have bought the good based on their priors had the expert not been available. However, in the equilibrium the firm is indifferent between serving a market where expert services are present and another where consumers purchase based entirely on their priors. The firm's decisions are impervious to the presence of an expert in the market. This might be due to the relatively small segment of consumers who consult the expert before buying the good.

On the contrary, more information on the good is beneficial to the consumers. Technological advances in the last decades have allowed the consumers to access different sources of information before they make the purchase decision. Chief among these are user reviews, which have become more prevalent and easy to access than ever before. The main difference between expert services and user reviews is that the latter are written by consumers who just happen to have bought the good in a previous period. Thus, although they are free to access or have a very small cost, the quality of the information they provide is lower than that offered by a professional critic. Naturally, a film critique published in *Cahiers du Cinéma* or *Film Comment* is hardly comparable to one posted by a user on *IMDb.com*, the same goes for *Yelp* and a *Michelin Guide* review and so forth. Nevertheless, user reviews offer a refinement on the priors the consumers have regarding the good's quality, thus having an effect on experience goods markets (Chevalier and Mayzlin 2006, Duan, Gu, and Whinston 2008, Cheung and Thadani 2012).

Due to their immediacy and ease of access, user reviews are becoming more important when informing the decisions of consumers in experience goods markets. From the perspective of the expert, this represents the existence of a competing source of information in the market. Consumers can actually decide to skip the expert and base their decisions on the information they obtain from user reviews. The second objective of our paper is to understand the effect of user reviews on expert services in an experience goods market. We first analyze the role of user reviews on their own, which we model through a mechanism that aggregates all the past-consumers' opinions in a binary rating system. That is, user reviews tell the consumers whether the good's quality is above the expected level or not, with the former case being awarded a *star review*. This type of reporting system is quite common in experience goods markets and can be observed in Amazon's *star reviews*, Rotten Tomatoes' *Certified Fresh* category or any other "thumbs up/thumbs down" system.

We find that whether a *star review* is observed or not alters the composition of the market, with higher-type consumers buying the good when its quality is revealed by the reviews to be low, and low-type consumers entering the market when the users review the good positively. In the presence of user reviews the consumers' surplus increases with respect both to the case when expert reviews are available and the no-information benchmark. The firm, on the other hand, remains indifferent between these three scenarios, obtaining identical profit levels in each equilibrium. Expert services are sensitive to competing sources of information, serving a smaller demand, charging a lower fee, and obtaining less profits when user reviews become available. Although the firm remains indifferent to the increase in information availability, charging the same price as in the benchmark and all the other informational scenarios, the consumers' surplus further improves when both user reviews and expert services are simultaneously present in the market.

These results are in line with what anecdotal evidence indicates. Expert services are affected by changes in the information flow in a market. Not long ago three Spanish magazines dedicated to publishing cultural goods reviews (*Go Mag*, *H magazine*, and the local version of *Cahiers du Cinéma*), closed their print edition due to their precarious economic panorama. Over the last couple of years this has also been the fate of seasoned US outlets like *Crawdaddy!*, *Paste magazine*, *The Village Voice*, and even *Newsweek*, among many others that have either migrated to online platforms (*Spin* magazine, *The Onion*) or shut down business entirely (*The Dissolve*). Our findings seem to support the argument that traditional expert-opinion outlets are negatively affected by the expansion and pervasiveness of user reviews. Nevertheless, considerable welfare-positive effects are generated when both expert services and user reviews are available simultaneously. To the best of our knowledge, this is the first study to theoretically assess the role expert services and user reviews play in experience goods markets.

The rest of this chapter is organized as follows: We first present a survey of the literature on expert services and user reviews in experience goods markets, then we develop the model and study the market only when user reviews are available. We later dedicate a section to an analysis of the behavior of the consumers, the firm, and the expert. Next, we introduce user reviews and look at the impact they have on the equilibrium behavior of the consumers, the firm, and particularly the expert. We finally discuss the interaction between user reviews and expert services, concluding with a review of the welfare effects arising from the presence of these sources of information in the market. All the proofs are included in a technical appendix.

4.2 Related Literature

The study of expert services goes as far back as the analysis of markets with asymmetric information itself. This line of research was arguably pioneered by Pitchik and Schotter (1987), who considered the expert as an agent that did not produce the good being exchanged but was better informed about it than the consumers. However, the authors allow the expert to "sell" the good despite not being in control of its quality, to some extent merging the expert's role with the firm's. More relevant to our model, Wolinsky (1993) included in the market "diagnose-only" agents who reported to the consumers whether they needed a given treatment or not. This role is similar to the one played by the uninvolved experts whose behavior we examine, though Wolinsky still permits some agents to offer both to diagnose and treat the consumers, not contemplating these two services as completely independent.

Many variations of the firm-expert-consumer setup have been explored in the literature. However, most studies focus on credence goods markets, where the expert identifies the service best suited to a consumer who remains uncertain about it even after the purchase (Wolinsky 1995, Emons 1997; 2001, Pesendorfer and Wolinsky 2003, Hyndman and Ozerturk 2011, Liu 2011, etc.). Several of these works are interested in the opportunities for fraudulent behavior that a persistent informational asymmetry creates.[1] Given that consumers learn an experience good's quality once they try it, our model forgoes all concerns about advantageous behavior from the experts, since they have no incentives to deviate from truthful reporting. The experts in our framework neither benefit from over-diagnose, for they do not sell the good, nor do they face different costs from biased reporting.

Spurred by the increased access to consumption data, the inquiry of expert services in experience goods markets has mainly been pursued from an empirical perspective. A seminal paper for this line of research is Reinstein and Snyder (2005), who look into the influence of film critics on a movie's box-office performance. Focusing on Siskel & Ebert's reviews, the authors use a difference-in-differences design to study the ticket sales of movies in relation to the critics' opinion. They find that once the effects of quality and publicity have been controlled, positive reviews have a positive influence on a movie's box-office performance. The effect is particularly strong on a film's opening-weekend revenue and for limited releases (*i.e.*, not blockbusters). These results fall in line with preceding studies, which hinted at a limited but positive relation between critics' reviews and a film's box-office run (Eliashberg and Shugan 1997).

Building on Reinstein and Snyder (2005)'s foundation, a large number of works examining the role of expert services in different experience goods markets have appeared in recent years. For instance, looking at the publishing sector (Clement, Proppe, and Rott 2007, Caliendo, Clement, and Shehu 2015), the wine market (Dubois and Nauges 2010, Hilger, Rafert, and Villas-Boas 2011, Friberg and Grönqvist 2012, Ashenfelter and Jones 2013), and the video game industry (Zhu and Zhang 2006); always from empiric or experimental perspectives and finding positive reviews to increase the demand for the goods.

To the best of our knowledge, the present work is the first theoretical study of an experience goods market where the expert and the firm act as completely indepen-

[1] A complete primer on expert services in credence goods markets can be found in Dulleck and Kerschbamer (2006).

dent agents; let alone one that incorporates user reviews as an alternative source of information for the consumers. The literature establishes an essential distinction between the information coming from professional critics and users, both from a qualitative and quantitative perspective (Jong and Burgers 2013, Cox and Kaimann 2015). Moreover, the analysis of user reviews and the role they play in experience good's markets has also been approached from an empirical perspective.

Moretti (2011) was one of the first to quantify the influence of user-generated information on the consumption decisions of individuals who are unaware of a given good's quality. Studying the film industry like Reinstein and Snyder (2005), Moretti finds that the effect of users' opinion on a movie's revenue is stronger when the *ex ante* uncertainty on the good is more significant, with a positive review playing a demand-enhancing role and a negative one going in the opposite direction. Other authors have argued the strength and nature of this relationship, focusing on the volume of online user reviews instead of their content, in the film (Duan, Gu, and Whinston 2008), music (Dhar and Chang 2009, Dewan and Ramaprasad 2014), and hospitality industries (Ye, Law, and Gu 2009; Ye et al. 2011). Despite the different approaches and nuances of these works, they all point at the existence of a relevant interaction between the demand for an experience good and the information user-generated reviews provide to the consumers.

Studies considering the simultaneous role of user reviews and professional critics' opinions are few and, by and large, empirical. In the current work we theoretically investigate the role these two informational sources play, how they interact and affect the decisions of the agents in an experience goods market. We find a close precedent for our inquiry in Chakravarty, Liu, and Mazumdar (2010), who look at consumers' evaluations of upcoming films through an experimental design. The authors suggest that different sources of information affect certain types of consumers differently, with less frequent consumers relying more on user-generated reviews and frequent consumers being more influenced by critics; in both cases with positive reviews leading to higher pre-purchase evaluations. The heterogeneous reaction to user reviews and expert opinions is not a concern in our framework. We can compare users and experts' reviews because they become available at the same time and we focus on a single shot game.

A few other papers support the hypothesis that the information coming from users and professional critics has a similar effect on the consumers' decisions. Amblee and Bui (2007) find that additional information has a significant impact on the consumption of software downloads, without any economic or statistical difference owing to its source. Similarly, Vermeulen and Seegers (2009) find a very small premium on expertise when comparing the effect of user and expert reviews in the hotel market, with both types of opinions increasing consumer awareness, irrespective of the valence of the review. This is important for our framework, since we build a model where user reviews can be positive or negative, with both scenarios deemed as equally informative.

4.3 The Model

We study a market where a single experience good with a quality $q \sim U(0,1)$ is exchanged. A monopolist sells the good at a price p, which he sets before learning the value of q. The quality of the good is not a strategic variable for the monopolist. A fitting example of the type of market we are looking at is the entertainment industry. The prices of a movie ticket or music album are set irrespective of the good's actual quality, which is arguably outside of the control of the cinema or the store selling the good.

Still with the entertainment industry in mind, we assume the marginal cost of the good to be negligible for the monopolist. This is not a far-fetched hypothesis for the market we are analyzing, considering that the cost of streaming a song, pressing an additional copy of an album or providing a single movie seat, is actually very small. Thus, in our model the firm sells the good at no cost.

There is a size-one mass of consumers in the market. All the consumers have a unique valuation for quality equal to 1 and are indexed by their type a, uniformly distributed over $[0, 1]$. That is, they all derive the same utility from consuming a good of a given quality q, but obtain an idiosyncratic, type-specific bonus. For instance, if the good were a movie we could say that a *good* movie is equally enjoyable for everyone – it complies with minimum, universal standards, etc. Yet, we all have particular preferences for different genres of film, which may lead us to derive higher utilities from a comedy rather than a drama if the former is the type of movie we most prefer. Thus, the consumers' utilities for given values of q and a have the following form:

$$U(q, a) = q + a - p,$$

where $a \in [0, 1]$ represents how much a consumer's type aligns with that of the good. For notational compactness, from now on whenever we mention the type we denote the extent of this match.

Each consumer knows her own type and can observe the good's, thus being aware of the value of a when estimating their expected utility. However, owing to the experience nature of the good, the good's quality q is not known by the consumers before purchase. The quality distribution and the price charged by the firm are both publicly known.

There is an expert in the market who perfectly observes the quality of the good and does so at no cost. The expert can reveal the good's quality to the consumers before they make the participation decision for a fee $\lambda > 0$. It is costless for the expert to report the information to the consumers. In our entertainment industry example, expert services with the characteristics we study could be encountered in the movie reviews one finds in film magazines or newspapers. The fee λ represents the magazine's price or the equivalent per-reader advertising revenue obtained by the outlet. The expert sets his pricing strategy independently from the monopolist.

The expert plays an uninvolved role in the market, $i.e.$, he has no stake in the profits of the firm selling the good. We can therefore assume he truthfully reports the good's characteristics to the consumers. We also assume that this information is not subject to arbitrage. That is, a consumer who learns q from the expert cannot relay the information to other consumers.[2] The demand for expert services is given by D^{XP}.

Without loss of generality we assume that p, the price set by the monopolist selling the good, will fall in the interval $\left(\frac{1}{2}, 1\right)$. It is possible to disregard pricing strategies outside such support because for smaller values of p all the consumers in the market would decide to buy the good based only on their priors, which renders the analysis of expert services uninteresting. This might explain why we rarely find expert reviews for low-grade consumer goods. In the case of higher values of p, the demand becomes too small for the firm to be interested in participating in the market, given that both the quality and the type cannot take values above one.

The timing of the game is the following:

1. The monopolist sets a price p for the good.
2. The expert sets a fee for the service of revealing the good's quality to the consumers.
3. The good's quality is drawn by nature: $q \sim U(0, 1)$.
4. The expert observes q.
5. Each consumer decides whether to consult the expert before buying the good. The value of q is revealed to those who consult the expert.
6. The purchase decision is made.

We solve the game by backwards induction, first looking at the decisions of the expert then later paying attention to those of the perfectly-informed monopolist.

[2]In section 4.5 we introduce a specific mechanism to consider information transmission between consumers.

4.4 Market Analysis when Expert Services are Available but not User Reviews

In this section we look at a market where the consumers can learn the good's quality through the expert. We compare the informational situation created by the presence of expert services with a benchmark where the consumers would take the purchase decision based solely on their priors. Our analysis considers the effect of expert services both on the side of the consumers and the monopolist.

Keeping the entertainment industry example, we can think of this market situation as the one that still takes place today with new movie releases. Film studios arrange screenings for a few professional critics to see an upcoming movie some time before its wide release. The critics write and publish their reviews in the days leading to the movie's opening, which means that consumers have not yet seen the movie, thus fending off the appearance of user reviews. For example, if *Captain America: Civil War* opens on May 6 in the US, the reviews published by media outlets before or on that date would stand to be examined under our current framework. Limited releases or festival premieres, such that the number of non-professionals who can see and review the film is insignificant, would similarly fit this situation.

4.4.1 Consumer Behavior and Expert's Pricing Strategies

We first study the behavior of the consumers and the pricing decisions of the expert. Generally speaking, the expert's equilibrium fee and demand depend on the price of the good: the more expensive the good becomes, the more consumers would be interested in consulting the expert before purchasing. However, whereas the expert's demand always increases in p, the optimal fee is a convex function of the good's price. Actually, there are different equilibrium fees depending on the price the monopolist sets. To study each of these we define three pricing levels: *low* when $p \in \left(\frac{1}{2}, \frac{3}{5}\right]$, *intermediate* when $p \in \left(\frac{3}{5}, \frac{2}{3}\right]$, and *high* when $p \in \left(\frac{2}{3}, 1\right)$. In the following propositions we formally present the equilibrium allocations for the expert in each of the pricing regions just described.

Proposition 1. *When the monopolist sells the experience good for a* low price, $p \in \left(\frac{1}{2}, \frac{3}{5}\right]$*, an expert reveals the good's quality to the consumers for a fee* $\lambda = \frac{2}{9}p^2$*, serving a demand* $D^{XP} = \frac{p}{3}$*, and obtaining profits* $\Pi^{XP} = \frac{2}{27}p^3$.

When the good's price is *low* the consumers do not have strong incentives to consult the expert before buying. For most consumers in the market their expectations on the good's quality are enough for them to decide to purchase, with no need for any additional information. It will mainly be consumers with low value types ($a \in \left[0, \frac{p}{3}\right]$) who will consult the expert when the good's price is *low*, checking whether their lackluster type-match bonus can be compensated with the good's quality. Those are the consumers who have incentives to learn the exact quality of the good before taking the purchase decision.

Accordingly, the expert's fee, demand, and profits positively depend on p within the *low* pricing range. The higher the good's price, the larger the segment of consumers who are potentially interested in demanding the expert's services. This is true even for some consumers with large type values, who become interested in the expert's service as the good turns more expensive and *riskier* to buy based only on their expectations. This effect carries on to the next pricing segment we analyze, corresponding to the case where p has an *intermediate* value. We present the result in the following proposition.

Proposition 2. *When the monopolist sells the experience good for an* intermediate price*,* $p \in \left(\frac{3}{5}, \frac{2}{3}\right]$*, an expert reveals the good's quality to the consumers for a fee* $\lambda = \frac{(1-p)^2}{2}$*, serving a demand* $D^{XP} = 2p - 1$*, and obtaining profits* $\Pi^{XP} = \frac{(1-p)^2}{2}(2p-1)$.

In the case where the monopolist charges an *intermediate* price for the good, the higher the good's price, the more the expert's demand expands. While some consumers exit the market as a consequence of the increase in p, other consumers with higher valuations enter the market as the good's price increases within the *intermediate* region. Some of the consumers who leave the market might have consulted the expert for lower values of p, but this demand reduction is compensated by the expansion among those who can afford a more pricey good given their type and who are interested in learning q before taking the purchase decision.

Seen as a function of p, the expert's fee is convex and negatively depends on the good's price. The expert's profits do not behave monotonically as p moves from the *low* into the *intermediate* pricing segment. This happens because a large increase in p has a double-sided effect in the market. First, it disincentives the good's purchase by taking consumers with low types out of the market. Therefore, some consumers who would have asked the expert for lower values of p, abandon the market. To compensate this decrease in his demand, the expert optimally charges a lower fee. Hence, it is possible to say that the increase in p indirectly pulls λ downwards in the equilibrium.

