Beliefs, credence goods and information campaigns.

Ferdinando Colombo* Giovanni Ursino*†

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Abstract

We study the role of beliefs about experts' honesty in a market for credence goods with second opinions and overtreatment. Experts are honest or dishonest. The population has a common belief about the share of honest experts, which may be incorrect. We characterize the belief that maximizes consumer's expected utility and show that it is generically different from the true share of honest experts and larger than the one that maximizes the equilibrium level of honesty. We then analyze the decision of an authority that has learned the actual share of honest experts whether to publicly reveal it through a costless information campaign, thus correcting people's beliefs, and show that it does not depend on how wrong beliefs are. We further show how increasing market transparency (making experts more aware of the number of opinions collected) affects the optimal belief and may have a positive as well as a negative effect on overtreament. Finally, we briefly see how a successful campaign run in Switzerland in the mid '80s to reduce excessive hysterectomy rates can be read through the lenses of our model and how accounting for beliefs about honesty might allow theoretical predictions to better fit experimental evidence.

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*Università Cattolica del Sacro Cuore, Milan.

†Corresponding author. Email: giovanni.ursino@unicatt.it

1 Introduction

In the novel The Colossus of Maroussi (1941), Henry Miller describes how he fell into the hands of a wily Greek guide, “who promised to show us everything of interest for a modest sum. [...] I knew we were going to be gypped [...]. The only thing that was solidly fixed in my mind about the Greeks was that you couldn’t trust them”. In The Lonely Planet Greece (8th edition), Hellander et al. (2008), after citing Miller’s tale, devote the whopping number of 41 lines of the section *Dangers and Annoyances* to Athenian taxi drivers behavior.

In a natural field experiment aimed at measuring frauds in the market for taxi rides in Athens, Balafoutas et al. (2013) found that (*i*) on average, 10% of the length of a ride was an unnecessary detour. Those passengers conveying the impression of being unfamiliar with the city (*i.e.*, those speaking in English) were, on average, taken on detours of more than double length compared to passengers in the role of Greek citizens; (*ii*) in 11% of rides passengers were overcharged through the application of incorrect tariffs. However, those passengers presumably perceived as unfamiliar with the tariff system were overcharged in 22% of cases, while this happened in only 6% of cases to passengers who did not. These results clearly show that the monetary reward from *overtreatment* and *overcharging* is high enough for some (but definitely not for the most part of) taxi drivers in Athens to “mistreat” their customers, in particular if they appear to be unfamiliar with the city or the tariff system.

Unfortunately, financial factors play a similar role in more socially sensitive and economically relevant sectors like the market for health services. Brownlee et al. (2017) illustrate a wealth of evidence on the overuse of medical services around the world summarizing a huge literature. For example, Berwick and Hackbarth (2012) claim that in the US, conservative estimates of spending on overuse based on the direct measurement of individual services range from 6% to 8% of total health-care spending, whereas Wennberg et al. (2002), in a study of geographical variation (an indirect measure), indicate that the proportion of Medicare spending on overuse is closer to 29%.[1] Worldwide, overuse of individual services can be as high as 89% in certain populations (Korenstein et al. (2012)).

Taxi rides, where a passenger unfamiliar with the city cannot be sure that the driver takes the shortest route to his destination, and medical treatments, where an uninformed patient may fear that the doctor voluntarily provides a wrong diagnosis in order to sell him a more costly treatment, are both examples of *credence goods* as defined by Darby and Karni (1973), *i.e.*, goods where an expert knows more about the quality a consumer needs than the consumer himself and the true quality cannot be ascertained by the consumer even after consumption.

There is therefore an obvious analogy between unnecessary detours in taxi rides and, for example,

[1] See also Gruber and Owings (1996), Gruber et al. (1999), Iizuka (2007), Huck et al (2016), Clemens and Gottlieb (2014), Acemoglu and Finkelstein (2008).

unnecessary hysterectomies.[2] They are both documented by mass media, although with quite a different coverage.[3] However, because of their social relevance, overuses of medical services have also induced public authorities and private foundations to promote widespread information campaigns. Among them, the one on hysterectomies run from February to October 1984 in Canton Ticino, Switzerland, has had powerful effects statistically well documented in Domenighetti et al. (1988).

In this article, we wish to study the potential effects in credence goods markets of warnings like "Some drivers don't like to bother with the meter and demand whatever they think they can get away with"(The Lonely Planet Greece), or rhetoric questions like "Is the number of hysterectomies in Ticino exaggerated?"complemented by data suggesting that the answer is definitely positive, as well as explicit advice to ask for a second opinion (public information campaign in Switzerland). The relevance of such messages stems from the obvious consideration that they can be the an important instrument of public policy.

In order to better understand the possible effects of such types of messages, it is worth emphasizing that Harding *et al* (2007), in the Lonely Planet guide on Scandinavian Europe, 8th edition, do not add any section *Dangers and Annoyances*, and do not make any comment on the behavior of taxi drivers.[4] It is hard to think that such a huge difference between the two guides is merely incidental. Our interpretation is that the authors of the guides assume that most of their English language readers have a general (*i.e.*, not country specific) "benevolent" view of taxi drivers, which they tend to use when they visit *any* country[5], unless they have some specific information on that country. As long as the actual behavior of taxi drivers is consistent with such view, the authors of the guide do not deem it necessary to explicitly state that "taxi drivers do not generally cheat their customers". On the other hand, when they write about countries or cities where the actual behavior differs in a substantial way from the one expected by their readers, they may decide that it is useful to say something like "If you do have a dispute, call the police" (The Lonely Planet, Greece, 8th edition). The readers will then take such information into account and change their point of view on taxi drivers in that country.[6]

The type of information we wish to analyze tends therefore to affect people's points of view, *i.e.*, their beliefs. We introduce beliefs in credence market models by assuming that there are two types of experts: dishonest and honest. Dishonest experts are experts who, given the "unmodeled working

[2] Brownlee et al. (2017) report direct evidence that 20% of hysterectomies are inappropriate in Taiwan, 13% in Switzerland, and between 16% and 70% across studies in the US.

[3] Typing the string "too many hysterectomies" in Google yields more than 2,000 results, including articles and videos in Time, The New York Times, CBS News, BBC Radio.

[4] In the same vein, in many countries, no information campaign on hysterectomies was ever aired.

[5] In this paper, we do not have a theory on how these (initial) beliefs are determined. In the taxi drivers example, they may be based on people's experience in their own country.

[6] In a similar way, we can imagine that most people think that doctors do not generally voluntarily perform unnecessary surgeries. In countries where overuses of medical services induced by doctors are widespread, an information campaign may therefore be particularly effective in modifying people's point of view on doctors' behavior.

environment" (prices, probability of being caught, legal rules, social stigma, ...), would choose to cheat their customers *if they were sure to receive the price for the service they are offering*, while they might provide the correct treatment otherwise. For example, a dishonest doctor could choose not to diagnose an inappropriate hysterectomy if he thought that his patient would ask for a second opinion, while he would surely diagnose it if he was certain that his patient would buy the treatment. On the other hand, given the "environment", honest experts are never willing to overtreat their customers.[7]

The dependence of the share of honest experts on the environment not only allows us to justify in a politically correct way the (supposed) difference in the share of honest taxi drivers in Athens and in Scandinavian Europe, which in turn explains the different coverage of taxi drivers behavior in Lonely Planet guides, but it also enables us to introduce beliefs that are not correct. We do so by assuming that people have a belief on the share of honest experts, which, because of their partial ignorance of the environment, may differ from the actual share.[8]

This raises two important research questions that we address in this article. The first question asks which is the believed share of honest experts that maximizes consumers' welfare. The possibility that such share differs from the actual share opens the door to quite intriguing but maybe morally disputable policy prescriptions, like the opportunity for a government, in the interest of consumers, to manipulate their beliefs by providing false information, or to avoid that some (true) information is released by the mass media. In this article, we mention such possibilities, but then we focus on the case where a government becomes aware with positive probability of the actual share of honest experts, in which case it has to decide whether to reveal it in a verifiable manner, for example through an information campaign. This leads to our second research question, *i.e.*, which values of such share, whenever known, would be revealed by a government that maximizes consumers' welfare. The answer to such question can help explain why some information campaigns are aired on some topics or in some countries and not on other topics or in other countries.

The answers to such questions would be trivial in a decision theory problem. First, maximization of consumers' welfare would call for consumers to have correct beliefs. Second, a government that maximizes consumers' welfare would always communicate the actual share of honest experts whenever known. These results are simple consequences of Blackwell (1951, 1953) theorem. The intuition is

[7] In the field experiment by Balafoutas et al. (2013), English speaking passengers are very likely to pay the price without any dispute. Nonetheless, many taxi drivers chose not to "mistreat" them. In our jargon, such taxi drivers are "honest". When the passenger is Greek, the "environment" is "less favorable" to a mistreatment, for example because it is now more likely that the passenger detects an unnecessary detour. This induces some taxi drivers who would overtreat a foreigner not to mistreat a Greek. In our jargon, the share of honest taxi drivers is now larger. Something similar occurs in the market for health services, where the share of unnecessary treatments may depend on the type of patient. For example, Domenighetti et al. (1993) found that the rate of surgeries is generally lower when patients are doctors or lawyers. To be clear, here honesty need not mean moral integrity.

[8] For example, after reading Balafoutas et al. (2013), we have a pretty clear (and probably correct) idea on the share of honest taxi drivers in Athens, while we have a very rough (and probably incorrect) idea on that same share in many cities around the world.

that the only effect of an incorrect belief is to induce consumers to take suboptimal actions. Consider for example the simplest model of taxi drivers one can imagine. A (female) tourist knows that the distance of her hotel from the airport is either 10 or 15 miles, with equal probability. If she enters the taxi uninformed, she knows that she could be overtreated. This occurs when the distance is actually 10 miles and the (male) taxi driver is dishonest. Suppose now that before entering the taxi, the passenger can discover the actual distance at a cost, and assume that if the passenger enters the taxi recognizably informed, also the dishonest taxi driver will behave honestly, for example because he anticipates that he will not be paid. Although described as a game, this is actually an individual decision problem, because there is a one-to-one relationship between action of the passenger and action of the dishonest taxi driver. For reasonable values of the parameters, the choice of the passenger will depend on the believed share of honest taxi drivers: below a threshold, the passenger will choose to become informed, while above such threshold, she will choose to remain uninformed. In this model, an incorrect belief would have some effect in only two cases, namely when the believed share is above while the actual one is below the threshold, and vice versa. In the first case, the passenger would choose to remain uninformed, while she would have been better off by becoming informed. In the second case, the passenger would choose to become informed, while she would have been better off by remaining uninformed. A passenger with correct beliefs is therefore always (weakly) better off than a passenger with wrong beliefs. But then a government that maximizes consumers' welfare would always communicate the actual share of honest experts whenever known,[9,10] unless this entails some (not too large) cost, in which case it would communicate the actual share only if it is sufficiently distant from the believed share.

