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Essays on Behavioral Health Economics

Edgardo Amílcar LARA CÓRDOVA

UNIVERSITAT AUTÓNOMA DE BARCELONA

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Edgardo Amílcar LARA CÓRDOVA

Supervisor:
Dr. Susanna ESTEBAN

Supervisor:
Dr. David PÉREZ CASTRILLO

Tutor:
Dr. Caterina CALSAMIGLIA COSTA

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Contents

Chapter 1

Introduction: Behavioral Economics and Health Economics

The complexities of the healthcare sector are many, multifaceted, and largely inherent. Some of the most noticeable of these derive from the profound informational asymmetries the environment entails (among patients and physicians, providers and insurers, etc.), as well as the immense significance that healthcare has on human affairs. Faced with decisions in such context, the proclivity of agents to behavioral biases comes as no surprise. By virtue of the aforementioned characteristics and their effect in the behavior and outcomes of market agents, we believe there to be many fruitful avenues for the analysis of the healthcare sector informed with the tools developed by the behavioral sciences. In particular, Behavioral Economics, understood as the combination of psychology and economics, can provide tools to investigate what happens in markets when some of the economic agents display limitations on their cognitive, computational or forward-looking skills (Mullainathan and Thaler, 2000).

Despite a veritable boom in the recent applications of Behavioral Economics' tools and models to various fields of economic theory, the introduction of behavioral models in the healthcare sector has been limited to the understanding of addictive behavior. Behavioral-based attemtps to explaining addictions were heralded by the development of the rational model of addiction by Becker and Murphy (1988). In that paper, Becker and Murphy postulate addictive behavior to be consistent with optimization according to certain stable preferences. Thus addictions, ordinarily thought to be irrational unto themselves, became compatible with perfect rationality. However, this rational model of addiction imposes too strong assumptions on the behavior of the decision maker. In particular, it imposes perfect forward looking skills and dynamic consistency. Later, scholars have enriched the environment by introducing behavioral models (O'Donoghue and Rabin

(1999a),Loewenstein (1999), Gruber and Köszegi (2001)) with the intent of endowing the agents with a "richer psychology".

However, considerably less attention has been paid to other potential applications of behavioral concepts and methodology to the healthcare sector. In his influential paper Arrow (1963) develops a very detailed survey of the special characteristics of the healthcare market, pointing possible directions in which the methods of Behavioral Economics can be of relevance. Moreover, Arrow makes some points that are worthwhile underlining for purposes or our present study.

Firstly, Arrow discusses the peculiar nature of the demand for medical services, which has two distinctive features: it is not steady at its origin, since the demand of medical services crucially depends on the health state of the consumers, and the fact that demand for this kind of goods is unavoidably related to an *assault* on personal integrity, meaning that consumers evaluate medical services thinking about health as an irreplaceable good. Secondly, Arrow argues that the (socially) expected behavior of the physicians cannot be comparable to the behavior of businessmen in general. Evidently, starting from the fact that the nature of the service they provide is profoundly different to any common good, and also considering the social and ethical restrictions that physicians face in their professional activities. Finally, Arrow points at the uncertainty of the product in the healthcare markets, which is more intense than in markets for other goods. Even for those which could be described as informational or experiential, since the possibility of learning from own past experience or from other consumers is very limited due to the small number of trials that the individual would have had in order to derive appropriate statistical inferences.

These features, brought out by Arrow (1963) and expanded upon by many other researchers, are the main motivation for the present work, which in essence stands as an attempt to bring forth some of the tools native to Behavioral Economics to explore the many interesting questions healthcare entails.

In this endeavour we have chosen to follow Mullainathan and Thaler (2000), who point out that the behavioral research program should include two steps: (*1*) identifying the way in which the agents' behavior differs from the standard model, and (*2*) showing how this behavior matters in economic contexts. Concerning the first step, the sector's features highlighted by Arrow (1963) are helpful in identifying the main differences between healthcare markets and others better described through the standard models' prediction. From such perspective, we can expect the methods of Behavioral Economics to induce changes to the traditional models, trying to better account for the features and peculiarities that appear to conflict with the notions of rationality in economic behavior.

The potential applications of behavioral economic models and tools to the healthcare sector that we have identified and considered worthwile to pursue as the core of the present work, are the following.

First, the Health Plan market naturally generates a time gap between the acceptance of the Health Plan contract and the delivery of the contracted services. Therefore, in decisions regarding the signing of Health Plan contracts consumers are required to create forecasts in order to choose their supplier. It is natural to assume that consumers lack the knowledge and apparatus to accurately predict their future needs for medical services, as predictions of such ilk demand a considerable level of expertise and access to relevant information. As a consequence, decisions in this market depend to a large extent on the beliefs hold by consumers. Moreover, consumers are very diverse in terms of such beliefs. In chapter 2 of this work we study the Health Plan market in presence of consumers with biased beliefs on the likelihood of their future health status. That is, they over or underestimate the probability for them to contract a disease.

We derive the implications of biased risk-of-disease estimations on the private and public healthcare systems. We find that when consumers hold biased beliefs departing from the objective probability distribution, private providers can capitalize on such biases. Biased beliefs then become relevant as they could be a reason to offer Health Plan contracts that provide treatment quantities that differ from efficient levels. We explore the interaction that arises between private and public healthcare provision under such circumstances. For this we compute the contracts offered by a public provider and show that the presence of biased beliefs create room for the entrance of private providers, who take advantage of consumers biases to make strictly positive profits. We also analyze how the public provider reacts to the presence of private providers.

Second, the choice of medical services providers (physicians, hospitals or Health Plans) involves a process of gathering information and a mechanism for estimating and evaluating the quality of said providers. These processes and mechanisms are also subject to behavioral biases. Specifically, in chapters 3 and 4 of the present work we analyze the sources of information that consumers use in order to make judgments about the quality of physicians. We mainly focus in the manners in which the environment affects the physicians' choice of quality. In other words, the competitive effects on the service offered, of the limited and partial estimations consumers base their decisions on. The standard model would assume that consumers have perfect information on the quality of physicians. However, there is ample empirical evidence suggesting that individuals evaluate quality of medical services providers on the base of anecdotes. For instance, the national survey on the use of information by U.S. consumers conducted by Henry J. Kaiser Family Foundation, shows that when asked what kind of information would they search when choosing their physician 70% of the surveyed individuals said they would ask family members, friends or co-workers while only 20% would contact a state rating agency. There are several models that deal with this issue, the most closely related to our work being Spiegler (2006b) and Szech (2011). In their analysis they abstract from the analysis of the endogenous and exogenous components of information which we instead make explicit.

Namely, in chapters 3 and 4 we study the ability choices and pricing strategies of physicians who operate in a market where consumers base their decisions on anecdotes. The consumers are aware of only some of the physicians in the market and estimate their abilities by taking a sample from the patients a given physician has previously treated. Consumers' decisions based on anecdotal evidence entail two hindrances: an over-reliance on small samples and the limited availability of information. On the one hand, the ability choice amounts for the endogenous element of information, which indeed reflects the fact that high-quality physicians will cure more patients and thus have more plentiful positive anecdotes for patients to sample. On the other hand, visibility is understood as a measurement of non-strategic and exogenous "fame" determining how easy it is for a patient to observe a given physician, irrespective of his specific ability level.

In this setting, situations arise where physicians have incentives to choose low levels of ability even when it is a costless choice for them. In particular, more information availability leads to more ability differentiation and a lower average ability level. When information on the physicians is readily available, the average ability in the equilibrium is not maximum. From a policy perspective, maximum average ability can be attained by fixing prices or restricting physicians to operate locally, *i.e.* by drastically reducing the availability of information.

The application of traditional economic models relying on rational, utility-maximizing agents with perfect information, has greatly contributed to the design and implementation of public policy in healthcare. Yet, we belief that the application of the tools from Behavioral Economics can be fruitful in further advancing the analysis of healthcare markets and institutions, particularly when one considers the peculiarities inherent to the sector. The present work is an attempt to contribute with some insights that could be helpful in developing a fuller understanding of some situations in the health-care market which we believe to be shaped, at least partially, by behavioral biases.

Chapter 2

Disease Incidence Misperception: Implications for the Health Plan Market

2.1. Introduction

The behavior of patients and healthcare providers in the presence of health insurance is a fundamental issue in health economics. Historically, the health insurance market has been dominated by *Fee-For-Service* and *indemnity* contracts that offered financial protection in the event health care was needed. In a nutshell, the individual who signed for the plan covered potential losses the insurer could incur if and when providing health care services. However, at the present day Health Plans are one of the most popular ways to deliver health care. Health plans combine alternatives to finance and the delivery of health care in one bundled package.

In this environment, the analysis of health plan choice should also consider the actual provision of treatment, rather than focusing only in the financial part of the choice problem. That is, expand its scope to include the type, quality, and quantity of care services provided. It is well established that the choice of a health plan depends on many factors: the severity of an illness, the probability of a particular health condition, personal characteristics like the level of risk aversion or an individual's emotional state when making the choice, not to mention subjective biases related to medical decisions into themselves.

To the best of our knowledge, little has been done to analyze how risk perceptions affect the decisions of agents in the market for Health Plans. Indeed, the *perception* a patient has of the health risk she faces would be expected to play a role in their decision to sign a contract with a Health Plan provider. Risk perceptions matter because the objective probability of a health condition may not match the risk a patient perceives herself to be under. Having a family member who has suffered a particular condition, although it bears no hereditary transmission or risk factors, might make a patient extremely perceptive of the risk surrounding such condition.

In the context of Health Plan choice it becomes interesting to analyze the role risk perceptions have on the interaction between the private and the public health sectors. A private Health Plan provider might try to offer health plan contracts that capitalize on these risk perceptions when they differ from the objective risk, while a "benevolent" public sector might want to offer plans that maximize the utility according to the objective risks.

Exploring these implications is relevant in view that governments are involved in the health market in many ways, most noticeably in the role of health insurers. For instance, in most OECD countries there is little reliance on private *out-of-pocket* spending, Governments devoting on average 6.5% of GDP to publicly funded prepayment pools (OECD, 2015b). Moreover, in almost all OECD countries, the public sector is the main source of health care financing. Around three-quarters of health care expenditure was publicly financed in 2013 (OECD, 2015a). Therefore, the public provision of care is an important factor in the way health plan contracts are designed.

We study the interaction between private and publicly offered health plans in a market where patients (from here on denoted as consumers) hold biased beliefs regarding the future status of their health.[1] A consumer is biased if he believes one particular state of his health to have a different likelihood than that indicated by an objective probability. We abstract from the issues generated by risk aversion on the market for Health Insurance, for our aim is to focus on the trade-offs generated by the discrepancies in beliefs.

Disease incidence misperception has been documented by medical and behavioral sciences. Skinner and Kreuter (1998) tested the existence of risk perception biases for breast cancer. The authors utilize a cross-sectional sample of 1803 females in community-based physician practices in North Carolina to measure the pervasiveness of risk perception biases. They conclude that 31% of the sample *underestimate* risk and 26% *overestimate* it. In plain words, more than one fourth of the sampled women are *optimistic*, since they believe themselves to be less likely to develop breast cancer than they actually are, and just below one third of the sampled women are *pessimistic*, believing to be more likely to develop the affliction more than what they objectively are. Carman and Kooreman (2011) go one step further, studying how perceived probabilities affect the adoption of preventive care

[1] In this regard Cutler (2002) examines the role that government should play in the health sector, both in the control of health related behaviors (smoking, for instance) and as health insurance provider.

in a panel of $5,686$ subjects in the Netherlands. They find that risk perception is a significant predictor for the usage of preventive care even when controlling for actual epidemiological (objective) risk. It is therefore reasonable to conclude that biased beliefs about disease incidence are pervasive among the consumers who take part in the market for health plans.

Our aim in this paper is to put forward a model which accounts for these biases, helping to understand their implications for public and private Health Plan providers. We develop a model departing from the standard model of choice under uncertainty in the inclusion of subjective health risk probabilities. This generates an asymmetry in the form of a discrepancy between the consumers' beliefs and the objective probabilities held by providers. We find that private Health Plan contracts take advantage of these biases, offering non-optimal care services for similarly distorted prices. We find that there are no selection issues in our setting, since providers can design contracts to separate consumers with different risk perceptions. That is, consumers self-select into the contracts designed for their type of risk perception bias.

We analyze whether the private sector can enter the market in the presence of a Public Provider who offers a contract maximizing a patient's surplus, having considered their risk perception biases. This exercise is relevant, since in most health systems we observe the coexistence of public and private providers. We conclude that Private Providers can always enter the market: The sole presence of a Public Provider does not deter private practitioners to provide care services at a higher expense. We further examine this point by allowing the potential ex-post entry of a private physician operating on a pay-per-visit scheme in a market where a Public Provider is already present. We find that such a scenario does not affect consumers' surplus but raises the ex-ante premium paid to the Public Provider.

2.2. Related Literature

The widespread dominance of Health Plans and Health Management Organizations in the US health market has triggered a stream of literature in Health Economics which studies these contracts.[2] In an example relevant to the present work, Glazer and McGuire, 2002 examine the practice of setting health plan premiums using risk adjusters in order to make sure plans do not discriminate. They conclude that using risk adjusters to set premiums leads not only to non discrimination but also gives incentives to health plans to choose the efficient level of quality for the various services offered.

Olivella and Vera-Hernandez, 2010 analyze the problem of adverse selection in the context of a particular form of Health plan contracts, charging

[2] Scanlon, Chernew, and Lave, 1997 offers a comprehensive review of the literature analyzing markets dominated by health plan contracts.

a subscription fee to affiliates and then providing them with the required health care with no additional charges. Hence, third-party payers cover the capitation in full and the providers do not have conditional deductibles to use as screening devises. That is why these kind of Health Plans, known as *First-Dollar-Coverage* contracts, might present adverse selection issues. The authors find that offering different contracts to different types of risks is a possible separating equilibrium.

A keystone assumption in these papers is that consumers can make informed choices based on the complete knowledge of their own risk. In other words, they know whether they are "high" or "low risk" consumers. This is an important difference with our paper, which introduces risk perception bias, deeming the actual risk of contracting a disease as uniform among a population of patients. Hence, another relevant feature separating our paper from these studies is that the main issue in their setting is adverse selection, while in our case the consumers are homogeneous in their objective risk. The only source of heterogeneity is their risk perception. Therefore, Health Plans do not have to screen consumers with different types of risk, but with different perceptions of the same risk.

Our paper is closely related to a growing research agenda exploring the effects of risk perceptions in the market for health insurance. The main focus of this literature is to examine whether different risk biases (say, overconfidence or pessimism) affect the predictions proposed by the traditional asymmetric information literature regarding adverse selection (Jeleva and Villeneuve (2004), Chassagnon and Villeneuve (2005)Sandroni and Squintani (2007) and Sandroni and Squintani (2013)). Again, the main difference with our model is that we abstract from selection concerns as our patients all have the same objective risk, differing only in their subjective perceptions of it. They are all equally likely to get a flu, but some perceive themselves to be under higher risk than the others.

Our model brings into the analysis of the health sector some well established findings from the field of risk perception. A major development in the alternative theories of decision making under risk took place in the last two decades, consisting in the identification of a set of mental strategies (heuristics) individuals implement to take decisions in complex and uncertain environments (Kahneman, Slovic, and Tversky, 1982). These heuristics may lead to large and persistent biases in the beliefs about future events. It comes as no surprise to find such heuristics to be prevalent and pervasive in health care decisions.

Two well established heuristics are relevant to our paper. First, the *availability heuristics* (Tversky and Kahneman, 1973) which asserts that a person evaluates the probability of events via the ease with which relevant instances come to mind. Second, *probability neglect* (Sunstein, 2003) which maintains that when strong emotions are involved people tend to focus on the "badness" of the outcomes rather than on the actual probability of the event. Therefore, variance in risk perceptions among individuals should not be expected to evaporate, as standard Bayesian-updating of beliefs would imply. These two concepts, brought from psychology, bring light to systematic biases found in these markets, and are the theoretical substantiation of our essential assumption: individuals are persistently biased in their risk perceptions.

Our papers intends to follow up on a stream in *Behavioral Economics* literature devoted to explore the problem of a perfectly rational firm contracting with boundedly rational individuals. Some of the most salient papers in this line are: O'Donoghue and Rabin (1999b) who propose a model where a risk neutral principal incurs a cost when tasks are delayed, and faces a time-inconsistent procrastinating agent. They study the optimal incentives to induce the agent to complete the tasks without delay. Esteban, Miyagawa, and Shum (2007) develop a model to examine the pricing behavior of a monopoly facing consumers with self-control problems *à la* Gul and Pesendorfer (2001).

To the best of our knowledge, three *Behavioral Economics* papers are the most closely related to ours. First, DellaVigna and Malmendier (2004) who analyze the problem of designing a profit-maximizing contract when rational firms face consumers with time-inconsistent preferences, and are (partially) naive about them. They model the time-inconsistency by considering consumers with quasi-hyperbolic preferences who demand a service where there is a time gap between the cost of consumption and the benefits obtained from consumption. Second, the work of Eliaz and Spiegler (2006) deems agents to be dynamically inconsistent in a different way: Agents are heterogeneous as they differ in their ability to predict changes in tastes in future periods, a consumer might want more of the good or less depending on these taste changes. These taste changes are modeled by assigning a probability to having a different preference ordering over quantities of some good. Third, in a follow up paper Eliaz and Spiegler (2008) study the design of the optimal menu of non-linear tariffs when consumers are biased in their prior beliefs regarding their future preferences. The authors compute the optimal menu of non-linear tariffs for consumers whose beliefs differ from those of the monopolist. They find that discrepancies in the beliefs between consumers and the monopolists create inefficiencies.

These papers are different from our model in various ways. First, they examine inconsistencies regarding changes in preferences over a good in the future, our paper analyses a change in the needs on the consumers. Namely, the treatment designed for one disease yields no utility to consumer if she gets a different disease, moreover, the Health Plan provider cannot supply a treatment for a disease which has not been realized. Derived from the previous, another difference is that they look for the optimal contract, while in this paper we look for optimality within classes of contracts that specify tariff and treatment quantity for each possible health condition. Finally, in this paper we explore the economic implications in a market where private and public sector coexist. While the papers mentioned above look at the monopoly problem and the first best solutions. The public-private interaction, in environments where consumers are biased in their beliefs, is a relevant area that deserves deeper exploration, which to the best of our knowledge has not been done for the healthcare market, this interaction is at the core of this paper. The Healthcare market setting we analyze has as an important feature the fact that a consumer with a certain disease has no interest in getting treatment for any other disease, this implies that biases in the beliefs affects tariffs and treatment provisions in a non-trivial manner.

The rest of the paper is organized as follows. In Section 2.3. we introduce the basic setting. In Section 2.4. we explore private contracts and see how they are affected by biases of consumers. In Section 2.5. we put forward a contract offered by a Public Provider whose objective is to maximize the objective expected utility of consumers. In Section 2.6. we study the interaction of a Private Provider and a Public System. Finally, in Section 2.7. we conclude.

2.3. The Model

We consider a health care market with a profit-maximizing monopolist – the *provider* – which supplies health care services through Health Plan contracts to patients – the *consumers* –, who will be in one of two mutually exclusive health conditions. Let health state 1 be a mild disease, while state 2 represents a more severe one. The two conditions differ from one another in their degree of severity.

On the one side of the market we have consumers, who are uncertain about their two possible health states. Consumers hold biased beliefs about the two possible future states of their health. Namely, they assign a certain probability to the realization of the two possible states, diverging from their true probability. Let p denote the *true probability* that state 2 will happen, and $1 - p$ the *true probability* that state 1 is realized. In order to model heterogeneity in beliefs in the most simple way, we allow consumers to be one of two different types: optimistic or pessimistic. We say that a consumer is *pessimistic* if she systematically assigns higher probability than the true occurrence rate to state 2, that is $\hat{p}^p > p$. Likewise, we say a consumer is *optimistic* if she assigns lower probability than the objective one to the realization of state 2, $\hat{p}^o < p$.

The source of heterogeneity in our model comes from these biases in risk perception, while all consumers in the market are identical in terms of their true risk. In plain words, a pessimistic and an optimistic consumers are objectively identical and are indistinguishable once one of the health states has realized (ex-post), the only possible distinction ex-post being the health condition that affects each consumer. To reiterate, ex-ante they only differ in the subjective probability they hold.

A patient of type $i \in \{o, p\}$ has preferences over the treatment she receives, $q_j\ \forall j \in \{1, 2\}$, and the tariff that she pays for such treatment, $t_j \in \mathbb{R}$. To represent the patient's preferences we use state-dependent utility functions. Let $u_1(\cdot)$ denote the utility derived from treatment in state 1 and $u_2(\cdot)$ denote the utility in state 2. Furthermore, a consumer whose health condition is 2 derives no utility in getting the treatment destined to cure health condition 1 and vice versa, that is, $u_j(q_k) = 0$ for $j \wedge k \in \{1, 2\}$ and $i \neq k$. Notice that utility functions do not depend on the type of consumer bias but only on the realized state. That is to say, two consumers of different type with the same ailment evaluate the same treatment quantity with the same utility function.

Preferences over the duple formed by treatment and tariff $(q_j, t_j)_{j \in \{1,2\}}$ are represented by the following quasilinear specification:

$$U_j(q_j, t_j) = u_j(q_j) - t_j \text{ for } j \in \{1, 2\}.$$

For the sake of analytic clarity we simplify by assuming $u_j(0) = 0$ for $j \in \{1, 2\}$. We also assume consumers to have continuous and marginally decreasing utilities on treatment. In plain words, they appreciate more the first units of treatment and less any additional unit.[3] We assume $u_j(\cdot)$ is twice differentiable for $j \in \{1, 2\}$. A patient of type $i \in \{o, p\}$ who is considering purchasing a contract described by a tuple $\langle (q_1, t_1), (q_2, t_2) \rangle$ evaluates this contract by estimating her ex-ante expected utility, which is given by

$$(1 - \hat{p}^i)(u_1(q_1) - t_1) + \hat{p}^i(u_2(q_2) - t_2) .$$

The adoption of a quasilinear representation of preferences entails that consumers are risk neutral with respect to cash, which makes void the role of health plans as financial insurers for future expenditure. This allows us to

[3] Additionally we assume $\lim_{q_j \to 0} u_j'(q_j) = +\infty$ and $\lim_{q_j \to \infty} u_j'(q_j) = 0$.

examine distinct alternative payment schemes with relative ease and enables us to focus on the distortions introduced exclusively by the discrepancies in beliefs.