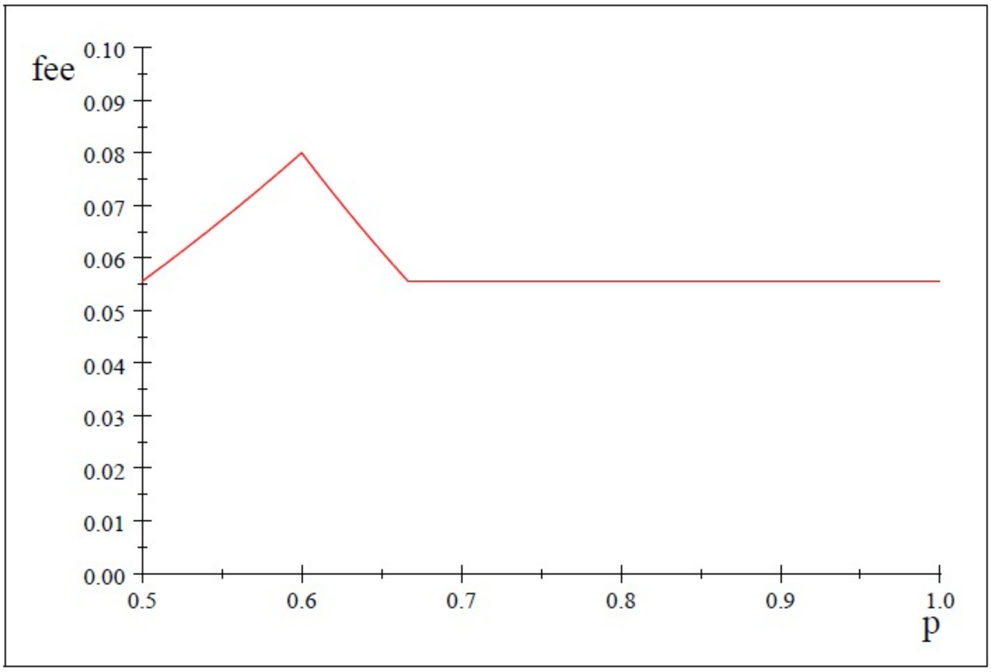
However, the equilibrium λ cannot be too high for *intermediate* values of p. If the expert's service is too expensive for the consumers to obtain sufficient expected utility from learning the quality of the good and later deciding to buy it, then the consumers will drop out of the market altogether. They neither ask the expert nor do they buy the good. Hence, in the equilibrium the expert charges a proportionally lower fee as p gets closer to the *high* pricing region. This is a behavior that extends to superior pricing regions. We formally present the results concerning such a pricing segment in the following proposition.

Proposition 3. *When the monopolist sells the experience good for a* high price*, $p \in \left(\frac{2}{3}, 1\right)$, an expert reveals the good's quality to the consumers for a fee $\lambda = \frac{1}{18}$, serving a demand $D^{XP} = \frac{1}{3}$, and obtaining profits $\Pi^{XP} = \frac{1}{54}$.*

When the good is sold for a price in the *high* region the demand for expert services stops being a function of p. Moreover, none of the equilibrium allocations depend on the good's price at all. When p is in the *high* pricing region only those consumers who have large type values ($a \in \left[p - \frac{2}{3}, p - \frac{1}{3}\right]$) consider consulting the expert before buying. The good's price causes all the potential demand for the expert coming from low-type consumers to disappear, as these decide to abandon the market without either buying the good or learning its quality. Thus, the expert services fee or profits he obtains do not depend on p in this case.

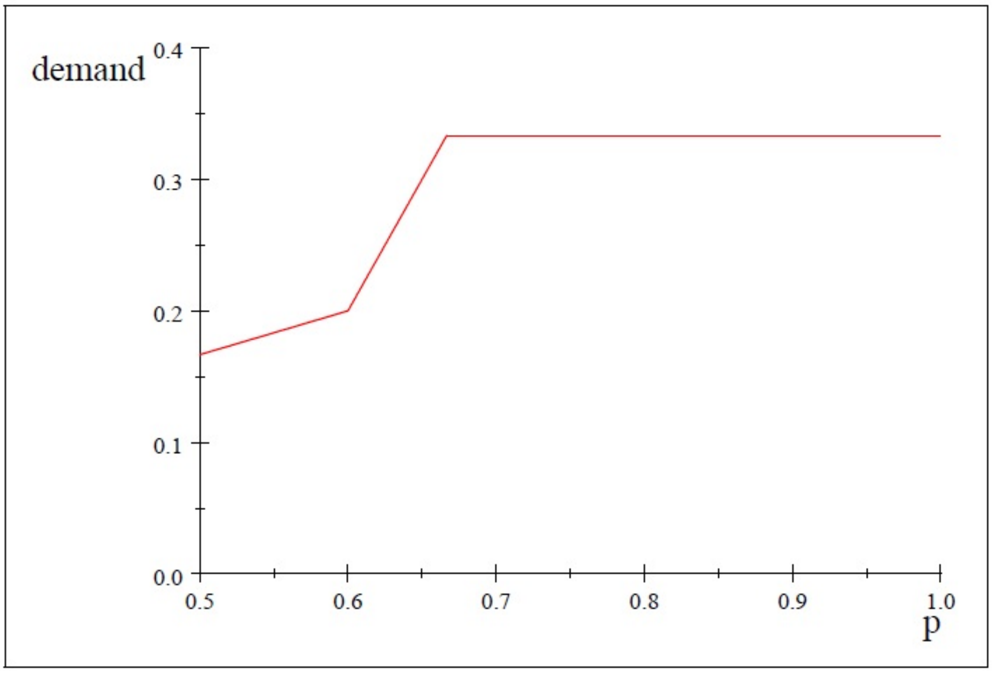
To better understand how the strategies of the firm and the expert interact with each other it is interesting to look at the expert's fee as a function of the good's price across the three pricing regions we have defined. The following graph presents the pricing decisions the expert adopts in the equilibrium when p moves across the three pricing regions. Notice that the highest levels the fee λ can attain occur when the good's price is *low* or *intermediate*.

Figure 4.1: **Expert's optimal fee as a function of the good's price**



Although the expert's fee can take the same value at given times for two different prices, for instance λ takes the same equilibrium value for $p = \frac{1}{2}$ and $p = 1$, the demand the expert serves and the profits he obtains are quite different under such scenarios. Hence, to be able to draw conclusions on the interaction between p and the expert's equilibrium strategies it is necessary to look at the behavior of his demand and profits as functions of the good's equilibrium price. In the following graph we present the demand for expert services as a function of p.

Figure 4.2: **Demand for expert services as a function of the good's price**



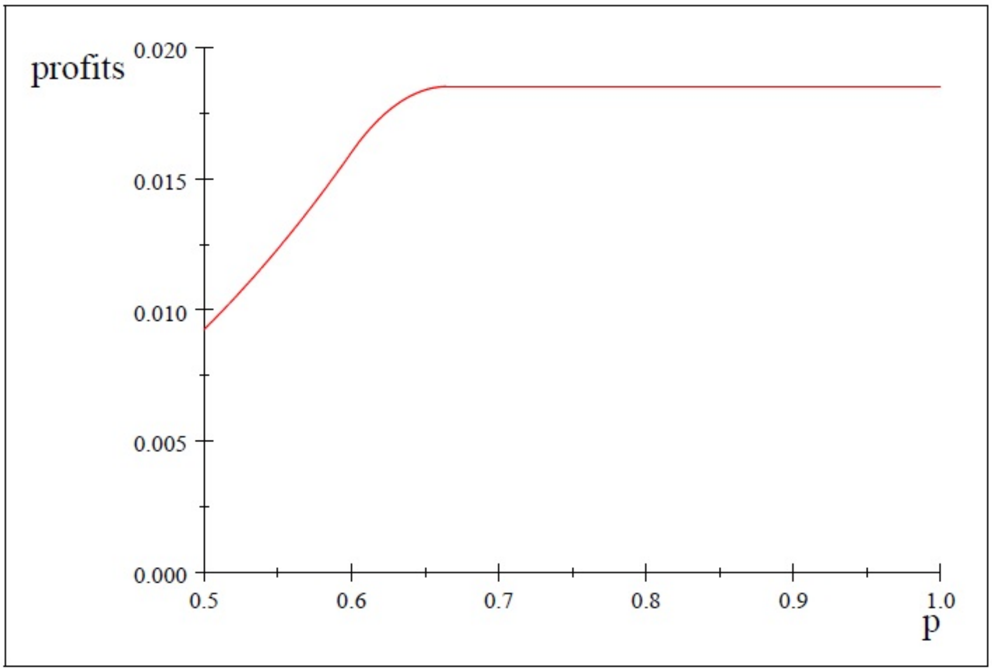
Looking at the demand faced by the expert as a function of p we see that its behavior mirrors that of the fee he charges in the equilibrium. When the good's price is *low*, as p moves toward the region's upper bound, more consumers start to consult the expert before buying the good. Thus, the demand has a positive slope. This demand expansion takes place despite the fact that the expert's fee λ also increases in the good's price when p is *low*.

This is not the case when the firm prices in superior regions. Although the demand for expert services positively depends on p for an *intermediate* pricing region, the fee decreases as the good turns more expensive, moving out of the *low* region. The expert follows this strategy in order to attract even more consumers. He tries to compensate the demand drop due to a high p by lowering his own fee. Although some consumers abandon the market because of the *intermediate* p, some others decide to enter. This effect holds for consumers with both low or high valuations, who become interested in the expert's service when p is *intermediate*. Hence the rapid growth of the demand in the *intermediate* pricing segment, represented by Figure 4.2's demand curve taking a much steeper slope.

The demand for expert services reaches a plateau when the good's price enters the *high* pricing region. We can understand this by looking at Figure 4.1, particularly the segment of the curve representing the expert's fee for a *high* value of p. The expert sets a unique optimal fee $\lambda = 0.055$ for the whole region, which means that a further increase in p will not affect the expert's fee, attenuating the impact that changes in the good's price have on the expert's strategies when p is in the *high* region. Therefore, neither more nor less consumers will be willing to consult the expert despite the hypothetical increases in the already *high* value of p. Thus, the demand the expert serves when the good's price is *high* is, so to speak, fixed and equal to the biggest value it can take.

Finally, we comment on the expert's profits as a function of the good's price. As we can observe in the graph below, the expert's profits grow as a function of p both when the good's price is in the *low* and *intermediate* regions. However, just like the demand, the profits reach a plateau in the *high* region due to the non price-dependent optimal fee adopted by the expert in the equilibrium. We present these results in the following figure.

Figure 4.3: **Profits for expert services as a function of the good's price**



The expert derives the most profits when the good's price is in the *high* region. That is also when his demand reaches the widest segment of the consumers mass. Notice how the equilibrium fee the expert charges takes its lowest value when p is in the *low* region. Nevertheless, such a value of λ is not lower than the one the expert charges when the good's price falls in the *high* region.

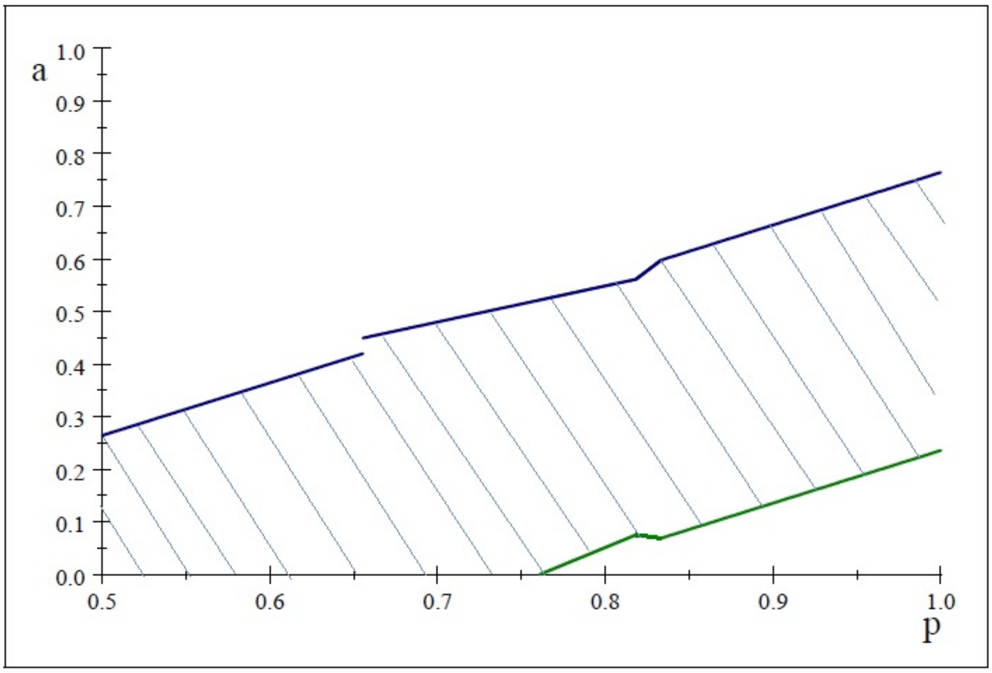
All these results point at a potential demand-attraction effect for the experience good, taking place when the expert is active in the market and regardless of the actual value of p. The monopolist would certainly consider this when choosing the good's price, as both his and the expert's strategies interact. The effects of expert services on the demand for the good are discussed in section 4.4.3.

4.4.2 Consumer Type and Expert Services

From our analysis in the preceding section it is quite evident that expert services allow consumers with lower valuations to consider buying the good. When the expert is not active only consumers with types $a \in \left[p - \frac{1}{2}, 1\right]$ would buy the good. On the other hand, when expert services become available the whole mass of consumers who consider buying the good expands. A new subsegment arises: those consumers who ask the expert and then decide to stay out of the market if the value of q is low.

In the following graph we present the demand for expert services as a function of the good's price and type when user reviews are not available.

Figure 4.4: **Demand for expert services as a function of the good's price and type without user reviews**



The demand for expert services increases in p, with higher types of consumers deciding to ask the expert as the good becomes more expensive. Interestingly, consumers with types as low as zero consult the expert when the price is *low*. Generally speaking, consumers with low type values consult the expert when p is in the *low* and *intermediate* pricing regions. When the monopolist sets an equilibrium price for the good in the *high* region, it is consumers with fairly high values of a who are interested in expert services.

4.4.3 Firm Behavior

In this section we analyze the behavior of the monopolist when expert services are available in the market. In particular, we look at the firm's demand, price, and profits in light of the preceding section's findings. We compare the decisions of the firm when expert services are available and when they are not, focusing on the interaction taking place between the firm and the expert's equilibrium strategies. We also examine the characteristics of the consumers who participate in the market in each scenario, to later discuss the welfare effects the expert services have over them.

The literature suggests that the information provided by third-party sources plays a demand-inducing role for experience goods (Cf. Reinstein and Snyder 2005, Chevalier and Mayzlin 2006, Liu 2006 Dellarocas, Zhang, and Awad 2007). The results we obtain in section 4.4.1 seem to confirm this, allowing consumers with lower type values to participate in the market under certain pricing conditions. To verify this hypothesis in our model we need a benchmark where the consumers have no other information but their priors when taking the purchase decision. The following lemma formally presents the equilibrium strategies of the firm when consumers have no additional information to decide whether to buy the experience good or not.

Lemma 1. *When expert services are not available in the market a monopolist sells an experience good at a price* $p = \frac{3}{4}$, *serving a demand* $D^G = \frac{3}{4}$, *and obtaining profits* $\Pi^G = \left(\frac{3}{4}\right)^2$.

We can see that the demand served by the monopolist in the equilibrium is quite large, comprising three quarters of the total mass of consumers. To be precise, all those consumers with a type bonus a above $\frac{1}{4}$ purchase the good when they base their participation decision solely on their priors.

The consumers' welfare for our analysis is measured through their expected *ex post* surplus. Therefore, when they decide to participate in the market based exclusively on their priors the consumers obtain a surplus of $\frac{9}{32}$.

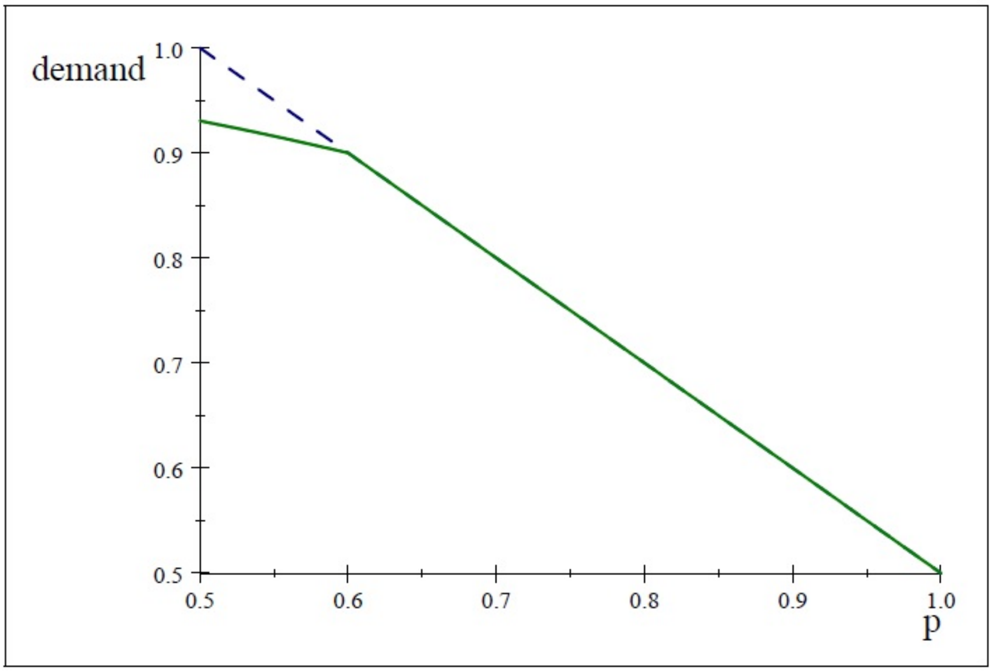
We next study the decisions of the firm when an expert is present in the market. That is, when consumers can learn the quality of the good before buying it. In the equilibrium the firm anticipates that the expert's strategy follows the behavior discussed in section 4.4.1. We formally present the result in the following proposition.