The answers to the two research questions are definitely much less trivial in a strategic context. In a game, the belief of one player, whenever known by the other players, might also affect the strategies of the latters. It is still true that an incorrect belief induces the player under consideration to take a suboptimal action. However, if the change in the other players' behavior is sufficiently favorable to him, he might actually gain from an incorrect belief. But then a government interested in the welfare of the players might deem it optimal not to provide information that leads to correct beliefs.

We analyze such possibility in a canonical credence good model with second opinion and fixed

[9] This also implies that if mass media only provides truthful information, for example in order to build or maintain a reputation, the government would welcome any information by the mass media. In the example of taxi drivers in Athens, the information provided by the Lonely Planet would therefore tend to increase consumers' welfare.

[10] The choice of a passenger to become informed is in fact a negative externality for a dishonest taxi driver. Hence, a government that maximizes a utilitarian social welfare function could deem it optimal to manipulate passengers' beliefs and/or to avoid revealing the actual share of honest taxi drivers. In this article, we do not consider the welfare of dishonest experts. However, this remark suggests that in a different context, the two research questions would not have trivial answers even in decision theory problems with externalities. For example, a government could be tempted to make people believe that smoking damages health more than it actually does, not only for paternalistic reasons, but also in order to take into account the external effects of smoking.

prices. A (female) consumer has a problem to be fixed. The problem is either major or minor. The consumer consults a first (male) expert, who knows the severity of the problem and proposes either a major intervention at a high price or a minor intervention at a low price. Such expert is either honest or dishonest, and this is private information. The commonly believed share of honest might differ from the actual share. Beliefs can therefore be, and generally are, incorrect. The explicit introduction in a credence goods' model of beliefs is the first novel feature of this article.

A standard liability assumption rules out undertreatment. When asked a low price, the consumer thus realizes that her problem will be fixed at the lowest possible price, so she buys the service. A verifiability assumption also rules out overcharging. When asked a high price, the consumer thus realizes that either the problem is actually major or she will be overtreated. She might therefore choose to address a second expert at a cost.

Most of the literature on second opinion in credence good markets assumes that an expert, when consulted, does not know whether the consumer has already consulted another expert (no transparency), while Marty (1999) assumes that the second consulted expert knows to be the second, so the first consulted expert logically infers to be the first (full transparency). We allow for any degree of transparency by assuming that the second consulted expert has a probability β to learn that the consumer has already consulted another expert. For example, a doctor may sometimes realize that the patient has already obtained a diagnosis from the way she describes her pathology, or some doctors share the same patients' database, which enables them to access the files of other doctors' patients, but the patients do not know which doctors share the same database. The parameter β represents therefore a measure of transparency. Only the polar cases $\beta = 0$ (no transparency) and $\beta = 1$ (full transparency) have been considered so far in the literature. This is therefore the second novel feature of our model. We will show that allowing for intermediate values of transparency is actually very useful, because it often leads to more "realistic" conclusions.

We make the standard assumption that the consumer buys from the last consulted expert. Hence, if the second consulted expert faces a minor problem, is dishonest and is aware to be the second, he will overtreat the customer. However, if he does not know to be the second, he might decide not to overtreat the customer, fearing that he is actually the first consulted expert and that the customer will ask for a second opinion.

In this model, there are therefore two non trivial strategies: the choice of a dishonest unaware (either first or second) expert who faces a minor problem (henceforth simply the expert) whether or not to overtreat the customer and the decision of a consumer who was proposed the more costly treatment by the first expert (henceforth simply the consumer) whether or not to ask for a second opinion.

Throughout the paper, we focus on the equilibrium that maximizes the probability that the expert does not overtreat the customer (henceforth, equilibrium level of honesty). We show that such (maximum) probability is positive only when both the expert and the consumer play a truly mixed strategy.

We initially study when such mixed strategies equilibrium exists. We analyze both the case where the monetary incentive to overtreat the consumer is relatively low (small markup) and where it is relatively high (large markup). In both cases, the equilibrium level of honesty is zero if the believed share of honest expert is sufficiently high. On the other hand, when it is not so high, the two cases lead to quite different conclusions. In the small markup case, if such share is sufficiently low, the mixed strategies equilibrium exists only if transparency is sufficiently low, while in the large markup case, it exists only for intermediate values of beliefs, and only if transparency is sufficiently high. Transparency can therefore both hamper and help the emergence of a "good" equilibrium.

The two research questions call for characterizing (i) the belief that the government would consider as optimal; (ii) the set of actual shares of honest expert which, whenever observed, would be publicly revealed. In order to address such questions, we have therefore to define the objective for the government. The first objective that we analyze is the equilibrium level of honesty, which reflects the expert's "disciplining effect" due to the *possibility* for the consumer to ask for a second opinion. Such objective does not however take into account the cost paid by the consumer when she *actually* asks for a second opinion. We chose therefore to also consider the consumer's expected utility as a second, and arguably more interesting, objective for the government.

We show that the belief that maximizes the equilibrium level of honesty crucially depends on the degree of transparency. In the small markup case, if transparency is sufficiently low, such belief is zero, whatever the environment as defined by the parameters of the model. The government would therefore always wish people to believe that all experts are dishonest. This very stark result necessarily obtains in the case generally considered in the literature (no transparency), but we do not think that it captures some important features of economic reality. Interestingly, when transparency is not so low, the belief that maximizes the equilibrium level of honesty is positive, and it depends on the environment. On the other hand, in the large markup case, when transparency is low, beliefs do not affect the equilibrium level of honesty, which is always equal to zero, while when transparency is not so low, the belief that maximizes the equilibrium level of honesty is positive, and it depends on the environment. In both cases, if transparency is not too low, the government has therefore a not trivial "optimally believed" world, which might differ from the actual world. In fact, since the equilibrium level of honesty depends on the believed share of honest experts but not on the actual share, the optimally believed world is generically different from the actual world.

As for the second objective of the government, we focus on the small markup case and show that in the cases considered in the literature (no transparency and full transparency), the belief that maximizes the equilibrium level of honesty is also the belief that maximizes consumer's expected utility. This implies that the optimally believed world does not depend on the actual world, a quite stark but somehow "unrealistic" conclusion. Interestingly, this is no more true when the degree of transparency takes intermediate values. Although in the latter case the optimally believed world depends on the actual world, we show that they are generically different. The government wishes therefore that the consumer and the experts (almost always) have incorrect beliefs, in the interest of the consumer.[11] The intuition is that the consumer benefits from *some* incorrect belief that increases the equilibrium level of honesty, although this also induces her to choose a suboptimal strategy. We also show that when the degree of transparency takes intermediate values, the belief that maximizes consumer's expected utility exceeds the belief that maximizes the equilibrium level of honesty. This result follows from solving a simple trade-off: holding a belief higher than the most disciplining one implies that the expert behaves less honestly — bad for the consumer — but the consumer asks for a second opinion less frequently — good, since it reduces the expected cost.

In this article, we do not allow the government to manipulate beliefs, but we assume that with some positive probability it learns the true share of honest experts, in which case it has to decide whether to publicly reveal it in a verifiable manner through an information campaign, which turns incorrect beliefs into correct ones. This leads us to the second research question.

The key result that the optimally believed world is generically different from the actual world clearly implies that in some cases the government might prefer that people maintain incorrect beliefs, so no information campaign will be aired, even if it entails no cost. This conclusion starkly contrasts with the result one would obtain in decision theory problems without externalities, where a government interested in consumers' welfare would always wish to correct beliefs, unless this entailed some cost, in which case an information campaign would be aired only when the degree of "incorrectness" of beliefs is sufficiently large.

We show that the set of shares of honest experts which, whenever observed, would be revealed by the government (henceforth, revelation set) is the same with the two objectives. When transparency is sufficiently low and/or beliefs are sufficiently high, the government chooses to correct beliefs if and only if they are optimistic, *i.e.*, the believed share of honest experts exceeds the actual share. In this case, an information campaign would always warn people that the actual world is grimmer than they believe. More interestingly, in the other cases, the revelation set is an interval which contains the optimally believed world, with one of the two extremes being the current belief. In a loose sense, an information campaign will be aired if and only if the actual share of honest experts is "closer" to the

[11] This result should hold even with a utilitarian social welfare function, which also takes into account the experts' expected utility. We think that this kind of result is actually quite general. Indeed, the equilibrium of many games is not socially optimal. A change in the beliefs may change the equilibrium outcome of the game, and so it may increase social welfare.

optimally believed share than the currently believed share.[12] The government could therefore choose to correct both optimistic and pessimistic beliefs.

We do not formally analyze the case where the information campaign is costly. It is however easy to understand that this would lead the government to reveal less. The degree of "incorrectness" would now play a role: shares that are sufficiently close to the believed ones would not be revealed, since the benefit of a campaign would fall short of the cost. However, shares that are sufficiently distant from the believed ones would also not be revealed. Hence, interpreting the revelation set with a costly information campaign in terms of how much initial beliefs are "incorrect" is misleading. What really matters is whether the actual world is "sufficiently closer" to the optimally believed world than the (initially) believed world.

We close the paper by relating the theoretical predictions of our model to available evidence. We first give an account of the successful information campaign described in Domenighetti et al. (1988) trough the lenses of our model and provide an explanation consistent with our theory. Secondly, we use data from an experiment run by Mimra et al. (2016) to test our theory. The experiment was run to examine the predictions of Süzle and Wambach (2005) modified to deliver overtreatment rather than overcharging, which boils down to our model with no honest types and no transparency. We use their data to calibrate our model's unobservable parameters and then compare its predictions to the behavior of their subjects. Since our model fits better the data collected in the experiment, we conclude that the addition of honest types and beliefs thereof allows for a noticeable step forward into the comprehension of actual behavior in credence goods markets.