We further assume that there is one representative consumer of each type. This is equivalent to saying that all *pessimistic* consumers hold the same beliefs, and all *optimistic* consumers have identical beliefs. Our particular modeling choice has the intention to focus on the different beliefs that consumers hold as the only source of heterogeneity.

On the other side of the market we have a Health Plan provider, who has full knowledge of the market setting. He is informed about the objective probability of each health state and is aware of the presence of the two bias types of consumers. That is, he knows $p, \hat{p}^o$ and $\hat{p}^p$ but is incapable of determining the type of each consumer he faces in the market. This is a sensible assumption, as health providers know risk better, while consumers very often have limited or imprecise sources of information, consequently sticking to inaccurate beliefs.

The provider offers health care in accordance to a menu of contracts aimed to separate types. A menu of contracts is described by $\langle (q_1^i, t_1^i), (q_2^i, t_2^i) \rangle_{i \in \{o,p\}}$, where $q_j^i \geq 0$ represents the specific treatment provided to a consumer of type $i \in \{o, p\}$ when the health state is $j \in \{1, 2\}$, and $t_j^i \geq 0$ is the corresponding tariff (contingent payment).

The health care services production technology is represented by a state-dependent cost function. Let $C_2(\cdot)$ be the cost of providing health care services in the case of treating a consumer in state 2 and $C_1(\cdot)$ in the case of state 1. Notice that whether a consumer is pessimistic or optimistic has no effect in the cost of providing health care. The only relevant variable is the specific treatment provided and its quantity. We assume $C_j' \geq 0$ and $C_j'' \geq 0$ for $j \in \{1, 2\}$. Therefore, the provider's expected profits obtained when consumers sign the contract meant for them from the menu $\langle (q_1^i, t_1^i), (q_2^i, t_2^i) \rangle_{i \in \{o,p\}}$, are given by

$$\sum_{i \in \{o,p\}} \left[(1-p)(t_1^i - C_1(q_1^i)) + p(t_2^i - C_2(q_2^i)) \right] .$$

The aim of this paper is to put forth some insights about the effects of risk perception biases on the interaction between between private and public providers. In that regard we build our analysis advancing throughout three different scenarios. First, we study different alternatives offered by a monopolist provider. Second, we examine a menu of contracts offered by a Public Provider whose sole purpose is to maximize the objective surplus of consumers, charging fees tailored to simply break-even. Finally, we focus on the analysis of two different sorts of interactions that might arise between public and private providers.

2.4. The Private Health Plans

In this section we analyze the mechanisms at work when there is a private monopolist in the market. We begin by establishing an analytic benchmark in the form of a contract offering the optimal treatment quantity on each health state. We refer to these quantities as the efficient treatment, characterized by

$$u_2'(q_2^*) = C_2'(q_2^*) \text{ and } u_1'(q_1^*) = C_1'(q_1^*).$$

Notice that, given our assumptions on the utility and the cost function $u_j(q_j^*) > C_j(q_j^*)$ for all $j \in \{1, 2\}$. The tariffs charged in each health state have no influence on the efficient quantities. This is a result of the quasiliniear specification of the utility function we adopted for each health condition.

Moreover, consumers are ex-post identical. That is, once one of the possible health conditions has been realized, there is no way of telling the difference between a *pessimist* or an *optimist* consumer. Hence, the efficient treatment quantity offered by the provider is the same for every type of consumer. In a market where there is a profit-maximizing monopolist the efficient treatments can be reproduced by a Fee-For-Services health provision scheme.

In a ***Fee-For-Service*** market setting there are no health plans. Therefore, knowing their health states, the consumers decide whether to purchase health care services once their health state has been realized. In simpler words, they seek treatment once they get sick. Thus, since the health service purchase decision is taken posterior to the realization of the health state, all consumers are identical and their risk-perception biases rendered irrelevant. A provider simply has to ensure that ex-post a consumer requiring health services is willing to participate in the market. This is captured by the following constraint:

$$u_2(q_2) - t_2 \geq 0 \text{ and } u_1(q_1) - t_1 \geq 0. \qquad \textit{(ex-post IR)}$$

As discussed above, ex-post all consumers are identical; the only distinction being the health state they end up being in. Hence, to guarantee participation of the consumer the care provider only has to guarantee that a patient's utility is positive for each of the health states. Thus, the provider solves a problem for each possible health state j,

$$\max_{\langle q_j, t_j \rangle} \quad t_j - C_j(q_j)$$
$$\text{s.t.}$$
$$u_j(q_j) - t_j \geq 0$$

Notice that the solution on this program does not depend on the bias of the individuals, as ex-post all individuals are identical, and is reported in Proposition 1. We denote this contract as $\langle (q_2^*, t_2^*), (q_1^*, t_1^*) \rangle$. This is the contract a monopolist operating in the market, and offering health care services once the health states have realized, will offer independently of the biases of consumers.

Proposition 1. *The Fee-For-Service contract a monopoly offers to every type of consumers is the same for both types of patients and it is given by*

$$u_2'(q_2^*) = C_2'(q_2^*) \text{ and } u_1'(q_1^*) = C_1'(q_1^*),$$

$$t_2 = u_2(q_2^*) \text{ and } t_1 = u_1(q_1^*).$$

Posterior to the health state realization, the provider chooses the treatment quantities maximizing the total social surplus and sets tariffs to seize it all. The *Fee-For-Service* is a payment model where services are unbundled and paid-for separately.

It is well established in the health literature that this payment scheme gives incentives for physicians or hospitals to provide as much treatment as the consumer is willing to take, clearly because payment is dependent only on the supplied treatment quantity. However, in our setting due to the increasing cost function and decreasing utility function, providing more treatment than the efficient quantity is not profitable for the monopolist. Indeed, the quantity that maximizes the total surplus – which is fully seized by the provider (equalization of marginal utility and marginal cost) – is precisely the efficient one. Thus, the Fee-For-Service contract with biased beliefs coincides with the efficient contract treatment quantities. The discrepancy between consumers' beliefs and objective probabilities has an effect only if the assessment of the contract is performed prior to the realization of a particular health state. See Figure 2.1 for a graphical illustration of this contract.

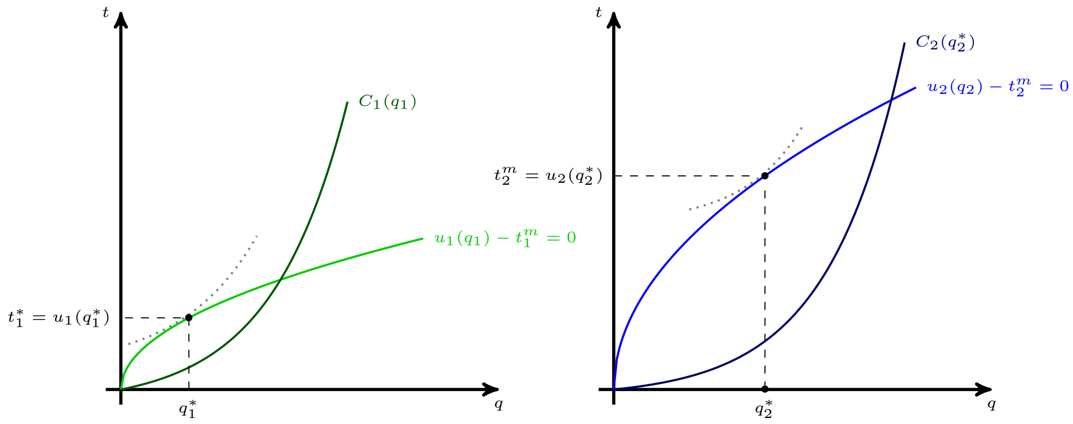


FIGURE 2.1: Fee-For-Service contract

This contract is offered in a situation in which consumers make the purchase decision once they have certainty about their health state. That is the reason for the efficient treatment quantities to be an equilibrium in this setting. Efficient treatment quantities serve as a benchmark to identify when biased beliefs play a role in determining the contract characteristics. We thus denote any deviation from the efficient treatment quantities as distortions. If a contract offers more than the efficient treatment quantities we call it *over-provision*, and if it offers less than the efficient treatment quantity we call it *under-provision*.

Risk perception biases exert particular influence in the Health Plan market outcomes when consumers are compelled to evaluate their purchase decision ex-ante. This environment becomes more relevant in the modern health market because one of the key provisions in the Affordable Care Act (better known as Obamacare) is individual mandate, which requires all individuals to buy a Health Plan or pay a penalty. Thus, consumers are obliged to evaluate their Health Plan purchases ex-ante, giving rise to a market where third parties (Health Plan providers) dominate the health industry rather than buyers (consumers) and sellers (physicians and hospitals). We thus consider worthwhile to analyze the health market where provision is manly based in Health Plan contracts. We study two kinds of contracts that are present in the U.S. Health Plan market.

If consumers are compelled to take the purchase decisions before the ailment realizes, then risk perception biases play a relevant role. Consumers assess the contract utilizing the beliefs they hold on the incidence of each possible health state. That is, a consumer of type i will only sign a contract $\langle (q_1^i, t_1^i), (q_2^i, t_2^i) \rangle_{i \in \{o,p\}}$ if it provides him with a subjective expected utility larger than opting out of the market. This is captured by the following ex-ante participation constraint

$$\hat{p}^i(u_2(q_2^i) - t_2^j) + (1-\hat{p}^i)(u_1(q_1^i) - t_1^i) \geq 0 \quad \text{for} \quad i \in \{o,p\}. \quad (\textit{ex-ante IR})$$

If a provider could tell apart a pessimistic consumer from an optimistic one, he could offer consumers with different beliefs only one contract explicitly destined for her type. In this way, he would advantage of her biased beliefs by distorting treatment quantities and tariffs. However, the provider of Health Plan contracts cannot distinguish individuals by their type, and each consumer can choose to sign the contract that provides her with the highest ex-ante utility. Therefore, providers design a menu of contract intended to separate individuals according to their types: So that an optimist consumer chooses a contract designed for her type and the same for a pessimistic consumer even when the provider is unable to tell them apart. This condition is given by the following constraint:

$$\hat{p}^i(u_2(q_2^i) - t_2^i) + (1-\hat{p}^i)(u_1(q_1^i) - t_1^i) \geq \hat{p}^i(u_2(q_2^k) - t_2^k) + (1-\hat{p}^k)(u_1(q_1^k) - t_1^k) \quad (\textit{ex-ante IC})$$

for $k \wedge i \in \{o,p\}$ and $k \neq j$.

The ***First-Dollar-Coverage*** contracts are very common in the U.S. market. They cover the payment of all medical expenses beginning with the first dollar and without the use of any type of deductibles or contingent payments, only charging an ex-ante subscription fee. Let us analyze this type of contracts, denoted (A, q_2, q_1), where A is a subscription fee that the patient pays independently of the realized state at the signing of the contract, and once the state is realized the individual is fully covered for the agreed treatment levels ($i.e.\ t_1 = t_2 = 0$). The provider solves the following optimization program in order to devise a menu of contracts $\langle(A^i, q_2^i, q_1^i)\rangle_{i\in\{o,p\}}$.

$$\max_{(A^i, q_1^i, q_2^i)_{i\in\{o,p\}}} \sum_{i\in\{o,p\}} A^i - pC_2(q_2^i) - (1-p)C_1(q_1^i)$$

s.t.

$$\hat{p}^o u_2(q_2^o) + (1-\hat{p}^o)u_1(q_1^o) - A^o \geq 0$$
$$\hat{p}^p u_2(q_2^p) + (1-\hat{p}^p)u_1(q_1^p) - A^p \geq 0$$
$$\hat{p}^o u_2(q_2^o) + (1-\hat{p}^o)u_1(q_1^o) - A^o \geq \hat{p}^o u_2(q_2^p) + (1-\hat{p}^o)u_1(q_1^p) - A^p$$
$$\hat{p}^p u_2(q_2^p) + (1-\hat{p}^p)u_1(q_1^p) - A^p \geq \hat{p}^p u_2(q_2^o) + (1-\hat{p}^p)u_1(q_1^o) - A^o.$$

Consumers make the purchase decision before health states are realized, hence being affected by their risk perception biases. A patient's decision to sign a contract is influenced by the biased beliefs she holds. The menu of contracts that solves the problem is incentive compatible precisely as a result of these biases. That is, an optimistic consumer assigns a higher expected value to the treatment received in state 1 so she would not sign a contract that offers less treatment on that health state than on the other one. The symmetric opposite is true for an optimistic consumer. Hence, the contradiction of subjective valuations between consumer types ensures incentive compatibility of the *First Dollar Coverage Plan* menu of contracts reported in Proposition 2.

Proposition 2. *The optimal First Dollar Coverage Plan menu of contracts,* $\langle (A^i, q_2^i, q_1^i) \rangle_{i\in\{o,p\}}$*, consists of treatment quantities such that:*

$$u_2'(q_2^i) = \frac{p}{\hat{p}^i} C_2'(q_2^i) \;\; \textit{and} \;\; u_1'(q_1^i) = \frac{1-p}{1-\hat{p}^i} C_1'(q_1^i),$$

and a subscription fee:

$$A^i = \hat{p}^i u_2(q_2^i) + (1-\hat{p}^i) u_1(q_1^i) \;\;\; \textit{for} \;\;\; i \in \{o, p\}.$$

The underlying mechanisms at work, due to the divergence in ex-ante and ex-post valuations, are described by DellaVigna and Malmendier (2004). In that paper the discrepancy is generated by hyperbolic discounting, while here it arises as a result of the dissonance in beliefs.

The *First Dollar Coverage* contract distorts both levels of treatment provision. The contract destined to an optimistic consumer over-provides in health state 1 and under-provides in health state 2. The reverse happens for a pessimistic patient. These distortions depend on the specific biases the patient displays. Indeed, such distortions serve a double purpose: First, they ensure that the *ex-ante IC* are not binding. A higher treatment in health state 2 is preferred by a pessimistic consumer but not by an optimistic one. The appositeness of preferences warrant that *ex-ante IC* will not be binding. Second, they increase the consumers' ex-ante willingness to pay.

The provider, when establishing treatment quantities for a given health state, intends to maximize the distance between the expected utility derived from and the expected cost of producing a certain quantity of treatment. For that purpose, the provider chooses a treatment level that equates the expected marginal cost from the point of view of the provider and and the expected marginal utility from the point of view of the consumer. When the expectations are computed using the same probability parameter the treatment quantity coincides with the efficient one. Nonetheless, when there are discrepancies in the beliefs the treatment quantities are distorted as stated in Remark 1.

Remark 1. *The First Dollar Coverage plan distorts optimal quantities depending on the consumers' biases:*

- *For pessimistic consumers, there is over-provision in health state* 2 *and there is under-provision in health state* 1*, this means that*

$$q_2^p > q_2^* \quad \text{and} \quad q_1^p < q_1^*.$$

- *For optimistic consumers, there is under-provision in health state* 2 *and there is over-provision in health state* 1*, this means that*

$$q_2^o < q_2^* \quad \text{and} \quad q_1^o > q_1^*.$$

By charging an ex-ante subscription fee the provider can extract the whole ex-ante willingness to pay from the consumer. The provider further increases the ex-ante willingness to pay by offering treatment levels that confirm the biases of the consumers. Thus, the optimal contract over-provides health care services on that state which is "salient"[4] to the consumer and under-provides on the "non-salient" state.

Could payment schemes affect the offered treatment quantities despite the risk neutrality we assumed? To answer this, let us consider a contract with a different payment scheme: a combination of an ex-ante payment and contingent payments. This sort of contracts, known as *indemnity* contracts, are also a type of Health Plans largely present in the U.S. Health Plan market.

An ***indemnity plan*** is one in which the consumer pays a premium when she acquires the plan, and an additional fee contingent on the realized health state. These contingent payments are usually called deductibles or capitation, and the ex-ante payment is usually called premium. Thus, the contract combines both a premium and a deductible. The optimization program that the provider solves in order to devise a menu of contracts, denoted

[4] Here we call "salient" the state which is deemed more probable than it objectively is by a consumer.

$\langle A^i, (q_1^i, t_1^i), (q_1^i, t_1^i)\rangle_{i\in\{o,p\}}$ is:

$$\max_{\langle A^i,(q_1^i,t_1^i),(q_1^i,t_1^i)\rangle_{i\in\{o,p\}}} \sum_{i\in\{o,p\}} \left[A^i + p(t_2^i - C_2(q_2^i)) + (1-p)(t_1^i - C_1(q_1^i))\right]$$

$$\begin{aligned}
& s.t. \\
& \hat{p}^o(u_2(q_2^o) - t_2^o) + (1-\hat{p}^o)(u_1(q_1^o) - t_1^o) - A^o \geq 0 \\
& \hat{p}_p(u_2(q_2^p) - t_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - t_1^p) - A^p \geq 0 \\
& u_2(q_2^o) - t_2^o \geq 0 \\
& u_2(q_2^p) - t_2^p \geq 0 \\
& u_1(q_1^o) - t_1^o \geq 0 \\
& u_1(q_1^p) - t_1^p \geq 0 \\
& \hat{p}^o(u_2(q_2^o) - t_2^o) + (1-\hat{p}^o)(u_1(q_1^o) - t_1^o) - A^o \geq \\
& \qquad \hat{p}^o(u_2(q_2^p) - t_2^p) + (1-\hat{p}^o)(u_1(q_1^p) - t_1^p) - A^p \\
& \hat{p}^p(u_2(q_2^p) - t_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - t_1^p) - A^p \geq \\
& \qquad \hat{p}^p(u_2(q_2^o) - t_2^o) + (1-\hat{p}^p)(u_1(q_1^o) - t_1^o) - A^o.
\end{aligned}$$

The optimal *indemnity* contract differs from the *First Dollar Contract* we analyzed before not only in the payment structure but also in the treatment provision distortions introduced by the provider. This contract is reported in Proposition 3.

Proposition 3. *The indemnity Health Plan menu of contracts is described as follows:*

- *A contract designed for an optimistic consumer:*

$$\begin{aligned} u_2'(q_2^o) = C_2'(q_2^o) \quad &\textit{and} \quad u_1'(q_1^o) = \tfrac{1-p}{1-\hat{p}^o} C_1'(q_1^o) \\ t_2^o = u_2(q_2^o), \quad t_1^o = 0 \quad &\textit{and } A^o = (1-\hat{p}^o)u_1(q_1^o), \end{aligned}$$

- *A contract designed for a pessimistic patient:*

$$\begin{aligned} u_1'(q_1^p) = C_1'(q_1^p) \quad &\textit{and} \quad u_2'(q_2^p) = \tfrac{p}{\hat{p}^p} C_2'(q_2^p) \\ t_1^p = u_1(q_1^p), \quad t_2^p = 0 \quad &\textit{and } A^p = \hat{p}^p u_2(q_2^p). \end{aligned}$$

It is interesting to explore why changing the payment structure affects the treatment provision.

Firstly, by a revealed preference argument we can affirm that the *Indemnity Contracts* menu is preferred by a private monopolist since he could have offered the *first dollar coverage* menu, but did not. Therefore, the former yields higher profits for the provider. Under this payment scheme the provider has the ex-ante and the ex-post payments to extract the willingness to pay from the consumer. The provider imposes a nonzero tariff on the state the consumer deems less probable than its true probability. In this way the provider levies what he knows to be a large enough fee while the consumer beliefs it is smaller. On the other state, the provider imposes a tariff equal to zero, increasing the subjective expected benefit from the consumers perspective and levying today, through the ex-ante payment, the overestimated expected value of future benefits, as this state is deemed to be more probable than it truly is.

Secondly, the provider distorts the treatment level in the salient state while holding the other at the efficient treatment provision level. On the one hand, the provider, by offering the efficient treatment level in the "non-salient" health state, maximizes the surplus in that state. On the other hand he is able to extract it due to the fact that consumer underestimate the payment contingent on its realization.

For illustrating purposes, consider an optimistic consumer. Such patient underestimates the benefit she would get in health state 2 as well as any imposed payment contingent on being in that state. This is the reason why the contract for an optimistic consumer offers the efficient treatment and fully extract the surplus generated. Symmetrically, she overestimates expected utility derived from treatment provision in state 1 and the same happens with any payment contingent on the realization of that state, because she deems it more probable than it truly is. The provider thus offers more than the efficient level and, instead of requiring a contingent payment, charges zero in that state. The provider obtains higher expected profits from that state by imposing an ex-ante payment which is overestimated by the consumer.

In a nutshell, in the "non-salient" health state the best thing the provider can do is offer the efficient treatment level and impose a contingent fee that fully extracts the generated surplus. While on the "salient" health state the provider "over-provides" treatment and charges a contingent fee equal to zero, which he recoups by imposing an ex-ante payment. This mechanism was not available in the *First Dollar Coverage* contract, which explain why these two contracts not only differ in their payment structure but also on the treatment provision levels. In a way, the *indemnity* contract has more tools to accommodate to the biased beliefs of consumers.

The previous two Health Plan modalities are largely prevalent in health systems such as the one currently in place in the U.S. These menus of contracts offer a bundle of fees and treatment coverage in order to attract consumers to the specific contracts designed for their type. We have concluded that a private monopolist can obtain higher profits by catering to the beliefs of the consumers. Therefore, we use the indemnity contract to analyze the interaction between the Public System and the Private Provider. We now proceed to introduce a Public contract in order to be able to analyze this interaction.