Proposition 4. *In a market where expert services are available a monopolist sells an experience good at a price $p = \frac{3}{4}$, serving a demand $D^G = \frac{3}{4}$, and obtaining profits $\Pi^G = \left(\frac{3}{4}\right)^2$.*

It is interesting to see that the demand-generating effect of expert services, as established in the literature and suggested by our analysis of the market in section 4.4.1, does not take place in our setup. Indeed, more consumers potentially consider buying the good when they have additional information in the form of expert reviews. Namely, the total mass of consumers who ask the expert is larger than the sum of consumers who bought the good based only on their priors. Yet, not all consumers buy the good after asking the expert. Hence, equal-size masses of consumers buy the good in the equilibrium when experts are present in the market and when they are not available.

The previous result does not hold for all levels of the good's price p. For any $p \in \left(\frac{1}{2}, 1\right)$ the demand for the good when the expert is present is smaller than or equal to the demand when the service is not available. We present a comparison of the demand for the good as a function of p in the following graph, both when expert reviews are available and when they are not present in the market.

Figure 4.5: **Demand for the good with and without expert services**



The demand for the good when the expert is active in the market is presented by the solid line in Figure 4.5. In a dashed line we present the demand for the good when the expert is not available. Surprisingly, the demand-attraction effect for the good is weak in the *low* pricing segment. This happens because for a *low* p the expert's fee λ is also small, hence more consumers ask the expert before buying the good. As a consequence, a larger mass of consumers stay out of the market after learning the good's quality from the expert. In simpler words, the expert actually dissuades some consumers from buying the good when the quality happens to be low and the good is inexpensive. The firm faces an identical demand irrespective of the presence of the expert for *intermediate* and *high* pricing levels.

In the equilibrium the firm obtains the same level of profits in both scenarios: $\Pi^G = \frac{9}{16}$. However, the consumer welfare measured through their *ex post* surplus when expert services are available is 0.2920, which is higher than the surplus obtained without expert reviews. We will further discuss the market-wide welfare effects of expert services and user reviews in section 4.6.

4.5 Market Analysis when Expert Services and User Reviews are Available

In this section we introduce user reviews as an alternative source of information for the consumers. We are interested in understanding how the consumers, the expert, and the firm adapt their strategies to the presence of an additional source of information. Namely, when the consumers can learn some information on the good's quality through free-to-access reviews.

This type of competition undermines the most essential characteristic of the service an expert offers: he is no longer in exclusive possession of superior information. In our benchmark, which we analyze in section 4.4, consumers can learn about the good's characteristics only through the expert. In the current section, user reviews provide the consumers with a costless refinement on their priors on the good's quality, which might change the participation decision of some consumers regarding their demand for expert services. Put differently, the information obtained from user reviews might make some consumers discard the idea of consulting the expert. How the expert deals with this situation will determine the impact of user reviews both in terms of the profits the expert obtains as well as the demand for the good itself, not to mention consumer welfare.

Formally speaking, we assume that in a previous period past consumers bought the same good the monopolist is currently selling. Although past consumers are no longer participating in the market, they are able to inform the consumers currently taking the purchase decision. Through the reviews they write, past consumers provide those currently taking the participation decision with some information on the good's characteristics.

We assume that the information provided by the user reviews is not as accurate as the information that can be bought from the expert. Although in most cases user reviews are cheaper than expert services, if not entirely cost-free, they do not have the same informational value due to the differences in skills, experience, training, and communication efficiency between the experts and past consumers. We model these differences by adopting a binary reporting mechanism for the user reviews. Henceforth, user reviews convey the quality of a good by telling the consumers whether the good's quality is above its expected value or not. That is, given that q is uniformly distributed between zero and one, whether the realization of the variable is above or below $\frac{1}{2}$. We say that the good gets a *star review* if $q \geq \frac{1}{2}$ and nothing otherwise.[3] In our model user reviews are available for free to all agents before the participation decision is taken.

The timing of the game is as follows:

1. The monopolist sets a price p for the good.
2. The expert sets a fee for the service of revealing the good's quality to the consumers.
3. The good's quality is drawn by nature: $q \sim U(0, 1)$.
4. The expert observes q.
5. User reviews become available to all consumers at no cost. All consumers learn whether $q \geq \frac{1}{2}$ or not.
6. Consumers decide whether to consult the expert or not. The value of q is revealed to those who consult the expert.
7. The purchase decision is made.

We solve the game by backwards induction, focusing on the decisions of the expert before considering the strategies of the monopolist selling the good. The user reviews are not strategic.

[3] This is a binary rating system not uncommon in the industry, found under the form of *thumbs up/thumbs down* mechanisms, Amazon's *star-reviews*, Rotten Tomatoes' *fresh/rotten* categories, etc.

4.5.1 Consumer Behavior and Expert Pricing Strategies when User Reviews are Available

In this section we study the behavior of experts when consumers do not know the good's quality but have updated their priors on q through user reviews. That is, at the moment of taking the participation decision each consumer knows whether the good got a *star review* from the users or not.

To carry out our analysis we define four pricing levels for the good: *low* when $p \in \left(\frac{1}{2}, 0.6555\right]$, *intermediate* when $p \in \left(0.6555, \frac{9}{11}\right]$, *high* when $p \in \left(\frac{9}{11}, \frac{5}{6}\right]$, and *very high* when $p \in \left(\frac{5}{6}, 1\right]$.[4] In the following propositions we formally present the equilibrium allocations for the expert, using the pricing levels just described.

Proposition 5. *When the monopolist sells the experience good for a* low price $p \in \left(\frac{1}{2}, 0.6555\right]$*, with user reviews available in the market, an expert reveals the good's quality to the consumer for a fee* $\lambda = \frac{1}{36}$*, serving a demand* $D^{XP} = \frac{1}{12}$*, and obtaining profits* $\Pi^{XP} = \frac{1}{432}$.

When the good's price is in the *low* pricing range the consumers do not have strong incentives to consult the expert before buying the good. This was already the case when user reviews were not available in the market. Actually, if the good's quality is revealed to be above the expected value ($i.e., q \geq \frac{1}{2}$) and p is *low*, no consumer asks the expert before buying. That is, all consumers who buy the good from the monopolist do so based on the information gathered from the user reviews. Thus, for a *low* price, the expert faces some demand for his services only when the good's quality is revealed by user reviews to be smaller than one half. In such case consumers with a small type bonus ($a \in \left[p - \frac{1}{3}, p - \frac{1}{6}\right]$) will want to learn the exact quality before deciding to purchase. As a consequence, the demand the expert faces at this pricing level is not a function of p, and neither is the optimal fee he sets.

[4]Notice that these regions are loosely defined for presentation clarity only and do not necessarily match the regions similarly denoted for the case without user reviews, as examined in section 4.4.

However, when the good's price moves outside the *low* region the expert has a chance to attract consumers both in case a *star review* is observed and when it is not. In such a case, fewer consumers buy the good based on the user reviews alone, as it is *riskier* to do so given the higher values of p.

Proposition 6. *When the monopolist sells the experience good for an* intermediate price $p \in \left(0.6555, \frac{9}{11}\right]$*, with user reviews available in the market, an expert reveals the good's quality to the consumer for a fee* $\lambda = \frac{4p^2}{81}$*, serving a demand* $D^{XP} = \frac{p}{6}$*, and obtaining profits* $\Pi^{XP} = \frac{2p^3}{243}$.

In the case where the monopolist charges an *intermediate* price, some consumers have incentives to learn the exact quality even when they find a *star review*. Hence, the fee that the expert charges is an increasing function of p. Moreover, the demand for expert services positively depends on the good's price as well, and is noticeably bigger than it was when p fell in the *low* region.

The more expensive the good turns, the more attractive expert services become. This also applies to the profits the expert obtains, which move in line with the demand and fee. For these levels of p the fee the expert charges positively depends on the good's price. Interestingly, in the equilibrium we observe both a bigger demand and a higher fee for values of p approaching the upper bound of the *intermediate* pricing region. We already found this, somewhat unusual, phenomenon in the demand for expert services when the good's price was *low* and no user reviews were available. What drives this behavior in the current scenario is that some consumers who for lower prices would have found enough information in the user reviews to decide to buy the good, now obtain a higher expected utility from basing their decision on the expert's report. Therefore, despite raising the fee he charges, the expert can attract more consumers.

Proposition 7. *When the monopolist sells the experience good for a* high price $p \in \left(\frac{9}{11}, \frac{5}{6}\right]$*, with user reviews available in the market, an expert reveals the good's quality to the consumer for a fee* $\lambda = (1-p)^2$*, serving a demand* $D^{XP} = \frac{4p-3}{2}$*, and obtaining profits* $\Pi^{XP} = \frac{1}{2}\left(-3 + 10p - 11p^2 + 4p^3\right)$.

When the good's price is *high* the expert is able to attract a potential demand both when a *star review* is found and when it is not. Although the demand for expert services behaves in a similar way in the *intermediate* and *high* pricing regions, there is a major difference: while the demand for expert services continues to depend positively on p, the expert's fee decreases as the good's price increases toward the region's upper boundary.

Indeed, the expert's services are more attractive when the good is costly, although the good's relative expensiveness leaves the expert little leeway to charge a high fee. Hence, the optimal λ decreases in p when the good's price is *high*. The reverse is true for the demand, which grows in p as λ drops.

Proposition 8. *When the monopolist sells the experience good for a* very high price $p \in \left(\frac{5}{6}, 1\right]$*, with user reviews available in the market, an expert reveals the good's quality to the consumer for a fee* $\lambda = \frac{1}{36}$*, serving a demand* $D^{XP} = \frac{1}{6}$*, and obtaining profits* $\Pi^{XP} = \frac{1}{216}$.

In the case where the good's price is *very high*, the demand for expert services is no longer a function of p. Actually, none of the equilibrium allocations depend on the good's price in this region. Something similar happened when user reviews were not available, since we found that the expert charged the same λ in the equilibrium when p was both in the highest and lowest pricing regions. Moreover, the demand for expert services reaches its biggest value when p is in the highest region, both when user reviews are available and when they are not. However, when user reviews appear, λ does not take its lowest value when p is in the high pricing region. This was the case in our benchmark, whereas when user reviews arise the expert's fee takes the lowest equilibrium value in the *intermediate* pricing segment instead.

Across all pricing levels, the fee, demand, and profits the expert obtained in the benchmark were significantly bigger than those under the presence of user reviews. Therefore, the expert is sensitive to competing sources of information; an effect consistent and strong over all the variables he controls. We will analyze and compare the strategies the expert adopts, both when user reviews are available and in our benchmark, in section 4.5.3.

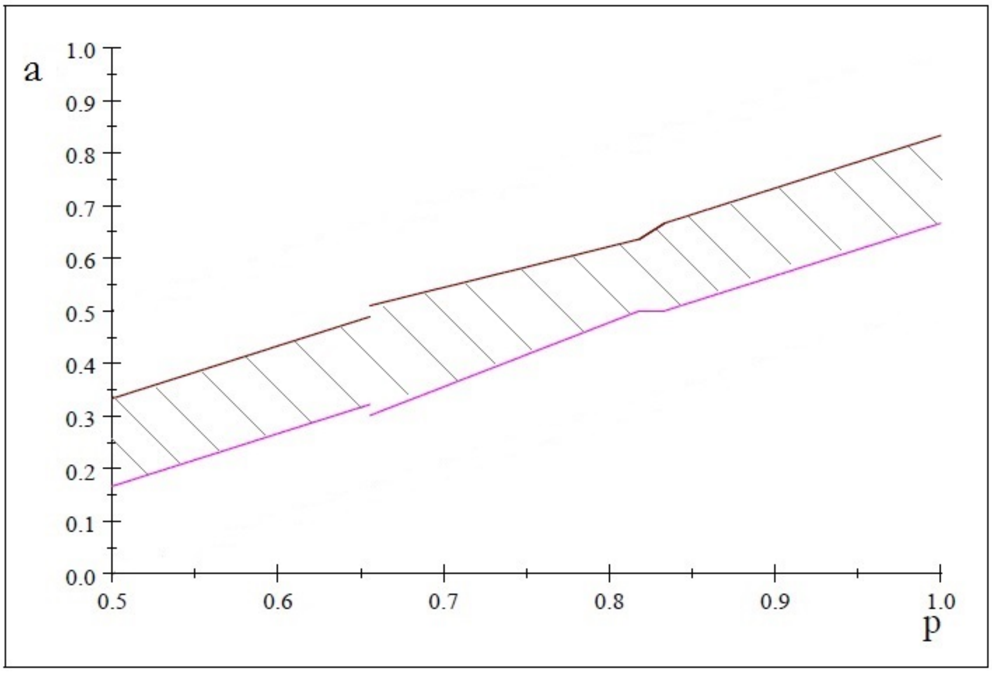
4.5.2 Consumer Type and Expert Services when User Reviews are Available

The incentives for consumers to consult the expert are quite different depending on the bent of the user reviews. Whether a *star review* causes a consumer to bypass expert services or not depends on two main variables: the good's price and the consumer's type. These two determine the expected utility a consumer considers at the time of deciding to consult the expert, buy the good directly or leave the market. Thus, it is interesting for the expert to understand how consumers react to positive and negative user reviews, as it will allow him to optimally set a fee that anticipates both scenarios.

From an informational perspective one could say that both when a *star review* is observed and when it is not, more information has become available with respect to our benchmark. By making an explicit distinction between the two scenarios we are able to identify the effect of the new information becoming available and that due to its actual content. This is an essential element to consider to avoid entangling the potential demand-attraction coming from a *star review* with the fact that even if the review is negative the consumers have more information, and can thus make a better-informed decision.

In the following graph we present the demand for expert services as a function of the good's price and the type-match bonus a, when a *non-star review* is observed.

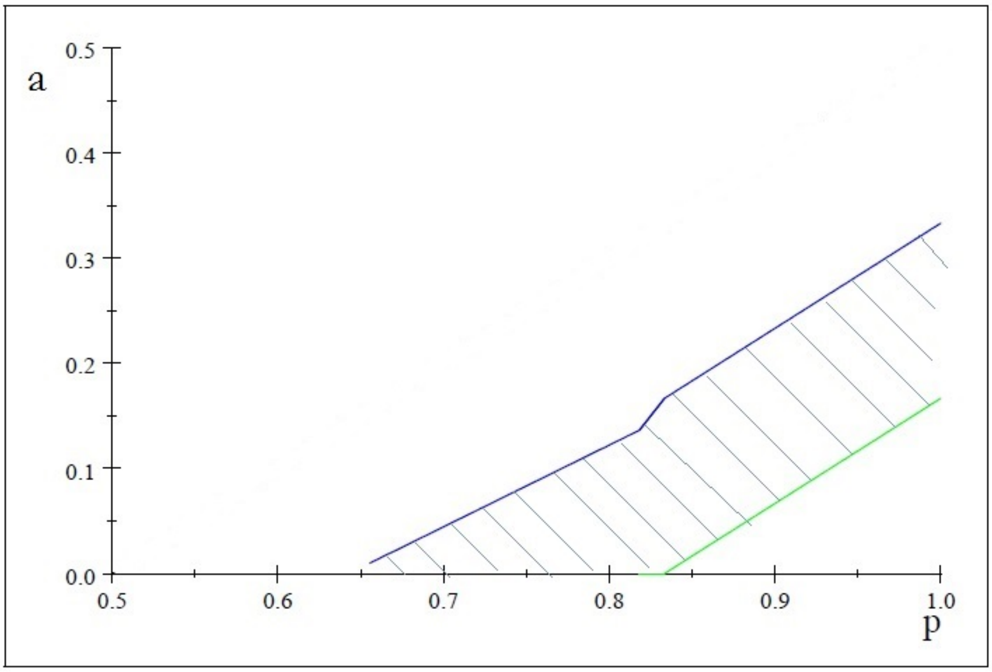
Figure 4.6: **Demand for expert services as a function of the good's price and type when $q < \frac{1}{2}$**



When a *non-star review* is found, the demand for expert services slightly increases with the good's price. The hashed area in Figure 4.6 represents the demand the expert faces as a function of p, with the consumers' type-match bonus a in the vertical axis. Though the mass of consumers who buy the good is quite consistent across the pricing regions, the biggest segment of consumers demanding the good is found when p falls just above the *low* pricing region's upper bound. On the other hand, the smallest segment is served when p falls in the boundary between the *intermediate* and *high* pricing regions. Notice that these are also the prices where the expert's equilibrium fee respectively takes its smallest and biggest values.

We can also see that the higher the price becomes, the higher the type of the consumers who consult the expert before buying. For instance, when p is *low* consumers with types $a \in [0.15, 0.35]$ ask the expert, whereas when the good's price is *very high*, only those with a type $a \in [0.6, 0.8]$ will ask the expert. Consumers with type bonuses smaller or larger than those respectively stay out of the market or get enough information to make the purchase decision from the user reviews. Nevertheless, the expert always faces some demand when a *non-star review* is found, irrespective of the good's price or type. This is not the case when a *star review* is observed, which we present in the following graph.

Figure 4.7: **Demand for expert services as a function of the good's price and type when** $q \geq \frac{1}{2}$



When a *star review* is found the expert faces some demand only if the good's price is at least in the *intermediate* pricing region, as indicated by the hashed area in Figure 4.7. Still, even in that case only consumers with low type values will be interested in the service. The biggest mass of consumers is served when the price of the good falls in the boundary between the *high* and *very high* regions.

Generally speaking, when a *star review* is found, consumers with small types are the ones most interested in asking the expert before buying. In fact, no consumer with a type a above 0.3 will ever consider asking the expert when $q \geq \frac{1}{2}$, no matter the size of p. Consumers with type bonuses as small as zero can ask the expert for prices in the *intermediate* and *high* regions. When the good's price is in the *very high* region, the type of the consumers who ask the expert increases in p. For such a p, consumers with type values close to zero will no longer consider asking the expert before buying.