The paper is organized as follows. Section 2 reviews the existing literature. Section 3 introduces the basic model. Section 4 analyzes the second opinion game. Section 5 shows how beliefs affect the equilibrium level of honesty and the consumer's welfare, deriving the optimal belief for each policy objective. Section 6 illustrates how policymakers can design communication campaigns in order to reach their policy goals. Section 7 discusses empirical and experimental evidence. Section 8 presents results for the case of high financial incentives to overtreat consumers. Section 9 concludes.

2 Literature review

Credence goods, second opinions and honest types. The economic incentives to defraud consumers in credence good markets are the subject of a wide theoretical literature, which is summarized in Dulleck and Kerschbamer (2006) and Balafoutas and Kerschbamer (2020). The former contribution also presents a unifying model which pins down various market inefficiencies to a set of four assumptions. The main result of the model is that, if the assumptions of consumers' homogeneity,

[12] The revelation set may not be centered around the optimally believed world, hence the term loose.

commitment to acquire the service and either expert's liability or verifiabilty of the service provided (or both) hold, then market institutions solve the fraudulent expert problem.

Our contribution adds to the literature on second opinions in credence good markets. Like Pitchik and Schotter (1987), Pesendorfer and Wolinsky (2003) and Süzle and Wambach (2005), we drop the commitment assumption and consider inflexible prices (the latter is done also by Darby and Karni (1973), Wolinsky (1993, p. 384), Marty (1999) and Emons (2001, 2013), where prices are fixed before demand uncertainty is resolved). In this way we are granted the existence of fraudulent overtreatment equilibria, which best fit the evidence mentioned in the introduction. If we dropped verifiability, our model could easily feature overcharging equilibria resembling more closely Süzle and Wambach (2005), the paper to which ours is closest. We share with it, and with Marty (1999), the baseline model which rests on Wolinsky (1993, 1995), except that we introduce and parametrize transparency, encompassing both Marty (1999) (full transparency) and the other contributions (no transparency). We also share with those papers, and with Pesendorfer and Wolinsky (2003), the three types of equilibria they characterize: a pure strategy full-fraud equilibrium and two high- and low-fraud mixed strategy equilibria.[13] However, because we introduce transparency and beliefs about experts' honesty, we uncover new equilibria in which dishonest experts are sometimes or even always fraudulent, but consumers are not discouraged and find it convenient to ask for second opinions. While such equilibria are marginal in our discussion, transparency and beliefs on honest types have not been considered so far by the literature, and allow us to study credence goods markets from new angles and to suggest unexplored policy interventions.

As to transparency, we are not aware of any other contribution on second opinion which studies the degree to which experts are aware of the customer's sampling order. More specifically, the standard assumption that a sampled expert is fully uninformed of whether another expert has been previously consulted (zero transparency) seems unchallenged to date, with the exception of Marty (1999), which makes the extreme opposite assumption of full transparency. As argued in the introduction, we believe that in many real contexts the zero as well as the full transparency assumptions are untenable and we show in the paper that relaxing them has relevant implications.

Honest types are not new: we model honest experts following Marty (1999), whose model is also discussed by Süzle and Wambach (2005, p. 171). In Marty (1999) a honest expert is similar to a behavioral type which prescribes the right treatment regardless of his convenience. Similarly, Fong et al. (2014) introduce behavioral honest types in a model with verifiability but without liability and show that, in their setting, honest types make it easier the emergence of the more inefficient equilibria. Liu (2011)'s conscientious expert is instead a monopolist who fixes a price for both a high and a

[13] More precisely, owing to the full transparency assumption, Marty (1999) does not feature the high-fraud mixed strategy equilibrium. This will be clear from our full results.

low repair and derives utility from the fact of solving the customer's problem. Hence, his decision to behave honestly is strategic. Liu (2011) shows that, under some circumstances, such pro-social preferences may result in more fraud compared to a selfish expert scenario. By contrast, in our model honest types are unambiguously good for consumer welfare. This is not true, however, for the belief about the share of honest experts. Indeed, we show that the optimal belief differs from the true share and is close to but lower than the one that induces the expert to behave most honestly.

That a relevant number of experts behave honestly has also been shown by a growing body of empirical and experimental evidence. Among others, we shall mention Beck et al. (2013) (guilt aversion), Kerschbamer et al. (2017) (heterogeneous non-selfish preferences) and Hennig-Schmidt et al. (2011), Godager and Wiesen (2013), Hennig-Schmidt and Wiesen (2014) and Green (2014), all showing that physicians' intrinsic motivation plays an important role and often prevails on financial incentives.

Finally, we shall mention some experimental evidence on secon opinions. Mimra et al. (2016) tested the predictions of Süzle and Wambach (2005)'s model, confirming that allowing for second opinions reduces overtreatment rates. We discuss this paper in Section 7 reinterpreting their data in light of our model. Agarwal et al. (2019) test the predictions of Pesendorfer and Wolinsky (2003) and find that the possibility of asking second opinions reduces overtreatment. Gottschalk et al. (2020) find no evidence that revealing to an expert (a dentist) that the patient is waiting for a second opinion affects overtreatment rates.

Information revelation, beliefs, public campaigns. We model information campaigns as an information disclosure decision of public authorities prior to the second opinion game. In this respect our model is indebted to the literature on information sharing in oligopolies which culminated in Raith (1996). The general idea of providing public information to affect welfare has been explored by Morris and Shin (2002) and the ensuing literature, which focuses on imperfect information (signals). More recently, the literature on Bayesian persuasion (see Kamenica and Gentzkow (2011)) has studied the conditions under which a sender may provide to his own advantage private signals to a receiver whose non-contractible action affects the welfare of both. Finally, in assuming that the prior common credence is a probability mass function, we model beliefs updating following Alchourrón et al. (1985).

From an empirical perspective, public campaigns have been little studied in economics, but are the subject of a specialized public health literature which typically reports the outcomes of campaigns run by public authorities. Beyond the one already mentioned, which aimed at reducing hysterectomy rates (Domenighetti et al. (1988)), most public campaigns have been run to curb smoking, drinking and to improve health behavior more generally, as reviewed by Wakefield et al. (2010).

3 Model

A consumer (she) is in need of a service to address an issue. The issue is major with probability η and minor with complementary probability. Fixing the issue at a price p allows the consumer to enjoy utility $v - p$, while leaving it unsolved yields her zero utility. To address the issue, the consumer must consult an expert (he), who knows its severity and the appropriate fix. The expert can propose a major intervention at a price $\overline{p}$, which fixes both types of issues, or a minor intervention at a lower price $\underline{p}$, which fixes only minor issues, while leaving unsolved major ones. After the expert's intervention, the consumer can tell (and prove to a court) whether the intervention was major or minor and whether the issue was solved, while she cannot tell whether the fix was appropriate. Hence, while overcharging – *i.e.*, charging for the major intervention but providing a minor intervention – and undertreatment — *i.e.*, providing a minor intervention when the issue is actually major — are immediately spotted and sanctioned (verifiability and liability assumptions), the consumer (and a court) cannot tell whether a major treatment was truly needed to fix a major issue or it was just fraudulent overtreatment — *i.e.*, providing a major intervention when the issue is actually minor. The severity of the issue is therefore *ex post* non verifiable and the service provided by the expert is a credence good.

We assume that prices are exogenous, with $v > \overline{p}$, *i.e.*, the consumer prefers to be overtreated to leaving the issue unfixed.[14] If we let $\overline{c}$ and $\underline{c}$ be the costs for the experts of, respectively, a major and a minor intervention, we assume that $\overline{p} - \overline{c} > \underline{p} - \underline{c} > 0$, *i.e.*, experts always gain from providing the service, and they gain more from major interventions. Hence, experts have a monetary incentive to overtreat their customers.

In order to introduce beliefs in the model, we assume that there are two types of experts. The type is private information. Given the environment, a fraction γ of "honest" experts always prescribe the right fix, while a fraction $1 - \gamma$ of "dishonest" experts have a utility function $u_e(p, c) = p - c$. Since we assumed that $\overline{p} - \overline{c} > \underline{p} - \underline{c} > 0$, a dishonest expert who faces a minor issue would therefore choose to overtreat his customer *if he was sure that the consumer would buy from him.*

Consumers and experts do not know the true share of honest experts, but they have a commonly known, possibly incorrect, expectation about it: γ^e. Their strategies are therefore based upon the believed rather than the actual fraction of honest types.

The consumer need not buy from the first audited expert (no commitment assumption), but she can consult a second expert at a cost $t > 0$. Consulting more than two experts is assumed to be too costly for the consumer. If the consumer receives the same diagnosis from both experts, she will hire

[14] The exogenous prices assumption, made for instance by Pitchik and Schotter (1987), is not particularly restrictive when the pricing of services is sufficiently standardized, as it is the case, for instance, with routine medical interventions (see, *e.g.*, the Diagnosis-Related Group (DRG) system adopted worldwide).

the last consulted expert.[15]

Finally, we assume that if the consumer asks for a second opinion, the second consulted expert learns with probability β that another expert has been previously consulted. Hence, β is a "conditional awareness probability", *i.e.*, the probability that the second expert is aware to be the second, conditional on being consulted. There are therefore two types of experts in terms of available information: the aware expert, who knows to be the second, and the unaware expert (either first or second), who computes the probability of being first or second using Bayes rule.

4 Second Opinion Game

Consider a consumer who consulted a second expert. Given the assumption $v > \overline{p}$, she will always buy the service, whatever the price charged. This implies that an aware dishonest expert who faces a minor issue, knowing to be the second expert, will always overtreat the consumer. On the other hand, an unaware dishonest expert who faces a minor issue must take into account the probability of being the first expert, and so the risk of losing the consumer to a second expert if he overtreats her and she asks for a second opinion. Hence, he might deem it optimal to behave honestly, *i.e.*, not overtreat the customer and charge a price $\underline{p}$. Let henceforth $\sigma_e \in [0,1]$ be the (endogenous) probability that an unaware expert facing a minor issue (henceforth, the expert) behaves honestly. Finally, given the assumption of liability, a dishonest expert (either aware or unaware) who faces a major issue will always propose a major intervention at a price $\overline{p}$.

Consider now a consumer who consulted a first expert. If a minor fix was suggested at a price $\underline{p}$, she infers that the issue is actually minor and will be fixed at the lowest possible price (liability assumption), so she buys the service. On the other hand, if the first expert suggested her a major fix at price $\overline{p}$, she cannot rule out the possibility of being overtreated. Hence, she might opt for a second opinion. Let henceforth σ_c be the (endogenous) probability that a consumer who has been proposed a major fix by the first expert (henceforth, the consumer) asks for a second opinion.