2.5. Public Provision

We now assume that Health Plan provision is in charge of the public sector, and that its aim is to maximize the objective expected utility of consumers. The Public Provider is also required to recover the whole cost of the health system through premiums and contingent fees. This requirement, essentially to have a balanced budget, induces a problem equivalent to the maximization of social welfare. The optimal *Public Health Plan* must be one that: *(i)* maximizes the objective expected utility of consumers who willingly participate in the system and *(ii)* breaks-even (balanced public budget). These two constraints are formally expressed as follows:

$$\hat{p}^i[u_2(q_2^i) - t_2^i] + (1-\hat{p}^i)[u_1(q_1^i) - t_1^i] - A^i \geq 0 \quad \text{for} \;\; i \in \{o,p\}, \quad (\textit{ex-ante IR})$$

and

$$\sum_{i\in\{o,p\}} \left[A^i + p[t_2^i - C_2(q_2^i)] + (1-p)[t_1^i - C_1(q_1^i)]\right] \geq 0 \quad \text{for} \;\; i \in \{o,p\}. \quad (\textit{Balanced Budget})$$

The Public Provider has to guarantee that the consumers willingly participate in the contract. Indeed, the public system cannot force consumers to enter the market. Therefore, it has to take into consideration the biases in consumers' beliefs when designing the contracts, as they take their participation decision ex-ante. Additionally, we also require the public contract to be ex-post individually rational. The provider's optimization program in order to devise a menu of contracts, denoted $\langle (q_1^i, t_1^i, q_2^i, t_2^i, A^i)\rangle_{i\in\{o,p\}}$, becomes

$$\max_{\langle (q_1^i, t_1^i, q_2^i, t_2^i, A^i)\rangle_{i\in\{o,p\}}} \sum_{i\in\{o,p\}} \left[p(u_2(q_2^i) - t_2^i) + (1-p)(u_1(q_1^i) - t_1^i) - A^i\right]$$

s.t.

$$\hat{p}^o(u_2(q_2^o) - t_2^o) + (1-\hat{p}^o)(u_1(q_1^o) - t_1^o) - A^o \geq 0$$
$$\hat{p}^p(u_2(q_2^p) - t_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - t_1^p) - A^p \geq 0$$
$$\textstyle\sum_{i\in\{o,p\}} \left[A^i + p(t_2^i - C_2(q_2^i)) + (1-p)(t_1^i - C_1(q_1^i))\right] \geq 0$$
$$u_2(q_2^o) - t_2^o \geq 0$$
$$u_2(q_2^p) - t_2^p \geq 0$$
$$u_1(q_2^o) - t_1^o \geq 0$$
$$u_1(q_2^p) - t_1^p \geq 0$$
$$\hat{p}^o(u_2(q_2^o) - t_2^o) + (1-\hat{p}^o)(u_1(q_1^o) - t_1^o) - A^o \geq$$
$$\qquad \hat{p}^o(u_2(q_2^p) - t_2^p) + (1-\hat{p}^o)(u_1(q_1^p) - t_1^p) - A^p$$
$$\hat{p}^p(u_2(q_2^p) - t_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - t_1^p) - A^p \geq$$
$$\qquad \hat{p}^p(u_2(q_2^o) - t_2^o) + (1-\hat{p}^p)(u_1(q_1^o) - t_1^o) - A^o.$$

The Public Health Plan provider has some degree of freedom when choosing the fees that he will charge to each type of consumer. In this program, one way to avoid a selection problem is to offer self-sustained contracts. By doing so, every type of consumer self-selects into the contract intended for him. Then, in the problem above we can break the third constraint into two individual constraints requiring non-negativity for each of the terms in the sum. Therefore, the Public Health Plan offers a menu of contracts presented in Proposition 4

Proposition 4. *The Public Health Plan offers a menu of two contracts described as follows:*

- *A contract for optimistic consumers:*

$$u_2'(q_2^*) = C_2'(q_2^*) \text{ and } u_1'(q_1^*) = C_1'(q_1^*),$$

$$t_1^o = 0, \quad t_2^o = C_2(q_2^*), \quad A^o = (1-p)C_1(q_1^*).$$

- *A contract for pessimistic consumers:*

$$u_2'(q_2^*) = C_2'(q_2^*) \text{ and } u_1'(q_1^*) = C_1'(q_1^*),$$

$$t_2^p = 0, \quad t_1^p = C_1(q_1^*), \quad A^p = pC_2(q_2^*).$$

The public sector offers a contract providing the efficient treatment quantities at the lowest possible tariffs, simply looking to break even. On the tariffs side the public sector has some freedom between the ex-ante payment and the contingent payments. Due to the biases of the consumer, the subjective expected utility of the consumer can be enhanced by charging a zero tariff for the salient health condition and adjusting the other tariffs to satisfy the *Balanced Budget*. Additionally, the Public Provider avoids the entry of a private competitor offering services ex-post by setting tariffs that would not allow him to make strictly positive profits. This would be an example of a Public Health System that finances health care through an ex-ante contribution to Social Security, charging a smaller fee in certain health occurrences.

Now that we have examined the public and the Private Provider's behavior separately, and analyzed the mechanisms at play in the presence of risk perception biases, we can answer the main question of this paper: How do disease incidence misperceptions affect the interaction between a Public Health System and a Private Provider?

2.6. Private-Public Interaction

Despite the overriding presence of public-dominated systems all across Europe, we are currently witnessing a "boom" in the presence of private

Health Plans providers, who have started to play more than a simply marginal role in systems where Public Providers were already present before.

Private Health Plans are gaining ground in the European Union, although they do not yet play a significant role in the provision of health care as they do in places like the US, Australia or Switzerland. Historically, countries in the European Union have aimed to preserve the principle that health care should be funded by the government and made available to every citizen.

The intuition tells us that selecting a contract offered by the Public Health Plan provider like the one in the previous section is the most advantageous situation for the consumer. Accordingly, a Public Provider offering this contract should be uncontested in the market. However, this does not seem to be the case, as we observe the coexistence of public and private providers in both European and American markets. Disease incidence misperceptions might provide a rationale for this observation.

We analyze the incentives a Private Health Plan provider has for entering a market where there is a Public Provider, who does not anticipate entry. It is interesting to analyze the characteristics of the contracts that the Private Provider offers in order to enter such a market. This might shed some light into the question of whether the sole presence of a public system deters the entrance of Private Providers. More importantly, it provides some clarity on whether the entrance of Private Providers is in detriment or in favor of consumers' welfare.

Assume now a Public Provider, like the one presented in the previous section, who offers a menu of contracts aimed to maximize the objective expected utility. That is, the expected utility computed using the true probability distribution rather than using the consumers' (biased) beliefs. Such menu of contracts provides the efficient treatment quantities for each health state and for every consumer type, and also adapts the tariffs in order to make them more appealing for each consumer type and thus ensure a balanced budget. Each consumer who signs the Public Health plan, regardless of her beliefs, gets an objective utility level given by:

$$U = p(u_2(q_2^*) - C_2(q_2^*)) + (1-p)(u_1(q_1^*) - C_1(q_1^*)),$$

by construction the maximum level attainable. The tariffs are such that the Public Provider just breaks even, which means that he obtains zero profits. These contracts entail no selection issues, for they are such that consumers self-select into the one that is specifically destined for their type. Moreover, a consumer afflicted with health condition 1 has no interest in passing herself as being afflicted by the other disease and viceversa.

Consumers, however, evaluate the contract ex-ante by computing the subjective expected utility, that is, using their biased beliefs. With these utilities in mind they decide which contract to sign. The subjective expected utility a consumer derives from the public contract does depend on the particular bias, for an optimistic it is given by

$$\underline{u}^o = \hat{p}^o(u_2(q_2^*) - C_2(q_2^*)) + (1-\hat{p}^o)u_1(q_1^*) - (1-p)C_1(q_1^*)$$

and for a pessimistic it is given by:

$$\underline{u}^p = (1-\hat{p}^p)(u_1(q_1^*) - C_1(q_1^*)) + \hat{p}^p u_2(q_2^*) - pC_2(q_2^*).$$

A Private Provider has to provide at least the same level of subjective expected utility than the Public Provider so that consumers sign his contract.

We solve the optimization program the private physician faces, in order to find the menu of contracts $\langle q_2^i, t_2^i, q_1^i, t_1^i, A^i \rangle_{i\in\{o,p\}}$, given by

$$\begin{aligned}
&\max_{\langle q_2^i, t_2^i, q_1^i, t_1^i, A^i \rangle_{i\in\{o,p\}}} \sum_{i\in\{o,p\}} \left[A^i + p(t_2^i - C_2(q_2^i)) + (1-p)(t_1^i - C_1(q_1^i))\right] \\
&\qquad s.t. \\
&\hat{p}^o(u_2(q_2^o) - t_2^o) + (1-\hat{p}^o)(u_1(q_1^o) - t_1^o) - A^o \geq \underline{u}^o \\
&\hat{p}^p(u_2(q_2^p) - t_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - t_1^p) - A^p \geq \underline{u}^p \\
&u_2(q_2^o) - t_2^o \geq 0 \\
&u_2(q_2^p) - t_2^p \geq 0 \\
&u_1(q_1^o) - t_1^o \geq 0 \\
&u_1(q_1^p) - t_1^p \geq 0 \\
&\hat{p}^o(u_2(q_2^o) - t_2^o) + (1-\hat{p}^o)(u_1(q_1^o) - t_1^o) - A^o \geq \\
&\qquad \hat{p}^o(u_2(q_2^p) - t_2^p) + (1-\hat{p}^o)(u_1(q_1^p) - t_1^p) - A^p \\
&\hat{p}^p(u_2(q_2^p) - t_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - t_1^p) - A^p \geq \\
&\qquad \hat{p}^p(u_2(q_2^o) - t_2^o) + (1-\hat{p}^p)(u_1(q_1^o) - t_1^o) - A^o.
\end{aligned}$$

By solving the optimization program described above we conclude that a Private Provider can profitably enter a market with biased consumers despite the presence of a Public Provider. The Private Provider does so by offering a contract that distorts the treatment quantities in the "salient" health state of each consumer type. The menu of contracts offered by a Private Provider, $\langle q_2^i, t_2^i, q_1^i, t_1^i, A^i \rangle_{i\in\{o,p\}}$ is described in Proposition 5.

Proposition 5. *If the Public Provider offers the menu of contracts that maximizes the consumers objective utility, then a private health care provider can profitably enter a market with biased consumers by offering the following contract menu.*

- *For the optimistic consumer treatment quantities characterized by:*

$$u_2'(q_2^o) = C_2'(q_2^o)\ ,\ u_1'(q_1^o) = \frac{1-p}{1-\hat{p}^o} C_1'(q_1^o).$$

  and tariffs are:

$$t_1^o = 0 \ \ ,\ \ t_2^o = C_2(q_2^o) \ \ \textit{and} \ \ A^o = (1-\hat{p}^o)u_1(q_1^o)+\hat{p}^o(u_2(q_2^*)-C(q_2^*))-\underline{u}^o,$$

- *For the pessimistic consumer treatment quantities characterized by:*

$$u_1'(q_1^p) = C_1'(q_1^p)\ ,\ u_2'(q_2^p) = \frac{p}{\hat{p}^p} C_2'(q_2^p)$$

  and tariffs:

$$t_1^p = C_1(q_1^p) \ \ ,\ \ t_2^p = 0 \ \ \textit{and} \ \ A^p = \hat{p}^p u_2(q_2^p)+(1-\hat{p}^p)(u_1(q_1^*)-C(q_1^*))-\underline{u}^p,$$

The Private Health Plan contract meant for a *pessimistic* consumer provides the efficient quantity of treatment and imposes a fee that recovers the cost of health treatment in health state 1 because a *pessimistic* consumer beliefs that state to be less frequent than it truly is. However, in health state 2 a Private Health Plan contract meant for a pessimistic consumer over-provides health care services and charges a zero tariff. This is more attractive to such type of consumer, as she beliefs that state to be more likely than it truly is ($\hat{p}^p > p$). This means that, in that particular health state the Private Provider would be incurring in a loss. Nonetheless, the Private Provider recoups the loss by charging a fixed fee that compensates and yields a positive profit. A symmetric reasoning follows for the case of an optimistic consumer.

The contract described in Proposition 5 grants the consumer exactly the same level of ex-ante subjective expected utility than the public contract, which is the restriction he has to comply in order to be able to enter the market. The subjective expected utility is the sole decision consideration a consumer takes into account, since she is unaware of her biases. Nonetheless, it is illustrative to compute the objective expected utility provided by these contracts. An optimistic consumer who signs the private contract meant for optimists gets an objective utility of

$$U^o = p(u_2(q_2^*)-C_2(q_2^*))+(1-p)(u_1(q_1^*)-C_1(q_1^*))-(1-\hat{p}^o)(u_1(q_1^o)-u_1(q_1^*)),$$

and a pessimistic consumer who signs the private contract meant for her type gets an objective utility level of

$$U^p = p(u_2(q_2^*) - C_2(q_2^*)) + (1-p)(u_1(q_1^*) - C_1(q_1^*)) - \hat{p}^p(u_2(q_2^p) - u_2(q_2^*)).$$

Both types of consumers get less objective utility than if signing their corresponding public counterpart. In our setting, we assumed a passive Public Provider who does not anticipate entry and has a different objective than the Private Provider. This is partially the reason why, despite providing efficient quantities and breaking even, there still is room for the profitable entrance of the Private Provider.

It is thus interesting to consider if the Public Provider can still grant consumers the maximum level of objective expected utility, at the same time avoiding the entrance of the Private Provider. We find that the Public Provider has incentives to offer a menu of contracts that prevents entry, and grant consumers a higher objective expected utility than the one the Private Provider would provide.

The best action the Public Provider can take is offering a menu of contracts $\langle q_1^i, t_1^i, q_2^i, t_2^i, \underline{A}^j \rangle_{i \in \{o,p\}}$ with the same distortions in health treatment quantities offered by the private *indemnity* contract at a lesser price in the manner described in Proposition 6

Proposition 6. *The best menu of contracts the Public Health Plan Provider can offer in the presence of a Private Provider in the market comprises:*

- *A contract for the optimistic consumers with treatment quantities characterized by:*

$$u_2'(q_2^*) = C_2'(q_2^*)\ ,\ u_1'(q_1^o) = \frac{1-p}{1-\hat{p}^o} C_1'(q_1^o).$$

  and tariffs given by:

$$t_1^o = 0\ ,\quad t_2^o = C_2(q_2^*)\ \text{ and }\ \underline{A}^o = (1-p)C_1(q_1^o),$$

- *A contract for the pessimistic consumers with treatment quantities characterized by:*

$$u_1'(q_1^*) = C_1'(q_1^*)\ ,\ u_2'(q_2^p) = \frac{p}{\hat{p}^p} C_2'(q_2^p)$$

  and tariffs given by:

$$t_1^p = C_1(q_1^*)\ ,\quad t_2^p = 0\ \text{ and }\ \underline{A}^p = pC_2(q_2^p).$$

This optimal menu prevents the entry of the Private Provider.

This menu of contracts provides consumers a higher subjective expected utility than the one offered by an uncontested Public Provider, presented in Section 2.5. However, the objective utility level is lower. For optimist consumers the objective expected utility is

$$\underline{U}^o = p(u_2(q_2^*) - C_2(q_2^*)) + (1-p)(u_1(q_1^o) - C_1(q_1^o)),$$

and for pessimistic the objective expected utility is

$$\underline{U}^p = p(u_2(q_2^p) - C_2(q_2^p)) + (1-p)(u_1(q_1^*) - C_1(q_1^*)).$$

These objective expected utility levels are superior than the ones obtained by consumers signing any of the contracts in the menu of contracts offered by an entrant Private Provider, presented in Proposition 5; but they are lower than if signing their corresponding contract offered by an uncontested Public Provider, presented in Proposition 4. By offering the contract presented in Proposition 6, the Public Provider avoids the entry of the private one although the blockage of the entrance of a Private Provider leads to a lower objective expected utility of consumers, compared to the situation where the Private Provider did not exist.

Another environment that is interesting to analyze, due to its common occurrence, is the one where a private physician offers health care services ex-post in a *Fee-For-Service* scheme. That is, a private physician could offer his services outside of a plan even in the presence of a public plan. This implies that the Private Provider decision takes place after the health state is realized, and so does the decision of consumers to obtain health care from the Private Provider. However, it is easy to prove that the contract menu presented in Proposition 4 is robust to the entrance of a Private Provider who operates with *Fee-For-Service* contracts.

From the analysis of the interaction between a Public Health Plan and Private Health Plan providers we can draw several conclusions. First, the presence of biases in the market leaves some room for the entrance of private competitors that offer contracts better accommodating to the biased beliefs of consumers, often in detriment of their objective surplus or their ex-post well-being. Second, the Public Provider has incentives to avoid the entry of Private Provider by offering a menu of contracts with treatment distortions that amount to a lesser objective expected utility compared to the scenario where there is not a potential private entry.

From our analysis we see that the structure of a health care system and the question on how much private presence should governments allow in the markets is far from being a closed issue. We claim that our paper presents some arguments in favor of public mandatory universal health insurance, enforced by legal and institutional mechanisms. The presence of private competitors leads the Public Provider to offer a menu of contracts comprising inefficient treatment provision. Private Providers do not obtain strictly positive profits, but this leads to inefficiencies.

2.7. Concluding Remarks

Optimism and pessimism, as definied in this paper, play an important role on how individuals assess health plan. Therefore have a direct influence on the decisions they make in the health plan market. In their book *Nudge*, Thaler and Sunstein (2008) assert that when people are boundedly rational it is unlikely that market interactions correct the biases. On the contrary, "markets provide strong incentives for firms to cater to the demands of consumers, and firms will compete to meet those demands whether or not those demands represent the wisest choice. While competition does drive down prices, it does not always lead to an outcome that is best for consumers" (Thaler and Sunstein, 2008, pg. 49).

In our model we depart from the standard assumption of patient-provider common priors with a particular interpretation in mind: patients have a systematic bias in forecasting their future health state, whereas the provider has access to an unbiased forecast due to its superior knowledge and technology. This setting might look arbitrary at first; however, it seems reasonable to think that a company with its team of health and statistical experts has better estimates on the likelihood of different health outcomes. On the other side, people commit "ditzy blunders" under certain circumstances. For instance, when decisions are "difficult and rare, for which they do not get prompt feedback, and when they have trouble translating aspects of the situation into terms that they can easily understand" (Thaler and Sunstein, 2008, pg. 72). The health plan decision fits this description. Thus, it is reasonable to think that consumers would not learn rapidly from the market and that competition would never drive contracts towards the first best.

We have shown that the discrepancy between risk perception and the objective risk has important implications on the objective consumer surplus, since a Private Provider might take advantage of its unbiased knowledge to offer contracts that *ex-ante* appear acceptable but would be unacceptable from an *unbiased* perspective. We have also shown that the private sector can enter the market despite the presence of a public incumbent offering the first best contract, resulting in loss in consumers surplus. Furthermore, the presence of private physicians in the market does not seem to improve the welfare of the patients, instead raising the premium charged by the public sector.

A natural extension of our work is to include risk aversion in the specification of utility function. This extension becomes complicated very easily, as besides dealing with different types of risk perception, provider also would have to deal with the fact that tariffs are not as easily transferable as in the present paper. However it is quite interesting to explore how the biases in risk perception operate under the insurance environments.

Another possible extension would entail making the patients' biased beliefs endogenous. One way to do it is to include a previous step in which a patient chooses his own beliefs. This extension may be constructed within the setting of cognitive dissonance developed by Akerlof and Dickens (1982). They propose a model in which individuals have preferences not just on the states of the world, but also on their beliefs about the state of the world. The authors assume that individuals have control over their beliefs and can choose to manipulate their beliefs by choosing sources of information that are likely to "confirm" the desired beliefs. Within this setting we would expect that providers find it optimal to induce biases (*e.g.* through marketing tools), given that they have no interest in educating the patient. We believe that, in its simplicity, the model we develop here can explain some of the empirical facts observed in the health plan marketplace.

Chapter 3

Information availability and ability choice in a market for *n* physicians

3.1. Introduction

Healthcare markets are among the most complex and heterogeneous one can study from an informational perspective.[1] Context and scenario-specific idiosyncrasies notwithstanding, at their core these markets entail an essential informational asymmetry: the physicians hold superior information concerning several aspect of their relation with the patients. One of the most salient of such asymmetries pertains the quality of the service being offered. The effort, ability, extent and nature of the treatment provided by a physician constitute a classic example of a credence good[2], for the patients cannot tell if the service they claim to have received is indeed what they needed or actually obtained.

In a previous paper (Lara and Rodríguez-Camacho, 2016) we studied the role of the informational asymmetry surrounding a physician's ability in the healthcare choices of patients. In particular, we focused on how boundedly-rational agents react to the lack of information on a physician's ability by estimating it via small samples taken from the past experiences of family and friends. We focused on a duopolistic market, which although relevant for a scenario where a patient bases her choice on the set of physicians who have previously treated a member of their family, it potentially falls short from capturing the mechanisms that operate in a larger market.

In this paper we look at a scenario where competition is heightened by the presence of a large number of physicians in the market. This is particularly relevant to the conclusions of Lara and Rodríguez-Camacho (2016),

[1]For a concise but complete overview of the issue see (Frank, 2007).

[2]Following Nelson (1970), those goods whose quality cannot be fully learned by the consumers even after purchase has taken place or the service been provided.

considering that we found the limited sampling and information asymmetries to allow physicians to offer subpar services and charge high fees due to their control over a captive demand. To be precise, those patients who only had access to one physician and based their decision on a single positive anecdote were, for all effects, part of a monopolistic market operating on the side of the competitive one. A physician could choose to focus on his captive segment and decrease the quality of the service without detriment to his profits, even when the cost of providing a high-quality service was zero. It is interesting to consider the effects of decreasing the size of such captive markets by putting more competitive pressure on the healthcare providers.

Thus, we here study the ability choices of a large set of physicians who compete in a market in terms of the fee they charge (a price) and the quality of their service (an ability). With ability we refer to the probability for a physician to change a patient's health state. Consumers value being healthy, hence favor visiting the highest ability physician they can afford. The ability of the physicians are unknown to the consumers, who gather anecdotes to from their family members, detailing whether their health improved after visiting a given physician or not.

Following the decision procedure described in Lara and Rodríguez-Camacho (2016), the patients (from here on consumers) estimate the physicians abilities resorting to the limited information at their disposal. When deciding which physician to visit, the consumers ask a small number of family members and friends about their experiences, forming estimations based on these anecdotes. Such simplifying heuristics entails two problems: an overreliance on small samples and the limited availability of information among the patients a consumer inquires. The physicians are aware of these deviations from rational decision-making in the patients and act strategically.

The literature on competitive markets would suggest that more competitive pressure on a specific physician might give him incentives to increase the quality of the service he offers or push his fee closer to the marginal cost. The mechanism that allowed physicians to choose low abilities to focus on their captive markets is essentially altered in the presence of strong competition. A market with a large number of physicians implies smaller captive segments for each provider, thus affecting their incentives to focus on them. In Lara and Rodríguez-Camacho (2016) we found that captive segments allowed for an equilibrium where physicians chose non-maximal abilities even when such decision was costless for them, with detrimental results for the consumers' welfare. It is interesting to consider whether a more competitive market could correct such distortion, leading to potential regulatory insights for a social planner to examine.

We find that low-ability physicians still can participate in the market despite the large number of competitors. Indeed, increasing the number of providers has a minimal impact over the participation decisions of patients. The anecdote-based reasoning the patients follow makes the existence of superior but unknown suppliers irrelevant. That is, if a patient decides to visit a physician upon finding a positive anecdote, it may not matter that she is unaware of a large number of high-ability rivals.