It is worthwhile noting that for all price levels the types of the consumers who ask the expert when a *star review* is found are smaller than those of the consumers who consult him when the review is negative. For example, a consumer with a type 0.3 would ask the expert only if a *star review* is found and p is *very high*. For any other p, he would buy the good based on the positive user review alone. On the contrary, the same consumer would stay out of the market if a *non-star review* is observed, unless the good's price is *low*. Such a hypothetical consumer would never buy the good based on the negative review alone, irrespective of the good's price. Either she would ask the expert first or refrain from buying. Similarly, a consumer with a type value 0.5 would never even consider asking the expert before buying if she observes a *star review*, but she would certainly be interested in the expert's service if the good's price is *high*. Her type match bonus is sufficiently high for her to decide to buy the good based on the user reviews, even if they are negative, when the good's price is *low*. She will abandon the market if p becomes *very high*, but has incentives to consult the expert before buying if the good's price is somewhere in between.

We have found that a similarly sized segment of consumers (with higher values of a) enter the market as the one comprising those (with very low types) who stop asking the expert before buying, when p rises through the pricing regions. Hence the relative consistency of the total mass of consumers who ask the expert; particularly when a *non-star review* is found or when the good's price is *high*. Thus, a more expensive good attracts more high-type consumers to the expert services, though the overall number of consumers who enter and exit the market are roughly equivalent. In the next section we compare these results with the benchmark where the expert was the only informational channel available to the consumers.

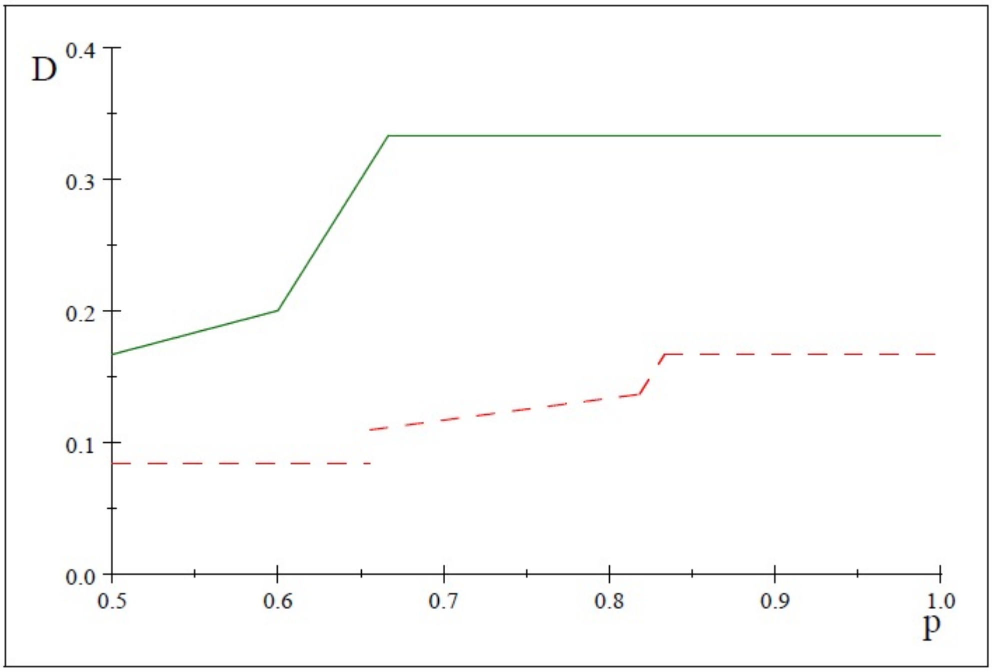
4.5.3 Effect of User Reviews on the Behavior of the Expert

In this section we use the results discussed in sections 4.4.1 and 4.5.1 to analyze the way user reviews affect the expert's strategies. With this in mind we compare the expert's equilibrium pricing decisions, his profits, and demand, both in our benchmark and when user reviews become available.

User reviews offer the consumers a refinement on the information they have at the moment of making the participation decision, which fundamentally alters their incentives to consult the expert. A twofold effect takes place as a consequence. First, directly influencing the demand for expert services due to the consumers who now have enough information to purchase based on the user reviews and thus dismiss the expert. Second, and perhaps less directly, by changing the decisions of the firm. These two effects do not need to go in the same direction, as a loss in demand due to the informational competition might be simultaneous to a decrease in the good's price, carried out by the firm to attract consumers in case the users review was not positive.

To better understand these dynamics, in the following graph we present a comparison of the demand served by the expert as a function of p, for the benchmark and the scenario when user reviews are available.

Figure 4.8: **Demand for expert services as a function of the good's price with and without user reviews**



The demand the expert faces in the presence of user reviews (the dashed line) is a non-decreasing function of p. However, it is much smaller than when the expert is the only source of information available to the consumers (the solid line). A free-to-access competing source of information is bound to detract from the expert's potential demand.

There is a discontinuity in the demand function with user reviews at the *intermediate* pricing region. This happens due to the entry of consumers who observe a *star review*. For *low* prices the expert only faces some demand from consumers who observe a negative review. Nevertheless, this increase is smaller than in the benchmark, as we can see by comparing the slopes of the demand functions in this pricing region. That said, the behavior of the demands as functions of p is quite similar in the two cases: more consumers are attracted as p increases, with a maximum demand segment being reached the closer p gets to the *very high* region. Interestingly, the maximum demand in the benchmark is served at a significantly lower price, $p = \frac{2}{3}$, while in the presence of user reviews this occurs at a price $p = \frac{5}{6}$.

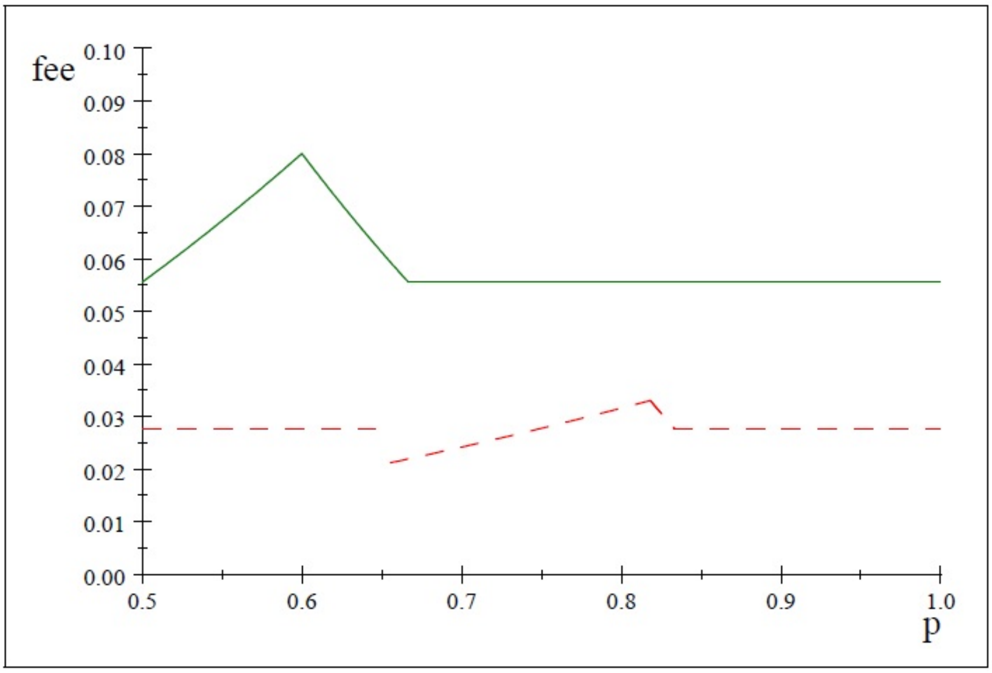
In terms of the types of consumers who consult the expert, we find that consumers with higher valuations are the ones interested in asking the expert when user reviews become available. Looking at figures 4.4, 4.6, and 4.7 we see that when the price of the good is *very high* consumers with types $a \in [0.25, 0.75]$ ask the expert before buying if user reviews are not available. Meanwhile, if the user reviews are negative, only consumer with types $a \in [0.6, 0.8]$ will consider asking the expert.

This effect takes the opposite direction when a *star review* is found. If the price of the good is *intermediate*, consumers with types as low as zero ask the expert both in the benchmark and when user reviews are available. However, no consumer with a type bonus above 0.15 will ask the expert if the user review is positive and p is close to the *intermediate* region lower bound. On the other hand, consumers with types up to 0.55 might ask the expert in the benchmark.

Therefore, some high-type consumers enter the expert services market when the user reviews are negative, while low-type consumers are the ones who may ask the expert if the user reviews are positive. The relative sizes of the masses of consumers who enter and leave the market under each scenario will determine whether the demand for expert services as a whole increases or decreases as a result of user reviews being freely available. Nonetheless, as we can see in Figure 4.8, the overall effect of user reviews on the demand for expert services is negative.

Now we look at the fee the expert charges – the only variable under his control. The equilibrium fee λ is presented as a function of p in the following graph, comparing the decisions of the expert both when user reviews are available and in the benchmark.

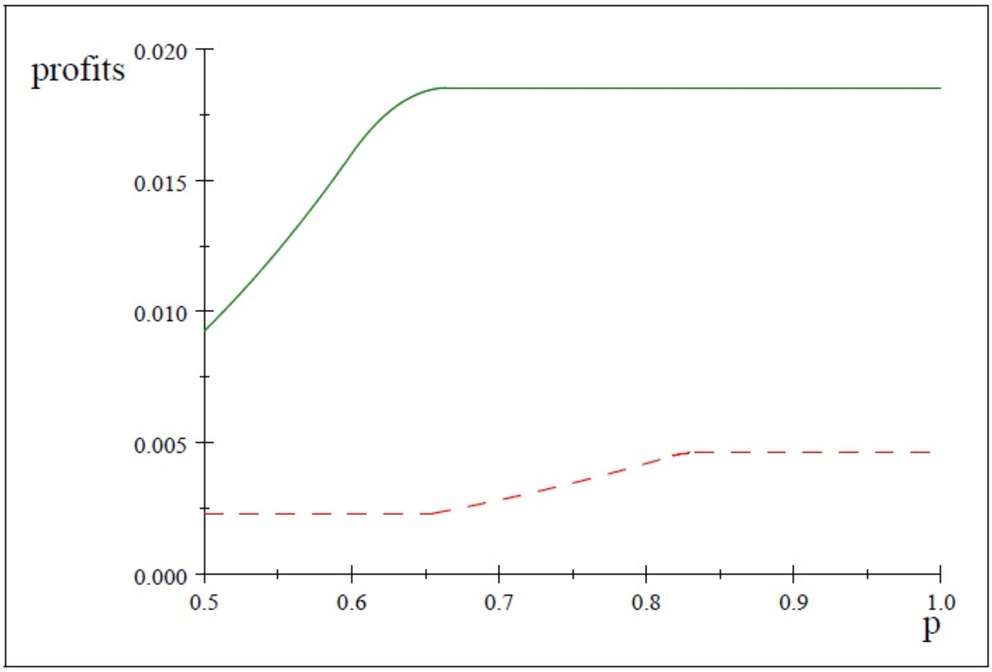
Figure 4.9: **Expert's fee as a function of the good's price with and without user reviews**



The expert can charge a much lower fee under the presence of user reviews, irrespective of the size of p. The highest fees the expert sets in the equilibrium occur when user reviews are not available and the good's price is *low*, as we can see in the solid line in Figure 4.9. When user reviews are present (the dashed line), the equilibrium λ attains its maximum value in the boundary of the *intermediate* and *high* regions.

Although still quite smaller than the fee charged when user reviews are not present, the equilibrium λ increases as a function of p through the *intermediate* pricing region when user reviews are available. This is explained by the demand the expert obtains in this region from the consumers who find a *non-star review*. Observing a negative review makes their expectations on q *worse*, reinforcing the incentives they have to consult the expert and thus allowing him to price highly despite the already high level of p. Both in the benchmark and when user reviews are available, the fee the expert charges when p is *very high* and *low*, take the same value. However, unlike what happens in the benchmark, this is not the lowest value λ can take in the equilibrium when user reviews are available. Instead, the lowest γ is found when p is in the *intermediate* region's lower bound.

Figure 4.10: **Expert's profits as a function of the good's price with and without user reviews**



We can see that an expert who charges a lower fee and serves a smaller demand in the presence of user reviews also obtains lower profits when a free-to-access source of information is available in the market. In Figure 4.10 we see that the expert's profit level increases in p both when user reviews are available and in our benchmark.

Nevertheless, even at the highest level of profits the expert attains with user reviews ($\Pi = 0.0035$ in the dashed line), these barely approach half the value of the lowest profit level the expert obtains when there are no competing sources of information ($\Pi = 0.0185$ in the solid line). Furthermore, the expert starts to obtain the maximum level of profits in the benchmark for values of p above $\frac{2}{3}$, while the maximum profit level is attained for prices over 0.833 when user reviews are present. Hence, the availability of alternative sources of information constrain the expert's strategies, allowing him to obtain large profits only for *very high* values of p.

We have completed the analysis of the expert's behavior when the good's type is publicly known and user reviews are freely available in the market. Clearly, the potential demand for expert services decreases when new information appears in the market. The same effect is observed in his pricing strategy and profits, which are quite smaller than the benchmark. Evidently, the expert is much worse off in such a scenario, confirming what anecdotal evidence had suggested: many outlets devoted to publishing film, music, and other entertainment goods reviews have closed down in recent years, as user reviews became more abundant and easier to access. Our model supports such an intuition, describing an equilibrium where an expert serves a smaller demand segment and obtains significantly lower profits when competing with free-to-access user reviews. One could even argue that for a high enough cost of providing the service (in our setup it is assumed to be zero), the expert would ultimately decide to exit the market.

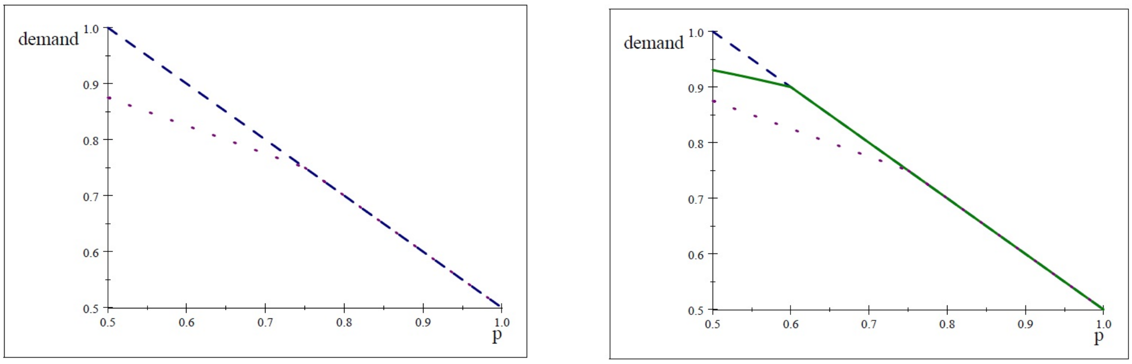
4.5.4 Firm Behavior when Expert Services and User Reviews are Available

In this section we analyze the firm's decisions when consumers can access information from the expert and user reviews before purchasing the experience good. We compare the equilibrium pricing strategies of the monopolist in the benchmark and when the expert must compete with user reviews as a rival source of information, focusing on the demand served by the firm and the profits it obtains in each case.

From the analysis of the benchmark carried out in section 4.4.3 we know that, in the equilibrium, the firm is indifferent between serving the market with or without expert services. That is, it obtains the same level of profits when the expert is present and when the service is unavailable. Now we first study whether user reviews alone have a similar effect on the decisions of the firm, without yet introducing the expert in the market. Indeed, we find that the presence of user reviews does not change the equilibrium decisions of the firm. We formally present the result in the following proposition.

Proposition 9. *A monopolist producing an experience good in a market where user reviews are available, sells the good at a price* $p^G = \frac{3}{4}$*, serving a demand* $D^G = \frac{3}{4}$ *and obtaining profits* $\Pi^G = \left(\frac{3}{4}\right)^2$.

We can see that the monopolist obtains the same level of profits, serves an identical demand, and charges the same equilibrium fee both when user reviews are available as the only source of information for consumers, than when they decide to purchase based exclusively on their priors or even when expert services are present. Therefore, the appearance of just one source of information in the market does not affect the decisions of the firm in the equilibrium. In order to understand whether this might be the case when more than one source of information appears, it is interesting to first consider the demand for the good as a function of p. In the following graphs we present the demand for the good as a function of the good's price in the three scenarios currently under discussion: with user reviews, with expert services, and without additional information.