The consumer realizes that the first expert proposes her a major fix at a price $\overline{p}$ either when the issue is major — which occurs with probability η — or when it is minor, the expert is dishonest and he chooses to overtreat the customer — which is expected to happen with (endogenous) probability $(1-\eta)(1-\gamma^e)(1-\sigma_e)$. Hence, she computes the equilibrium probability that the issue is minor:

$$\Pr(\text{min.}|\overline{p}) = \frac{(1-\eta)(1-\gamma^e)(1-\sigma_e)}{\eta + (1-\eta)(1-\gamma^e)(1-\sigma_e)}. \tag{1}$$

[15] This tie-break rule, which is common in the literature, seems realistic if one takes into account the existence of unmodeled costs, either psychic or economic. For example, as patients, we would feel somehow uneasy to come back to the first consulted doctor after some time from his diagnosis. This could also entail some costs for retaking exams that need to be updated.

In this article, whenever there are multiple equilibria, we focus on the one that maximizes the probability of honest behavior σ_e. We will show that if in such equilibrium $\sigma_e > 0$, the consumer asks for a second opinion with probability $\sigma_c \in (0,1)$, *i.e.*, she plays a mixed strategy. This calls for the consumer to be indifferent between paying $\overline{p}$ to the first expert and auditing a second expert. The cost of a second opinion must therefore equal the expected benefit:

$$t = \Pr(\text{min.}|\overline{p})\left(\gamma^e + (1-\gamma^e)(1-\beta)\sigma_e\right)(\overline{p} - \underline{p}). \tag{2}$$

The consumer benefits from a second opinion (saving in prices $\overline{p} - \underline{p}$) only if the problem is actually minor (probability $\Pr(\text{min.}|\overline{p})$) and either (i) the second expert is honest (probability γ^e) or (ii) he is dishonest, unaware and behaves honestly (probability $(1-\gamma^e)(1-\beta)\sigma_e$). There are therefore two different motives for hearing a second opinion.[16]

A quick inspection of (2) reveals that if either t is high enough or the price difference is low enough, the expected benefit from a second opinion always falls short of the cost, so the consumer never hears a second expert. But then the expert overtreats the customer. The unique equilibrium is therefore $\sigma_e = 0$ and $\sigma_c = 0$, whatever the values of γ^e and β. To avoid this uninteresting outcome, we assume throughout the paper that

$$\tau < \tau_{max} \equiv \frac{1-\sqrt{\eta}}{1+\sqrt{\eta}}, \quad \text{where } \tau \equiv \frac{t}{\overline{p} - \underline{p}}. \tag{A1}$$

A deeper inspection of (1) and (2) reveals that the expected benefit of a second opinion is concave in σ_e, eventually leading to two solutions of (2).[17]

The next lemma characterizes the conditions on the parameters of the model that guarantee the existence of at least one strategy σ_e that satisfies (2). They represent therefore a necessary condition for the existence of a mixed strategy equilibrium in which the consumer asks for a second opinion with probability $\sigma_c \in (0,1)$.

Lemma 1. *There exist* $0 < \beta_1 < \beta_2 < 1$ *and* $0 < \underline{\underline{\gamma}} < \underline{\gamma} < \overline{\gamma} < 1$ [18] *such that*

$$\sigma_e = 1 - \frac{(1-\beta(1-\gamma^e)) - \tau - \sqrt{((1-\beta(1-\gamma^e)) - \tau)^2 - 4\tau(1-\beta)\frac{\eta}{1-\eta}}}{2(1-\gamma^e)(1-\beta)} \in (0,1) \tag{3}$$

[16] Two polar cases are worth mentioning: if $\beta = 1$, only the first motive matters; if $\gamma^e = 0$, only the second one does.

[17] A greater σ_e reduces the probability that the problem is minor given a severe diagnosis (which tends to reduce the expected benefit from a second opinion), but it also increases the probability that the second expert behaves honestly (which tends to increase the value of the second motive for a second opinion). This helps to explain why the expected benefit function is concave in σ_e. For some parameter values, it is also non-monotone and (2) has two solutions.

[18] The respective mathematical expressions are in the Appendix. It can be useful to know that $\underline{\gamma}$, $\overline{\gamma}$, β_1 and β_2 only depend on τ and η, while $\underline{\underline{\gamma}}$ also depends on β, with $\underline{\underline{\gamma}}(\beta_1) = 0$, $\underline{\underline{\gamma}}(\beta)$ increasing in β and $\underline{\underline{\gamma}}(\beta_2) = \underline{\gamma}$.

satisfies (2) *if and only if*

$$\gamma^e \in \begin{cases} \left[0, \overline{\gamma}\right] & \text{if} \quad \beta < \beta_1 \\ \left[\underline{\underline{\gamma}}, \overline{\gamma}\right] & \text{if} \quad \beta \in (\beta_1, \beta_2) \\ \left[\underline{\gamma}, \overline{\gamma}\right] & \text{if} \quad \beta > \beta_2 \end{cases} \tag{4}$$

If (4) does not hold, the unique equilibrium of the game is $\sigma_e = 0$ *and* $\sigma_c = 0$.

We define as S the set of parameters (β, γ^e) characterized by (4). Figure 1 below illustrates the set S for given values of the parameters η and τ, with $\tau < \tau_{max}$.[19] In the shaded area above $\underline{\gamma}$, (3) is the unique σ_e that satisfies (2), while in the shaded area below it, there exists a second one, which is characterized by a lower value of σ_e.[20]

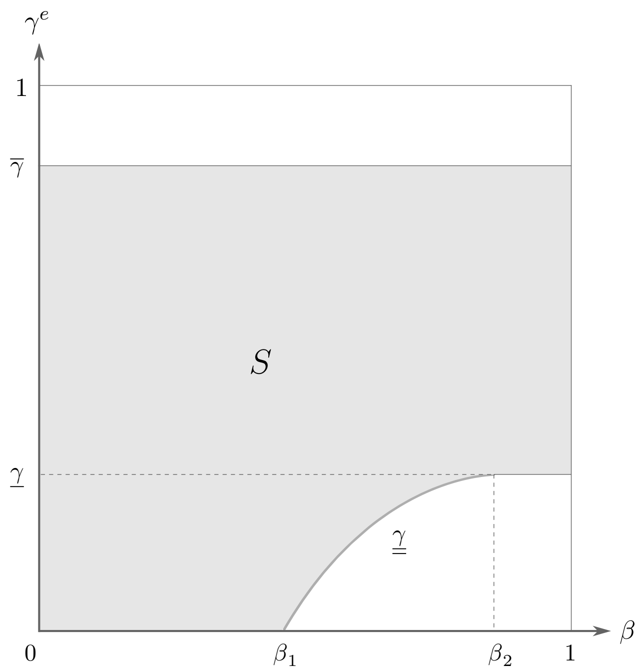


Figure 1: Set S (parameter region in which σ_e is well defined).

When $(\beta, \gamma^e) \notin S$, in the unique equilibrium of the game, the consumer never asks for a second opinion ($\sigma_c = 0$) and the expert always overtreats the consumer ($\sigma_e = 0$). The intuition is the following. When $\gamma^e > \overline{\gamma}$, the first expert is likely honest, so the diagnosis of a major problem is likely due to the problem actually being major. Hence, it is not worth paying t to receive the same diagnosis with high probability. The consumer chooses therefore not to hear a second expert. When $\gamma^e < \underline{\gamma}$, even though there is a high probability that the problem is minor, the first motive for hearing a second expert by itself is not worth the cost t — since the second expert is likely dishonest. The consumer

[19] We let $\tau = 0.1$ and $\eta = 0.48$, so that $\underline{\gamma} = 0.22$, $\overline{\gamma} = 0.88$, $\beta_1 = 0.45$ and $\beta_2 = 0.85$.

[20] Since (2) reduces to a second degree equation in σ_e, this solution is (3) with the square root changed of sign and, *mutatis mutandis*, corresponds to the high-fraud solutions found in Pesendorfer and Wolinsky (2003) and Süzle and Wambach (2005).

will then have a positive net benefit from a second opinion only if the value of the second motive is sufficiently high, which calls for the probability $(1-\gamma^e)(1-\beta)\sigma_e$ that the second expert is dishonest, unaware and behaves honestly to be sufficiently high. If $\beta < \beta_1$, the value of the second motive is so high that the consumer is willing to ask for a second opinion for beliefs as low as $\gamma^e = 0$, when the first motive does not even matter. By contrast, if β is sufficiently high ($\beta > \beta_2$), the expert is so very likely aware that the second motive has little value and the consumer does not hear a second opinion. Finally, when $\beta \in (\beta_1, \beta_2)$, the value of the second motive is larger, but the consumer asks for a second opinion only if the value of the first motive is also sufficiently high, *i.e.*, γ^e is sufficiently high. Hence, when $\gamma^e < \underline{\underline{\gamma}}$, the consumer chooses not to hear a second expert.[21] Of course, if the consumer never asks for a second opinion, it is optimal for the expert to overtreat her, *i.e.*, $\sigma_e = 0$.[22]

If (4) is satisfied, *i.e.*, $(\beta, \gamma^e) \in S$, then from (3), $\sigma_e \in (0,1)$, *i.e.*, the strategy of the expert that makes the consumer indifferent between paying the price $\overline{p}$ and hearing a second opinion is a truly mixed strategy.[23] This can actually be an equilibrium strategy only if the expert is indifferent between charging and obtaining $\underline{p}$ for sure and charging $\overline{p}$ and risk losing the customer. His expected payoff from overtreating the customer depends on his probabilistic assessment of being the first expert,

$$\Pr(1^{st}|\text{unaware}) = \frac{1}{1+(1-\beta)(1-\gamma^e)(1-\sigma_e)\sigma_c}, \tag{5}$$

where we have imposed the natural assumption that the consumer randomizes equally among *ex ante* identical experts. If the unaware expert charges $\overline{p}$ and turns out to be the first expert, he will lose the customer if the latter chooses to ask for a second opinion (probability σ_c). The unaware expert is therefore indifferent between behaving honestly and overtreating the customer if

$$\underline{p} - \underline{c} = \left(1 - \Pr(1^{st}|\text{unaware})\sigma_c\right)(\overline{p} - \overline{c}). \tag{6}$$

From (5) and (6), the mixed strategy of the consumer is

$$\sigma_c = \frac{x}{1 - x(1-\gamma^e)(1-\beta)(1-\sigma_e)} > 0, \tag{7}$$

where σ_e must satisfy (2) and

$$x \equiv 1 - \frac{\underline{p} - \underline{c}}{\overline{p} - \overline{c}} \in (0,1) \tag{8}$$

denotes the percent margin loss for the expert from behaving honestly (*i.e.*, not overtreating the

[21] Recall that $\underline{\underline{\gamma}}$ is increasing in $\beta \in (\beta_1, \beta_2)$: the higher is β, the lower is the value of the second motive, and so the higher is the minimum value of γ^e that makes the value of the first motive high enough to induce the consumer to hear a second expert.