In terms of their equilibrium pricing strategies, the availability of more physicians entails a decrease in the information consumers have across the market, allowing for high equilibrium fees. This is a counter-intuitive result, since more competition would not be be expected to lead to prices different to the marginal cost. No matter how small, the captive market segment causes physicians to price as monopolists. Thus, many suppliers serving their small captive segments for a positive fee viably exist in the competitive equilibrium.

This result, outlining a peculiar relation between the number of physicians in the market and the fees they charge has previously been described in the literature. Several pioneering econometric analyses of healthcare markets found a partial positive correlation between the physicians stock and prices (Feldstein (1970); Fuchs and Kramer (1972)). Such results contradict the predictions of the standard competitive model, opening the door for alternative explanations, one of which might be the informational route this paper proposes.

3.2. Related Literature

This work is part of the literature studying markets where the quality of a good or service is hard for the consumers to ascertain. More specifically, we focus on a healthcare market in a setting where consumers follow a boundedly rational rule to learn the quality of the service being offered. The anecdote-based procedure we model in this paper is a simplifying heuristics adopted by consumers who base their decisions on a single past experience gathered from a third-party agent. In simpler words, consumers estimate the abilities of physicians through small samples of anecdotal evidence obtained from past consumers. We apply this rule as a departure from the Bayesian reasoning expected from perfectly rational agents, building on Lara and Rodríguez-Camacho (2016), who themselves follow Osborne and Rubinstein (1998), Gilboa and Schmeidler (2001), and Spiegler (2006b).

The medical literature has long established the complexity of the decision making processes that patients face when engaging with the market. Health status, environmental factors, lack of medical literacy, communication barriers between the physician and the patients, are some of the factors driving such difficulties (Osborn et al. (2011), Say, Murtagh, and Thomson (2006), Joseph-Williams, Elwyn, and Edwards (2014)). It is therefore not surprising for patients to resort to the evidence the closest to them, coming from family members and friends whom they already share certain bonds with. Empirical evidence and relevant theoretical developments on such an issue can be found in Henry J. Kaiser Family Foundation (2000), Tu and Lauer (2008), Freed et al. (2010), Mostaghimi, Crotty, and Landon (2010), Azu, Lilley, and Kolli (2012), among others.

The use of small samples to inform consumer decisions is prevalent in healthcare markets and leads to non-standard outcomes. For a survey on this issue from a healthcare perspective see Lipkus, Samsa, and Rimer (2001), Peters et al. (2006) or Reyna et al. (2009). From the side of the economic literature, Rabin (2002) among many others studied the effects of consumer over-reliance on limited-size samples, finding that it induces suboptimal decisions in consumers, allowing low-skilled competitors to take part in the market.[3] This is a significant issue for our study since it suggests a connection between market distortions and non-rational, sample-based decisions.

For this study we take as our springboard Lara and Rodríguez-Camacho (2016) and examine how the competitive and informational mechanisms there identified transform when the number of physicians in the market grows.

Studying the consequences of increasing the number of healthcare providers in a market is a longstanding research interest in the literature. (Feldstein (1970) and Fuchs and Kramer (1972)) are among the first to examine competitive markets for physicians, finding a positive partial correlation between the physician stock and prices. This is an observation clearly inconsistent with the competitive model. Several lines of research emerged to explain this, the closest to our analysis being the analysis of monopoly power in the market for physicians.

Other research paths relevant to our work attempted to import early behavioral economics ideas to the analysis. Chief among these was the satisficing model (Simon, 1959). Evans (1974), which suggested that physicians might set higher prices to achieve a “target income” different to their optimal fees, in part because maximizing behavior may be seen as socially undesirable given the context. A different approach introduced the notion of “physician induced demand” in the context of a model of profit maximization. Evans (1974) postulates that physicians create demand for their own services by exploiting their role as an agent for the incompletely informed patient. Considering that we explore the role of information in the market

[3] A primer on small-sample effects on economic decisions is found in Tversky and Kahneman (1971).

for physicians, particularly deeming information to involve an exogenous and endogenous component, we can include our work in a line of this ilk.

We posit that consumer sample-based choices produce a demand structure (captive and contested demand segments) which induces rational and profit-maximizing physician to price higher than marginal cost even if competition is heightened by the presence of a larger number of competitors. By doing so, we blend the informational and behavioral streams of the literature in the analysis of a competitive market for physicians with boundedly-rational patients.

3.3. General Setting

We consider a market comprising a mass of consumers indexed by their willingness to pay for healthcare services θ, uniformly distributed over $[0, 1]$. We define health as a binary variable r such that $r = 1$ when a consumer is in full health and $r = 0$ when she is ill.

All the consumers in the market suffer the same ailment, unique in type and with identical severity. The physicians are the only agents who can change a consumer's health state. Thus, each consumer seeks for a physician for treatment. A consumer who stays out of the market remains ill. The probability for a consumer who visits a physician to improve is positive and depends on the physician's ability.

There are n physicians in the market, indexed by $i \in N = \{1, 2, \cdots, n\}$. The physicians compete in prices and abilities. We define the ability $\alpha_i \in [0, 1]$ as the probability for a physician i to change a patient's health state. The physicians compete in abilities and prices. The ability choice is costless for the physicians, assuming it captures the sunk cost of acquiring a diagnose technology. The physicians charge a fee $p_i \in (0, 1)$ for their services. We assume the marginal cost for providing healthcare services to be negligible.

All the physicians choose their abilities independently and simultaneously, before meeting the consumers. The physicians are fully rational and perfectly informed. That is, they observe the ability chosen by all the other physicians in the market once it has been chosen. Next, they simultaneously set prices to maximize their individual profits. The physicians' fees are publicly known, whereas their abilities are unknown to the consumers. The consumers estimate these abilities through small samples of anecdotal-evidence gathered from past consumers.

Not all physicians in the market are equally visible to the consumers, owing to the size of the market and non-ability related asymmetries.[4] The consumer might not be aware of every physician present in the market. When sampling for anecdotal evidence a consumer has access to a limited subset of physicians. She will only be able to gather anecdotes about those physicians who have treated someone she knows. We denote $\gamma_i \in (0,1]$ for all $i \in N = \{1, 2, \cdots, n\}$ to be Physician i's visibility, the exogenously given probability for him to be considered by any particular consumer. All visibilities are known by the physicians.

The patients base their participation decisions on a sampling rule, which they use to estimate the ability of every physician they can observe. Each patient estimates the ability of the physicians they consider visiting through the anecdotal evidence gathered from friends, family members, and acquaintances. In order to do this, a consumer draws a single anecdote for each physician she is aware of and then, if the anecdote is positive, she believes she will also be cured if she visits such physician, estimating his ability to be 1. On the other hand, she discards the idea of visiting the physician upon finding a negative anecdote, which amounts to taking his ability to be 0.

Once the sampling process has taken place, over all the physicians a consumer is aware of, she compares the subset of physicians for which she found positive anecdotes. The consumer believes she will be cured with probability 1 if she visits any of such physicians. Thus, she bases her decision on the fees they charge.

The timing of the game is the following:

1. The physicians choose their abilities independently and simultaneously.
2. The physicians, aware all other competitors' abilities and visibilities, set a fee.
3. Each consumer takes a size-one sample from each physician in her consideration set.[5]
4. Based on her sampled outcomes, the publicly known fees, and her willingness to pay for healthcare services, each consumer takes the participation decisions.
5. Fees are payed and healthcare services are provided.

[4]Lara and Rodríguez-Camacho (2016) hypothesize these competitive advantage difference to come from inherited factors – $i.e.$ when a physician is part of a family saga in the profession – or exogenous issues like a physician's fame or school "pedigree".

[5]The consideration set of a given consumer includes all the physicians who have treated someone she knows.

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

3.4. The Sampling Process

The consumers do not know the abilities of the physicians in the market. Therefore, they independently sample a single past-patient from each of the physicians in their consideration sets. We define a given consumer's consideration set as the set of physicians who have treated someone she knows. Thus, she can gather samples and estimate the ability for the physicians who are included in such subset of the market; the rest of competitors remain unknown to her. In practical terms, these consideration sets represent the how a consumer's family may have a few or even just one practitioner or healthcare provider they rely on.

The set of all possible consideration sets is the power set of N. The visibilities, $\gamma_i \ \forall i \in N = \{1, 2, \cdots, n\}$, define a probability distribution over this power set, which could be understood as the probability that a given consumer has each of the possible consideration sets.

For instance, in the duopoly case, 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 $(1-\gamma_1)(1-\gamma_2)$. Likewise, it is reasonable to understand these probabilities as the proportion of consumers who have a particular consideration set.

Each consumer takes an independent, size-1 sample for each physician in her consideration set. Thus, for the market with n competitors we consider, 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, for all those within a given consideration set. Thus, when she samples, a consumer who is aware of Physician i observes a positive anecdote from a patient who visited him with probability α_i.

The consumers build their beliefs on the abilities of the physicians based entirely on the anecdotal evidence they find in their consideration sets. Therefore, probability α_i can also be understood as the expected proportion of consumers who observe a positive anecdote from Physician i.

As a result of the sampling process, a consideration set is also divided in subsets comprising all the physicians for whom the consumer has found a positive anecdote. We denote these as the sets of *acceptable physicians*, since all the physicians comprised in them are estimated by a consumer to be of maximal ability. A physicians from whom a patient has observed a negative anecdote is excluded from her *acceptable* set, for the consumer believes she will not be cured after visiting such physician. If she can afford it, the consumer will visit the "cheapest" of the acceptable physicians – $i.e.$ those included in the *acceptable* set. Indeed, she believes them all to be equivalent in abilities; thus, that she will recover no matter whom she visits out of them.

3.5. Consumer Behavior

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

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

We normalize the utility of a healthy consumer to 1 and assume that the consumers derive no utility from being sick: $u(r = 1) = 1$ and $u(r = 0) = 0$. Then, the utility under perfect information for a patient with willingness to pay for healthcare θ who visits Physician i would be:

$$\theta\alpha_i - p_i.$$

In the setting we described in the preceding section, this is not the case. Consumers here not only do not possess information on the ability of every physicians in the market, but base their decisions on anecdotes gathered from their closest acquaintances. A consumer would visit Physician i if three conditions hold together: he was included in the **acceptable physicians** set, $\theta - p_i \geq 0$, and $p_i < p_j$ for all acceptable physician $j \neq i$.

That is, she decides to visit Physician i if he offers her the best price among all those physicians she is aware of and has found positive anecdotes for. The expected utility for such a consumer is given by: $\theta - p_i$.

The anecdotal evidence observed by each consumer depends on the ability chosen by physicians and on their respective visibilities, both independent random variables. Per our assumption on the physicians' visibilities, every one of them has a positive probability of being included in a given consumer's consideration set. Thus, α_i represents the probability that any one consumer would observe a positive anecdote subject to Physician i 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 included in their respective **acceptable physicians** sets, only the ones with a high-enough willingness to pay end up visiting the physician. In particular, from all those consumers who only have Physician i in such set – having found negative anecdotes for all they rivals in her consideration set –, only the consumers with a willingness to pay at least as high as Physician i's fee will visit him.

With this in mind, we build the demand Physician i faces, which encompasses the consumers who have any possible consideration set including Physician i.

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, either being unaware or observing negative anecdotal evidence for every Physician $j \neq i$, Physician i becomes her only alternative. Physician i's *captive demand segment* comprises all such consumers. Physician i could act as a monopolist over this segment of the demand, for these consumers know no other physician or estimate them to be inferior.

The *contested demand segment* includes all the consumers who, while being aware of more than one physicians, found positive anecdotal evidence about all or some of them. That is, the contested demand segment for Physician i comprises all consumers who have Physician i and at least one other physician in their *acceptable* set. In this segment the main deciding factor for each consumer is the fee charged by the physicians, direct price competition taking place between them.

Since we restrict our analysis to uniform non-discriminatory prices, the main trade-offs regarding the decisions of the physicians emerge from these demand structure. A higher price would allow a physician to obtain larger profits from his captive demand while diminishing his appeal in the contested demand segment.

The size of the captive and contested demand depend not only on his own ability choice and exogenously set visibility, but also on those of his rivals. For example, if $n = 4$ the demand for Physician 1 would be the following:

$$
\begin{aligned}
D_1 = & \gamma_1\alpha_1 \left[\gamma_2\gamma_3\gamma_4(1-\alpha_2F_2(p_1))(1-\alpha_3F_3(p_1))(1-\alpha_4F_4(p_1))+\right. \\
& \gamma_2\gamma_3(1-\gamma_4)(1-\alpha_2F_2(p_1))(1-\alpha_3F_3(p_1))+ \\
& \gamma_2(1-\gamma_3)\gamma_4(1-\alpha_2F_2(p_1))(1-\alpha_4F_4(p_1))+ \\
& (1-\gamma_2)\gamma_3\gamma_4(1-\alpha_3F_3(p_1))(1-\alpha_4F_4(p_1))+ \\
& \gamma_2(1-\gamma_3)(1-\gamma_4)(1-\alpha_2F_2(p_1))+ \\
& (1-\gamma_2)\gamma_3(1-\gamma_4)(1-\alpha_3F_3(p_1))+ \\
& (1-\gamma_2)(1-\gamma_3)\gamma_4(1-\alpha_4F_4(p_1))+ \\
& \left.(1-\gamma_2)(1-\gamma_3)(1-\gamma_4)\right](1-p_1),
\end{aligned}
$$

Where $F_j(p)$ represents the cumulative distribution of probabilities physician j assigns to prices in the pricing domain up to price p. We use this as a way to represent the possible mixed pricing strategies of physicians.

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

Conversely, given physician j's mixed strategy, $F_j(p_i)$ represents the probability that the fee set by physician j falls below a particular fee p_i. Thus, $\alpha_jF_j(p_i)$ is the expected proportion of consumers who visit physician j because they observed a positive anecdote on physician j and got a lower fee from him. Hence, $(1-\alpha_jF_j(p_i))$ comprises all those consumers who observed a negative anecdote on Physician j or, having observed a positive anecdote on him found a particular Physician i's fee p_i to be lower than Physician j's.

When rewritten, this expression reduces to:

$$
D_1(p) = \gamma_1\alpha_1(1-\alpha_2\gamma_2F_2(p))(1-\alpha_3\gamma_3F_3(p))(1-\alpha_4\gamma_4F_4(p))\,(1-p_1)
$$

Using similar arguments, for the n-physicians case the demand a Physician i faces, where $i \in N$, is:

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

Although when written in this way it is not immediate to notice the different consideration sets possibly observed by the consumer, nor the two segments of the demand, the aforementioned trade-offs remain. That is, the physicians must choose between pricing as monopolists over their captive demands or to compete for the consumers included in the contested segment. As uniform and non-discriminatory prices are the only ones allowed, this two pricing strategies cannot be divided, thus generating the trade-off.

The physicians are rational and perfectly informed, thus aware of their potential demands. They maximize their profits contingent on such demands. We discuss these decisions in the following section.

3.6. Price Competition with Exogenous Abilities

For the sake of expositional clarity in the analysis of the physicians' pricing strategies, and *without loss of generality*, we assume that $\gamma_n\alpha_n \geq \gamma_{n-1}\alpha_{n-1} \geq \cdots \geq \gamma_1\alpha_1 > 0$. We also assume $1 > \gamma_n\alpha_n$. These assumptions entail three main implications: First, that no matter how low a physician's ability is, a non-zero portion of the consumers will observe him. Second, some of the patients who have been treated by a given physician in the past will be cured irrespective of the physician's ability level. Third, there may be physicians who are dominant in a combination of visibility and ability. We loosely denote this interaction as a proxy for the information available on a physician. That is, it is easier to find anecdotes for a physician with a superior $\gamma_i\alpha_i$, particularly positive ones.

It is important to notice that, unlike what is observed in standard models of price competition with vertical differentiation, there is no Nash Equilibrium in pure strategies for the game we solve. This happens because, regardless of the rivals' pricing strategies, a physician will always serve a positive portion of the demand even if being undercut by a competitor. A physician who faces a low-pricing rival still serves the consumers in his captive segment. Per our assumption on the sizes of their abilities and visibilities, all the physicians in the market hold a captive demand segment, thus rendering an equilibrium in pure strategies unfeasible.

Thus, undercutting cannot be carried out in our set-up to the point where prices reach the marginal cost. We have assumed the cost of providing the service to be negligible for the physicians. Setting a price equal to the marginal cost would yield zero profits for a physician, and he would rather set any positive price and derive profits from his captive segment, irrespective of the rivals' pricing strategies. This is only possible because $\alpha_i\gamma_i > 0$ and $\alpha_i\gamma_i < 1$ for all i; one of the implications derived from the assumption opening this section. Hence, setting a price equal to the marginal cost does not constitute a Nash Equilibrium in pure strategies. Neither does setting a unique positive price – a monopolist fee, for instance –, since there are incentives to undercut the rivals and obtain the whole contested demand.

Carrying this analysis into the backwards-induction solution of the pricing stage of the game, we find an asymmetric Nash Equilibrium in mixed strategies for price competition.

The mixed strategy equilibrium is such that every physician randomizes over some of the pure strategies available. In particular, every physician in the market randomizes over some price interval between zero and one-half. The price interval supporting a physician's strategies is defined by the relative size of his combined ability and visibility with respect to those of his rivals. Indeed, how *plentiful* information on a physician is directly impacts on the pricing strategies available to him.

In the mixed strategy Nash Equilibrium we set forth below, physicians mix over different price intervals. Every physician i mixes over a strategy support $[p^L, p_i^H]$. Given the abilities $\alpha_i \in (0,1] \quad \forall i \in N$, and exogenous probabilities of being considered $\gamma_i \in (0,1] \quad \forall i \in N$. We define a sequence of prices $\{p_1^H, p_2^H, \cdots, p_n^H\}$ with $p_1^H \leq p_2^H \leq \cdots \leq p_n^H$, where:

$$p_j^H = \frac{1 - \sqrt{1 - \frac{\prod_{h=j+1}^{n-1}(1-\alpha_h\gamma_h)}{(1-\alpha_j\gamma_j)^{(n-j-1)}}}}{2}$$

for $j \in N \setminus \{n-1, n\}$ and $p_n^H = p_{n-1}^H = \frac{1}{2}$

The following figure illustrates what the strategy supports will typically look like.

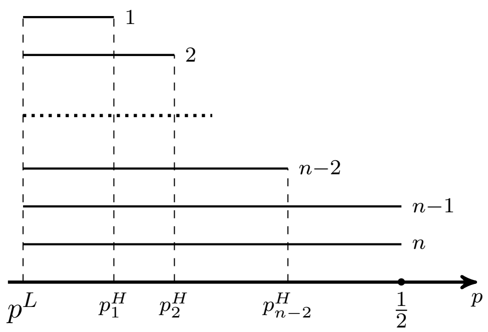


FIGURE 3.1: Strategy supports

From a game-theoretical point of view, the asymmetry in equilibrium pricing strategies comes from the very definition of mixed strategy Nash Equilibrium. Such an equilibrium requires that, for a physician to randomly choose from any two available prices, the profits associated with them to be the same, thereby making him indifferent. If this were not the case, the physician would choose the price that yields the higher profits to him instead of randomizing. In our setting this strategic thinking derives in an asymmetric mixed strategy Nash Equilibrium in which dominated ability-visibility physicians price more aggressively. That is, physicians for whom information is less plentiful set lower prices.

Positive anecdotes for dominated physicians, conditional on being observed, are harder for consumers to come by. Hence, in order to be more competitive, such physicians need to be found less expensive than their dominant rivals. A lower price allows them to attract demand from their contested segment with a higher probability, given the relatively small captive segments they hold. This leads to an equilibrium in which the more dominant a physician is, the larger his pricing interval and the higher his average price. In principle, this is a counterintuitive result. A dominant physician would be expected to price more aggressively, if only due to his contested demand segment being larger. This is not the case in the equilibrium we find, where dominated physicians set low prices with higher probability. Moreover, the fact that physicians whose information is more plentiful choose to set higher prices and focus on deriving profits from their captive segments, resonates with the duopolistic setting described in Lara and Rodríguez-Camacho (2016).

All things being equal, a higher ability level allows a physician for a larger pricing support and a higher expected price in the equilibrium. Proposition 7, presented below, formally describes the equilibrium strategies.

Proposition 7. *In the price competition stage of the game, with n physicians active in the market, there is a Nash equilibrium in mixed strategies characterized by the following c.d.f.:*

$$F_i(p) = \frac{1}{\alpha_i \gamma_i} \left[1 - \left(\frac{\prod_{h=j}^{n-1} (1 - \alpha_h \gamma_h)}{4p(1-p)} \right)^{\frac{1}{n-j}} \right] \quad \textit{for } \; p \in [p_{j-1}^H, p_j^H] \subset (p^L, p_i^H]$$

for $j < i$ with $F_i(p) = 0$ for all $p < p^L$ where $p^L = \frac{1 - \sqrt{1 - \prod_{\kappa \neq n}(1 - \alpha_\kappa \gamma_\kappa)}}{2}$ and $F_i(p) = 1$ for all $p \geq p_i^H$.

We believe such equilibrium to provide some interesting intuitions. First, a dominant physician (one with a higher visibility and superior care-provision capabilities) is more likely to set a high price than less popular and less able competitors. In some sense, ability-visibility dominance provides physicians with superior market power which allows them to price highly and obtain higher equilibrium profits from both of the. To some extent, the asymmetry in equilibrium pricing strategies mimics the asymmetry we assumed in the ability-visibility combination.

What this result a priori implicates is the interest for physicians to increase the information available on them. While they have no control over their visibilities, ability choice will certainly be affected by the pricing equilibrium we find.

The pricing strategy support available to the dominant physician goes up to the price a physician would set if he where to focus only on the captive demand segment. Indeed, this upper bound coincides with the fee a physician would set if he were to operate as a monopolist. On the other hand, the lower bound of such pricing domain is the lowest price a physician would set in order to ensure at least the same profits level he would get if focusing on his captive segment. That is, he is willing to compete only if he can get equal or larger profits than if he were to serve his captive consumers only.

The dominance we hypothesized generates a particularly interesting asymmetry. Such asymmetry is a reflection of the demand structure, for only the most dominant physician places a mass point on the price that would maximize his profits if he would be acting as a monopolist. This comes from the fact that the dominant physician holds a larger captive demand and therefore focuses on maximizing the profits obtained from such segment. If this dominance tends to disappear, so does the mass point in the physician's mixed strategy. Any two physicians with the same visibility-ability combination will behave identically.