(a) **Demand for the good with user reviews**

(b) **Demand for the good with user reviews and expert services**

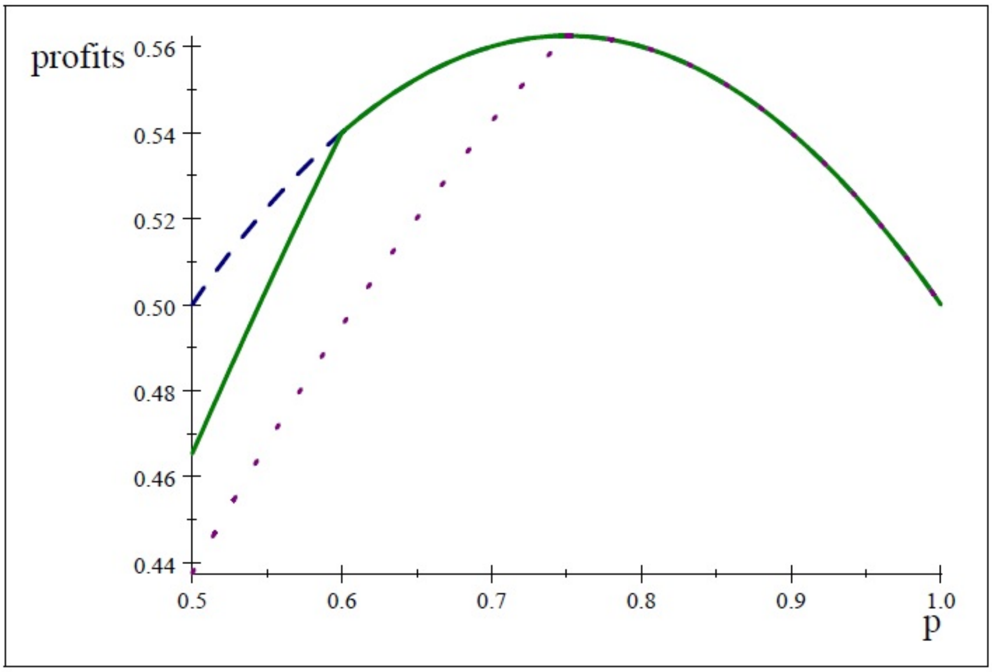
Figure 4.11: **The monopolist's demand a function of p when only one source of information is available**

On the left we see the demand for the good as a function of p when no additional information is available (the dashed line) and when only user reviews appear in the market (the dotted line). The demand is predictably price-sensitive, although it is surprising that fewer consumers buy the good when user reviews are available and p is *low* than when the consumers decide based only on their priors. This happens because of all the consumers who drop out of the market when they find a negative review. Of course, this effect continues to take place at higher pricing levels, with a caveat: For a *high* p few consumers buy the good based on their priors, but just enough for those who drop out of the market not to be fewer than the total mass of consumers who would buy the good if they found a positive review at this pricing level. In simpler words, the consumers who enter the market because of a positive user review even-out those who exit due to a negative one or a high price. Actually, the demands are equal for any value of p in the *intermediate*, *high* or *very high* regions, as we can see in Figure 4.11a.

On the right side of the same graph we add the demand for the good as a function of the price when the expert is present but there are no user reviews (the solid line). We find that the mass of consumers who buy the good in any of the three scenarios decreases in p. However, the demand drop for *low* pricing levels that we also observe in the presence of user reviews, is smaller. That is, less consumers abandon the market after learning q from the expert when p is *low* than those who, at the same pricing level, leave the market after observing a negative user review. Evidently, the demand drop is attenuated because the consumers do not underestimate the quality of the good as they did when observing a *non-star review*. They learn the actual value of q from the expert. This is also why the demand with user reviews equalizes the one where no information is available at a much lower value of p than what happened with the dotted line in Figure 4.11a, representing the demand for the good when only user reviews are available.

As the equilibrium demands in the three cases are equal and the demand functions themselves overlap from that price onwards, we anticipate a similar behavior for the profit functions. In the graph below we present the equilibrium profits for the firm, as a function of the good's price, when user reviews, expert services, and no information are available to consumers at the moment of taking the participation decision.

Figure 4.12: **The monopolist's profits as a function of p when only one source of information is available**



We observe that the profits functions when no information is available (the dashed line), the expert is present in the market (the solid line), and user reviews appear (the dotted line), indeed replicate the behavior of their respective demands. All profits functions are convex in p, overlapping and decreasing from the equilibrium price $\frac{3}{4}$ onwards. Thus, the firm is evidently indifferent between either scenario, meaning that it is not concerned about where the consumers can obtain extra information on the good's quality or if there is any information available for them to begin with.

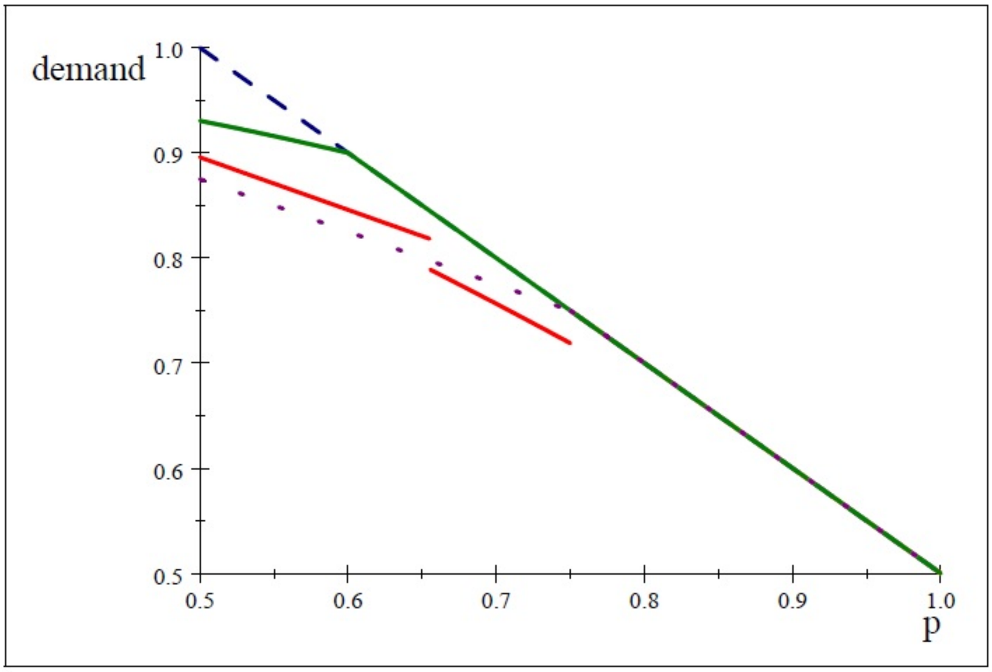
The firm's indifference lies on the fact that the mass of consumers who exit the market due to the positive information received, neutralizes the mass that abandon the market because of some negative information. However, it is not clear that this will also be the case when more than one source of information is available in the market at the same time. The simultaneous presence of expert services and user reviews might lead to less underestimation (and overestimation as well) in the equilibrium. In the following proposition we present the decisions of the firm when user reviews and expert services are available at the same time.

Proposition 10. *A monopolist producing an experience good of quality q unknown to the consumers and a type a publicly known, in a market where user reviews and expert services are available simultaneously, sells the good at a price $p^G = \frac{3}{4}$, serving a demand $D^G = \frac{3}{4}$, and obtaining profits $\Pi^G = \left(\frac{3}{4}\right)^2$.*

We find that the firm is indifferent between a scenario where both the user reviews and expert services are available at the same time and when the consumers have no information other than their priors to base their decisions. The monopolist's equilibrium strategies are the same in the two cases. He obtains the same level of profits, serves an identical demand, and charges the same price. Moreover, the monopolist is also indifferent between these two informational situations and the one where only user reviews or expert services are present. That is, the firm's strategies are not affected by the additional information coming from having two instead of a single source of information for consumers to learn about the good.

Before wholly discarding the demand-attraction effect of information in our model, we look at the demand functions in all four of the cases we analyze. In the following graph we present the demand for the good as a function of p when no information is available, user reviews and expert services are simultaneously present, and when either of the two are available separately.

Figure 4.13: **Demand for the good as a function of p when one or more sources of information are available**



As was the case when only one of the sources of information was available, the demand for the good is a decreasing function of p when user reviews and expert services are simultaneously present. However, the demand for the good when the two sources appear at the same time is not continuous (the solid red line in Figure 4.13; we keep the same notation as in Figure 4.11 for the other demands depicted). This demand comprises three separate segments corresponding to the *low*, *intermediate*, and *high* pricing regions. The consumers behave differently when the good's price falls in each of these regions. Their incentives to ask the expert despite already having the information from user reviews depend on p, which causes the jumps we observe in the demand for the good.

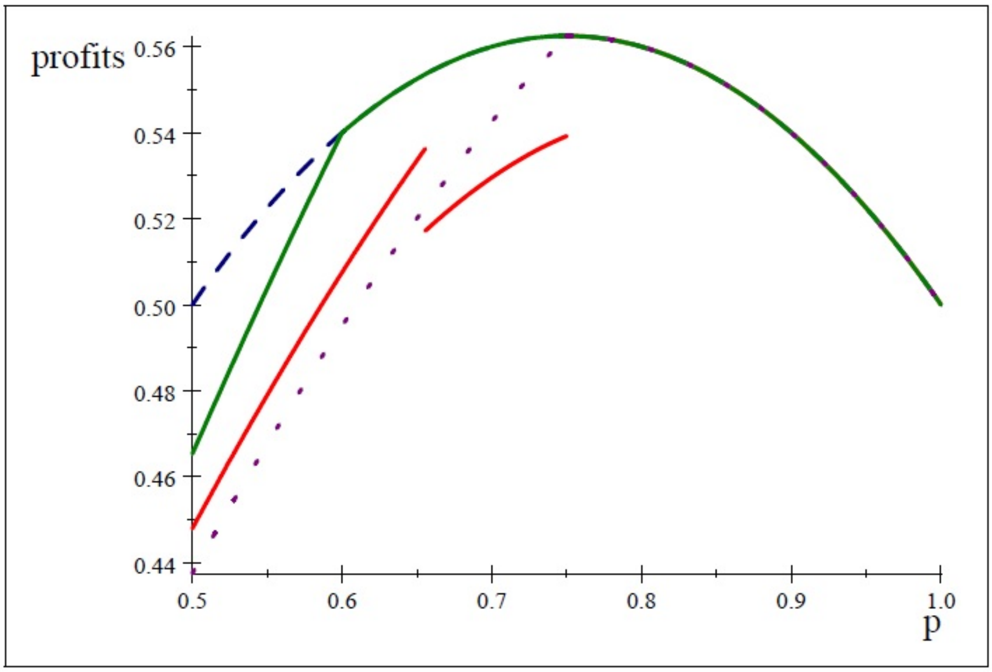
When a single source of information is available all the demands are equalized from the equilibrium price onwards. In the case where user reviews and the expert appear at the same time, this happens when p is in the *high* region. In the *low* pricing region the demand for the good when the two sources are available falls in-between the demands when only user reviews and the expert are active, above the former and below the latter. This indicates that there is some demand induction taking place at this pricing level. The effect comes from the consumers who decide to buy the good after asking the expert but who would have otherwise stood out of the market if they had to base their decisions solely on the user reviews. However, that demand is still quite smaller than the one the monopolist would face for a *low* price if there was no extra information in the market at all. Actually, it is even smaller than the demand the firm would serve if only the expert were present in the market. This hints at some underestimation from consumers who observe a negative user review and stay out of the market without asking the expert. But also, in the case with no extra information, there is some overestimation due to the low price and the crude expectations the consumers originally have. In both of these cases the over/underestimation is measured with respect to the demand the firm would serve when the real q is learned by some consumers through the expert.

For *intermediate* levels of p the demand when both sources of information are available falls below all other cases' demands. This happens because more consumers exit the market after learning the quality of the good from the expert. The *intermediate* price level also entails that more consumers will drop out of the market after learning q. Adding to this effect the mass of consumers who abandon the market simply because of the price – and particularly upon observing a negative review – we can understand the significant drop in demand observed when the two sources of information are available simultaneously and p is *intermediate*.

We find a very similar behavior in the monopolist's profits, with the firm obtaining the same level at the equilibrium price $\frac{3}{4}$ across the four scenarios we analyze. In the following graph we present the profits the monopolist obtains as a function of

p when all the combinations of informational sources discussed are available, either alone or simultaneously, for consumers to access.

Figure 4.14: **Profits for the monopolist as a function of p when one or more sources of information are available**



For a price bigger or equal than $\frac{3}{4}$, the firm is indifferent between any of the informational situations. That is, it obtains identical profits $\Pi^G = \frac{9}{16}$ when no additional information is available (the dashed line), only the expert (the solid green line) or the user reviews (the dotted line) are present at once, or simultaneously (the solid red line). For *low* pricing levels we find that the firm is worse off when only user reviews are present, as it obtains the lowest profits of the four cases. The scenario without extra information continues to dominate all others, but at a *low* pricing level the firm would prefer only the expert to be available, as that yields him the second highest profits of the four scenarios, bigger than when both user reviews and the expert – or only user reviews – are present. Hence, we can say that the firm would, in general, prefer to keep user reviews out of the market when the good's price is *low*.

The situation is somewhat similar for *intermediate* values of p. The worst scenario for the firm is the one where both sources of information are simultaneously active. This outcome derives from the fact that the demand served by the monopolist is also the smallest at this pricing level. Interestingly, for *intermediate* values of p the firm is indifferent between the scenario where no information is available and the one where only the expert is present. Similarly, the firm would prefer the user reviews to be available on their own, over both the expert and user reviews being simultaneously present. This shows that for *low* prices the firm benefits from the consumers' overestimation of the good's quality, as scenarios with increasing levels of information diminish his demand. On the other hand, the monopolist suffers from underestimation when the good's price is *intermediate*, with more consumers dropping out when their information is refined by the user reviews but not entirely accurately.

Although the firm is indifferent between all the informational scenarios in the equilibrium, this does not mean that user reviews or expert services do not play a role in the market. While it is true that their information-refining effects cancels out in the equilibrium demand, the internal dynamics of the market are quite different in each informational situation. The types of consumers who enter the market and consider the purchase, be it due to the information provided by user reviews or the expert, are not the same in the four scenarios. We examine this in the following section, looking at the market-wide effects of expert services and user reviews through a measure of consumer welfare.

4.6 Welfare Effects of Expert Services and User Reviews

In this section we study the welfare implications of the presence of different sources of information in a market for experience goods. From our analysis in sections 4.4 and 4.5 we know that in the equilibrium the firm is indifferent between all of these scenarios. However, in section 4.5.4 we already perceive the potential gains in consumer welfare coming from the increased availability of information. Over and underestimations of the good's quality become diminished as more accurate information regarding q is acquired by a wide range of consumers.

In the following table we present the monopolist's profits, the consumer surplus, and the expert's profits in the equilibrium, across the four informational cases we have been studying.

Table 4.1: **Social Welfare when User Reviews and Expert Services are Available in a Market for Experience Goods**

Informational Situation	Consumer Surplus	Firm Profits	Expert Profits	Total Welfare
No Information	0.2812	0.5625	-	0.8437
Expert Only ($\lambda = 0.0555$)	0.2920	0.5625	0.0185	0.8730
User Reviews Only	0.3125	0.5625	-	0.8750
Both Simultaneously ($\lambda = 0.0278$)	0.3308	0.5625	0.0035	0.8969

We already know that the firm is indifferent between the four informational scenarios. This is made evident by the monopolist's profits being identical in the four cases. On the other hand, as described in section 4.5.3, the expert is worse off when competing with user reviews as a source of information. The expert charges a fee barely half the value of what he would if user reviews were not available, obtaining a sixth of the profit level.

The consumers' welfare, measured through their *ex post* surplus, increases as more information becomes available. Thus, it is the highest when the expert and user reviews are simultaneously active. This is also true for the total social welfare, taken as the sum of our three agents' profits and/or surplus. However, notice that the consumers' welfare is smaller when expert services are the only source of information than when user reviews alone are present. This is mostly due to the fee the expert charges for his service.

The quality of the information obtained by the consumers is important, despite both the total welfare and the consumers' surplus being higher when only user reviews are available than when only the expert is. We can clearly see this in the case where both are simultaneously available, causing over and underestimation to drastically reduce among the consumers. The welfare-improving effect of the finer information offered by the expert is partially mitigated by the transfer taking place between the consumers and the expert in the form of λ. Hence, on the grounds of their surplus, the consumers would seem to prefer only the user reviews to be available over only the expert being active. However, the consumers' welfare significantly improves when both sources of information are available simultaneously. As a consequence, it is possible to say that more (if not better information) leads to socially-desirable states.

Therefore, we can conclude that the consumers are better off with some information, no matter its cost or source, rather than none. This confirms what the theory has long suggested: better-informed consumers make better decisions in markets where information is not symmetric.

We believe that the lack of an effect over the firm's equilibrium decisions is a consequence of some modeling choices; namely, the linearity of the utility functions. Some consumers improve their welfare by deciding not to buy the good after consulting the expert and paying his fee, while they would have bought the good (to an *ex post* loss) if the decision had been based only on their priors or information obtained from user reviews. Some others decide to buy the good after learning q through the expert, though they would not have participated in the market in any other informational scenario. This masses of consumers have equivalent sizes given the characteristics of our model, which causes their effects on the good's demand to seemingly cancel out. That said, the society at large is better off the more information becomes available, as we can infer from the evolution of the total welfare in Table 4.1.

4.7 Conclusions

In this work we study the role of expert services and user reviews in experience goods markets. We first develop a theoretical model to understand how the information provided to the consumers by these agents affects the market outcomes. Later we introduce free-to-access user reviews in the market, from which consumers can learn some information on the good. We find that both expert services and user reviews increase consumers' welfare with respect to a benchmark where they decide to purchase based on their priors. In particular, user reviews grant the consumers a superior surplus to expert services. Despite user reviews offering less accurate information on the good's quality, they are available for free and diminish the negative effects of under/overestimation. On the contrary, although expert services reveal the good's exact quality, they are costly for the consumers. This downplays the welfare-enhancing effect the service has. Moreover, the total welfare in the market is also smaller under the presence of expert services alone than when only user reviews are present. Thus, even though user reviews might still lead to under/overestimation in the good's purchase, the effect they have over the consumers' surplus – not least owing to their gratuity – is large enough to compensate this.

On the other hand, the firm selling the experience good is not affected by the presence of expert services. In the equilibrium the monopolist charges the same price and serves the same demand as in the benchmark. Demand-inducing effects do not appear to take place, though the composition of the market does change. Consumers with low valuations enter the market, while some at the upper end of the valuations distribution stop purchasing after learning the good's quality. That is, consumers who would otherwise not have entered the market participate in the informational exchange with the expert, in some cases buying the good afterwards. Others, who would have bought the good based on their priors, learn its real quality and no longer purchase. The intermediate market thus generated is much bigger than the demand for the good, although in the equilibrium the consumers who enter the experience good's market after consulting the expert cancel out the mass of those who stop buying once they learn the good's quality. Hence, the firm is indifferent between selling the good without any additional information and when expert services are present.