[22] This full-fraud equilibrium has been found in several works on second opinions: among others, Süzle and Wambach (2005) in the closest setting, Pesendorfer and Wolinsky (2003) and Alger and Salanié (2006) in less similar contexts.

[23] In fact, equilibria with $\sigma_c \in (0,1)$ and $\sigma_e = 0$ also exist, but they occur with probability zero, since they call for either $\gamma^e = \overline{\gamma}$ or $\gamma^e = \underline{\gamma}$ and $\beta > \beta_2$.

customer) in case the consumer does not (or cannot) ask for a second opinion, *i.e.*, she buys any service proposed by the expert. The higher is x, the more tempting is overtreatment.

A candidate for a mixed strategy equilibrium is the pair of strategies σ_e given by (3), which does not depend on x, and σ_c given by (7), which is increasing in x. For any $(\beta, \gamma^e) \in S$, if x lies below a threshold, then $\sigma_c < 1$, so (3) and (7) define a mixed strategy equilibrium. On the other hand, for any $(\beta, \gamma^e) \in S$, with $\beta < 1$, if x lies above a threshold, then $\sigma_c > 1$, so (3) and (7) is not an equilibrium.[24,25] Hence, the region of existence of the mixed strategy equilibrium (3) and (7) crucially depends on the value of x.

With the exception of Section 8, we assume that the markup on the major intervention is not too much larger than the markup on the minor intervention (henceforth, *small* markup case):

$$x < \frac{1}{2 - \underline{\gamma}}. \tag{A2}$$

This assumption guarantees that (*i*) σ_c given by (7) is lower than one; (*ii*) there exist no equilibria with $\sigma_c = 1$. By result (*i*), Lemma 1 provides necessary and sufficient conditions for (3) and (7) being a mixed strategy equilibrium. By result (*ii*), there cannot exist equilibria other than the ones we have considered so far.[26]

The following proposition characterizes the equilibrium that maximizes σ_e.

Proposition 1. *Let $\tau < \tau_{\max}$ and $x < \frac{1}{2-\underline{\gamma}}$.*

1. *If $(\beta, \gamma^e) \in S$, the equilibrium that maximizes σ_e is the mixed strategy equilibrium given by equations (3) and (7).*
2. *If $(\beta, \gamma^e) \notin S$, the unique equilibrium of the game is $\sigma_e = 0$ and $\sigma_c = 0$.*

Proposition 1 suggests that if the parameters of the model are such that in equilibrium the expert always overtreats his customer ($\sigma_e = 0$), a government could try to modify the game so that the mixed strategy equilibrium ($\sigma_e > 0$) obtains. We briefly focus here on three different channels that could be used by the government, which might differ significantly on feasibility, effectiveness and cost. They are transparency, prices and beliefs. In this paper, we are mainly interested in beliefs.

From Proposition 1 (see Figure 1), transparency plays a role in the existence of the mixed strategy equilibrium only when $\gamma^e < \underline{\gamma}$. In this case, the desired equilibrium obtains only if β is sufficiently

[24] If $\beta = 1$, then $\sigma_c = x < 1$, so for any $(1, \gamma^e) \in S$, *i.e.*, for any $\gamma^e \in (\underline{\gamma}, \overline{\gamma})$, (3) and (7) is a mixed strategy equilibrium.

[25] As mentioned after Lemma 1, in a subset of S there exists another strategy $\sigma_e \in (0, 1)$ satisfying (2) (see Footnote 20). This strategy has a lower value of σ_e and does not depend on x. From (7), σ_c is decreasing in σ_e. Hence, if with σ_e given by (3) it holds $\sigma_c > 1$, this also occurs when σ_e has a lower value. It follows that the strategy under consideration gives rise to a mixed strategy equilibrium only in a subset of (β, γ^e) for whom (3) and (7) is an equilibrium. Given our focus on the equilibrium that maximizes σ_e, we henceforth neglect the inferior strategy and denote as σ_e the strategy in (3).

[26] Figure 1 illustrates the set S of existence of the mixed strategy equilbrium (3) and (7) under (A2). If $\gamma^e \in (\underline{\gamma}, \overline{\gamma})$, such equilibrium is unique, while if $\gamma^e < \underline{\gamma}$ there exist two additional equilibria, both featuring a lower value of σ_e: a pure strategy equilibrium $\sigma_e = 0$ and $\sigma_c = 0$ and the mixed strategy equilibrium discussed in Footnote 25.

low. The government should therefore try to *decrease* the degree of transparency in the market.

The second tool that can be used by the government to induce a mixed strategy equilibrium are (administered) prices. In our model, an increase in $\overline{p}$ and/or a decrease in $\underline{p}$ decreases $\underline{\gamma}$, it increases $\overline{\gamma}$ and it decreases $\underline{\underline{\gamma}}$, so the set S widens. For given beliefs, the policy prescription for the government is therefore, somewhat paradoxically, to *increase* the profit for the expert from overtreating the customer.

Note, however, that such changes in prices create an environment that is more favorable to overtreatment, so we think that this should also lead both the actual share γ and the believed share γ^e of honest experts to decrease, not necessarily by the same magnitude. The (unmodeled) effect on γ^e can either help or hinder the emergence of the mixed strategy equilibrium. For example, consider $\beta = 1$, so that the mixed strategy equilibrium exists if and only if $\gamma^e \in (\underline{\gamma}, \overline{\gamma})$. If initially $\gamma^e > \overline{\gamma}$, the decrease in γ^e induced by an increase in $\overline{p}$ and/or a decrease in $\underline{p}$ reinforces the positive effect of the increase in $\overline{\gamma}$ in favoring the emergence of the mixed strategy equilibrium. On the other hand, if $\gamma^e < \underline{\gamma}$, the decrease in γ^e contrasts the positive effect of the decrease in $\underline{\gamma}$.

We think that the effects of prices on beliefs should play a crucial role when the government uses prices to manage the overtreatment inefficiency. In this article, prices are given. However, the government is sometimes able to affect beliefs directly, for example through a public campaign that provides verifiable information on the actual share of honest experts – or a proxy indicator, as it was the case with the number of hysterectomies in Switzerland. Let us assume this is the case and focus on the third channel of policy intervention: beliefs. From Proposition 1, the mixed strategy equilibrium does not exist when $\gamma^e > \overline{\gamma}$. In this case, the government should try to *decrease* the believed share of honest experts, inducing pessimism on experts' honesty. Beliefs also play a role in the existence of the mixed strategy equilibrium when $\gamma^e < \overline{\gamma}$ and $\beta > \beta_1$ (see Figure 1). In this case, the desired equilibrium obtains only if γ^e is not too low. The government should therefore try to *increase* the believed share of honest experts, inducing optimism. Hence, the direction of the change in beliefs needed to induce dishonest experts to behave honestly with positive probability crucially depends on the environment. However, a cursory look at Figure 1 suggests that when transparency is not too low (above β_1), beliefs should not be too "extreme".

Of course, the government could decide to affect transparency, prices and beliefs not only to give rise to a mixed strategy equilibrium, but also to affect an existing one. In order to evaluate the effects of such changes, we need to define the objective for the government. In this section, we follow Pitchik and Schotter (1987) and focus on the "equilibrium level of honesty" σ_e. In particular, we study the effects on the mixed strategy equilibrium of a change in transparency and prices, while we postpone the analysis of a change in beliefs to the next section, where we will also consider the case where government's objective is to maximize consumer's expected utility.

From (3), σ_e is decreasing in β. Hence, a government interested in maximizing the equilibrium level of honesty would choose the lowest degree of transparency that gives rise to a mixed strategy equilibrium, *i.e.*, $\beta = 0$.

From (3), σ_e is also decreasing in τ. An increase in $\overline{p}$ and/or a decrease in $\underline{p}$ decreases τ, and so it increases σ_e (for given γ^e). The equilibrium level of honesty therefore increases if the relative convenience for the expert from overtreating the customer *increases*. This result has been known since Pitchik and Schotter (1987, p. 1034).[27] Our model confirms that it holds even when people have generic beliefs γ^e on the share of honest experts and when the expert is "aware" with some (conditional) probability β. However, as we pointed out before, we think that an increase in $\overline{p}$ and/or a decrease in $\underline{p}$ should also reduce γ^e, which in turn affects the value of σ_e. There is therefore a second channel through which changes in prices can affect the equilibrium level of honesty, *i.e.*, through changes in beliefs.

In the next section, we study how beliefs affect the two possible objectives for the government we consider in this article, *i.e.*, the equilibrium level of honesty and consumer's expected utility.

5 Beliefs and welfare

We wish first to study, for any degree of transparency β, which is the believed share γ^e that maximizes the equilibrium level of honesty. This can be a reasonable objective for a government, since it reflects the expert's "disciplining effect" due to the possibility for the consumer to ask for a second opinion. Such objective does not however take into account the cost paid by the consumer when she actually asks for a second opinion. We then consider consumer's expected utility as a second, and arguably more interesting, objective for the government.

5.1 Equilibrium level of honesty

The following lemma shows how the mixed strategy σ_e depends on γ^e.

Lemma 2. *There exists $\beta_0 > 0$, with $\beta_0 < \beta_1$, such that*

1. *when $\beta \leq \beta_0$, then σ_e is decreasing in γ^e.*
2. *when $\beta > \beta_0$, then σ_e is concave in γ^e, with maximum at*

$$\hat{\gamma}^e = \frac{1}{2} + \frac{\tau}{2} - \frac{1}{2}\frac{1-\beta}{\beta}\frac{(1-\tau)^2 - 4\frac{\eta}{1-\eta}\tau}{1-\tau}. \tag{9}$$

[27] Pitchik and Schotter (1987) considered a reduced form version of a second opinion game. More recently, Süzle and Wambach (2005) analyzed a more complete version of such game and showed that in the equilibrium where physicians diagnose more honestly (in our jargon, which maximizes σ_e), an increase in the coinsurance rate (*i.e.*, the share of the price that is paid by the patient) reduces the probability of fraudulent advice. In our paper, an increase in the coinsurance rate amounts to an increase in $\overline{p} - \underline{p}$, which actually increases σ_e (taking γ^e as given). Pitchik and Schotter (1987) also showed that "decreasing the probability that the repair needed is costly has the effect of increasing the expert's honesty", which also occurs in our model, since σ_e is decreasing in η.