In Corollary 1 we report the profits physicians expect to obtain from playing the strategies described in Proposition 7.

Corollary 1. *The equilibrium profits, taking the abilities,* $\alpha_i \quad \forall\ i \in N$*, and visibilities,* $\gamma_i \ \ \forall\ i \in N$*, as given, are:*

$$\pi_i(\boldsymbol{\alpha}, \boldsymbol{\gamma}) = \frac{1}{4}\gamma_i\alpha_i \prod_{j \neq n}(1 - \gamma_j\alpha_j) \qquad \forall i \in N$$

The expressions above suggest that one dominant physician will always get more profits than the rivals. Following the assumption introduced in the beginning of this section, a physician who has a superior combination of ability and visibility – which Lara and Rodríguez-Camacho (2016) interpret as a measure of the availability of information on given physician – will be in an advantageous position, profits-wise, than his rivals. For the sake of comparisons and interpretation, we follow the authors in denoting such Physician as the "relatively dominant" player.

The profits of the relatively dominant physician depend negatively on the product of the ability-visibility combination of his rivals and positively on his own combination of these variables. However, it is interesting to notice that the profits of every other physician present in the market do not depend on the dominant physician's ability-visibility combination. This directly influences the incentives physicians have in the ability choice stage.

In this section we presented a first glance at the incentives for ability differentiation between physicians, as they derive from the demand structure and the second-order effects operating between the physician's profits functions and the abilities and visibilities of their rivals. We continue to solve the game by backwards induction, moving now to the stage where the physicians choose their ability level. We analyze these decisions in the following section.

3.7. Ability Choice

In this stage of the game, the physicians strategically set their respective abilities, anticipating their expected profits from the pricing competition stage. In our model this means that the physicians decide the probability with which a patient who visits them will be cured, and also how easy it will be for consumers to find a positive anecdote on them, conditional on the physician being in their consideration sets.

Since the consumers reason anecdotically, the ability choices resonate in the demand the physicians face. This is particularly true for the setting we are currently analyzing, given that we consider the probability of finding a past patient to be exogenous and positive. Hence, a higher α_i *ceteris paribus* increases the probability for a consumer to find a positive anecdote on a specific physician i. Furthermore, when it is assumed to be a costless choice, the existence of an equilibrium where the physicians set any other value but the maximal one ($\alpha_i = 1$) is interesting.

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 as a consequence of the ability-estimation process, as seen in Ireland (1993) and Szech (2011), but also because of the inherent visibility asymmetries and the captive demand segments they originate, as discussed in our previous work (Lara and Rodríguez-Camacho, 2016).

It is the latter mechanism that interests us the most. Generally speaking, a high-ability physician whose past-patients are hard to find will likely have a smaller captive segment than a well-known competitor with a lower ability level. The reverse argument is not necessarily true in a market with many competitors. A physician with a large visibility will be included in a large number of patients' consideration sets. However, a low ability could avoid him from being included in the acceptable set if the anecdote found for him were a negative one, therefore rendering his innate visibility-advantage irrelevant in the market. Therefore, the trade-off between ability and visibility becomes crucial for the physicians' decisions.

The next proposition shows that for a given set of visibilities there is a unique Nash equilibrium, which we report in Proposition 8.

Proposition 8. *In the ability choice stage of the game and given exogenous physicians' visibilities such that $\gamma_n \geq \gamma_i \; \forall i \in N$, the equilibrium abilities are:*

$$\alpha_i^* = \begin{cases} \frac{1}{2\gamma_1} & if\ \gamma_i > \frac{1}{2} \\ 1 & if\ \gamma_i \leq \frac{1}{2} \end{cases} \quad \textit{for} \quad i < n$$

and

$$\alpha_n^* = 1$$

The main implication of this equilibrium is that the better-known physician always chooses the maximum ability level. That is, the physician who is included in the most number of consideration sets is also the one who most often appears in the consumers' *acceptable* sets. One interpretation for this behavior might be that the physician whose past patients are more numerous, hence being more visible, has incentives to consolidate his innate competitive advantage by choosing a high ability level. Since the ability choice is assumed to be costless in our model, it is natural for the equilibrium decision of such physician to be the maximal ability value.

Every non-dominant physician i maximizes his profits by choosing his ability level such that the ability-visibility combination is $\alpha_i\gamma_i = \frac{1}{2}$ – whenever possible. However, when the physician's visibility is below one half he is unable to reach this ability-visibility combination level. Thus, he chooses the maximum level of ability available to him, which is $\alpha_i = 1$. This results in non-dominant physicians following either of two strategies, depending on the size of their visibility. If a physician's visibility is below $\frac{1}{2}$ he chooses the maximum ability level. Otherwise, the physician sets a lower ability level as a function of his own visibility. Therefore, differentiation in abilities is observed between the portion of physicians who have a visibility level of at least $\frac{1}{2}$ and those whose value for γ_j falls below such threshold.

These equilibrium strategies carry several interesting implications. First, in terms of the ability, the relatively-dominant physician is pooled with those physicians who have lower visibilities. This is not entirely surprising given the rationale that if a physician's visibility is low only a small portion of the population is aware of his presence. Thus, by choosing a high ability the physician increases the mass of consumers who could potentially demand his services. In practical terms, if a consumer has the relatively dominant physician and another with visibility below $\frac{1}{2}$ in her *acceptable* set, the two physicians are deemed to be identical in abilities for her, competing exclusively in terms of their fees. The fact that the ability is costless allows for such an equilibrium to arise.

The truly peculiar market outcome appears in the segment of physicians whose visibility is above $\frac{1}{2}$, thus closer to that of the relatively dominant one. These physicians, a priori in lesser of an informational disadvantage than the physicians with visibilities below the threshold, settle for a lower ability. This result extends into a competitive environment what Lara and Rodríguez-Camacho (2016) found in the duopolistic setting.

Indeed, we find that more plentiful information leads to more differentiation in abilities even when there are many physicians in the market. Moreover, the less visible a physician is, the more his equilibrium ability converges to the maximal level. Thus, the physician who per our hypothesis on the sizes of the visibilities, could be considered immediately behind the relatively dominant player, sets an ability nearly half the value of the equilibrium ability set by the dominant one. Hence, if information on all the physicians were abundant and thus led to high visibilities across the market, the average equilibrium abilities would decrease with respect to a scenario were visibilities were below $\frac{1}{2}$.

This result leads to a puzzling situation for a planner. Intuition would suggest that releasing more information in healhcare markets should be beneficial for the patients in the sense that it could correct some of the distortions generated by the patient-physician informational asymmetry. We find that not to be the case, particularly when considering that patients usually base their decisions on boundedly-rational rules. If the goal of a planner is to increase the mass of high-ability providers, which would indeed lower the equilibrium prices as well, he would have to decrease the physicians' visibilities. One way of interpreting this policy is making information less plentiful, which can be achieved by further increasing competitive levels so that information is further spread in the market.

In our model this would entail making the physician's captive demand segments smaller. We can identify three types of physicians per their equilibrium ability choices: the relatively dominant one, those who are very visible and set a low ability, and those who are not very visible and set a high ability. The second type of physicians are the ones who focus on their captive demand segments. The closer in visibility they are to the dominant physician, the bigger their captive segment is and the stronger the incentives for them to focus on it. The further the physicians visibilities are from the relatively dominant one, the more they compete over the patients comprised in the contested demand segment. Yes, it is harder to find anecdotes overall for a physician with a low visibility, but that is also particularly true for their captive demand. The physicians closer in visibility to the dominant player have captive demand segments big enough for it to be attractive for them to trade-off competing over the contested segment with the profits derived from acting as a monopolist over their respective captive segments. These physicians set a lower ability and a higher fee compared both to the relatively dominant player and to less visible physicians.

In equilibrium the better-known physician is in a relatively advantageous position given his superior visibility, $\gamma_n \geq \gamma_i \; \forall i \in N$. By choosing the highest possible ability, $\alpha_n = 1$, the better-known physician prices higher, serves a bigger demand, and obtains superior profits to those of his rivals. Actually, physician n's profits do not depend on any variable, given that they come from the maximization of the physician's captive segment. On the other hand, profits of all other physicians increase with their visibility.

To summarize, in the equilibrium the market will comprise: a very visible physician who charges a high fee but offers a high-quality service, a few physicians who are quite visible but not as much as the relatively-dominant player and charge a smaller fee for a service of relatively lesser quality, and a mass of smaller and hardly visible physicians who compete for patients in prices and offer a service of quality comparable to that of the relatively dominant provider. A planner might affect the composition of such market by controlling the physicians visibilities, higher values of such variable leading to lower average equilibrium abilities. Moreover, if all visibilities were equal to one – all physicians being universally visible –, we get an analogue of Spiegler (2006a) 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.

3.8. 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 consider a competitive market for physician in which information possesses exogenous and strategic components. We respectively denote this as the physician's visibility and ability. The interaction of these variables determines the type of sample consumers have at their disposal when estimating the physician's abilities. In turn, the sampling process induces a demand structure entailing a mechanism for physicians to trade-off between serving a captive segment or a competitive demand.

In terms of the ability choices, we can characterize three types of physicians depending on their decision. A relatively dominant physician who is included in most consumers' *acceptable* set. A set of physicians who have high visibility but set a low ability level, which entails surrendering some of their demand to the relatively dominant physician in order to focus on their own captive segments. Finally, a set of physicians who are not as visible as the rest but by choosing a maximal ability level capitalize on those who see him. These physicians are in less of an advantageous position than the other two types of providers, thus deciding to compete for patients over the contested demand segment instead of exerting their monopoly power over their respective captive segments.

Hence, whether ability differentiation is observed in the equilibrium depends on the physicians' visibilities. More ability differentiation is observed when information on the physicians is more readily available, the subset of physicians who decide to focus on their respective captive segments being larger. A high average ability equilibrium requires information to be "less plentiful", in the form of visibilities being lower. This result does not change despite the heightened competitive pressure.

We believe our results to open an interesting research line in the pursuit of the physician's inclusion in consideration and *acceptable* sets. If such decision were not strategic but provided as a default characteristic for some physicians, for instance due to reputational issues or pre-existing contractual agreements, the equilibrium ability choices might be altered as well.

Chapter 4

Past-patients sampling in the healthcare market: Alternative approach to anecdote-based reasoning

4.1. Introduction

Many studies pursued from the perspective of economics, medicine, and the behavioral sciences, have shown the adoption of simplifying heuristics to be widespread when patients face healthcare choices.[1] In the previous chapter we analyzed the so called "sample-based" procedure, which entails that patients base their decision to visit a given physician on the anecdotal evidence they obtain from their families and friends. In particular, we focused on an extreme case where the decision is based on a single anecdote, with the patient visiting a physician if it were positive and discarding him if it were not. This is what Osborne and Rubinstein (1998) called $S(1)$ procedure.

Despite the fact that there is evidence showing that patients resort to limited samples when searching for information to support their healthcare choices,[2] it is reasonable to consider that less trivial ailments would lead consumers to gather more information than a single anecdote. In this chapter, we expand the sample size upon which the consumers base their decision, considering a set of K anecdotes before visiting a given physician. The consumers estimate the ability of some of the physicians who compete in the market through that sample.

In Lara and Rodríguez-Camacho (2016), we found the sampling process

[1] For a survey from a healthcare perspective, see Lipkus, Samsa, and Rimer (2001), Peters et al. (2006) and Reyna et al. (2009)

[2] The limitations in size, character, and reliability of such sources, as well as their prevalence, are discussed in Henry J. Kaiser Family Foundation (2000), Tu and Lauer (2008), Freed et al. (2010), Mostaghimi, Crotty, and Landon (2010), Azu, Lilley, and Kolli (2012)

to give rise to captive demand segments for the physicians, allowing for an equilibrium with low average ability levels. It was enough for a consumer to observe a positive anecdote, no matter if it came from the only patient who ever recovered after visiting a lousy physician, for her to decide to visit him. Furthermore, the physician could charge those consumers who were aware only of him a fee as high as the one a monopolist might charge. Hence, an equilibrium where high visibilities lead to differentiation in abilities is found, even when ability choice is assumed to be costless for the physicians.

To a very large extent, the market distortions we found hinge on consumers sampling one and only one patient. In this chapter, we are interested in understanding how the market behaves when consumers are allowed wider samples. Thus, we let each consumer draw $K > 1$ anecdotes from past patients who visited each physician she is aware of. That is, if three different physicians have treated some members of her family, she will gather K anecdotes for each of them, estimate their respective abilities, and then decide which one to visit if at all.[3] The information gathering process is exactly the same as the one assumed in Spiegler (2006a) although it is necessary to include some additional considerations regarding the way our consumers process the information they gather.

Generally speaking, the consumers need to understand how to draw inferences from the information on the ability of a physician present in the market. The concern in this setting in which consumers collect a larger number of anecdotes is not only how this information is gathered, but also which mechanisms consumers use to process the obtained information. There can be an ample number of ways a consumer can interpret the K reports she receives from each observed physician. In this paper we consider one of these options.

The sample-processing procedure is slightly altered with respect to the one introduced by Lara and Rodríguez-Camacho (2016). Here, we assume that finding a negative anecdote from a physician drives the consumer to discard such physician, no matter if the consumer had found some positive anecdotes. A negative anecdote out of the K sampled is equivalent to assigning the physician an ability equal to zero. Hence, in order to consider visiting a given physician the consumer must get exactly K positive anecdotes. A physician from whom she only heard positive anecdotes is attributed an ability of one.

This type of reasoning finds its rationale in the behavioral bias known as

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

negativity bias, defined as the tendency for humans to pay more attention or give more weight to negative experiences over neutral or positive counterparts. In his book, *Thinking Fast and Slow,* Kahneman maintains that for evolutionary reasons human brains contain a mechanism that is designed to give priority to bad news. Our brain has evolved biologically to be more responsive to fear than hope (Kahneman, 2011, pg. 32), in what appears to be a byproduct of a self-preservation instinct.

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

In this chapter, access to information is modeled to incorporate two distinct features. First, the visibility of the physician, interpreted as the ability-independent recognition, "fame" or popularity of the practitioner. Second, the size of the sample taken by the consumers, larger than one but still rather limited, in what we consider to be a result of the patients' cognitive limitations and behavioral biases.

The physicians in the market compete in prices and abilities. Their ability indeed affects the sample the consumers will find when making their choices. We analyze the ability competition stage both with costless ability, and with the choice of ability entailing some cost for the physician. We do so both as a robustness check of our results and as a way to emphasize the strategic bite of ability choice, affecting not only the composition of the sampled past-patients but the actual outcome a consumer might expect when visiting a physician.

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

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

However, when we include a costly choice of ability, the differentiation result not only is maintained but takes place even when information availability is low. That is, even physicians who are not subject to great scrutiny sample-wise, choose to set a high ability level.

Going back to the duopolistic illustration, we find that the more visible physician will not always choose the maximum level of ability, though he will always choose a superior ability than his competitor. That said, both favor equilibrium ability levels superior to those found when the choice was costless and the physician's visibilities high.

The structure of this chapter mimics the way in which we solve the model we propose in Section 4.2., and we do it by backwards induction. In Section 4.3. we examine the decision making procedure consumers undergo as a result of the heuristic we described. Next, in Section 4.4., we discuss the price competition equilibrium and the implications the increment in the sample size has for it. In Section 4.5. we study ability choice by the physicians, which is the first stage of the game. We do this analysis under both environments mentioned before: one with costless ability and another with costly ability choice. Finally, in Section 4.6. we discuss future research paths and present our concluding remarks.

4.2. The Model

In order to develop a first approach to understanding the effects of sample size in the market outcomes, we analyze a market setting where there are only two physicians present in the market. We consider a market for physicians where a mass of initially-ill consumers indexed by their willingness to pay for health services θ, uniformly distributed over $[0, 1]$, search for a physician to treat them.

Health is a binary variable $r \in \{0, 1\}$ with $r = 0$ when the consumer is ill and $r = 1$ when she is in full health. Physicians are the only agents capable of healing consumers. All consumers suffer an illness unique in type and severity, which will not improve unless a physician is consulted.

The market we study consists of two physicians, indexed by $i \in \{1, 2\}$. The physicians are rational and fully informed, competing in prices (p_i with $i \in \{1, 2\}$) and abilities (α_i with $i \in \{1, 2\}$). Physician i's ability is defined as the probability for a patient who visits him to recover. Thus, α_i captures a physician's healing capabilities. A consumer who visits Physician i recovers her health with probability α_i. The marginal cost of providing the service is zero.

A physician's ability is unknown to the consumers, but can be observed by the rivals. We assume ability choice to be costless for the physicians, and later on we introduce an ability cost to perform some comparative analysis. Additionally, physicians are exogenously endowed with a visibility parameter $\gamma_i \in (0, 1]$. This parameter captures how well known a physician is, and therefore how easy it is to find past patients who can provide anecdotal evidence about the outcomes obtained from visiting him. It is possible to interpret this parameters as the proportion of consumers in the market who are aware of each physician, or know some patients who have been treated by him in the past.

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

The consumers build their beliefs on the physicians' abilities based entirely on the anecdotal evidence they gather, following the procedure outlined before. They discard any physician for whom they get a negative anecdote out of their K draws. Namely, if at least one of the anecdotes they draw is negative – one or more of the past-patients sampled was not cured despite visiting a given physician –, the consumers believe they will not be cured either. Thus, the ability of the physician is estimated as zero and the idea of visiting him discarded. On the contrary, if the K collected anecdotes are positive – all the past patients inquired for a given physician were cured –, the consumer thinks she will also be cured when visiting the same physician, estimating the physician's ability to be 1. All the physicians whose ability is estimated to be maximal by the consumer are included in the *acceptable* set. A consumer considers all the physicians in such set to be equivalent in abilities and thus decides based on her willingness to pay and the fee each physician charges.

The timing of the game is the following:

1. Both physicians choose their abilities independently and simultaneously.

2. The two physicians, aware of each other's abilities and visibilities, set a fee.
3. Each consumer takes a K size sample from each physician in her consideration set and forms an estimate of each physician's ability.
4. Based on her ability estimates, the publicly known fees, and her willingness to pay for care services, consumers take their purchase decisions.

As stated before, we proceed to solve this game by backwards induction, starting with an analysis of the choice made by consumers.

4.3. Consumer behavior

In this section we study the way consumers process the information gathered from the K-sized sample they take from their closest network. We then analyze the effect this has on their demand for healthcare services.

The consumers use the information they obtain to estimate the ability of the physicians, which they do not observe. The consumers build their beliefs on the abilities of the physicians based entirely on such anecdotal evidence. Namely, if at least one of the anecdotes they draw is negative (the past-patient sampled was not cured despite visiting a given physician), the consumers believe they will not be cured either. On the contrary, if the K collected anecdotes are positive (all inquired past patients were cured by the physician), the consumers think they will also be cured when visiting the physician.

We start our analysis by studying the consumers' purchase decisions. Indeed, the sample-processing stage through which patients form their estimates is the most important difference between this chapter and the model presented in Lara and Rodríguez-Camacho (2016).

When sampling for anecdotes, the consumers can only see some of the physicians active in the market. Physician i's visibility γ_i represents the probability for a consumer to be aware of his presence. That is, to be able to find K past-patients of his to rely the consumer an anecdote. More formally, for the physician to be included in a consumer's *consideration set*. Similarly, α_i represents the probability for a consumer to observe a positive anecdote conditional on Physician i being in her consideration set.

Therefore, the probability for a consumer to observe exactly K positive anecdotes for Physician i is: α_i^K. Conversely, $1-\alpha_i^K$ represents the probability for a consumer to observe at least one negative anecdote in her sample. Since we are dealing with a size–1 mass of consumers, these probabilities can also be interpreted as proportions of consumers. These proportions will later determine the demand segments arising for each physician. Thus, the demand Physician 2 faces in the duopolistic setting we study could be written in the following manner:

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

As it was the case in the previous chapter, the demand for each physician comprises a captive and a contested demand segment. In the expression above the first two terms on every line represent the *captive segment*, which arise either because consumers are only aware of Physician 2 or because they got one or more negative anecdotes for Physician 1. The last term in the first two lines represents the *contested segment*. That is, those consumers who are aware of both physicians and found K positive anecdotes for both of them. If both physicians charge the same fee, this segment of the demand is equally split between the two. Otherwise, the demand corresponding to the segment goes to the physician with the lower price. The demand Physician 2 faces can be rewritten as:

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

We restrict our analysis to uniform, non-discriminatory prices. Thus, the main trade-offs regarding the decisions of the physicians originate from the demand structure. Namely, a higher fee allows a physician to obtain superior profits from his captive demand while diminishing those derived from his contested demand segment. Evidently, the relative size of both segments depend to some extent on the ability chosen by the physicians. Hence, this trade-off becomes crucial for the strategic ability-choice stage.

4.4. Price competition stage

Continuing by backwards induction, we move on to the price competition stage. Thus, we here take the physicians' abilities (α_1, α_2) as given.[4] Due to the demand structure described above, there is no Nash Equilibrium in pure strategies for this stage. There is a unique mixed strategies Nash equilibrium, as reported in Proposition 9.

Proposition 9. *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*

[4]We assume that $\alpha_2^K\gamma_2 \geq \gamma_1\alpha_1^K > 0$.

characterized by the following c.d.f.s:

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

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

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

The mixed strategies Nash Equilibrum we found aligns with the one introduced in Lara and Rodríguez-Camacho (2016). Nevertheless, there are some interesting implications deriving from the increase in sample size. First, the domain of the mixed equilibrium price strategies shrinks towards $\frac{1}{2}$ as the sample size increases. Second, the $c.d.f$s characterizing the equilibrium are increasing functions of the sample size K. In sum, higher expected average prices appear in the market when consumers are allowed to collect a larger number of anecdotes before deciding to visit a physician.

What this entails for consumers is that a larger sample of anecdotes leads to higher fees. The way in which consumers process the larger amount of information gathered modifies the sizes of the demand segments, making setting lower fees lees profitable for the physicians. This occurs because the consumers do not construct a more accurate estimator of physicians abilities with the greater quantity of information they gather. For instance, a high ability physician might be sampled negatively once, and then be deemed to have ability zero.