Later, in what we believe to be the first theoretical effort to pursue this question, we analyze the effect of user reviews on the behavior of the expert when both are simultaneously active. Expert services are sensitive to competing sources of information; in essence, what user reviews are. In the equilibrium the expert charges a fee nearly half the value of what he could charge when operating alone. The expert also serves a smaller demand and obtains lower profits. The firm stays indifferent to the appearance of two sources of information in the market. The experience good's price, the demand served, and profits obtained are identical in the benchmark, when either the expert or user reviews appear, and even when both are available simultaneously. Nevertheless, a significant increase in the total consumers' surplus is observed when the two sources of information appear. Over/underestimation is thoroughly reduced when consumers can further refine the information obtained from user reviews by asking the expert if they so desire. Therefore, there are clear welfare-improving effects from the increase in information due to user reviews and expert services becoming available in the market.

From the latter result we see that although the firm may not be interested in keeping user reviews and expert services active in a market for experience goods, a planner would be. Particularly considering the experts, whose situation deteriorates when user reviews appear. Some external agent could sustain expert services in the market through subsidies or direct transfers. This scheme is not entirely unlike what one can observe in everyday life, where native advertising and sponsored content have become prevalent in many critical outlets. While these mechanism could be considered as direct transfers from the firm, they nonetheless operate as a way to replace consumer purchase/subscription as a regular source of revenue for the expert.

We chose the entertainment industry, and movies in particular, to illustrate our model because films offer the clearest, most representative, and quotidian example of an experience good. Other characteristics that make the film industry an interesting case to showcase our model are: the timing of expert and user reviews, with the former becoming available prior to a film's release, the use of non-quality related prices, negligible marginal costs for the sellers, and the possibility of considering a horizontal and vertical differentiation in the goods. However, expert services and user reviews of the type we study are also found outside of the entertainment industry, which makes our findings potentially relevant to other sectors.

It is interesting to consider the research paths that are opened by our results, mainly allowing us to refine our understanding of the expert's behavior in a market of this ilk. First, we could look at repeated interactions, where the consumer can choose between buying some good that she is completely unfamiliar with and another she has tried before. This gives the expert room to offer bundles of reviews, considerably expanding his pricing and reviewing strategies. Second, we could let the firm strategically decide the good's quality, which is given by nature in the framework we have discussed. Thus, we would move closer to markets with more persistent informational asymmetries; $i.e.$, credence goods markets. In that line, making the good's type unknown to the consumers is another intriguing route to pursue, as so is exploring alternative ways to model the expert's revenue. For example, including advertising aside from the direct sale of information. Finally, allowing the firm to signal the good's quality to the consumers, thus augmenting the information sources available to the consumers at the time of making the participation decision, poses an interesting informational scenario to dissect. A deeper consideration of all these questions, along the results we here discuss, will help us set the foundations toward a finer understanding of experience goods markets and the role information plays in them, either through expert services, user reviews or both.

Technical Appendix

Proof of Propositions 1, 2, and 3. We begin by finding the segment of consumers who would buy the good based only on their priors; that is, those whose expected utility is such that:

$$EU^{BB}(a,p) = \frac{1}{2} + a - p \geq 0 \iff a \geq a_0 \equiv p - \frac{1}{2}.$$

We know that the participation cut-off a_0 always falls in the region where the types are supported: $a_0 \in (0,1)\, \forall p \in \left(\frac{1}{2}, 1\right)$.

Thus, consumers with types $a \in (p, 1]$ would be willing to demand the expert's services given the good's price and their type. After consulting the expert, the consumer acquires the good if its quality is high enough. That is:

$$U^{ex-post}(q,a,p) = q + a - p \geq 0 \iff q \geq q^X \equiv p - a.$$

The minimum quality will fall in the supported values for the variable if:

$$q^X \geq 0 \iff a \leq p, \text{ and}$$
$$q^X \leq 1 \iff a \geq p - 1.$$

Therefore, the consumers who consult the expert will obtain a positive ex-post utility from consulting the expert and buying the good ($i.e.$, the information will be *useful* to them) if the quality reported is $q \in \left[q^X, 1\right]$ and the consumer's type is $a \in [0,p]\ \forall p \in \left(\frac{1}{2}, 1\right)$. No consumer with a type superior to p will ever consider consulting the expert before purchase, no matter how small λ is.

Hence, the expected utility from consulting the expert is given by:

$$EU^{XP}(a,p) = \begin{cases} \int_{p-a}^{1} (q + a - p)dq - \lambda & \text{if } a \in [0,p] \\ 0 & \text{otherwise.} \end{cases}$$

An expression we can rewrite as follows:

$$EU^{XP}(a,p) = \begin{cases} \frac{(1+a-p)^2}{2} - \lambda & : \text{ if } a \in [0,p] \\ 0 & \text{otherwise.} \end{cases}$$

We now consider the participation decision of the consumers who may be willing to consult the expert. For that to be the case, the expected utility obtained must be positive and superior to what the consumers would get from buying the good based on their priors. That is:

$$EU^{XP}(a,p) \geq 0 \iff a \geq a_1 \equiv p - 1 + \sqrt{2\lambda},$$
$$EU^{XP}(a,p) \geq EU^{BB}(a,p) \iff a \leq a_2 \equiv p - \sqrt{2\lambda}.$$

We can easily see that $a_1 > 0 \iff \lambda > \frac{(1-p)^2}{2}$, $a_1 < p \iff \lambda < \frac{1}{2}$ and $a_2 > 0 \iff \lambda < \frac{p^2}{2}$.

Therefore, the relevant values for the type are:

$$
\begin{aligned}
EU^{XP}(a,p) \geq 0 \ \text{ for all } \ a \in [0,1] \text{ if } \lambda \in \left[0, \frac{(1-p)^2}{2}\right] \ \text{ or} \\
\text{for all } \ a \in [a_1,1] \text{ if } \lambda \in \left(\frac{(1-p)^2}{2}, \frac{1}{2}\right), \\
EU^{XP}(a,p) \geq EU^{BB}(a,p) \ \text{ for all } \ a \in [0,a_2] \ \text{ if } \lambda \in \left[0, \frac{p^2}{2}\right].
\end{aligned}
$$

Also, notice that $a_2 > a_1 \iff \lambda \in \left(0, \frac{1}{8}\right)$.

With this information we can build the demand system for the expert, conditional on the fee he charges and the price of the good.

First, consider the case where $\lambda \in \left(0, \frac{(1-p)^2}{2}\right]$. A graphic representation of the demand faced by the expert, considering the arrangement of the relevant cut-off levels, is given by the dashed segment:

Figure 4.15: **Expert services market when** $\lambda \in \left(0, \frac{(1-p)^2}{2}\right]$ **and** $p \in \left(\frac{1}{2}, 1\right)$

Where $a_1 < 0$ implies that for the given λ and p, $EU^{XP}(p,\lambda) > 0 \ \forall a \in [0,1]$. Moreover, $EU^{XP}(p,\lambda) \geq EU^{BB}(p,\lambda) \ \forall a \in [0,a_2]$. Hence, the demand for expert services in this case is given by:

$$D^{XP}(\lambda,p) = a_2.$$

Next, consider the case where $\lambda \in \left(\frac{(1-p)^2}{2}, \frac{1}{8}\right]$. Again, the demand faced by the expert is given by the dashed segment:

Figure 4.16: **Expert services market when** $\lambda \in \left(\frac{(1-p)^2}{2}, \frac{1}{8}\right]$ **and** $p \in \left(\frac{1}{2}, 1\right)$

Here $a_1 > 0$, which implies that for the given λ and p, $EU^{XP}(p,\lambda) > 0 \ \forall a \in [a_1,1]$. Moreover, $EU^{XP}(p,\lambda) \geq EU^{BB}(p,\lambda) \ \forall a \in [0,a_2]$. Hence, the demand for expert services in this case is given by:

$$D^{XP}(\lambda,p) = a_2 - a_1.$$

Last, consider the case where $\lambda \in \left(\frac{1}{8}, \frac{p^2}{2}\right]$. Here $a_1 > a_2$, which implies that there is no demand for the expert for the given λ and p. Hence:

$$D^{XP}(\lambda,p) = 0.$$

Therefore, the demand for expert services can be written as follows:

$$D^{XP}(\lambda,p)=\begin{cases} p-\sqrt{2\lambda} & : \text{ if } \lambda\in\left[0,\frac{(1-p)^2}{2}\right] \\ 1-2\sqrt{2\lambda} & : \text{ if } \lambda\in\left[\frac{(1-p)^2}{2},\frac{1}{8}\right] \\ 0 & \text{otherwise.}\end{cases}$$

There are two cases to consider, corresponding to each segment of the demand function, when solving the expert's maximization problem. We denote these *Case I* and *II*, such that:

$$\begin{aligned} \max_{\lambda}\quad & \Pi^{XP-I}=\lambda(p-\sqrt{2\lambda}) \\ \text{s.t.}\quad & \lambda\geq 0 \\ & \lambda\leq\frac{(1-p)^2}{2}, \end{aligned}$$

is the maximization problem for *Case I*, and

$$\begin{aligned} \max_{\lambda}\quad & \Pi^{XP-II}=\lambda(1-2\sqrt{2\lambda}) \\ \text{s.t.}\quad & \lambda\geq\frac{(1-p)^2}{2} \\ & \lambda\leq\frac{1}{8}, \end{aligned}$$

is the maximization problem for *Case II*.

From the respective Kuhn-Tucker conditions we find that each maximization problem has two valid solutions, depending on the size of p. For *Case I*:

$$\lambda_1^I=\frac{2}{9}p^2 \;\text{ if } p\in\left(\frac{1}{2},\frac{3}{5}\right] \;\text{ and } \lambda_2^I=\frac{(1-p)^2}{2} \;\text{ if } p\in\left(\frac{3}{5},1\right).$$

And for *Case II*:

$$\lambda_1^{II}=\frac{(1-p)^2}{2} \;\text{ if } p\in\left(\frac{1}{2},\frac{2}{3}\right] \;\text{ and } \lambda_2^{II}=\frac{1}{18} \;\text{ if } p\in\left(\frac{2}{3},1\right).$$

However, one can easily find the expert's optimal fee for each pricing region. When $p\in\left(\frac{1}{2},\frac{3}{5}\right]$ both λ_1^I and λ_1^{II} are feasible candidates, but λ_1^I dominates the other since they are respectively an internal and corner solution for the maximization problem under the established values of p. The same happens when $p\in\left(\frac{2}{3},1\right)$, where both λ_2^I and λ_2^{II} are valid but the latter dominates the former, being an interior solution. There is only one valid candidate when $p\in\left(\frac{3}{5},\frac{2}{3}\right]$: $\lambda_2^I=\lambda_1^{II}=\frac{(1-p)^2}{2}$.

The demand the expert serves and the profits he obtains given a pricing level, are:

$$\begin{aligned}
&\text{If } p \in \left(\frac{1}{2}, \frac{3}{5}\right] \text{ then } D^{XP} = \frac{p}{3},\ \Pi^{XP} = \frac{2}{27}p^3.\\
&\text{If } p \in \left(\frac{3}{5}, \frac{2}{3}\right] \text{ then } D^{XP} = 2p-1,\ \Pi^{XP} = \frac{(1-p)^2}{2}(2p-1).\\
&\text{If } p \in \left(\frac{2}{3}, 1\right) \text{ then } D^{XP} = \frac{1}{3},\ \Pi^{XP} = \frac{1}{54}.
\end{aligned}$$

■

Proof of Lemma 1. The segment of consumers who would be willing to buy the good based only on their expectations is:

$$EU^{BB}(a,p) = \frac{1}{2} + a - p \geq 0 \iff a \geq a_0 \equiv p - \frac{1}{2}.$$

Clearly, for the values of p that the firm can set, the participation cut-off computed falls in the region where the types are supported: $a_0 \in (0,1)\, \forall p \in \left(\frac{1}{2}, 1\right)$.

Therefore, the demand is given by:

$$D^G = 1 - a_0 = \frac{3}{2} - p.$$

The firm's maximization problem is the following:

$$\max_p \quad \Pi^G = p\left(\frac{3}{2} - p\right).$$

From which we find that the optimal price is:

$$p = \frac{3}{4}.$$

The demand the firm serves is $D^G = \frac{3}{4}$, obtaining profits $\Pi^G = \left(\frac{3}{4}\right)^2$. ■

Proof of Proposition 4. From the proof of *propositions 1, 2, and 3* we know that consumers with a type $a \in [a_0, 1]$ obtain a positive utility from buying the good based only on their priors.

We also know the expected utility for those consumers who buy the good after consulting the expert:

$$EU^{XP}(a,p) = \begin{cases} \frac{(1+a-p)^2}{2} - \lambda & : \text{ if } a \in [0,p] \\ 0 & \quad \text{otherwise.} \end{cases}$$

Moreover:

$$EU^{XP}(a,p) \geq 0 \iff a \geq a_1 \equiv p - 1 + \sqrt{2\lambda},$$
$$EU^{XP}(a,p) \geq EU^{BB}(a,p) \iff a \leq a_2 \equiv p - \sqrt{2\lambda}.$$

There are three cases to consider:

1. When the price is in the *low* region, $p \in \left(\frac{1}{2}, \frac{3}{5}\right]$.

   We know that the demand for the good will comprise those consumers who would have bought the good based only on their priors and those who, once they learn q from the expert, obtain a positive *ex post* utility. That is, those consumers who ask the expert and learn that the quality is at least $q^X \equiv p - a$. The expert sets an optimal fee $\lambda = \frac{2p^2}{9}$ in this region. Therefore, the demand for the good is given by:

   $$D^G = (1 - a_2) + \int_0^{a_2} (1 - (p - a))da = 1 - \frac{5p^2}{18}.$$

   From solving the maximization problem we get $p = \sqrt{\frac{6}{5}}$ as a candidate solution. However, it falls outside of the supported pricing region, being bigger than 1. Hence, the maximization problem's solution is not interior, taking the maximum value for the price: $p^G = \frac{3}{5}$, with profits $\Pi^G = \frac{27}{50}$.

2. When the price is in the *intermediate* region, $p \in \left(\frac{3}{5}, \frac{2}{3}\right]$.

   Here the demand continues to be given by:

   $$D^G = (1 - a_2) + \int_0^{a_2} (1 - (p - a))da,$$

   although the fee charged by the expert is: $\lambda = \frac{(1-p)^2}{2}$. Therefore, the demand for the good in this case is given by:

   $$D^G = \frac{3}{2} - p.$$

   From solving the maximization problem we get the candidate solution $p = \frac{3}{4}$. However, it falls outside of the supporting pricing region. Thus, the optimal price set by the firm is: $p^G = \frac{2}{3}$, obtaining profits for $\Pi^G = \frac{5}{9}$.

3. Finally, when the price is in the *high* region, $p \in \left(\frac{2}{3}, 1\right]$.

   As in the previous two cases, the demand for the good is given by:

   $$D^G = (1 - a_2) + \int_0^{a_2} (1 - (p - a))da,$$

   with the expert charging a fee $\lambda = \frac{1}{18}$. Therefore, the demand for the good in this pricing region is:

   $$D^G = \frac{3}{2} - p.$$

In this case the candidate solution obtained from solving the maximization problem $p = \frac{3}{4}$ is supported by the pricing region. Hence, the optimal price set by the firm is $p^G = \frac{3}{4}$, with profits $\Pi^G = \frac{9}{16}$.

By comparing the different profits levels we can see that the expert gets the highest profits when setting a price in the *high* region. Thus, his optimal fee is $p^G = \frac{3}{4}$.

■

Proof of propositions 5, 6, 7, and 8. This proof follows the general structure of *Proposition 1, 2 and 3*'s proof, although we adjust the consumers' decisions to include the new information available from user reviews (from now on UR). Therefore, we must consider two cases: *Case A* when the UR tell the consumers that the good's quality is above $\frac{1}{2}$, and *Case B* when the UR reveal the quality of the good to be below $\frac{1}{2}$.

We begin by studying *Case A,* where $q \geq \frac{1}{2}$. Upon seeing a *star review* from the UR, the consumers update their priors on the good's quality, such that: $q \sim U\left(\frac{1}{2}, 1\right)$. Thus, the consumers' expected value for the quality is $\int_{\frac{1}{2}}^{1} 2q\, dq = \frac{3}{4}$. Hence, the expected utility for the consumers who purchase without consulting the expert is:

$$EU^{BB}(p,a) = \frac{3}{4} + a - p.$$

Furthermore, consumers with a type such that:

$$EU^{BB}(p,a) \geq 0 \iff a \geq a_{BB} \equiv p - \frac{3}{4},$$

will consider buying the good based solely on their UR-updated priors. Notice that $a_{BB} \geq 0 \iff p \geq \frac{3}{4}$. Thus, we need to consider two participation scenarios: the first when $p \in \left(\frac{1}{2}, \frac{3}{4}\right]$ so that any consumer in the market obtains positive expected utility from buying the good based on the UR, and the second when $p \in \left(\frac{3}{4}, 1\right)$ and only consumers with $a \in (a_{BB}, 1]$ would buy the good based on the information coming from the UR.

A consumer who reads the UR and potentially considers consulting the expert before buying, cannot have a type parameter such that his utility from purchasing based on his UR-updated priors is positive even when the quality of the good takes the lowest value ($q = \frac{1}{2}$). That is:

$$EU^{min}(a,p) = \frac{1}{2} + a - p \geq 0 \iff a \geq a_0 \equiv p - \frac{1}{2}.$$

Thus, the segment of consumers who may consult the expert have a type in the following region: $a \in [0, a_0]$. Notice that $a_{BB} < a_0$ for any value of p. Then, there may be a potential demand for the expert between consumers who observe the star review and still want to consult with him before buying the good. These are the consumers with types in the $a \in (a_{BB}, a_0]$ segment.