Lemma 2 suggests that the analysis of a change in γ^e on σ_e is more interesting than the analysis of a change in the other parameters of the model. Indeed, σ_e is unambiguously increasing in $\overline{p}$ and η and decreasing in t, $\underline{p}$ and β, while if β exceeds a threshold, σ_e is non-monotone in γ^e.[28] Hence, the direction of the change in γ^e that is needed in order to increase σ_e depends in a crucial way on its initial value, as well as on the values of all the parameters that characterize equation (9).

Figure 2 describes σ_e as a function of γ^e for different values of β.[29] Notice how a decrease in β gives rise to an upward shift of the curve. It also leads to an increase in the set of values γ^e such that $\sigma_e \in (0,1)$ exists. Finally, the belief $\hat{\gamma}^e$ that maximizes σ_e decreases.[30]

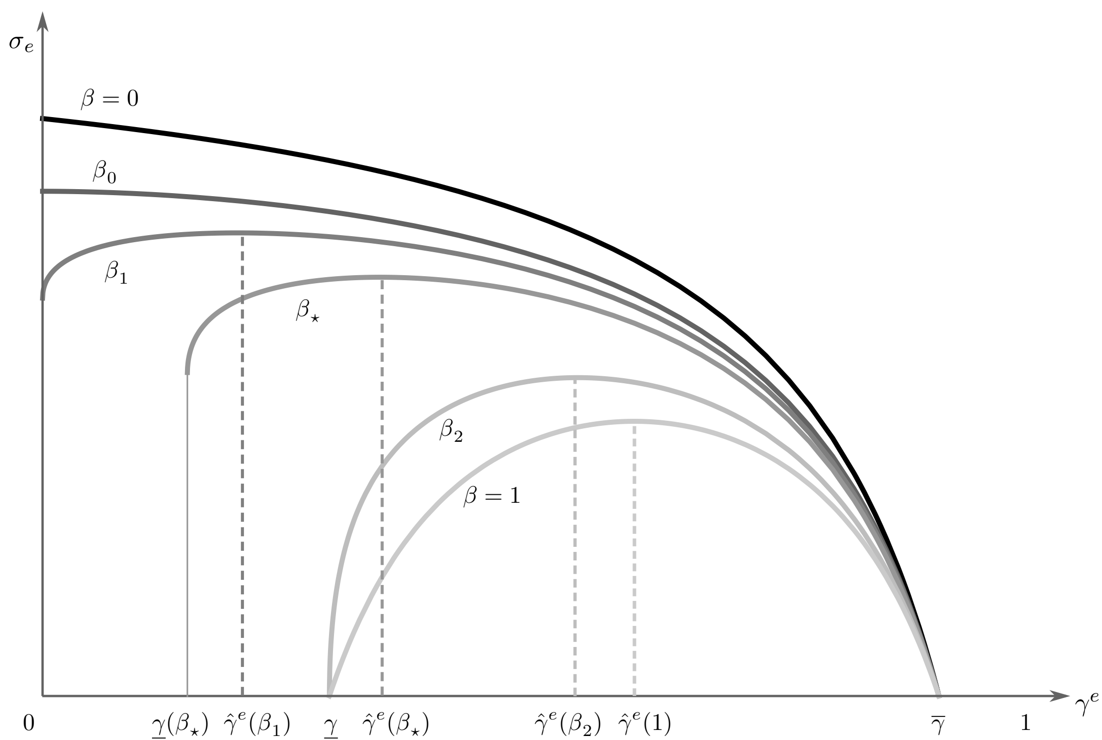


Figure 2: Beliefs and honest behavior.

Lemma 2 also provides an interesting comparative statics result within the mixed strategies equilibrium that enables us to answer a question we raised at the end of Section 4. We showed that an

[28] The consumer asks for a second opinion when its expected benefit (equation (2)) is large enough. The latter is maximized (roughly) when the uncertainty on experts' honesty is high: there is no point in asking for a second opinion when all experts are honest (the issue is major) or dishonest (the second expert also charges a price $\bar{p}$). Such uncertainty is somehow proportional to $\gamma^e(1-\gamma^e)$, which is non-monotone. Hence, the consumer's incentive to hear a second expert is highest for intermediate values of γ^e and, to keep her indifferent, honest behavior σ_e must follow the same non-monotonic pattern. However, with very low transparency ($\beta < \beta_0$), the expected benefit from a second opinion decreases monotonically with γ^e since the higher unawareness of the second expert, which pushes him to behave more honestly, compensates for the lower probability that he is honest when γ^e is low. Put differently, the second motive is high with low β's and raises the value of a second opinion even with very pessimistic views on honesty. Hence, following the decreasing incentives to hear a second opinion, σ_e is monotone decreasing in γ^e.

[29] Again, $\tau = 0.1$ and $\eta = 0.48$, so that $\beta_0 = 0.31$, $\beta_1 = 0.45$ and $\beta_2 = 0.85$. Moreover, we let $\beta_\star = 0.62 \in (\beta_1, \beta_2)$.

[30] These properties follow from three facts: (i) σ_e is decreasing in β; (ii) $\underline{\underline{\gamma}}$ is increasing in β; (iii) $\hat{\gamma}^e$ is increasing in β.

increase in $\overline{p}$ and/or a decrease in $\underline{p}$ has a direct, positive effect on σ_e. However, it also has an indirect, unmodeled effect: it tends to decrease γ^e, which in turn affects σ_e. Lemma 2 says that such indirect effect contrasts the direct effect when $\beta > \beta_0$ *and* $\gamma^e < \hat{\gamma}^e$, while it reinforces it otherwise. Hence, the effectiveness of such policy might depend on how much a change in prices affects the belief γ^e, as well as on its initial value.

The mixed strategy σ_e exists if and only if $(\beta, \gamma^e) \in S$ (Lemma 1). If $(\beta, \gamma^e) \in S$, such strategy also characterizes the equilibrium that maximizes honest behavior (Proposition 1).[31] Hence, the belief that maximizes the equilibrium level of honesty immediately follows from Lemma 2 (see Figure 2). It is characterized in Proposition 2 and plotted as a function of the degree of transparency in Figure 3.

Proposition 2. *Let $\tau < \tau_{max}$, $x < \frac{1}{2-\underline{\gamma}}$ and γ^{e*} be the belief that maximizes σ_e in equilibrium.*

1. *If $\beta \leq \beta_0$, then $\gamma^{e*} = 0$.*
2. *If $\beta > \beta_0$, then $\gamma^{e*} = \hat{\gamma}^e$.*

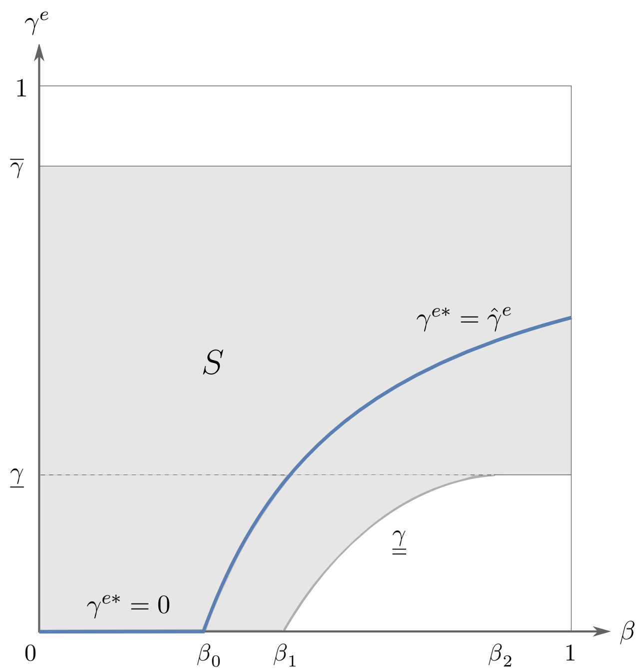


Figure 3: γ^e that maximizes σ_e.

If the government is interested in maximizing the equilibrium level of honesty σ_e, it would like people to believe that the share of honest experts is γ^{e*} as defined by Proposition 2. This share does not depend on γ, since σ_e only depends on beliefs. Hence, with probability one, γ^{e*} differs from γ. This implies that if the government knew the actual share of honest experts, it would generically find it optimal to conceal it and provide false signals of pessimism or optimism, at least as long as they are

[31] This need not be true when the markup is not small, as we will see in Section 8. This is the reason why we wrote both Lemma 1 and Proposition 1, which in the case of a small markup are equivalent.

believed. Proposition 2 also says that the type of signal the government would like to provide crucially depends on the initial belief γ^e, as well as on the values of the parameters that characterize γ^{e*}. For example, if $\beta \leq \beta_0$, the government would like people to believe that all experts are dishonest, whatever the initial belief and the values of the other parameters. On the other hand, and more interestingly, if $\beta > \beta_0$, it would like to depict a rosier world than the actual one (but not too rosy) whenever, for example, $\gamma < \gamma^e < \gamma^{e*}$, and a darker world (but not too dark) whenever, for example, $\gamma > \gamma^e > \gamma^{e*}$. Note how in both cases the government is happy that consumers and experts have incorrect beliefs, but it would like to drive them towards even "more incorrect" ones. Finally, truthful information disclosed, for example, by mass media could be either welcomed or ostracized by such government. This depends on both the information and the environment. For example, if $\beta \leq \beta_0$, the government would welcome any revelation of $\gamma < \gamma^e$, while if $\beta > \beta_0$ *and* $\gamma^e \leq \gamma^{e*}$, it would like any $\gamma < \gamma^e$ (the same information as above) *not* to be revealed.

A remark on prices is also worth mentioning. An increase in the price difference $\overline{p} - \underline{p}$ reduces τ, thereby decreasing the most disciplining belief $\hat{\gamma}^e$. Hence, *ceteris paribus*, the government would welcome more pessimistic expectations in countries where the monetary incentive to overtreat customers is larger.