One important consequence of the sample-size increase is that both segments of the demand become smaller for each physician. Therefore, as the sample size grows the trade-off between the two segments of the demand becomes less relevant for the physicians' pricing strategy. Namely, with a smaller sample size physicians have a larger contested demand and by placing some probability on lower fees they increase the probability of serving that segment of the demand. On the contrary, a lager sample size diminishes the portions of consumers in the contested demand reducing the incentives to set lower fees and pushing physicians to focus on their captive segment, however small it might bee, and price accordingly. In terms of the distribution functions, a higher K induces the physicians to assign more probability to higher prices, making lower prices not worth taking into account.

A priori, a reduction in the captive demand segments should lead to lower fees. Visibilities seem to preclude more competitive pressure to result in lower fees, physician's abilities notwithstanding. The reduction of demand sizes is intuitive in the sense that, for any non-maximal ability, the probability of finding K positive anecdotes decreases as the sample size grows. The "luck" element of the ability estimation process is purged as the sample size becomes larger. A larger sample size diminishes the distortions originated from the over-reliance on small samples when estimating the ability of a bad quality physician.[5].

However, this comes at the cost of under-estimating the ability of a "good but not perfect" physician. As long as the ability parameter of a physician is less than 1, an increase in the sample size will always have the same effect: increasing the probability of finding one or more negative case among the K anecdotes drawn. Hence, also raising the probability of being discarded by the consumers. Clearly, this has an effect on the strategic choice of abilities.

As a result of the price competition we obtain the profits that physicians will get from playing the mixed strategy in Proposition9. Notice that these profits do not depend on the prices, as one requisite of a mixed Nash equilibrium is that players' payoffs are constant for all actions in the strategy support. We report the physicians' profits in Corollary 2.

Corollary 2. *The equilibrium profits, taking the abilities,* $\alpha_i \quad \forall\ i \in \{1,2\}$*, visibilities,* $\gamma_i \quad \forall\ i \in \{1,2\}$*, and the sample size* K *as given, and assuming* $\alpha_2 \geq \frac{\gamma_1}{\gamma_2}\alpha_1$ *are:*

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

and

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

The expressions above suggest that one dominant physician will always get more profits than the rival. In both cases, the profits derived depend on the number of anecdotes consumers gather for each physician.

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

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

[5]This was one of the factors considered when explaining the market distortions found in Lara and Rodríguez-Camacho (2016)

4.5. Ability competition stage

The ability competition stage, where physicians set their abilities, is the first one in the timeline of the game we are currently solving. Therefore, it is the one we analyze in this section. In particular, we address two different scenarios: one where ability is costless for the physicians, and another where the physicians choose their respective ability at some cost.

Costless ability choice:

In order to proceed by backwards induction to the ability competition stage, we consider the profits functions for each physician as functions of their respective αs.

The physicians choose their ability knowing that they will later compete in prices. Two equilibria in abilities are possible, depending on physician 1's visibility.[6] These equilibria are reported in Proposition 10.

Proposition 10. *In the ability choice stage of the game, and assuming $\gamma_2 \geq \gamma_1$, two equilibria are possible:*

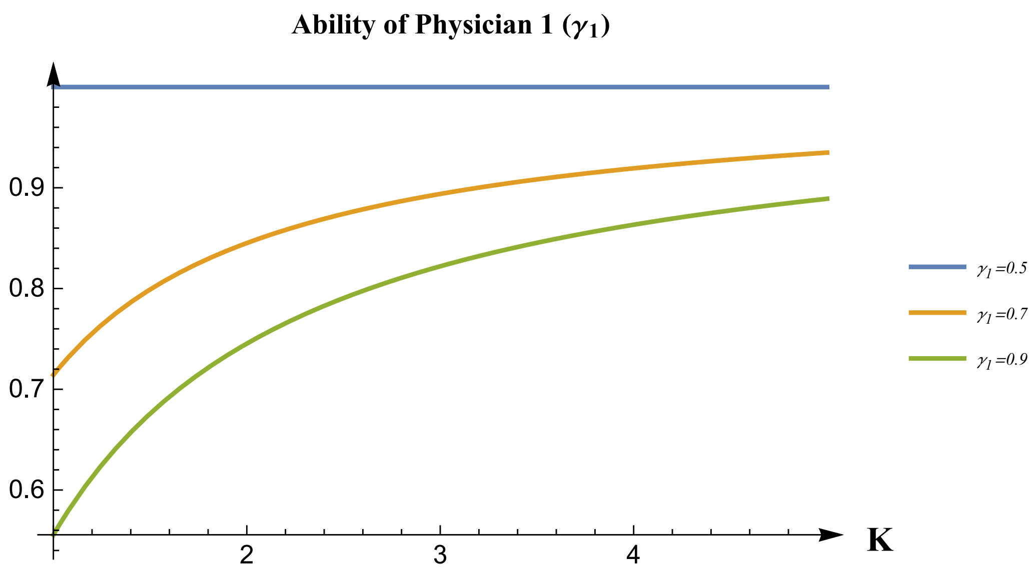
- *If $\gamma_1 < \frac{1}{2}$, then the physicians do not differentiate in abilities, both of them choosing $\alpha_1 = \alpha_2 = 1$.*
- *If both physicians' visibilities are above one half, equilibrium abilities are $\alpha_1 = \left(\frac{1}{2\gamma_1}\right)^{\frac{1}{K}}$ and $\alpha_2 = 1$.*

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

Two things are worth commenting from this equilibrium. First, when the visibilities of both physicians are equal, there are two possibilities. If the γs are below one half both physicians choose the maximum ability level, $\alpha_1 = \alpha_2 = 1$. If the γs are above one half, two equilibria are equally possible: one in which Physician 1 chooses the maximum ability level and Physician 2 differentiates by choosing an ability level proportional to his visibility, and other when Physician 1 chooses the maximum ability level and Physician 2 chooses an ability level lower than 1. Second, a very small difference in visibilities causes a large differentiation. In fact the closer the visibility of the dominated physician becomes to the maximal level, the lower the ability level chosen by him.

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

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



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

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

From the perspective of information, a planner cannot conclude per our results that more information is necessarily beneficial for consumers. However, "bad" providers are expelled from the market by the actions of the consumers themselves, who, by taking larger samples to estimate the physicians' abilities minimize the risk of over-estimating the ability of a "bad" physician. Consumers, by taking a larger sample and processing the obtained information in an oversimplified way, force the physicians to acquire superior ability. It seems reasonable to believe that, when diseases are more serious consumers seek a larger number of anecdotes K, forcing physicians to choose higher ability in order to stay competitive in the market for such disease. Regarding the nature of the decision procedure, we believe expanding the sample size is a relevant change to consider. Despite their proclivity for basing decisions on limited information, consumers might be inclined to acquire more inputs, if the health condition they face is more serious.

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

Costly ability choice:
We are interested in how the tendency to choose higher abilities, due to the expanded sample sizes, is affected by the introduction of a costly choice of abilities. This is a relevant question when facing the issue from a policy perspective, for providing more information might not be sufficient to improve average physician ability in the market, if the cost of ability choice is too high. We perform this exercise by introducing a costly choice of ability.

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

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

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

and

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

The equilibrium outcomes reported in proposition 11 show that when ability choice is costly, physician 1 sets an ability level that is bounded from above by the ability level he would choose if ability were costless. That is $\left(\frac{1}{2\gamma_1}\right)^{\frac{1}{K}}$ whenever $\gamma_1 > \frac{1}{2}$. On the other hand, physician 2 sets an ability which is bounded from below by the ability set by Physician 1.

Proposition 11. *If the choice of ability level α_i generates a cost $c(\alpha_i)$ to physician i, then there exists an equilibrium where:*

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

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

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

$$\frac{1}{4}K\gamma_2\overline{\alpha}_2^{K-1}(1-\gamma_1\underline{\alpha}_1^K) = c'(\underline{\alpha_2})$$

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

Furthermore, notice that the ability levels in the equilibrium are further limited by the cost function. While, in the costless ability scenario, $\gamma_1 \leq \frac{1}{2}$ implied that both physicians would choose an ability level equal to the maximum, in the costly ability scenario the implication depends on the cost function. Moreover, Physician 2 will always choose a superior or equal ability to his rival, though it will not always be the at the maximal level.

4.6. Conclusion and Discussion

In this chapter, we study the role of sample-based decisions in a market for physicians where consumers base their choice on anecdotes gathered from their closest network of friends and family. In particular, we propose and extension for the sample gathering apparatus presented in Lara and Rodríguez-Camacho (2016). Here we allow consumers to inquire a larger number of patients that visited each physician in the past. On the information processing aspect, we assume that consumers who see one or more negative anecdotes from a physician are dissuaded from even considering him as an alternative for getting healthcare services. Thus, it is enough for a consumer to discard a physician if she finds one negative out of the K anecdotes she samples.

We find that larger sample size K leads to higher abilities to be chosen if it is costless. In our setting, when a consumer asks for K anecdotes from a physician, it becomes more difficult that a physician with an ability parameter lower than 1 gets no negative anecdotes. Therefore, there are incentives to choose higher ability level, provided that it is costless. When the choice of ability is set to be costly, we find ability differentiation to persist.

This paper raises additional questions which may be the subject of further research. First, if the numbers of reports K_i would differ among the physicians, their chosen abilities will also be different: A physician on whom patients gather a larger number of anecdotes has incentives to choose a higher ability, because failures to cure a patient results in a higher probability of not being considered. Hence, we see that patients gathering more information pushes physicians to improve the "quality" of the care they provide. This result is appealing from a normative perspective, for it holds even the processing of the information is very unsophisticated and naive.

Second, an alternative way of pushing forward this line of research would be to introduce alternative ways for consumers to construct ability estimators using the K anecdotes sampled. We could assume consumers calculate the proportion of successes in the sample and expect the average of the reports they get to be the physicians' true ability. The idea would be to allow individuals who decide among different alternative physician the use of a more sophisticated estimator of the ability, although still taking a limited sample and acting as if the statistics they construct were representative of the whole population. This particular procedure leads to discontinuities in the demand each physician faces, hence deserving a more careful analysis.

Appendix A

Proofs - Chapter 2

Proof of Proposition 1. Because higher tariffs yield higher expected profit the participation constraints in (2.4.) bind, then

$$t_j = u_j(q_j^*) \; \forall j \in \{1,2\},$$

Substituting in the objective function we obtain

$$\max_{q_j,t_j}(u_j(q_j) - Cj(q_j))\text{j}$$

For each $j \in \{1,2\}$. By taking the fist order conditions, the optimal quantities are characterized by

$$C_j'(q_j^*) = u_j'(q_j^*) \; \forall j \in \{1,2\},$$

This defines the same efficient quantity of treatment independently of the bias in beliefs of the individuals. ■

Proof of Proposition 2. We solve the problem assuming that the incentive compatibility constraints are not binding, and then we verify them.

Since the expected profit function is increasing in A^i, the ex-ante participation constraints hold in equality, thus:

$$A^o = \hat{p}^o u_2(q_2^o) + (1-\hat{p}^o)u_1(q_1^o)$$

and

$$A^p = \hat{p}^p u_2(q_2^p) + (1-\hat{p}^p)u_1(q_1^p).$$

Rewriting the maximization problem we obtain

$$\max_{(q_1^i,q_2^i)_{i\in\{o,p\}}} \sum_{i\in\{o,p\}} \left[\hat{p}^i u_2(q_2^i) + (1-\hat{p}^i)u_1(q_1^i) - pC_2(q_2^i) - (1-p)C_1(q_1^i)\right]$$

computing the first order conditions, and solving for the optimal quantities we obtain

$$u_2'(q_2^i) = \frac{p}{\hat{p}^i}C_2'(q_2^i) \text{ and } u_1'(q_1^i) = \frac{1-p}{1-\hat{p}^i}C_1'(q_1^i) \;\; \forall\, i \in \{o,p\}.$$

These results indicate that for an optimistic consumer in health state 1 there is *over-provision* of treatment and in health state 2 there is *under-provision* of treatment. Simmetrically, for a pessimistic patient in health state 1 there is *under-provision* of treatment and in health state 2 there is *overprovision* of medical treatment.

Now we verify whether the contracts are incentive compatible, by checking that a consumer who purchases a contract not designed for him gets negative utility. For a pessimistic consumer this can be written as:

$$\hat{p}^p u_2(q_2^o) + (1-\hat{p}^p)u_1(q_1^o) - A^o \leq 0$$

and for an optimistic consumer this would be

$$\hat{p}^o u_2(q_2^p) + (1-\hat{p}^o)u_1(q_1^p) - A^p \leq 0.$$

In the case of the pessimistic consumer

$$\hat{p}^p u_2(q_2^o) + (1-\hat{p}^p)u_1(q_1^o) - \hat{p}^o u_2(q_2^o) - (1-\hat{p}^o)u_1(q_1^o) \leq 0$$

$$(\hat{p}^p - \hat{p}^o)u_2(q_2^o) - (\hat{p}^p - \hat{p}^o)u_1(q_1^o) \leq 0$$

$$(\hat{p}^p - \hat{p}^o)[u_2(q_2^o) - u_1(q_1^o)] \leq 0$$

$$u_2(q_2^o) - u_1(q_1^o) \leq 0$$

In the case of the optimistic consumer

$$\hat{p}^o u_2(q_2^p) + (1-\hat{p}^o)u_1(q_1^p) - \hat{p}^p u_2(q_2^p) - (1-\hat{p}^p)u_1(q_1^p) \leq 0$$

$$(\hat{p}^p - \hat{p}^o)u_1(q_1^p) - (\hat{p}^p - \hat{p}^o)u_2(q_2^p) \leq 0$$

$$(\hat{p}^p - \hat{p}^o)[u_1(q_1^p) - u_2(q_2^p)] \leq 0$$

$$u_1(q_1^p) - u_2(q_2^p) \leq 0$$

■

Proof of Proposition 3. We solve the problem assuming that the incentive compatibility constraints are not binding, and then we verify this.

Since profits are increasing in A^i for $i \in \{o, p\}$, then the ex-ante participation constraints hold in equality, and we can establish an expression that defines A^i:

$$A^i = \hat{p}^i(u_2(q_2^i) - t_2^i) + (1-\hat{p}^i)(u_1(q_1^i) - t_1^i),$$

substituting in the objective function

$$\max_{(q_2^i,t_2^i,q_1^i,t_1^i,A^i)_{i\in\{o,p\}}} \quad \sum_{i\in\{o,p\}} \left[\hat{p}^i(u_2(q_2^i)-t_2^i)+(1-\hat{p}^i)(u_1(q_1^i)-t_1^i)+ \right.$$
$$\left. +p(t_2^i-C_2(q_2^i))+(1-p)(t_1^i-C_1(q_1^i))\right]$$
$$s.t.$$
$$u_2(q_2^o)-t_2^o\geq 0$$
$$u_2(q_2^p)-t_2^p\geq 0$$
$$u_1(q_1^o)-t_1^o\geq 0$$
$$u_1(q_1^p)-t_1^p\geq 0.$$

From the above problem we can establish the sign of the coefficients of t_1^i for $i\in\{o,p\}$, given by $sign(\hat{p}^i-p)$) and the sign of the coefficient of t_2^i for $i\in\{o,p\}$, given by $sign(p-\hat{p}^i)$. So the sign of the coefficient depend on the biases in the beliefs of consumers.

For the optimistic consumer the sign of the coefficient of t_1^o is negative and the coefficient of t_2^o is positive, therefore the provider wants to make $t_1^o=0$ and by the ex-post participation constraint $t_2^o=u_2(q_2^o)$.

For the pessimistic consumer the signs are reversed, positive for t_1^p and negative for t_2^p, therefore the provider wants to make $t_2^p=0$ and by ex-post participation constraint $t_1^p=u_1(q_1^p)$. Substituting these results, we can rewrite the provider's problem:

$$\max \quad [\hat{p}^p u_2(q_2^p)+-pC_2(q_2^p)+(1-p)(u_1(q_1^p)-C_1(q_1^p))]+$$
$$+[(1-\hat{p}^o)u_1(q_1^o)+p(u_2(q_2^o)-C_2(q_2^o))-(1-p)C_1(q_1^o)]$$

and taking first order conditions with respect to quantities gives us the optimal quantities:

$$u_1'(q_1^p)=C_1'(q_1^p)\ ,\ u_2'(q_2^p)=\frac{p}{\hat{p}}C_2'(q_2^p)$$

and

$$u_2'(q_2^o)=C_2'(q_2^o)\ ,\ u_1'(q_1^o)=\frac{1-p}{1-\hat{p}}C_1'(q_1^o).$$

We verify whether the ex-ante incentives compatibility constraint hold. For a pessimistic consumer this can be rewritten as:

$$\hat{p}^p(u_2(q_2^o)-t_2^o)+(1-\hat{p}^p)(u_1(q_1^o)-t_1^o)-A^o\leq 0$$

and for an optimistic consumer:

$$\hat{p}^o(u_2(q_2^p)-t_2^p)+(1-\hat{p}^o)(u_1(q_1^p)-t_1^p)-A^p\leq 0$$

Let us prove it first for a pessimistic consumer:

$$\hat{p}^p(u_2(q_2^o)-u_2(q_2^o))+(1-\hat{p}^p)(u_1(q_1^o)-0)-A^o\leq 0$$

$$(1-\hat{p}^p)u_1(q_1^o)-A^o\leq 0$$

where $A^o = (1-\hat{p}^o)u_1(q_1^o)$

$$(1-\hat{p}^p)u_1(q_1^o) - (1-\hat{p}^o)u_1(q_1^o) \leq 0$$

$$(\hat{p}^o - \hat{p}^p)u_1(q_1^o) \leq 0$$

Which is always the case. We now prove it for the optimistic consumer

$$\hat{p}^o(u_2(q_2^p) - 0) + (1-\hat{p}^o)(u_1(q_1^p) - u_1(q_1^p)) - A^p \leq 0$$

$$\hat{p}^o u_2(q_2^p) - A^p \leq 0$$

where $A^p = \hat{p}^p u_2(q_2^p)$

$$\hat{p}^o u_2(q_2^p) - \hat{p}^p u_2(q_2^p) \leq 0$$

$$(\hat{p}^o - \hat{p}^p)u_2(q_2^p) \leq 0$$

Which is always the case. ■

Proof of Proposition 4. We solve the problem assuming that the incentive compatibility are not binding, and then we verify them.

Since the objective function is decreasing in A, and the Public system is not interested in making profits, and offers Health plans that are self sustained, we can divide the *Balanced Budget Constraint* in two constraints, one for each type, that must hold in equality. Solving for each A^i for $i \in \{o,p\}$ we get:

$$A^i = p(C_2(q_2^i) - t_2^i) + (1-p)(C_1(q_1^i) - t_1^i)$$

substituting in the objective function we get:

$$\sum_{i\in\{o,p\}} \left[p(u_2(q_2^i) - C_2(q_2^i)) + (1-p)(u_1(q_1^i) - C_1(q_1^i))\right]$$

we can also substitute this in the ex-ante participation constraints and we get:

$$\hat{p}^o u_2(q_2^o) - pC_2(q_2^o) + (1-\hat{p}^o)u_1(q_1^o) - (1-p)C_1(q_1^o) + (p-\hat{p}^o)(t_2^o - t_1^o) \geq 0$$

and

$$\hat{p}^p u_2(q_2^p) - pC_2(q_2^p) + (1-\hat{p}^p)u_1(q_1^p) - (1-p)C_1(q_1^p) + (\hat{p}^p - p)(t_1^p - t_2^p) \geq 0$$

We can rewrite the maximization problem as:

$$\max_{(q_2^i, t_2^i, q_1^i, t_1^1, A^i)_{i\in\{o,p\}}} \sum_{i\in\{o,p\}} \left[p(u_2(q_2^i) - C_2(q_2^i)) + (1-p)(u_1(q_1^i) - C_1(q_1^i))\right]$$

s.t.

$$\hat{p}^o u_2(q_2^o) - pC_2(q_2^o) + (1-\hat{p}^o)u_1(q_1^o) - (1-p)C_1(q_1^o) + (p-\hat{p}^o)(t_2^o - t_1^o) \geq 0$$
$$\hat{p}^p u_2(q_2^p) - pC_2(q_2^p) + (1-\hat{p}^p)u_1(q_1^p) - (1-p)C_1(q_1^p) + (\hat{p}^p - p)(t_1^p - t_2^p) \geq 0$$
$$u_2(q_2^o) - t_2^o \geq 0$$
$$u_2(q_2^p) - t_2^p \geq 0$$
$$u_1(q_2^o) - t_1^o \geq 0$$
$$u_1(q_2^p) - t_1^p \geq 0.$$

There is some freedom when setting the tariffs. However, the last term of the rewritten ex-ante participation constraint is the largest when the tariff with the negative coefficient is zero and the other is the largest allowed by the ex-post participation constraint.

Therefore for an optimistic consumer Public Provider could choose $t_1^o = 0$ and $t_2^o = C_2(q_2^o)$. Likewise for a pessimistic consumer a the Public Provider could choose $t_2^p = 0$ and $t_1^p = C_1(q_1^p)$. This ensures that all the ex-post participation constraints either do not bind. Additionally, it ensures that a provider offering treatment ex-post does not enter the market making strictly positive profits We can rewrite the problem as:

$$\max_{(q_2^i, q_1^i)_{i\in\{o,p\}}} \sum_{i\in\{o,p\}} \left[p(u_2(q_2^i) - C_2(q_2^i)) + (1-p)(u_1(q_1^i) - C_1(q_1^i))\right]$$

s.t.

$$p(u_2(q_2^o) - C_2(q_2^o)) + (1-\hat{p}^o)u_1(q_1^o) - (1-p)C_1(q_1^o) \geq 0$$
$$\hat{p}^p u_2(q_2^p) - pC_2(q_2^p) + (1-p)(u_1(q_1^p) - C_1(q_1^p)) \geq 0$$

This problem is maximized when the treatment quantities are the efficient ones, that is,

$$u_2'(q_2^*) = C_2'(q_2^*) \text{ and } u_1'(q_1^*) = C_1'(q_1^*).$$

regardless of the type, thus $q_2^o = q_2^p = q_2^*$ and $q_1^o = q_1^p = q_1^*$, and the ex-ante payment for an optimistic consumer is:

$$A^o = (1-p)C_1(q_1^*)$$

and for a pessimistic consumer

$$A^p = pC_2(q_2^*)$$

We verify that the solution is incentive compatible. Let us start by demonstrating that the optimistic consumer self-selects into his contract:

- If he chooses the contract meant for the pessimistic:

$$\hat{p}^o(u_2(q_2^*) - 0) + (1-\hat{p}^o)(u_1(q_1^*) - C_1(q_1^*)) - pC_2(q_2^*) =$$

$$= \hat{p}^o u_2(q_2^*) + (1-\hat{p}^o)(u_1(q_1^*) - C_1(q_1^*)) - pC_2(q_2^*) \cdots (1)$$

- If he chooses the contract meant for him:

$$\hat{p}^o(u_2(q_2^*) - C_2(q_2^*)) + (1-\hat{p}^o)(u_1(q_1^*) - 0) - (1-p)C_1(q_1^*) =$$

$$= (1-\hat{p}^o)u_1(q_1^*) + \hat{p}^o(u_2(q_2^*) - C_2(q_2^*)) - (1-p)C_1(q_1^*) \cdots (2)$$

- For this contract to be incentive compatible we need that $(2) - (1) \geq 0$ which gives us:

$$(p - \hat{p}^o)C_1(q_1^*) + (p - \hat{p}^o)C_2(q_2^*) \geq 0$$

  that is always the case.