Out of those consumers some will be interested in asking the expert, given the good's price and their own type, if the quality revealed is high enough for them to obtain an *ex post* positive utility. That is:

$$U^{ex-post}(q,a,p) = q + a - p \geq 0 \iff q \geq q^X \equiv p - a.$$

The minimum quality will fall in the supported interval if:

$$q^X \geq \frac{1}{2} \iff a \leq a_0 \equiv p - \frac{1}{2}, \text{ and}$$
$$q^X \leq 1 \iff a \geq a_1 \equiv p - 1.$$

Notice that $a_1 < 0$ for $p \in \left(\frac{1}{2}, 1\right)$. Therefore, the expected utility consumers with types $a \in [0, a_0]$ obtain from consulting the expert is given by:

$$EU^{XP}(a,p) = \begin{cases} 2\int_{p-a}^{1}(q+a-p)dq - \lambda = (1+a-p)^2 - \lambda & : \text{ if } a \in [0,a_0] \\ 0 & \text{otherwise.} \end{cases}$$

We now consider the participation decisions of the consumers who may be willing to consult the expert. The expected utility they obtain must be positive and superior to what the consumers would get from buying the good based on their priors. That is:

$$EU^{XP}(a,p) \geq 0 \iff a \leq a_2 \equiv p - 1 - \sqrt{\lambda} \text{ or } a \geq a_3 \equiv p - 1 + \sqrt{\lambda}$$
$$\text{and}$$
$$EU^{XP}(a,p) \geq EU^{BB}(a,p) \iff a \leq a_4 \equiv p - \frac{1}{2} - \sqrt{\lambda} \text{ or } a \geq a_5 \equiv p - \frac{1}{2} + \sqrt{\lambda}.$$

However, not all of the cut-offs computed fall in the supported region for the types. We can easily see that $a_2 < 0$ and $a_5 > a_0$ for $p \in \left(\frac{1}{2}, 1\right)$ and $\lambda > 0$. We thus discard these.

Furthermore:

$$a_3 > 0 \iff \lambda > (1-p)^2 \text{ and}$$
$$a_3 < a_0 \iff \lambda < \frac{1}{4} \text{ and}$$
$$a_3 < a_{BB} \iff \lambda < \frac{1}{16}.$$

Similarly:

$$a_4 > 0 \iff \lambda < \frac{(1-2p)^2}{4} \text{ and}$$
$$a_4 < a_0 \text{ for } \lambda > 0 \text{ and } p \in \left(\frac{1}{2}, 1\right), \text{ and}$$
$$a_4 < a_{BB} \iff \lambda > \frac{1}{16}.$$

Also, notice that:

$$a_4 > a_3 \iff \lambda \in \left(0, \frac{1}{16}\right).$$

Hence, we know that the expert faces no demand whenever he charges a fee higher than $\frac{1}{16}$.

We first study *Case I*, where $p \in \left(\frac{1}{2}, \frac{3}{4}\right]$. We know that for this pricing level $(1-p)^2 >$

$\frac{1}{16} > \frac{(1-2p)^2}{4} > 0$. With this information we can build the demand system for the expert, conditional on the fee he charges and the good's price.

First, consider the case where $\lambda \in \left(0, \frac{(1-2p)^2}{4}\right]$. A graphic representation of the demand faced by the expert, considering the arrangement of the relevant cut-off levels, is given by the dashed segment:

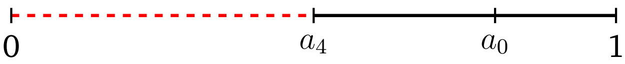


Figure 4.17: **Expert services market when** $\lambda \in \left(0, \frac{(1-2p)^2}{4}\right]$ **and** $p \in \left(\frac{1}{2}, \frac{3}{4}\right]$

Where $a_3 < 0$ implies that for the given λ and p, $EU^{XP}(p, \lambda) > 0 \ \forall a \in [0, a_0]$. Moreover, $EU^{XP}(p, \lambda) \geq EU^{BB}(p, \lambda) \ \forall a \in [0, a_4]$. Hence, the demand for expert services in this case is given by:

$$D^{XP-A}(\lambda, p) = a_4 = p - \frac{1}{2} - \sqrt{\lambda}.$$

Next, we consider the case where $\lambda \in \left(\frac{(1-2p)^2}{4}, \frac{1}{16}\right]$. Here the size of λ implies that $a_4 < 0$, which means that no consumer can get a higher utility from consulting the expert than when buying the good based on their UR-updated priors; the fee is just too high to compensate the value of the information obtained from the expert. Hence, there is no demand for the expert for the given values of λ and p:

$$D^{XP-A}(\lambda, p) = 0.$$

Now we move to *Case II*, where $p \in \left(\frac{3}{4}, 1\right)$. Thus, we know that for this pricing level: $\frac{(1-2p)^2}{4} > \frac{1}{16} > (1-p)^2 > 0$.

First, consider the case where $\lambda \in \left(0, (1-p)^2\right]$. A graphic representation of the demand faced by the expert, considering the arrangement of the relevant cut-off levels, is given by the dashed segment:

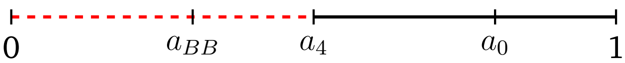


Figure 4.18: **Expert services market when** $\lambda \in (0, (1-p)^2]$ **and** $p \in \left(\frac{3}{4}, 1\right)$

Where $a_3 < 0$ implies that for the given λ and p, $EU^{XP}(p, \lambda) > 0 \ \forall a \in [0, a_0]$. Moreover, $EU^{XP}(p, \lambda) \geq EU^{BB}(p, \lambda) \ \forall a \in [0, a_4]$. Hence, the demand for expert services in this case is given by:

$$D^{XP-A}(\lambda, p) = a_4 = p - \frac{1}{2} - \sqrt{\lambda}.$$

Next, consider the case where $\lambda \in \left((1-p)^2, \frac{1}{16}\right]$. Again, the demand faced by the expert is given by the dashed segment:

Figure 4.19: **Expert services market when** $\lambda \in \left((1-p)^2, \frac{1}{16}\right]$ **and** $p \in \left(\frac{3}{4}, 1\right)$

Here $a_3 > 0$ implies that for the given λ and p, $EU^{XP}(p, \lambda) > 0 \; \forall a \in [a_3, a_0]$. Moreover, $EU^{XP}(p, \lambda) \geq EU^{BB}(p, \lambda) \; \forall a \in [0, a_4]$. Hence, the demand for expert services in this case is given by:

$$D^{XP-A}(\lambda, p) = a_4 - a_3 = \frac{1}{2} - 2\sqrt{\lambda}.$$

Lastly, consider the case where $\lambda > \frac{1}{16}$. Here $a_3 > a_4$, which implies that there is no demand for the expert for the given levels of λ and p. Hence:

$$D^{XP-A}(\lambda, p) = 0.$$

Having completed the analysis of the case where the good's quality is revealed by the UR to be above the expected value, we move to *Case B*, where $q < \frac{1}{2}$. That is, the consumers do not see a *star review* from the users, updating their priors on the good's quality such that: $q \sim U\left(0, \frac{1}{2}\right)$. Thus, the consumers' expected value for the quality is $\frac{1}{4}$. Hence, the expected utility for the consumers who purchase without consulting the expert, is:

$$EU^{BB-2}(p, a) = \frac{1}{4} + a - p.$$

Furthermore, consumers with a type such that:

$$EU^{BB-2}(p, a) \geq 0 \iff a \geq a_{BB-2} \equiv p - \frac{1}{4},$$

will consider buying the good based only on their UR-updated priors. Notice that $a_{BB-2} \geq 0 \iff p \geq \frac{1}{4}$, which is always the case for $p \in \left(\frac{1}{2}, 1\right)$. Thus, consumers with $a \in (a_{BB-2}, 1)$ would buy the good based on the information coming from the UR.

A consumer who reads the UR and potentially considers consulting the expert before buying cannot have a type parameter such that his utility from purchasing based on his UR-updated priors is positive even when the quality takes the lowest value possible ($q = 0$). That is:

$$EU^{min}(a, p) = 0 + a - p \geq 0 \iff a \geq a_{0-B} \equiv p.$$

Thus, the segment of consumers who may consult the expert have a type in the region $[0, a_{0-B})$. Notice that $a_{0-B} > a_{BB-2}$ for $p \in \left(\frac{1}{2}, 1\right)$.

Out of these consumers some will be interested in consulting the expert, given the good's price and their own type, if the quality revealed is high enough for them to obtain an *ex post* positive utility. That is:

$$U^{ex-post}(q, a, p) = q + a - p \geq 0 \iff q \geq q^{X-B} \equiv p - a.$$

The minimum quality will fall in the supported values for the variable if:

$$q^{X-B} \geq 0 \iff a \leq a_{0-B} \equiv p, \quad \text{and}$$
$$q^{X-B} \leq \frac{1}{2} \iff a \geq a_{1-B} \equiv p - \frac{1}{2}.$$

Where $a_{1-B} \in (0, a_{BB-2})$ for $p \in \left(\frac{1}{2}, 1\right)$. Thus, the consumers potentially ask the expert if and only if their type is $a \in [a_{1-B}, a_{0-B}]$. Consumers with higher or lower type values either buy the good based on their own priors or just stay out of the market.

The consumers' expected utility from consulting the expert is given by:

$$EU^{XP}(a,p) = \begin{cases} 2\int_{p-a}^{\frac{1}{2}}(q+a-p)dq - \lambda = \frac{1}{4}(1+2a-2p)^2 - \lambda & : \text{ if } a \in [a_{1-B}, a_{0-B}] \\ 0 & \text{otherwise.} \end{cases}$$

We now consider the participation decisions of the consumers who may be willing to consult the expert. We proceed as in this proof's first case:

$$EU^{XP}(a,p) \geq 0 \iff a \geq a_{2-B1} \equiv p - \frac{1}{2} + \sqrt{\lambda} \text{ or },$$
$$a \leq a_{2-B2} \equiv p - \frac{1}{2} - \sqrt{\lambda}.$$

and

$$EU^{XP}(a,p) \geq EU^{BB-2}(a,p) \iff a \leq a_{3-B} \equiv p - \sqrt{\lambda} \text{ or,}$$
$$a \geq a_{4-B} \equiv p + \sqrt{\lambda}.$$

However, not all of the cut-offs computed fall in the supported region. We can easily see that $a_{1-B} > a_{2-B2}$ and $a_{4-B} > a_{0-B}$ for all values of p and λ. We thus discard a_{2-B2} and a_{4-B}. Furthermore:

$$a_{2-B1} > a_{1-B} \text{ for } p \in \left(\frac{1}{2}, 1\right) \text{ and } \lambda > 0, \quad \text{and}$$
$$a_{2-B1} > a_{0-B} \iff \lambda > \frac{1}{4}, \quad \text{and}$$
$$a_{2-B1} < a_{BB-2} \iff \lambda \leq \frac{1}{16}.$$

Similarly

$$a_{3-B} < a_{0-B} \text{ for } p \in \left(\frac{1}{2}, 1\right) \text{ and } \lambda > 0, \quad \text{and}$$
$$a_{3-B} > a_{1-B} \iff \lambda \leq \frac{1}{4}, \quad \text{and}$$
$$a_{3-B} < a_{BB-2} \iff \lambda > \frac{1}{16}.$$

Also notice that:

$$a_{3-B} \geq a_{BB-2} \geq a_{2B-1} \iff \lambda \in \left(0, \frac{1}{16}\right] \text{ and}$$
$$a_{2B-1} > a_{BB-2} > a_{3-B} \iff \lambda > \frac{1}{16}$$

We need to consider two cases when computing the demand faced by the expert: *Case I - B* when $\lambda \in \left(0, \frac{1}{16}\right]$ and *Case II - B* when $\lambda \in \left(\frac{1}{16}, \frac{1}{4}\right]$. The expert faces no demand when charging higher fees.

We begin the analysis of the demand with *Case I-B*. A graphic representation of the demand faced by the expert, considering the arrangement of the relevant cut-off levels, is given by the dashed segment:

Figure 4.20: **Expert services market when** $\lambda \in \left(0, \frac{1}{16}\right]$ **and** $p \in \left(\frac{1}{2}, 1\right]$

Where for the given values of λ and p, $EU^{XP}(p, \lambda) > 0 \ \forall a \ \in [a_{2B-1}, a_{0-B}]$. Moreover, $EU^{XP}(p, \lambda) \geq EU^{BB-2}(p, \lambda) \ \forall a \ \in [a_{1-B}, a_{3-B}]$. Hence, the demand for expert services in this case is given by:

$$D^{XP-B}(\lambda, p) = a_{3-B} - a_{2B-1} = \frac{1}{2} - 2\sqrt{\lambda}.$$

Next, consider the case where $\lambda \in \left(\frac{1}{16}, \frac{1}{4}\right]$. Charging a fee on this level implies that $a_{2B-1} > a_{3-B}$; hence, no consumer obtains a positive expected utility from buying the good after consulting the expert. Therefore, the expert faces no demand when charging a fee in this level:

$$D^{XP}(\lambda, p) = 0.$$

We can now write the demand for expert services, corresponding to each of the good's pricing levels. In each case, the demand comprises the expected sum of what the expert would face when the good's quality is above and below $\frac{1}{2}$, respectively: $ED^{XP} = \frac{1}{2}D^{XP-A} + \frac{1}{2}D^{XP-B}$.

For $p \in \left(\frac{1}{2}, \frac{3}{4}\right]$, the expected demand is given by:

$$ED^{XP-I}(\lambda, p) = \begin{cases} \frac{1}{2}(p - \frac{1}{2} - \sqrt{\lambda}) + \frac{1}{2}\left(\frac{1}{2} - 2\sqrt{\lambda}\right) = \frac{1}{2}\left(p - 3\sqrt{\lambda}\right) & : \text{ if } \lambda \in \left[0, \frac{(1-2p)^2}{4}\right] \\ \frac{1}{2}(0) + \frac{1}{2}\left(\frac{1}{2} - 2\sqrt{\lambda}\right) = \frac{1}{4} - \sqrt{\lambda} & : \text{ if } \lambda \in \left(\frac{(1-2p)^2}{4}, \frac{1}{16}\right] \\ 0 & \text{otherwise.} \end{cases}$$

For $p \in \left(\frac{3}{4}, 1\right]$, the expected demand is given by:

$$ED^{XP-II}(\lambda, p) = \begin{cases} \frac{1}{2}\left(p - \frac{1}{2} - \sqrt{\lambda}\right) + \frac{1}{2}\left(\frac{1}{2} - 2\sqrt{\lambda}\right) = \frac{1}{2}\left(p - 3\sqrt{\lambda}\right) & : \text{ if } \lambda \in \left[0, (1-p)^2\right] \\ \frac{1}{2}\left(\frac{1}{2} - 2\sqrt{\lambda}\right) + \frac{1}{2}\left(\frac{1}{2} - 2\sqrt{\lambda}\right) = \frac{1}{2} - 2\sqrt{\lambda} & : \text{ if } \lambda \in \left((1-p)^2, \frac{1}{16}\right] \\ 0 & \text{otherwise.} \end{cases}$$

Since the expert is perfectly informed, he maximizes his profits as he is aware of the demand system just described. We first look at *Case I*, when $p \in \left(\frac{1}{2}, \frac{3}{4}\right]$.

There are two subcases to consider here. The corresponding maximization problems are the following. For *Case I-1*:

$$\begin{aligned} \max_{\lambda} \quad & \Pi^{XP\, I-1} = \lambda \left(\frac{1}{2} \left(p - 3\sqrt{\lambda} \right) \right) \\ \text{s.t.} \quad & \lambda \geq 0 \\ & \lambda \leq \frac{(1-2p)^2}{4} \end{aligned}$$

From the respective Kuhn-Tucker conditions we find that the maximization problem has the following candidate solutions:

$$\lambda_{I-1} = \frac{(1-2p)^2}{4} \text{ if } p \in \left(\frac{1}{2}, \frac{9}{14}\right] \text{ and } \lambda_{I-1B} = \frac{4p^2}{81} \text{ if } p \in \left(\frac{9}{14}, \frac{3}{4}\right],$$

The profit levels associated to each optimal fee, are:

$$\Pi^{XP\, I-1} = \frac{1}{16}(3 - 16p + 28p^2 - 16p^3) \text{ if } p \in \left(\frac{1}{2}, \frac{9}{14}\right] \text{ and } \Pi^{XP\, I-1B} = \frac{2p^3}{243} \text{ if } p \in \left(\frac{9}{14}, \frac{3}{4}\right],$$

The maximization problem for *Case I-2* is:

$$\begin{aligned} \max_{\lambda} \quad & \Pi^{XP\, I-2} = \lambda \left(\frac{1}{4} - \sqrt{\lambda} \right) \\ \text{s.t.} \quad & \lambda \geq \frac{(1-2p)^2}{4} \\ & \lambda \leq \frac{1}{16} \end{aligned}$$

From the respective Kuhn-Tucker conditions we find that the maximization problem has the following candidate solutions:

$$\lambda_{I-2} = \frac{1}{36} \text{ if } p \in \left(\frac{1}{2}, \frac{2}{3}\right] \text{ and } \lambda_{I-2B} = \frac{(1-2p)^2}{4} \text{ if } p \in \left[\frac{2}{3}, \frac{3}{4}\right],$$

The profit levels associated to each optimal fee, are:

$$\Pi^{XP\, I-2} = \frac{1}{432} \text{ if } p \in \left(\frac{1}{2}, \frac{2}{3}\right] \text{ and } \Pi^{XP\, I-2B} = \frac{1}{16}(3 - 16p + 28p^2 - 16p^3) \text{ if } p \in \left[\frac{2}{3}, \frac{3}{4}\right].$$

Finally, from comparing the candidate solutions for $Case\ I$'s maximization problem we get:

$$\Pi^{XP\,I-1B} > \Pi^{XP\,I-2} \text{ for } p \in \left[\left(\frac{243}{864}\right)^{\frac{1}{3}}, \frac{3}{4}\right].$$

Therefore, depending on the good's pricing level, the expert optimally sets the fees:

$$\lambda = \frac{1}{36} \text{ if } p \in \left(\frac{1}{2}, 0.655\right], \text{ and}$$

$$\lambda = \frac{4p^2}{81} \text{ if } p \in \left(0.655, \frac{3}{4}\right].$$

We now look at *Case II*, when $p \in \left(\frac{3}{4}, 1\right)$.