5.2 Consumer's expected utility

The important result that γ^{e*} is generically different from γ should not come as a surprise, since σ_e only depends on γ^e, and not on γ. We consider now consumer's expected utility as a second possible objective for the government, and study how it is affected by a change in beliefs. Notice how such utility is a function of both γ^e (which affects σ_e and σ_c) and γ. Hence, the optimally believed world might now depend on the actual world.

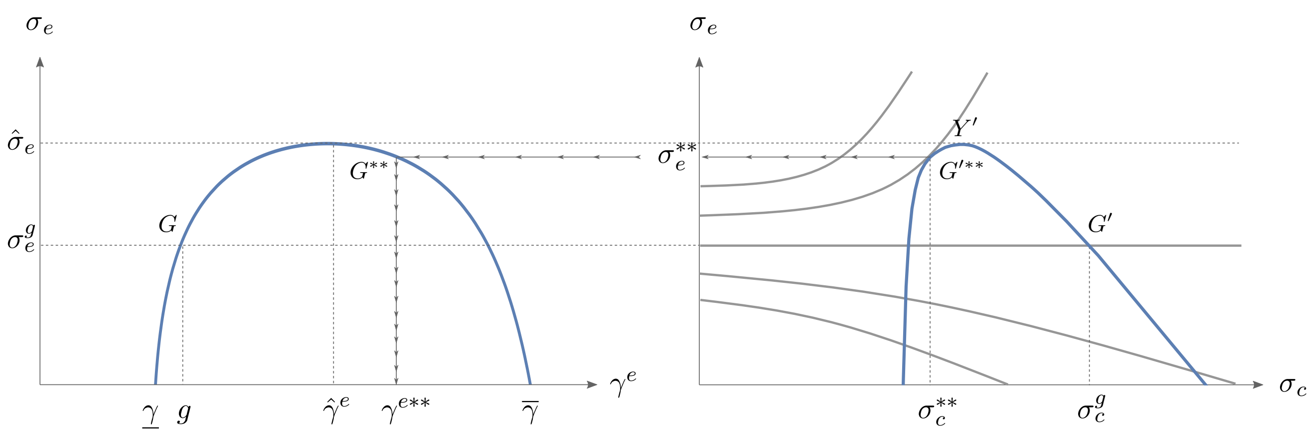
$$\begin{aligned} EU_c \quad = \quad v - & \overbrace{\Big(\eta\,\overline{p} + (1-\eta)\left(\gamma\underline{p} + (1-\gamma)\,\overline{p}\right)\Big)}^{\text{expected price if she can only consult one expert}} \\ & + \overbrace{(1-\eta)\,(1-\gamma)\,\Big(\sigma_e + (1-\sigma_e)\,\sigma_c\left(\gamma + (1-\gamma)\,(1-\beta)\,\sigma_e\right)\Big)\left(\overline{p} - \underline{p}\right)}^{\text{expected price saving if she can hear a second opinion}} \\ & - \overbrace{\Big(\eta + (1-\eta)\,(1-\gamma)\,(1-\sigma_e)\Big)\sigma_c t}^{\text{expected second opinion cost}} \end{aligned} \tag{10}$$

Equation (10) represents the *objective* expected utility for the consumer. Given their (possibly incorrect) belief γ^e, the expert and the consumer choose, respectively, the strategies σ_e and σ_c. In a mixed strategy equilibrium, they are indifferent between their two pure strategies, *i.e.*, such strategies give them the same *subjective* expected utility. However, when their belief is incorrect, one of their two pure strategies would give them a higher *objective* expected utility.

Note that for given σ_c, the value of EU_c is increasing in σ_e. There is therefore a positive relationship between equilibrium level of honesty and consumer's expected utility. However, this does not mean that any change in γ^e that increases σ_e benefits the consumer, since it also affects σ_c. If her belief is incorrect, one of her two pure strategies is *objectively* better for her, so the change in σ_c induced by the change in γ^e can either benefit or harm the consumer, according to whether it increases or it decreases the probability that she plays the *objectively* better strategy.

We now study welfare and the scope for policy intervention. We assume that $(\beta, \gamma^e) \in S$ and $(\beta, \gamma) \in S$, *i.e.*, the mixed strategy equilibrium obtains under both the believed and the actual share of honest experts. This means that we rule out extreme values of γ^e and γ that would give rise to the uninteresting equilibrium $\sigma_e = 0$ and $\sigma_c = 0$.

Figure 4, which refers to the case where $\beta \in (\beta_2, 1)$, helps us understand the next two propositions and will also be used in the next section to analyze the opportunity for an information campaign.



(a) Equilibrium expert strategy. (b) Equilibrium and isoutility curves.

Figure 4: Consumer welfare maximizing credence γ^{**} (when $\beta > \beta_2$).

Figure 4a is simply Figure 2, while the inverse U-shaped, strictly concave curve (henceforth, *equilibrium curve*) in Figure 4b describes the equilibrium pairs of strategies (σ_c, σ_e) given by (3) and (7). Moving anticlockwise through such curve amounts to increasing γ^e. The downward sloped part of the curve refers to the beliefs $\gamma^e < \hat{\gamma}^e$, while the upward sloped part refers to $\gamma^e > \hat{\gamma}^e$.

The remaining curves in Figure 4b are a family of isoutility curves associated to a given value of γ. To understand how they are drawn, suppose that $\gamma = g$. If beliefs are correct, *i.e.*, $\gamma^e = g$, then in equilibrium, $\sigma_e = \sigma_e^g$ (point G in Figure 4a) and $\sigma_c = \sigma_c^g$ (point G' in Figure 4b). Given $\sigma_e = \sigma_e^g$, any mixed strategy σ_c gives the consumer the same *objective* expected utility. Hence, the *isoutility curve* for the consumer is a horizontal line (Figure 4b). On the other hand, if a wrong belief $\gamma^e \neq g$

induces $\sigma_e > \sigma_e^g$, then the *objective* expected benefit of a second opinion falls short of the cost, so the consumer would benefit from a reduction in σ_c. Her isoutility curves above the horizontal one are therefore upward sloped. It turns out that they are also strictly convex.[32]

Maximizing consumer's expected utility calls for finding the point of the equilibrium curve that lies on the highest isoutility curve. The belief that gives rise to such equilibrium is denoted as γ^{e**}. For example, Figure 4b depicts the pair of strategies $(\sigma_c^{**}, \sigma_e^{**})$ that maximize consumer's expected utility when $\gamma = g$ (point G'^{**}). Moving back to Figure 4a, we find the belief γ^{e**} that induces σ_e^{**}.

If $\gamma = \hat{\gamma}^e$, the highest isoutility curve on the equilibrium curve is the horizontal line, so $\gamma^{e**} = \gamma$. On the other hand, for any $\gamma \neq \hat{\gamma}^e$, the horizontal isoutility line crosses the equilibrium curve, so $\gamma^{e**} \neq \gamma$. This explains the next proposition, which also takes into account the other cases.[33]

Proposition 3. *Let γ^{e**} be the belief that maximizes consumer's expected utility in the mixed strategy equilibrium. Then $\gamma^{e**} = \gamma$ if and only if $\gamma = \gamma^{e*}$.*

The first part of the proposition says that if the actual share of honest experts equals the believed share that maximizes σ_e (*i.e,* $\gamma = \gamma^{e*}$), then the belief that maximizes EU_c is the correct belief (*i.e,* $\gamma^{e**} = \gamma$). The intuition is the following. If $\gamma^e = \gamma^{e*}$, the value of σ_e is maximized. Moreover, if $\gamma^e = \gamma$, the belief is correct, so the two pure strategies give the consumer the same *objective* expected utility. Hence, there is no reason to advocate for an incorrect belief $\gamma^e \neq \gamma^{e*}$, which would reduce σ_e *and* induce the consumer to choose a suboptimal strategy.

The second, more interesting, part of the proposition says that if the actual share of honest experts differs from the believed share that maximizes σ_e (*i.e.*, $\gamma \neq \gamma^{e*}$), then the belief that maximizes EU_c is *not* the correct belief (*i.e.*, $\gamma^{e**} \neq \gamma$). Hence, unless $\gamma = \gamma^{e*}$, the consumer always benefits from *some* incorrect belief that increases σ_e, although it induces her to choose a suboptimal strategy. This is a key result of the paper. The best situation for the consumers calls for consumers and experts to believe that they live in a world that is generically different from the real one. Consumers could therefore even praise a government that provides false but believed information.[34]

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[32] The remaining isoutility curves are inessential to our analysis since the consumer welfare can only be maximized in a point above the horizontal isoutility curve. However, they are fully characterized in the Appendix.

[33] The cases $\beta \in (\beta_0, \beta_1)$ and $\beta \in (\beta_1, \beta_2)$ are almost identical, the only difference being that the lower bound of existence of the equilibrium is, respectively, 0 and $\underline{\underline{\gamma}}$, with $\sigma_e(0) > 0$ and $\sigma_e\left(\underline{\underline{\gamma}}\right) > 0$. On the other hand, if $\beta \in (0, \beta_0)$, the curves in Figures 4a and 4b are, respectively, downward and upward sloped. Finally, if either $\beta = 0$ or $\beta = 1$, the equilibrium curve is a vertical line.

[34] In this article, we assume that the government is interested in consumer's welfare and neglects the experts' welfare. The reason for such choice is that in our model, the consumer always buys the service from one of the two experts, so taking into account the experts' profit would matter only if the government gave a positive weight to the extra profit due to overtreatment, which is something that we decided to avoid. Notice that this is exactly what would occur with a utilitarian function $EU_c + EU_e$. There is however no reason why $\gamma^e = \gamma$ should maximize such function. For example, in the limiting case where $\overline{p} - \overline{c} \simeq \underline{p} - \underline{c} \simeq 0$, the profit for the expert is zero, so $EU_c + EU_e = EU_c$, and the optimal belief is still γ^{e**}. In fact, we think that for (almost) any utility function of the government, the optimally believed world is generically different from the actual world.

Let us turn again to Figure 4b. We have a strictly concave equilibrium curve and, for any $\gamma \neq \hat{\gamma}^e$, a set of increasing and strictly convex isoutility curves. Hence, the point on the equilibrium curve that lies on the highest isoutility curve needs to be a point of tangency on the left of Y'. Coming back to Figure 4a, it must be that $\gamma^{e**} > \hat{\gamma}^e$. Moreover, note that Figure 4 assumes that the actual share of honest experts is $\gamma = g$. For any other value of γ, we have a different set of isoutility curves, and so, generically, a different optimal belief. Figure 4 thus suggests that for any $\beta \in (\beta_2, 1)$, the optimal belief depends on γ and it exceeds $\hat{\gamma}^e$. The first result says that when the government has the ability to affect people's beliefs, it has the incentive to learn the actual world in order to target in a more effective way the believed world. The second result says that maximization of consumer's expected utility calls for accepting a lower equilibrium level of honesty ($\gamma^{e**} \neq \gamma^{e*}$) in order to decrease the expected cost of a second opinion.