The same proceeding with the pessimistic shows that she self-selects into the contract ment for her:

- If he chooses the contract meant for the optimistic:

$$\hat{p}^p(u_2(q_2^*) - C_2(q_2^*)) + (1-\hat{p}^p)(u_1(q_1^*) - 0) - (1-p)C_1(q_1^*) =$$

$$(1-\hat{p}^p)u_1(q_1^*) + \hat{p}^p(u_2(q_2^*) - C_2(q_2^*)) - (1-p)C_1(q_1^*) \cdots (3)$$

- If he chooses the contract meant for him:

$$\hat{p}^p(u_2(q_2^*) - 0) + (1-\hat{p}^p)(u_1(q_1^*) - C_1(q_1^*)) - pC_2(q_2^*) =$$

$$\hat{p}^p u_2(q_2^*) + (1-\hat{p}^p)(u_1(q_1^*) - C_1(q_1^*)) - pC_2(q_2^*) \cdots (4)$$

- For this contract to be incentive compatible we need that $(4) - (3) \geq 0$ which gives us:

$$(\hat{p}^p - p)C_2(q_2^*) + (\hat{p}^p - p)C_1(q_1^*) \geq 0$$

  that is always the case.

■

Proof of Proposition 5. We compute the menu of contracts offered by the private, given the menu of contracts offered by the Public Provider, to see if the Private Provider decides to enter the market. Afterwards we prove that it can profitably do so.

The problem of the Private Provider is given by:

$$\max_{(q_2^i, t_2^i, q_1^i, t_1^i, A^i)_{i\in\{o,p\}}} \quad \sum_{i\in\{o,p\}} \left[A^i + p(t_2^i - C_2(q_2^i)) + (1-p)(t_1^i - C_1(q_1^i))\right]$$

$$s.t.$$

$$\begin{aligned}
&\hat{p}^o(u_2(q_2^o) - t_2^o) + (1-\hat{p}^o)(u_1(q_1^o) - t_1^o) - A^o \geq \underline{u}^o \\
&\hat{p}^p(u_2(q_2^p) - t_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - t_1^p) - A^p \geq \underline{u}^p \\
&u_2(q_2^o) - t_2^o \geq 0 \\
&u_2(q_2^p) - t_2^p \geq 0 \\
&u_1(q_1^o) - t_1^o \geq 0 \\
&u_1(q_1^p) - t_1^p \geq 0 \\
&\hat{p}^o(u_2(q_2^o) - t_2^o) + (1-\hat{p}^o)(u_1(q_1^o) - t_1^o) - A^o \geq \\
&\qquad \hat{p}^o(u_2(q_2^p) - t_2^p) + (1-\hat{p}^o)(u_1(q_1^p) - t_1^p) - A^p \\
&\hat{p}^p(u_2(q_2^p) - t_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - t_1^p) - A^p \geq \\
&\qquad \hat{p}^p(u_2(q_2^o) - t_2^o) + (1-\hat{p}^p)(u_1(q_1^o) - t_1^o) - A^o.
\end{aligned}$$

Where $\underline{u}^i$ for, $i \in \{o,p\}$, represent the utility consumers get when purchasing the public contract. Furthermore, ex-post the only outside option is to remain without health care services.

We solve the problem assuming that the incentive compatibility constraints do not bind, and then we verify that it is the case for the proposed contract menu. We follow the same procedure as the one we did for the indemnity contract.

Since profits are increasing in A^i for $i \in \{o,p\}$, then the ex-ante participation constraints hold in equality, and we can establish an expression that defines A^i:

$$A^i = \hat{p}^i(u_2(q_2^i) - t_2^i) + (1-\hat{p}^i)(u_1(q_1^i) - t_1^i) - \underline{u}^i,$$

substituting in the objective function, the problem can be rewritten as

$$\begin{aligned}
\max_{(q_2^i, t_2^i, q_1^i, t_1^i)_{i\in\{o,p\}}} \sum_{i\in\{o,p\}} &\left[\hat{p}^i(u_2(q_2^i) - t_2^i) + (1-\hat{p}^i)(u_1(q_1^i) - t_1^i) - \underline{u}^i + \right. \\
&\left. + p(t_2^i - C_2(q_2^i)) + (1-p)(t_1^i - C_1(q_1^i))\right]
\end{aligned}$$

$$s.t.$$

$$\begin{aligned}
&u_2(q_2^o) - t_2^o \geq 0 \\
&u_2(q_2^p) - t_2^p \geq 0 \\
&u_1(q_1^o) - t_1^o \geq 0 \\
&u_1(q_1^p) - t_1^p \geq 0.
\end{aligned}$$

From the above problem we can establish the sign of the coefficients of t_1^i for $i \in \{o,p\}$, given by $sign(\hat{p}^i - p))$ and the sign of the coefficient of t_2^i for $i \in \{o,p\}$, given by $sign(p - \hat{p}^i)$. So the sign of the coefficients depend on the biases in the beliefs of consumers.

For the optimistic consumer the sign of the coefficient of t_1^o is negative and the coefficient of t_2^o is positive, therefore the provider wants to make $t_1^o = 0$ and $t_2^o = C_2(q_2^o)$.

For the pessimistic consumer the signs are reversed, positive for t_1^p and negative for t_2^p, therefore the provider wants to make $t_2^p = 0$ and $t_1^p = C_1(q_1^p)$.

Substituting these we can rewrite the provider's problem:

$$\max_{(q_1^i,q_2^i)_{i\in\{o,p\}}} \quad [\hat{p}^p u_2(q_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - C_1(q_1^p)) - pC_2(q_2^p) - \underline{u}^p] + \\ + [(1-\hat{p}^o)u_1(q_1^o) + \hat{p}^o(u_2(q_2^o) - C_2(q_2^o)) - (1-p)C_1(q_1^o) - \underline{u}^o]$$

Taking the first order conditions with respect to quantities we get the following characterization of quantities:

$$u_1'(q_1^p) = C_1'(q_1^p)\ ,\ u_2'(q_2^p) = \frac{p}{\hat{p}^p}C_2'(q_2^p)$$

and

$$u_2'(q_2^o) = C_2'(q_2^o)\ ,\ u_1'(q_1^o) = \frac{1-p}{1-\hat{p}^o}C_1'(q_1^o).$$

and tariffs are:

$$t_1^p = C_1(q_1^p)\ \ ,\ \ t_2^p = 0 \text{ and } A^p = \hat{p}^p u_2(q_2^p) + (1-\hat{p}^p)(u_1(q_1^*) - C(q_1^*)) - \underline{u}^p,$$

$$t_1^o = 0\ \ ,\ \ t_2^o = C_2(q_2^o) \text{ and } A^o = (1-\hat{p}^o)u_1(q_1^o) + \hat{p}^o(u_2(q_2^*) - C(q_2^*)) - \underline{u}^o,$$

The private entrant chooses prices and quantities to match the utility level the individuals would get if choosing the contract offered to them by the public incumbent for their type. Then, to verify whether the ex-ante incentive compatibility constraint hold, we prove:

$$\hat{p}^p(u_2(q_2^o) - t_2^o) + (1-\hat{p}^p)(u_1(q_1^o) - t_1^o) - A^o \leq \underline{u}^p,$$

and for an optimistic consumer:

$$\hat{p}^o(u_2(q_2^p) - t_2^p) + (1-\hat{p}^o)(u_1(q_1^p) - t_1^p) - A^p \leq \underline{u}^o.$$

For a pessimistic consumer, taking into account the expressions for A^o, t_1^o, t_2^o, the inequality becomes:

$$(\hat{p}^p - \hat{p}^o)(u_2(q_2^*) - C(q_2^*)) + (\hat{p}^o - \hat{p}^p)u_1(q_1^o) \leq \underline{u}^p - \underline{u}^o,$$

Which is always the case. To prove the inequality note that:

$$\underline{u}^p - \underline{u}^o = (\hat{p}^p - \hat{p}^o)u_2(q_2^*) - (p - \hat{p}^o)C_2(q_2^*) + (\hat{p}^o - \hat{p}^p)u_1(q_1^*) + (\hat{p}^p - p)C_1(q_1^*)$$

We can write the inequality as

$$(\hat{p}^p - \hat{p}^o)u_2(q_2^*) - (p - \hat{p}^o)C_2(q_2^*) + (\hat{p}^o - \hat{p}^p)u_1(q_1^*) + (\hat{p}^p - p)C_1(q_1^*) \geq \\ (\hat{p}^p - \hat{p}^o)(u_2(q_2^*) - C(q_2^*)) + (\hat{p}^o - \hat{p}^p)u_1(q_1^o)$$

Simplifying

$$(\hat{p}^p - p)C_2(q_2^*) + (\hat{p}^p - \hat{p}^o)(u_1(q_1^o) - u_1(q_1^*)) + (\hat{p}^p - p)C_1(q_1^*) \geq 0$$

as $\hat{p}^p > p > \hat{p}^o$ and $u_1(q_1^o) > u_1(q_1^*)$ the inequality is always true. The same reasoning holds for the optimistic consumer. So, the contracts are ex-ante incentive compatible.

We now prove that the Private Provider can enter the market profitably. The expected profits of the Private Provider are the sum of the profits for each type of consumers. Here we do the proof for the pessimistic type:

$$\Pi^p = p[t_2^p - C_2(q_2^p)] + (1-p)[t_1^p - C_1(q_1^p)] + A^p$$

$$\Pi^p = -pC_2(q_2^p) + A^p,$$

we know that $A^p = \hat{p}^p u_2(q_2^p) + (1-\hat{p}^p)(u_1(q_1^*) - C_1(q_1^*)) - \underline{u}^p$, and $\underline{u}^p = \hat{p}^p u_2(q_2^*) - pC_2(q_2^*) + (1-\hat{p}^p)(u_1(q_1^*) - C_1(q_1^*))$ then:

$$A^p = \hat{p}^p(u_2(q_2^p) - u_2(q_2^*)) + pC_2(q_2^*) - (1-\hat{p}^p)(u_1(q_1^*) - C_1(q_1^*))$$

which we can substitute in the profits function

$$\Pi^p = p(C_2(q_2^*) - C_2(q_2^p)) + \hat{p}^p(u_2(q_2^p) - u_2(q_2^*)) + (1-\hat{p}^p)(u_1(q_1^*) - C_1(q_1^*)),$$

We know that $q_2^p > q_2^*$ in the optimal contract derived above, and also that if Private Provider would offer the efficient quantity for state 2 in the contract meant for pessimistics he would get positive profits equal to $(1-\hat{p}^p)(u_1(q_1^*) - C_1(q_1^*))$, so it suffices to compute the following derivative and verify whether it is positive, if it is the case the private will enter profitably by offering the specified contract.

$$\left.\frac{\partial \Pi^p}{\partial q_2^p}\right|_{q_2^p = q_2^*} = \hat{p}^p u_2'(q_2*) - pC_2'(q_2^*).$$

And since $u_2'(q_2^*) = C_2'(q_2^*)$ and $\hat{p}^p > p$ the sign of the above derivative is positive.

$$\left.\frac{\partial \Pi^p}{\partial q_2^p}\right|_{q_2^p = q_2^*} > 0.$$

Which means that the Private Provider can always enter, and obtains strictly positive profits. ∎

Proof of Proposition 6. First, we take as given the public contract presented in Proposition 6, solve the optimization program that the Private Provider would solve in order to consider entering the market and then prove that he obtains zero profits by offering the menu of contracts resulting from this optimization program.

The optimization program of the Private Provider is given by:

$$
\begin{aligned}
\max_{(q_2^i,t_2^i,q_1^i,t_1^i,A^i)_{i\in\{o,p\}}} \quad & \textstyle\sum_{i\in\{o,p\}} \left[A^i + p(t_2^i - C_2(q_2^i)) + (1-p)(t_1^i - C_1(q_1^i))\right] \\
s.t. \quad & \\
& \hat{p}^o(u_2(q_2^o) - t_2^o) + (1-\hat{p}^o)(u_1(q_1^o) - t_1^o) - A^o \geq \underline{\underline{u}}^o \\
& \hat{p}^p(u_2(q_2^p) - t_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - t_1^p) - A^p \geq \underline{\underline{u}}^p \\
& u_2(q_2^o) - t_2^o \geq 0 \\
& u_2(q_2^p) - t_2^p \geq 0 \\
& u_1(q_1^o) - t_1^o \geq 0 \\
& u_1(q_1^p) - t_1^p \geq 0 \\
& \hat{p}^o(u_2(q_2^o) - t_2^o) + (1-\hat{p}^o)(u_1(q_1^o) - t_1^o) - A^o \geq \\
& \qquad \hat{p}^o(u_2(q_2^p) - t_2^p) + (1-\hat{p}^o)(u_1(q_1^p) - t_1^p) - A^p \\
& \hat{p}^p(u_2(q_2^p) - t_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - t_1^p) - A^p \geq \\
& \qquad \hat{p}^p(u_2(q_2^o) - t_2^o) + (1-\hat{p}^p)(u_1(q_1^o) - t_1^o) - A^o.
\end{aligned}
$$

Where $\underline{\underline{u}}^j$ for, $i \in \{o,p\}$, represent the subjective expected utility consumers get when purchasing the public contract presented in Proposition 6. These subjective utility levels are given by:

$$\underline{\underline{u}}^o = (1-\hat{p}^o)u_1(q_1^o) - (1-p)C_1(q_1^o) + \hat{p}^o(u_2(q_2^*) - C_2(q_2^*)),$$

for the optimistic consumer, and for the pessimistic

$$\underline{\underline{u}}^p = (1-\hat{p}^p)(u_1(q_1^*) - C_1(q_1^*)) + \hat{p}^p u_2(q_2^p) - pC_2(q_2^p).$$

We solve the relaxed program, assuming that the incentive compatibility constraints do not bind. Since profits are increasing in A^i for $i \in \{o,p\}$, then the ex-ante participation constraints hold in equality, and we can establish an expression that defines A^i:

$$A^i = \hat{p}^i(u_2(q_2^i) - t_2^i) + (1-\hat{p}^i)(u_1(q_1^i) - t_1^i) - \underline{\underline{u}}^j,$$

substituting in the objective function

$$
\begin{aligned}
\max_{(q_2^i,t_2^i,q_1^i,t_1^i,A^i)_{i\in\{o,p\}}} \quad & \textstyle\sum_{i\in\{o,p\}} \left[\hat{p}^i(u_2(q_2^i) - t_2^i) + (1-\hat{p}^i)(u_1(q_1^i) - t_1^i) - \underline{\underline{u}}^j + \right. \\
& \qquad \left. + p(t_2^i - C_2(q_2^i)) + (1-p)(t_1^i - C_1(q_1^i))\right] \\
s.t. \quad & \\
& u_2(q_2^o) - t_2^o \geq 0 \\
& u_2(q_2^p) - t_2^p \geq 0 \\
& u_1(q_1^o) - t_1^o \geq 0 \\
& u_1(q_1^p) - t_1^p \geq 0.
\end{aligned}
$$

From the above problem we can establish the sign of the coefficients of t_1^i for $i \in \{o,p\}$, given by $sign(\hat{p}^i - p))$ and the sign of the coefficient of t_2^i for $i \in \{o,p\}$, given by $sign(p - \hat{p}^i)$. So the sign of the coefficient depend on the biases in the beliefs of consumers.

For the optimistic consumer the sign of the coefficient of t_1^o is negative and the coefficient of t_2^o is positive, therefore the provider wants to make $t_1^o = 0$ and by the ex-post participation constraint $t_2^o = C_2(q_2^o)$.

For the pessimistic consumer the signs are reversed, positive for t_1^p and negative for t_2^p, therefore the provider wants to make $t_2^p = 0$ and by ex-post participation constraint $t_1^p = C_1(q_1^p)$.

This means that ex-post participation constraints either hold in equality or do not bind. Substituting these we can rewrite the provider's problem:

$$\max_{(q_1^i, q_2^i)_{i\in\{o,p\}}} \left[\hat{p}^p u_2(q_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - C_1(q_1^p)) - pC_2(q_2^p) - \underline{\underline{u}}^p\right] + \\ + \left[(1-\hat{p}^o)u_1(q_1^o) + \hat{p}^o(u_2(q_2^o) - C_2(q_2^o)) - (1-p)C_1(q_1^o) - \underline{\underline{u}}^o\right]$$

Taking the first order conditions with respect to quantities we get the following characterization of quantities:

$$u_1'(q_1^*) = C_1'(q_1^*) \; , \; u_2'(q_2^p) = \frac{p}{\hat{p}^p} C_2'(q_2^p)$$

and

$$u_2'(q_2^*) = C_2'(q_2^*) \; , \; u_1'(q_1^o) = \frac{1-p}{1-\hat{p}^o} C_1'(q_1^o).$$

and tariffs are:

$$t_1^p = C_1(q_1^*) \quad , \quad t_2^p = 0 \;\; \text{and} \;\; A^p = pC_2(q_2^p),$$

$$t_1^o = 0 \quad , \quad t_2^o = C_2(q_2^*) \;\; \text{and} \;\; A^o = (1-p)C_1(q_1^o),$$

The private entrant chooses prices and quantities to match the subjective utility level the individuals would get if choosing the contract offered to them by the public menu presented in Proposition 6. Now we verify if the contract gives positive profits to the Private Provider:

$$\Pi = p[t_2^o - C_2(q_2^o)] + (1-p)[t_1^o - C_1(q_1^o)] + A^o + p[t_2^p - C_2(q_2^p)] + (1-p)[t_1^p - C_1(q_1^p)] + A^p$$

Substituting the contract values we get:

$$\Pi = 0$$

Therefore this menu of contracts is not profitable and the Private Provider does not enter the market at profits equal to zero.

We now prove that this is the minimal distortion that serves its purpose of avoiding the entrance of the Private Provider, breaking even and keeping the objective utility as high as possible. Indeed, given that the ICC never bind we can follow the analysis of either type of individual.

Suppose Public Provider devices a contract for the pessimistic with quantities characterized by:

$$u_1'(q_1^*) = C_1'(q_1^*) \; , \; q_2^* < q_2^{p'} < q_2^p$$

where q_2^* is the efficient quantity and q_2^p is such that $u_2(q_2^p) = \frac{p}{\hat{p}^p} C_2'(q_2^p)$. On the side of the tariffs the Public Provider sets the payment scheme in order to maximize the subjective expected utility given the above specified treatment quantities, in the following maner:

$$t_1^p = C_1(q_1^*) \quad , \quad t_2^p = 0 \text{ and } A^p = pC_2(q_2^p).$$

Signing this contract provides a subjective expected utility to consumer given by:

$$\underline{\underline{u}}^{p'} = \hat{p}^p u_2(q_2^{p'}) - pC_2(q_2^{p'}) + (1-\hat{p}^p)(u_1(q_1^*) - C_1(q_1^*))$$

To prove that the Private Provider can still enter when the Public Provider offers this contract we follow a procedure similar to the one followed in the *Proof of Proposition 5*, but with only one type. For that we solve the optimization program of the Private Provider, given by:

$$\begin{aligned}
\max_{(q_2^p, t_2^p, q_1^p, t_1^p, A^p)} \quad & A^p + p(t_2^p - C_2(q_2^p)) + (1-p)(t_1^p - C_1(q_1^p)) \\
s.t. \quad & \\
& \hat{p}^p(u_2(q_2^p) - t_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - t_1^p) - A^p \geq \underline{\underline{u}}^{p'} \\
& u_2(q_2^p) - t_2^p \geq 0 \\
& u_1(q_1^p) - t_1^p \geq 0.
\end{aligned}$$

Since profits are increasing in A^p, then the ex-ante participation constraints hold in equality, and we can set A^p:

$$A^p = \hat{p}^p(u_2(q_2^p) - t_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - t_1^p) - \underline{\underline{u}}^{p'},$$

substituting in the objective function

$$\begin{aligned}
\max_{(q_2^p, t_2^p, q_1^p, t_1^p, A^p)} \quad & \hat{p}^p(u_2(q_2^p) - t_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - t_1^p) - \underline{\underline{u}}^{p'} \\
& +p(t_2^p - C_2(q_2^p)) + (1-p)(t_1^p - C_1(q_1^p)) \\
s.t. \quad & \\
& u_2(q_2^p) - t_2^p \geq 0 \\
& u_1(q_1^p) - t_1^p \geq 0.
\end{aligned}$$

From the above problem we can establish the sign of the coefficients of t_1^p, which is positive and the sign of the coefficient of t_2^p which is negative.