There are two subcases to consider here. The corresponding maximization problems are the following. For *Case II-1*:

$$\begin{aligned} \max_{\lambda} \quad & \Pi^{XP\,II-1} = \lambda\left(\frac{1}{2}\left(p - 3\sqrt{\lambda}\right)\right) \\ \text{s.t.} \quad & \lambda \geq 0 \\ & \lambda \leq (1-p)^2 \end{aligned}$$

From the respective Kuhn-Tucker conditions we find that the maximization problem has the following candidate solutions:

$$\lambda_{II-1} = \frac{4p^2}{81} \text{ if } p \in \left(\frac{3}{4}, \frac{9}{11}\right] \text{ and } \lambda_{II-1B} = (1-p)^2 \text{ if } p \in \left(\frac{9}{11}, 1\right),$$

The profit levels associated to each optimal fee, are:

$$\Pi^{XP\,II-1} = \frac{2p^3}{243} \text{ if } p \in \left(\frac{3}{4}, \frac{9}{11}\right] \text{ and } \Pi^{XP\,II-1B} = \frac{1}{2}(-3 + 10p - 11p^2 + 4p^3) \text{ if } p \in \left[\frac{9}{11}, 1\right).$$

The maximization problem for *Case II-2* is:

$$\begin{aligned} \max_{\lambda} \quad & \Pi^{XP\,II-2} = \lambda\left(\frac{1}{2} - 2\sqrt{\lambda}\right) \\ \text{s.t.} \quad & \lambda \geq (1-p)^2 \\ & \lambda \leq \frac{1}{16} \end{aligned}$$

From the respective Kuhn-Tucker conditions we find that the maximization problem has the following candidate solutions:

$$\lambda_{II-2} = \frac{1}{36} \text{ if } p \in \left(\frac{5}{6}, 1\right] \text{ and } \lambda_{I-2B} = (1-p)^2 \text{ if } p \in \left(\frac{3}{4}, \frac{5}{6}\right].$$

The profit levels associated to each optimal fee, are:

$$\Pi^{XP\,II-2} = \frac{1}{216} \text{ if } p \in \left(\frac{5}{6}, 1\right] \text{ and } \Pi^{XP\,II-2B} = \frac{1}{2}(-3+10p-11p^2+4p^3) \text{ if } p \in \left(\frac{3}{4}, \frac{5}{6}\right].$$

Finally, from comparing the two candidate solutions for $Case\ II$'s maximization problem we get that depending on the good's pricing level, the expert optimally sets the fees:

$$\begin{aligned} \lambda &= \frac{4p^2}{81} \text{ if } p \in \left(\frac{3}{4}, \frac{9}{11}\right], \text{ and} \\ \lambda &= (1-p)^2 \text{ if } p \in \left(\frac{9}{11}, \frac{5}{6}\right], \text{ and} \\ \lambda &= \frac{1}{36} \text{ if } p \in \left(\frac{5}{6}, 1\right). \end{aligned}$$

Therefore, the optimal pricing scheme for the expert is:

$$\lambda_* = \begin{cases} \frac{1}{36} & : \text{ if } p \in \left(\frac{1}{2}, 0.6555\right] \\ \frac{4p^2}{81} & : \text{ if } \lambda \in \left(0.6555, \frac{9}{11}\right] \\ (1-p)^2 & : \text{ if } \lambda \in \left(\frac{9}{11}, \frac{5}{6}\right] \\ \frac{1}{36} & : \text{ if } \lambda \in \left(\frac{5}{6}, 1\right) \end{cases}$$

■

Proof of Proposition 9. Since the user reviews can take two opposite values, we must consider the firm's decisions in two different cases:

1. When the review is positive: $q \geq \frac{1}{2}$

   In this case the consumer's expected value for the good's quality is $\frac{3}{4}$. Thus, the expected utility for a consumer with type a is given by:

   $$EU^{UR} = \frac{3}{4} + a - p.$$

   When only user reviews and no other sources of information are available in the market, consumers who obtain a positive expected utility decide to buy the good. That is:

   $$EU^{UR} \geq 0 \iff a \geq a_{UR} \equiv p - \frac{3}{4}.$$

We can see that a_{UR} falls in the support for the type distribution for $p \in \left[\frac{3}{4}, 1\right]$. Therefore, there are two subcases to consider:

- When $p \in \left(\frac{1}{2}, \frac{3}{4}\right]$:
  For these values of p, $a_{UR} < 0$. Thus, all consumers with types $a \in [0, 1]$ buy the good. The demand for the good is given by:

  $$D^{G-S} = 1.$$

- When $p \in \left(\frac{3}{4}, 1\right]$: For these values of p, $a_{UR} > 0$. Thus, consumers with types $a \in [a_{UR}, 1]$ buy the good. The demand for the good is given by:

  $$D^{G-S1} = 1 - a_{UR} = \frac{7}{4} - p.$$

2. When the review is negative: $q < \frac{1}{2}$
   In this case the consumer's expected value for q is $\frac{1}{4}$. Thus, the expected utility for a consumer with type a is given by:

   $$EU^{UR} = \frac{1}{4} + a - p.$$

   A consumer will buy the good if:

   $$EU^{UR} \geq 0 \iff a \geq a_{UR-2} \equiv p - \frac{1}{4}.$$

   We can see that a_{UR-2} falls in the support of the type distribution for any value of $p \in \left(\frac{1}{2}, 1\right)$. Thus, the demand for the good is given by:

   $$D^{G-NS} = 1 - a_{UR-2} = \frac{5}{4} - p.$$

We can see that there are two cases to consider when computing the expected demand for the good:

1. If $p \in \left(\frac{1}{2}, \frac{3}{4}\right]$, the expected demand is given by:

   $$ED^{G} = \frac{1}{2}D^{G-S} + \frac{1}{2}D^{G-NS} = \frac{9-4p}{8}.$$

2. If $p \in \left(\frac{3}{4}, 1\right)$, the expected demand is given by:

   $$ED^{G} = \frac{1}{2}D^{G-S1} + \frac{1}{2}D^{G-NS} = \frac{3-2p}{2}.$$

From solving the maximization problem in *Case 1* we find the candidate solution $p = \frac{9}{8}$, which falls outside of the support for the prices. Therefore, we have a corner solution in $p = \frac{3}{4}$. Looking at *Case 2* we find that the candidate solution is also $p = \frac{3}{4}$. Therefore, in the equilibrium the firm charges an optimal price $p^G = \frac{3}{4}$, serves a demand $D^G = \frac{3}{4}$, and obtains profits $\Pi^G = 0.5625$. ■

Proof of Propositions 10. To find the optimal pricing allocation for the firm we compare the optimal price for each of the pricing regions we have defined. Throughout this proof we use the utility expressions derived in the proof of propositions 4, 5, 6, and 7.

- **When** $p \in \left(\frac{1}{2}, 0.6555\right]$

  In this region the expert charges a fee $\lambda = \frac{1}{16}$. There are two subcases to consider in the *low* pricing region, depending on the size of q.

  1. When $q \geq \frac{1}{2}$:

     The relevant consumer decisions to calculate the demand for the good are:

$$\begin{aligned} EU^{UR} \geq 0 &\iff a \geq a_0 \equiv p - \frac{3}{4}, \\ EU^{XP} \geq 0 &\iff a \geq a_3 \equiv p - 1 + \sqrt{\lambda}, \text{ and,} \\ EU^{XP} \geq EU^{UR} &\iff a \leq a_4 \equiv p - \frac{1}{2} - \sqrt{\lambda}. \end{aligned}$$

     However, a_0, a_3 and a_4 all are smaller than zero for the values of p and λ in the region. Thus, the demand for the good when $q \geq \frac{1}{2}$ is given by:

$$ED^G = 1.$$

  2. When $q < \frac{1}{2}$:

     The relevant consumer decisions to calculate the demand for the good are:

$$\begin{aligned} EU^{UR} \geq 0 &\iff a \geq a_{0-B} \equiv p - \frac{1}{4}, \\ EU^{XP} \geq 0 &\iff a \geq a_{2B-1} \equiv p - \frac{1}{2} + \sqrt{\lambda}, \text{ and,} \\ EU^{XP} \geq EU^{UR} &\iff a \leq a_{3-B} \equiv p - \sqrt{\lambda}. \end{aligned}$$

     For the values of p and λ in the region we have that:

$$a_{0-B} > a_{3B} > a_{2B-1}.$$

     Therefore, the demand for the good when $q < \frac{1}{2}$ comprises consumers who buy based on the user reviews and those who do so after asking the expert, and is given by:

$$ED^{G-2} = (1 - a_{3B}) + \int_{a_{2B-1}}^{a_{3B}} (1 - (p - a))da = \frac{31}{24} - p.$$

  Thus, the expected demand for the region is:

$$D^G = \frac{1}{2}ED^G + \frac{1}{2}ED^{G-2} = \frac{55}{48} - \frac{p}{2}.$$

  From solving the maximization problem we get the candidate solution $\frac{55}{48}$, which falls outside of the support. Thus, the optimal price is a corner solution: $p^G = 0.6555$. The monopolist serves a demand $D^G = 0.1778$ and obtains profits $\Pi^G = 0.1166$ in this region.

- **When** $p \in \left(0.6555, \frac{3}{4}\right]$

  In this region the expert charges a fee $\lambda = \frac{4p^2}{81}$. There are two sub-cases to consider depending on the size of q.

  1. When $q \geq \frac{1}{2}$:
     The relevant consumer decisions to calculate the demand for the good are:

     $$\begin{aligned} EU^{UR} \geq 0 &\iff a \geq a_0 \equiv p - \frac{3}{4}, \\ EU^{XP} \geq 0 &\iff a \geq a_3 \equiv p - 1 + \sqrt{\lambda}, \text{ and,} \\ EU^{XP} \geq EU^{UR} &\iff a \leq a_4 \equiv p - \frac{1}{2} - \sqrt{\lambda}. \end{aligned}$$

     For the values of p and λ in the region we have that:

     $$a_{0-B} > a_4 > 0 > a_3.$$

     Therefore, the demand for the good when $q \geq \frac{1}{2}$ comprises consumers who buy based on the user reviews and those who do so after asking the expert, and is given by:

     $$ED^{G-2} = (1 - a_4) + \int_0^{a_4} (1 - (p - a))da = \frac{9}{8} + \frac{p(18 - 77p)}{162}.$$

  2. When $q < \frac{1}{2}$:
     The relevant consumer decisions to calculate the demand for the good are:

     $$\begin{aligned} EU^{UR} \geq 0 &\iff a \geq a_{0-B} \equiv p - \frac{1}{4}, \\ EU^{XP} \geq 0 &\iff a \geq a_{2B-1} \equiv p - \frac{1}{2} + \sqrt{\lambda}, \text{ and,} \\ EU^{XP} \geq EU^{UR} &\iff a \leq a_{3-B} \equiv p - \sqrt{\lambda}. \end{aligned}$$

     For the values of p and λ in the region we have that:

     $$a_{0-B} > a_{3B} > a_{2B-1}.$$

     Therefore, the demand for the good when $q < \frac{1}{2}$ comprises consumers who buy based on the user reviews and those who do so after asking the expert, and is given by:

     $$ED^{G-2} = (1 - a_{3B}) + \int_{a_{2B-1}}^{a_{3B}} (1 - (p - a))da = \frac{763 - 16p(36 + p)}{648}.$$

  Thus, the expected demand for the region is:

  $$D^G = \frac{1}{2}ED^G + \frac{1}{2}ED^{G-2} = \frac{373 - 9p(14 + 9p)}{324}.$$

From solving the maximization problem we get the candidate solution 0.8245, which falls outside of the support. Thus, the optimal price is a corner solution: $p^G = 0.75$. The monopolist serves a demand $D^G = 0.7189$ and obtains profits $\Pi^G = 0.5392$ in this region.

- **When** $p \in \left(\frac{3}{4}, \frac{9}{11}\right]$

  In this region the expert charges a fee $\lambda = \frac{4p^2}{81}$. There are two sub-cases to consider depending on the size of q.

  1. When $q \geq \frac{1}{2}$:
     The relevant consumer decisions to calculate the demand for the good are:

     $$\begin{aligned} EU^{UR} \geq 0 &\iff a \geq a_0 \equiv p - \frac{3}{4}, \\ EU^{XP} \geq 0 &\iff a \geq a_3 \equiv p - 1 + \sqrt{\lambda}, \text{ and,} \\ EU^{XP} \geq EU^{UR} &\iff a \leq a_4 \equiv p - \frac{1}{2} - \sqrt{\lambda}. \end{aligned}$$

     For the values of p and λ in the region we have that:

     $$a_{0-B} > a_4 > 0 > a_3.$$

     Therefore, the demand for the good when $q \geq \frac{1}{2}$ comprises consumers who buy based on the user reviews and those who do so after asking the expert, and is given by:

     $$ED^{G-2} = (1 - a_4) + \int_0^{a_4} (1 - (p - a))da = \frac{9}{8} + \frac{p(18 - 77p)}{162}.$$

  2. When $q < \frac{1}{2}$:
     The relevant consumer decisions to calculate the demand for the good are:

     $$\begin{aligned} EU^{UR} \geq 0 &\iff a \geq a_{0-B} \equiv p - \frac{1}{4}, \\ EU^{XP} \geq 0 &\iff a \geq a_{2B-1} \equiv p - \frac{1}{2} + \sqrt{\lambda}, \text{ and,} \\ EU^{XP} \geq EU^{UR} &\iff a \leq a_{3-B} \equiv p - \sqrt{\lambda}. \end{aligned}$$

     For the values of p and λ in the region we have that:

     $$a_{0-B} > a_{3B} > a_{2B-1}.$$

     Therefore, the demand for the good when $q < \frac{1}{2}$ comprises consumers who buy based on the user reviews and those who do so after asking the expert, and is given by:

     $$ED^{G-2} = (1 - a_{3B}) + \int_{a_{2B-1}}^{a_{3B}} (1 - (p - a))da = \frac{763 - 16p(36 + p)}{648}.$$

Thus, the expected demand for the region is:

$$D^G = \frac{1}{2}ED^G + \frac{1}{2}ED^{G-2} = \frac{373 - 9p(14 + 9p)}{324}.$$

From solving the maximization problem we get the candidate solution 0.8245, which falls outside of the support. Thus, the optimal price is a corner solution: $p^G = 0.75$. The monopolist serves a demand $D^G = 0.75$ and obtains profits $\Pi^G = 0.5625$ in this region.

- **When** $p \in \left(\frac{9}{11}, 1\right]$

  In this region the expert charges a fee $\lambda = \frac{1}{36}$. There are two sub-cases to consider depending on the size of q.

  1. When $q \geq \frac{1}{2}$:
     The relevant consumer decisions to calculate the demand for the good are:

  $$\begin{aligned} EU^{UR} \geq 0 &\iff a \geq a_0 \equiv p - \frac{3}{4}, \\ EU^{XP} \geq 0 &\iff a \geq a_3 \equiv p - 1 + \sqrt{\lambda}, \text{ and,} \\ EU^{XP} \geq EU^{UR} &\iff a \leq a_4 \equiv p - \frac{1}{2} - \sqrt{\lambda}. \end{aligned}$$

     For the values of p and λ in the region we have that:

  $$a_{0-B} > a_4 > 0 > a_3.$$

     Therefore, the demand for the good when $q \geq \frac{1}{2}$ comprises consumers who buy based on the user reviews and those who do so after asking the expert, and is given by:

  $$ED^{G-2} = (1 - a_4) + \int_0^{a_4} (1 - (p - a))da = \frac{11}{9} - \frac{p^2}{2}.$$

  2. When $q < \frac{1}{2}$:
     The relevant consumer decisions to calculate the demand for the good are:

  $$\begin{aligned} EU^{UR} \geq 0 &\iff a \geq a_{0-B} \equiv p - \frac{1}{4}, \\ EU^{XP} \geq 0 &\iff a \geq a_{2B-1} \equiv p - \frac{1}{2} + \sqrt{\lambda}, \text{ and,} \\ EU^{XP} \geq EU^{UR} &\iff a \leq a_{3-B} \equiv p - \sqrt{\lambda}. \end{aligned}$$

     For the values of p and λ in the region we have that:

  $$a_{0-B} > a_{3B} > a_{2B-1}.$$

     Therefore, the demand for the good when $q < \frac{1}{2}$ comprises consumers who buy based on the user reviews and those who do so after asking the expert, and is given by:

$$ED^{G-2} = (1 - a_{3B}) + \int_{a_{2B-1}}^{a_{3B}} (1 - (p - a))da = \frac{31}{24} - p.$$

Thus, the expected demand for the region is:

$$D^G = \frac{1}{2}ED^G + \frac{1}{2}ED^{G-2} = \frac{181 - 36p(2 + p)}{144}.$$

From solving the maximization problem we get a candidate solution which falls outside of the support. Thus, the optimal price is a corner solution: $p^G = 0.8181$. The monopolist obtains profits $\Pi^G = 0.5567$ in this region.

Finally, by comparing the equilibrium profits in all the regions, we can see that the firm obtains the highest profit level setting a price $p^G = 0.75$.

■

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