Therefore the Private Provider wants to make $t_2^p = 0$ and by ex-post participation constraint $t_1^p = C_1(q_1^p)$. substituting this, the objective function is:

$$\hat{p}^p(u_2(q_2^p)) - pC_2(q_2^p) + (1-\hat{p}^p)(u_1(q_1^p) - C_1(q_1^p)) - \underline{\underline{u}}^{p'}$$

Taking the first order conditions with respect to quantities we get the following characterization of quantities:

$$u_1'(q_1^*) = C_1'(q_1^*) \, , \, u_2'(q_2^p) = \frac{p}{\hat{p}^p} C_2'(q_2^p)$$

and tariffs are:

$$t_1^p = C_1(q_1^p) \quad , \quad t_2^p = 0 \text{ and } A^p = \hat{p}^p u_2(q_2^p) - \underline{\underline{u}}^{p'},$$

this defines the exante payment as:

$$A^p = \hat{p}^p(u_2(q_2^p) - u_2(q_2^{p'}) + pC_2(q_2^{p'}),$$

We still have to confirm that Private Provider can enter the market profitably.

$$\Pi^p = p(t_2^p - C_2(q_2^p)) + (1-p)(t_1^p - C_1(q_1^p)) + A^p$$

$$\Pi^p = -pC_2(q_2^p) + A^p$$

$$\Pi^p = \hat{p}^p(u_2(q_2^p) - u_2(q_2^{p'}) + p(C_2(q_2^{p'}) - C_2(q_2^p))$$

We know that $q_2^p > q_2^{p'}$, and also that if Private Provider would offer $q_2^{p'}$, he would get zero profits. Therefore if suffices to compute the following derivative and verify whether it is positive, if it is the case the private will enter profitably.

$$\left.\frac{\partial \Pi^p}{\partial q_2^p}\right|_{q_2^p = q_2^{p'}} = \hat{p}^p u_2'(q_2^{p'}) - pC_2'(q_2^{p'}).$$

We have defined $q_2^{p'} < q_2^p$, and we know that q_2^p is such that

$$u_2'(q_2^p) = \frac{p}{\hat{p}^p} C_2'(q_2^p),$$

rewriting this

$$\hat{p}^p u_2'(q_2^p) = pC_2'(q_2^p),$$

by our assumptions on utility and cost functions we know that $u_2'(\cdot)$ is decreasing and $C_2'(\cdot)$ is increasing, therefore we know that

$$\hat{p}^p u_2'(q_2^{p'}) > pC_2'(q_2^{p'}),$$

because $q_2^p > q_2^{p'}$ which means that

$$\left.\frac{\partial \Pi^p}{\partial q_2^p}\right|_{q_2^p = q_2^{p'}} > 0.$$

Which means that the Private Provider can enter profitably if the Public Provider distorts less than the quantity indicated in Proposition 6, that is if the Public Provider offers any quantity between q_2^* and q_2^p. Any distortion beyond q_2^p is in detriment of the consumer and it has no sense avoiding the entrance of the private if the public contract is even worse than the private. ■

Appendix B

Proofs - Chapter 3

Proof of proposition 7. We prove that the one proposed in Proposition 7 is a possible mixed strategy equilibrium.[1] In order to complete the proof we need to recall some elements from the game, which we enumerate before starting the formal proof:

(i) The demand for any physician i is given by the function:

$$D_i(p) = \alpha_i \gamma_i \prod_{j \neq i} (1 - \alpha_j \gamma_j F_j(p))(1 - p),$$

(ii) The profits of physician i, as if he would choose p while all other physicians mix according to the proposed strategies

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

With these elements as argumentative building blocks, we turn to the three main steps of the proof

Step 1: *Physician i's equilibrium profits are constant for all prices on his strategy support*

Assume an equilibrium where every physician $j \neq i$ plays a mixed strategy $F_j(p)$ as defined in Proposition 7. Then, we need to prove that if physician i sets any $p \in [p^L, p_i^H]$ his profits are constant on the strategy support and equal to:

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

a) If $p = p^L$ the profits are:

$$\pi_i(p^L) = p^L(1 - p^L)\alpha_i \gamma i \prod_{j \neq i} (1 - \alpha_j \gamma_j F_j(p^L)),$$

[1] We are not interested in hereby proving this equilibrium to be unique. At the moment we are still refining our proof for equilibrium unicity

at price p^L for every physician j it is true that $F_j(p^L) = 0$. Therefore, we can rewrite physician i's profits as

$$\pi_i(p^L) = p^L(1 - p^L)\alpha_i \gamma i.$$

When substituting the lower bound price $p^L = \frac{1-\sqrt{1-\prod_{\kappa \neq n}(1-\alpha_\kappa \gamma_\kappa)}}{2}$

$$\pi_i(p^L) = \left[\frac{1 - \sqrt{1 - \prod_{\kappa \neq n}(1 - \alpha_\kappa \gamma_\kappa)}}{2}\right]\left[1 - \frac{1 - \sqrt{1 - \prod_{\kappa \neq n}(1 - \alpha_\kappa \gamma_\kappa)}}{2}\right]\alpha_i \gamma i,$$

$$\pi_i(p^L) = \left[\frac{1}{4} - \left(\frac{\sqrt{1 - \prod_{\kappa \neq n}(1 - \alpha_\kappa \gamma_\kappa)}}{2}\right)^2\right]\alpha_i \gamma i,$$

$$\pi_i(p^L) = \left[\frac{1}{4} - \left(\frac{1 - \prod_{\kappa \neq n}(1 - \alpha_\kappa \gamma_\kappa)}{4}\right)\right]\alpha_i \gamma i,$$

$$\pi_i(p^L) = \frac{1}{4}\alpha_i \gamma_i \prod_{j \neq n}(1 - \alpha_j \gamma_j).$$

b) If $p = p_i^H$ then $F_j(p_i^H) = 1 \ \forall j < i$, and also $F_k(p_i^H) < 1 \ \forall k > i$

$$\pi_i(p_i^H) = p_i^H(1 - p_i^H)\alpha_i \gamma i \prod_{j<i}(1 - \alpha_j \gamma_j) \prod_{k>i}(1 - \alpha_k \gamma_k F_k(p_i^H)).$$

By substituting p_i^H in the expression $p_i^H(1 - p_i^H)$, we get:

$$p_i^H(1 - p_i^H) = \frac{\prod_{h=i+1}^{n-1}(1 - \alpha_h \gamma_h)}{4(1 - \alpha_i \gamma_i)^{(n-i-1)}}.$$

We thus can write

$$\pi_i(p_i^H) = \frac{\alpha_i \gamma i}{4} \frac{\prod_{h \neq n}(1 - \alpha_h \gamma_h)}{(1 - \alpha_i \gamma_i)^{(n-i)}} \prod_{k>i}(1 - \alpha_k \gamma_k F_k(p_i^H)).$$

We now need to find $F_k(p_i^H)$

$$F_k(p_i^H) = \frac{1}{\alpha_k \gamma_k}\left[1 - \left(\frac{\prod_{h=i}^{n-1}(1 - \alpha_h \gamma_h)}{4p_i^H(1 - p_i^H)}\right)^{\frac{1}{n-i}}\right],$$

and we substitute again the expression for $p_i^H(1 - p_i^H)$

$$F_k(p_i^H) = \frac{1}{\alpha_k \gamma_k}\left[1 - \left(\frac{\prod_{h=i}^{n-1}(1 - \alpha_h \gamma_h)}{\frac{\prod_{h=i}^{n-1}(1-\alpha_h \gamma_h)}{(1-\alpha_i \gamma_i)^{(n-i)}}}\right)^{\frac{1}{n-i}}\right].$$

Simplifying:

$$F_k(p_i^H) = \frac{\alpha_i \gamma_i}{\alpha_k \gamma_k},$$

which we substitute back in the profits expression we had before

$$\pi_i(p_i^H) = \frac{\alpha_i\gamma i}{4}\frac{\prod_{h\neq n}(1-\alpha_h\gamma_h)}{(1-\alpha_i\gamma_i)^{(n-i)}}\prod_{k>i}(1-\alpha_k\gamma_k\frac{\alpha_i\gamma_i}{\alpha_k\gamma_k}),$$

$$\pi_i(p_i^H) = \frac{\alpha_i\gamma i}{4}\frac{\prod_{h\neq n}(1-\alpha_h\gamma_h)}{(1-\alpha_i\gamma_i)^{(n-i)}}\prod_{k>i}(1-\alpha_i\gamma_i),$$

$$\pi_i(p_i^H) = \frac{\alpha_i\gamma i}{4}\frac{\prod_{h\neq n}(1-\alpha_h\gamma_h)}{(1-\alpha_i\gamma_i)^{(n-i)}}((1-\alpha_i\gamma_i)^{(n-i)}),$$

$$\pi_i(p_i^H) = \frac{1}{4}\alpha_i\gamma i\prod_{h\neq n}(1-\alpha_h\gamma_h),$$

c) If $p \in (p_{r-1}^H, p_r^H) \subset [p^L, p_i^H)$ and $r \leq i$. This means that $F_j(p) = 1$ for all $j < r$ and $F_k(p) < 1$ for all $k > r$, and profits function is:

$$\pi_i(p) = p(1-p)\alpha_i\gamma i\prod_{j<r}(1-\alpha_j\gamma_j)\prod_{k>r}(1-\alpha_k\gamma_k F_k(p)),$$

and we know $F_k(p)$ for all $k \geq r$

$$F_k(p) = \frac{1}{\alpha_k\gamma_k}\left[1-\left(\frac{\prod_{h=r}^{n-1}(1-\alpha_h\gamma_h)}{4p(1-p)}\right)^{\frac{1}{n-r}}\right],$$

substituting it in the profits function:

$$\pi_i(p) = p(1-p)\alpha_i\gamma i\prod_{j<r}(1-\alpha_j\gamma_j)\prod_{k>r}\left(1-\left[1-\left(\frac{\prod_{h=r}^{n-1}(1-\alpha_h\gamma_h)}{4p(1-p)}\right)^{\frac{1}{n-r}}\right]\right),$$

$$\pi_i(p) = p(1-p)\alpha_i\gamma i\prod_{j<r}(1-\alpha_j\gamma_j)\prod_{k>r}\left(\frac{\prod_{h=r}^{n-1}(1-\alpha_h\gamma_h)}{4p(1-p)}\right)^{\frac{1}{n-r}}.$$

The elements in the last product across k, do not depend on k. We power them to $n-r$:

$$\pi_i(p) = p(1-p)\alpha_i\gamma i\prod_{j<r}(1-\alpha_j\gamma_j)\left(\frac{\prod_{h=r}^{n-1}(1-\alpha_h\gamma_h)}{4p(1-p)}\right),$$

simplifying

$$\pi_i(p) = \frac{1}{4}\alpha_i\gamma i\prod_{j\neq n}(1-\alpha_j\gamma_j),$$

Step 2: *There is no profitable deviation for physician i if he sets a price $p < p^L$*

Propostition 7 establishes $F_i(p) = 0$ **for all** $p < p^L$. Therefore, we can write physician i's profits as:

$$\pi_i(p) = p(1-p)\alpha_i\gamma i.$$

We compare these to the equilibrium profits:

$$p(1-p)\alpha_i\gamma i < \frac{1}{4}\alpha_i\gamma i \prod_{h\neq n}(1-\alpha_h\gamma_h)$$

$$p(1-p) < \frac{1}{4}\prod_{h\neq n}(1-\alpha_h\gamma_h),$$

in order to find the prices for which this inequality is true. Thus, we need to find the prices for which the following equality holds:

$$p(1-p) = \frac{1}{4}\prod_{h\neq n}(1-\alpha_h\gamma_h)$$

From such expression we obtain the price

$$p = \frac{1 \pm \sqrt{1-\prod_{h\neq n}(1-\alpha_h\gamma_h)}}{2}.$$

Therefore, for any price lower than $p' = \frac{1-\sqrt{1-\prod_{h\neq n}(1-\alpha_h\gamma_h)}}{2}$ or higher than $p'' = \frac{1+\sqrt{1-\prod_{h\neq n}(1-\alpha_h\gamma_h)}}{2}$, the inequality holds.

Notice that $p' = p^L$; therefore, setting a lower price yields lower profits for the physician, which indeed proves no deviation in such direction to be profitable.

Step 3: *There is no profitable deviation for a physician i if he sets a price $p > p_i^H$*

a) Assume $\frac{1}{2} > p > p_s^H$, where $s \in \{i, \cdots, n\}$. Then $F_j(p) = 1$ for all $j < s$ and $F_k(p) < 1$ for all $k > s$, with the corresponding profits functions:

$$\pi_i(p) = p(1-p)\alpha_i\gamma i \prod_{j<s}(1-\alpha_j\gamma_j)\prod_{k>s}(1-\alpha_k\gamma_k F_k(p)),$$

and we need to find $F_k(p)$ for all $k \geq s$

$$F_k(p) = \frac{1}{\alpha_k\gamma_k}\left[1 - \left(\frac{\prod_{h=s}^{n-1}(1-\alpha_h\gamma_h)}{4p(1-p)}\right)^{\frac{1}{n-s}}\right],$$

which we substitute in the expression for profits:

$$\pi_i(p) = p(1-p)\alpha_i\gamma i \prod_{j<s}(1-\alpha_j\gamma_j)\prod_{k>s}\left(1 - \left[1 - \left(\frac{\prod_{h=s}^{n-1}(1-\alpha_h\gamma_h)}{4p(1-p)}\right)^{\frac{1}{n-s}}\right]\right),$$

$$\pi_i(p) = p(1-p)\alpha_i\gamma i \prod_{j<s}(1-\alpha_j\gamma_j)\prod_{k>s}\left(\frac{\prod_{h=s}^{n-1}(1-\alpha_h\gamma_h)}{4p(1-p)}\right)^{\frac{1}{n-s}}.$$

The elements in the last product in the expression above, do not depend on k. We can hence power them to $n-s$

$$\pi_i(p) = p(1-p)\alpha_i\gamma i \prod_{j<s}(1-\alpha_j\gamma_j)\left(\frac{\prod_{h=s}^{n-1}(1-\alpha_h\gamma_h)}{4p(1-p)}\right),$$

simplifying we get

$$\pi_i(p) = \frac{1}{4}\alpha_i\gamma i \prod_{j\neq n}(1-\alpha_j\gamma_j),$$

which is equal to the physician's profits in equilibrium. Therefore, such a deviation is not deemed profitable.

b) Assume $p = \frac{1}{2}$. Then $F_j(\frac{1}{2}) = 1$ for every physician $j \neq i$, the Profits of i being:

$$\pi_i(p) = \frac{1}{4}\alpha_i\gamma i \prod_{j\neq n}(1-\alpha_j\gamma_j).$$

We need to compare these to the equilibrium profits

$$\frac{1}{4}\alpha_i\gamma i \prod_{j\neq i}(1-\alpha_j\gamma_j) < \frac{1}{4}\alpha_i\gamma i \prod_{j\neq n}(1-\alpha_j\gamma_j).$$

Simplifying we get

$$(1-\alpha_n\gamma_n) < (1-\alpha_i\gamma_i),$$

which is always the case for $\alpha_n\gamma_n > \alpha_i\gamma_i$ for all $i \neq n$, which indeed holds for all cases in our setting.

c) Finally, selecting $p > \frac{1}{2}$ cannot be a profitable deviation. For that price level $F_j(\frac{1}{2}) = 1$ for every physician $j \neq i$. Then the profits of i are

$$\pi_i(p) = p(1-p)\alpha_i\gamma i \prod_{j\neq n}(1-\alpha_j\gamma_j).$$

which are lower than

$$\frac{1}{4}\alpha_i\gamma i \prod_{j\neq n}(1-\alpha_j\gamma_j).$$

because $p(1-p)$ has its maximum at $p = \frac{1}{2}$ with a maximal value of $\frac{1}{4}$. And the above expression is lower than the equilibrium profits as proven in previous point, *b*).

■

Proof of Proposition 8. Once the equilibrium prices are found, we go back one stage in the game to when physician's abilities are chosen. Without loss of generality, let us assume, as before, that $\gamma_n \geq \gamma_i \ \forall i \in N$. As found in the proof of Proposition 7, the physicians' profits given the abilities are:

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

$$\pi_n = \frac{1}{4}\gamma_n \alpha_n \prod_{j \neq n} (1 - \gamma_j \alpha_j)$$

Thus, the equilibrium abilities would be given by:

$$\alpha_i^* = \begin{cases} 1 & if \ \gamma_i \leq \frac{1}{2} \\ \frac{1}{2\gamma_1} & if \ \gamma_i > \frac{1}{2} \end{cases}$$

and

$$\alpha_n^* = 1$$

These equilibrium levels depend only on the own visibility parameter,and not on the choice made by any other physician. The only important factor is the ordering of the top dominant physician. ■

Appendix C

Proofs - Chapter 4

Proof of Proposition 9. 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 unique Nash Equilibrium in mixed strategies for the price competition stage.

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

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

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

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

$$\Pi_i = p_i D_i \quad \forall i = \{1, 2\}.$$

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 $\frac{1}{2}$. This is the maximizing price when undercutting a price larger than $\frac{1}{2}$. 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:

$$\Pi_2 = \frac{1}{4} \alpha_2^K \gamma_2 \left(1 - \frac{\alpha_1^K \gamma_1}{2}\right).$$

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

$$\Pi_2^d = p_2^d (1 - p_2^d) \alpha_2^K \gamma_2.$$

Finding the a price that yields the same profits for Physician 2, by equating both expressions, we get:

$$p^d = \frac{1}{2} \pm \frac{1}{4}\sqrt{2\alpha_1^K \gamma_1}.$$

In fact, any price $p^d \in \left(\frac{1}{2} - \frac{1}{4}\sqrt{2\alpha_1\gamma_1}, \frac{1}{2}\right)$ constitutes a profitable deviation. 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 symmetric pure strategies Nash Equilibrium is possible on a price strictly larger than 0.

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 $\alpha_i^K \gamma_i \geq \gamma_j \alpha_j^K$ 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 $\alpha_2^K \gamma_2 \geq \gamma_1 \gamma_2 \alpha_1^K$. 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:

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

Where $F_1(p_2)$ is the probability that p_1 is smaller or equal than the price p_2.

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. 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 $F_i(p) = 0 \; \forall p < p_i^L$. 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. On the RHS we have the maxmin and on the left we have the profits he gets when undercutting the rival, $i.e.$ the lower bound.

$$\begin{aligned} p_i' \alpha_i^K \gamma_i \left(1 - \alpha_j^K \gamma_j F_j(p_i')\right)(1 - p_i') &= \frac{1}{4} \alpha_i^K \gamma_i (1 - \alpha_j^K \gamma_j) \iff \\ p_i'(1 - p_i') &= \frac{1}{4}(1 - \alpha_j^K \gamma_j) \iff \\ p_i' &= \frac{1 \pm \sqrt{\alpha_j^K \gamma_j}}{2}. \end{aligned}$$

Thus, Physician i will never set a price below $\frac{1 - \sqrt{\alpha_j^K \gamma_j}}{2}$, 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: $p_1' = \frac{1 - \sqrt{\alpha_2^K \gamma_2}}{2}$ and $p_2' = \frac{1 - \sqrt{\alpha_1^K \gamma_1}}{2}$.

Since every result up to now is symmetric for both physicians, we can assume without loss of generality that $\gamma_2 \alpha_2^K > \gamma_1 \alpha_1^K$. 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, $p_1^L = p_2^L = \frac{1-\sqrt{\alpha_1^K\gamma_1}}{2}$.

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

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

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:

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

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

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

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

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

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:

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

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

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

■

Proof of Proposition 10. Once the equilibrium prices are found, we go back one stage in the game to when physician's abilities are chosen. Without loss of generality, let us assume, as before, that $\gamma_2 \geq \gamma_1$. As found in the proof of Proposition **??**, the physicians' profits given the abilities are:

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

and

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

Thus, the equilibrium abilities would be given by:

$$\alpha_1 = \begin{cases} 1 & if\ \gamma_1 \leq \frac{1}{2} \\ (\frac{1}{2\gamma_1})^{\frac{1}{K}} & if\ \gamma_1 > \frac{1}{2} \end{cases}$$

and

$$\alpha_2 = 1$$

These equilibrium levels depend only on the own visibility parameter,and not on the choice made by any other physician. The only important factor is the ordering of the top dominant physician. ■

Proof of Proposition 11: We have assumed without loss of generality that $\gamma_2 \geq \gamma_1$, which is just an order of the visibilities. Additionally, we have assumed that the cost of choosing ability level α_i, where $c(\cdot)$ is a continuously differentiable, increasing and convex function, with $c(0) = 0$ and $c'(0) = 0$

Therefore the profits functions for each physician can be written as:

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

and

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

To choose his ability Physician 1 solves the following maximization problem:

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

$$\text{st.}$$

$$\alpha_2^K \geq \frac{\gamma_1}{\gamma_2}\alpha_1^K,$$

We assume the restriction is not binding, later we verify that in equilibrium that is the case. We take the First Order Conditions:

$$\frac{\partial \Pi_1}{\partial \alpha_1} = \frac{1}{4}\gamma_1 \left(K\alpha_1^{K-1} - 2K\gamma_1 \alpha_1^{2K-1}\right) - c'(\alpha_1),$$

rewrittin it

$$\frac{1}{4}K\gamma_1 \alpha_1^{K-1} \left(1 - 2\gamma_1 \alpha_1^K\right) = c'(\alpha_1).$$

The left hand side of the above equation becomes zero in $\alpha_1 = \left(\frac{1}{2\gamma_1}\right)^{\frac{1}{K}}$ as we have seen in the proof of Proposition 10, and is strictly decreasing in the interval $\left(0, \left(\frac{1}{2\gamma_1}\right]^{\frac{1}{K}}\right)$. The right hand side of the equation is strictly increasing starting at $c(0) = 0$. This proves that there exist an ability level, that we denote $\underline{\alpha_1}$, which solves the equation and is in the interval, $\underline{\alpha_1} \in \left(0, \left(\frac{1}{2\gamma_1}\right)^{\frac{1}{K}}\right] \subseteq (0, 1)$. The highest value of the ability α_1 is 1 and the upper bound of interval described just before is larger than 1 whenever $\gamma_1 < \frac{1}{2}$ in that case the upper bound of the interval is 1.

Physician 2 solves the following maximization problem:

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

Again, we assume the restriction does not bind and later we check that in equilibrium that is the case. We take the First Order Conditions:

$$\frac{\partial \Pi_2}{\partial \alpha_2} = \frac{1}{4}K\gamma_2\alpha_2^{K-1}\left(1 - \gamma_1\alpha_1^K\right) - c'(\alpha_2) = 0,$$

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

Physician 2 has to best respond to the strategy of Physician 1 so we substitute here the optimal α_1 chosen:

$$\frac{1}{4}K\gamma_2\alpha_2^{K-1}\left(1 - \gamma_1\underline{\alpha}_1^K\right) = c'(\alpha_2),$$

Imagine that $\alpha_2 = \underline{\alpha}_1$, then it must be that

$$\frac{1}{4}K\underline{\alpha}_1^{K-1}\left(1 - \gamma_1\underline{\alpha}_1^K\right) > c'(\underline{\alpha}_1),$$

Therefore the solution of First Order Condition must be an alpha $\overline{\alpha}_2 \in (\underline{\alpha}_1, 1)$

We verify that the restriction in both maximization problems hold and it immediatly does as by our assumption $\gamma_2 > \gamma 1$ and in equilibrium $\overline{\alpha}_2 \geq \underline{\alpha}_1$. ■

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