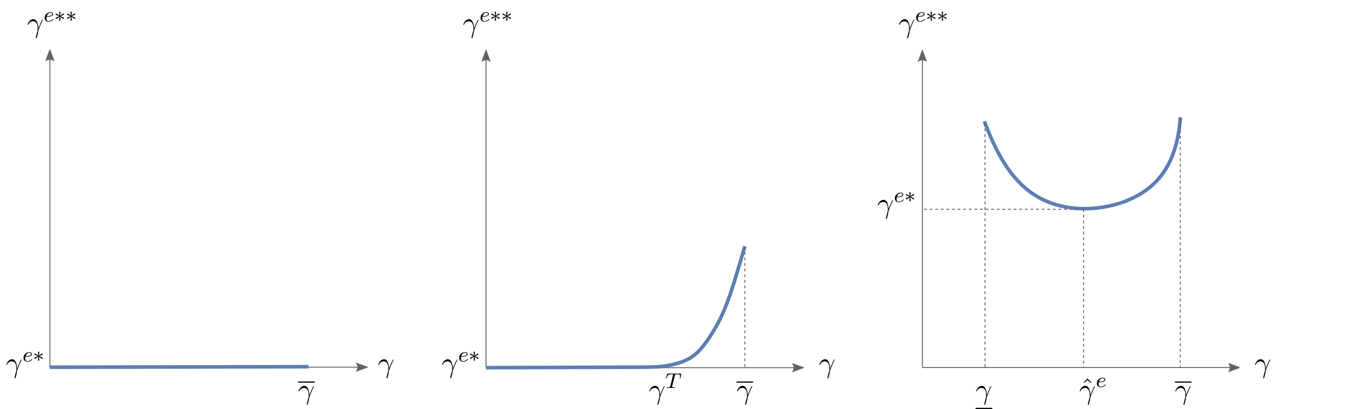
The changes in the qualitative features of Figure 4 when $\beta \in (\beta_0, \beta_2)$ are minor, and do not undermine the validity of the previous reasoning, so the same conclusions obtain. Proposition 4 below also says that, for any $\beta > \beta_0$, the belief γ^{e**} is not monotone in γ: it is decreasing in γ for all $\gamma < \hat{\gamma}^e$ and increasing for all $\gamma > \hat{\gamma}$ (see Figure 5c).

The situation is quite different in the two extreme cases considered in the literature: $\beta = 0$ and $\beta = 1$. In both cases, the equilibrium curve is a vertical line, so the point on this curve that lies on the highest isoutility curve needs to be the point at the top. If $\beta = 0$, this point obtains when $\gamma^e = 0$, while if $\beta = 1$, it obtains when $\gamma^e = \hat{\gamma}^e$. These two beliefs also maximize the equilibrium level of honesty. Hence, $\gamma^{e**} = \gamma^{e*}$. The result that the optimally believed world is the same with the two objectives for the government and that it does not depend on the actual world is a quite stark conclusion, which, however, does not seem to capture an important feature of economic reality. Interestingly, as we have seen above, this is no more true if we allow for an intermediate degree of transparency.

The final situation to be considered is $\beta \in (0, \beta_0)$. The equilibrium curve is now strictly increasing and strictly concave, and its slope at the top is positive. If $\gamma = 0$, the highest isoutility curve on the equilibrium curve is the horizontal line that touches the top of the equilibrium curve, so $\gamma^{e**} = 0$. Notice how, in that point, the slope of the isoutility curve (zero) is strictly lower than the slope of the equilibrium curve. Hence, by continuity, $\gamma^{e**} = 0$ also for values of γ that are "sufficiently close" to zero. Proposition 4 below says that two cases are actually possible. The first calls for $\gamma^{e**} = 0$ for "low" values of γ (below a threshold, γ^T in Figure 5b) and $\gamma^{e**} > 0$ increasing in γ for larger values of γ (above the threshold). This case clearly obtains when β is "sufficiently close" to β_0.[35] The second case calls for $\gamma^{e**} = 0$ for all values of γ. This case clearly obtains when β is "sufficiently

[35] Let $\beta \in (\beta_0, 1)$. When β tends to β_0, then $\hat{\gamma}^e$ tends to zero. From Proposition 4, γ^{e**} is increasing in γ for all values of γ. In this case, the slope of the equilibrium curve at the top tends to zero, so $\gamma^{e**} = 0$ only when $\gamma = 0$. If we slightly reduce β, such slope becomes moderately positive, so, by continuity, $\gamma^{e**} = 0$ not only when $\gamma = 0$, but also when γ is "sufficiently close" to zero.

close" to zero.[36] Numerical simulations unequivocally suggest that the behavior is quite "regular" for intermediate values of β, so the first case obtains for "high" values of β (above a threshold, β^T in Figure 5a and 5b), while the second case obtains for lower values of β (below the threshold).



(a) $\beta \in (0, \beta^T)$, $\beta^T < \beta_0$ (b) $\beta \in (\beta^T, \beta_0)$ (c) $\beta \in (\beta_0, 1)$

Figure 5: Qualitative illustration of γ^{e**} as a function of γ.

The following proposition shows when the belief that maximizes consumer's expected utility depends on the actual share of honest experts and when it differs from the belief that maximizes the equilibrium level of honesty. Interestingly, the answers to these two questions turn out to be the same, and they crucially depend on the degree of transparency.

Proposition 4. *$\gamma^{e**} \geq \gamma^*$ for all values of β. In particular,*

1. *If either $\beta = 0$ or $\beta = 1$, then $\gamma^{e**} = \gamma^{e*}$, which does not depend on γ.*
2. *If $\beta \in (\beta_0, 1)$, then $\gamma^{e**} > \gamma^{e*}$ for all $\gamma \neq \gamma^{e*}$, with γ^{e**} decreasing in γ for all $\gamma < \gamma^{e*}$ and increasing in γ for all $\gamma > \gamma^{e*}$.*[37]
3. *If $\beta \in (0, \beta_0)$, then either $\gamma^{e**} = \gamma^{e*}$ for all γ or there exists $\gamma^T \in (0, \bar{\gamma})$ such that $\gamma^{e**} = \gamma^{e*}$ for all $\gamma < \gamma^T$ and $\gamma^{e**} > \gamma^{e*}$ increasing in γ for all $\gamma > \gamma^T$.*

Proposition 4 confirms that, even with this second objective, the government might wish to distort beliefs either upward or downward, and to favor or ostracize truthful revelation of information by third parties. The main (important) difference is that if it does not know the state of the world (in the model, the share of honest experts), it might not know which is the *actual* optimally believed world, so its decisions will be based on its (possibly incorrect) beliefs. Government's action could therefore even damage consumers. This can give the government the incentive to invest money for learning the

[36] When β tends to zero, the slope of the equilibrium curve tends to $+\infty$. By continuity, for values of β that are "sufficiently close" to zero, the slope of the equilibrium curve at the top of the curve must exceed the slope of the isoutility curve that passes for that point, so $\gamma^{e**} = 0$ for all γ.

[37] If $\gamma = \gamma^{e*}$, from Proposition 3, $\gamma^{e**} = \gamma^{e*}$.

actual state of the world. There is, however, another reason why the government might benefit from knowing the state of the world, which works with both objectives: whenever known, the government might deem it optimal to make it public in a verifiable manner, thus affecting the beliefs of consumers and experts and, accordingly, their strategies. The next section analyzes such possibility.

6 Information campaigns

In this section, we consider a government that has privately learned the true share γ of honest experts and ponders whether to publicly reveal it in a verifiable manner through an information campaign. Such campaign is assumed to become common knowledge. Consumers and experts then realize that their initial belief γ^e is incorrect, and replace it with the true share γ.[38] We assume that airing an information campaign entails no cost.

6.1 Equilibrium level of honesty

We initially analyze the case where the government aims at maximizing the equilibrium level of honesty. Such government will choose to reveal the true share γ if and only if this raises σ_e. Since σ_e is a concave function of the share of honest experts, the revelation set I_r^* is an interval.

Proposition 5. *The set of values of γ which, whenever observed, would be revealed by a government interested in maximizing the equilibrium value of σ_e is*

$$I_r^* = \{\gamma : \sigma_e(\gamma) > \sigma_e(\gamma^e)\}.$$

Let l be the lowest value of γ^e in the set S when $\beta < \beta_2$, i.e., $l = 0$ if $\beta < \beta_1$ and $l = \underline{\underline{\gamma}}$ if $\beta \in (\beta_1, \beta_2)$, and, for any $\beta \in (\beta_0, \beta_2)$, define as $\tilde{\gamma} \in (\hat{\gamma}^e, \overline{\gamma})$ the unique value such that $\sigma_e(\tilde{\gamma}) = \sigma_e(l)$. Then

1. *$I_r^* = (\gamma^e, b)$, with $\sigma_e(b) = \sigma_e(\gamma^e)$ if $\beta > \beta_0$ and $\gamma^e < \hat{\gamma}^e$.*
2. *$I_r^* = (a, \gamma^e)$, with $\sigma_e(a) = \sigma_e(\gamma^e)$ if either $\beta > \beta_2$ or $\beta \in (\beta_0, \beta_2)$ and $\gamma^e \in (\hat{\gamma}^e, \tilde{\gamma})$.*
3. *$I_r^* = [l, \gamma^e)$ if either $\beta < \beta_0$ or $\beta \in (\beta_0, \beta_2)$ and $\gamma^e > \tilde{\gamma}$.*

The revelation set is thus characterized by either two or one threshold value (respectively, cases 1 and 2 and case 3). Figure 6 assumes that $\beta \in (\beta_1, \beta_2)$, so that all three cases are possible. The same is true if $\beta \in (\beta_0, \beta_1)$, the only difference being that l is no more $\underline{\underline{\gamma}}$ but 0. On the other hand, if $\beta > \beta_2$, only cases 1 and 2 are possible. Finally, if $\beta < \beta_0$, case 3 always obtains.

Proposition 5 gives another key result of the paper. An obvious aim of a public campaign based on verifiable information is to turn incorrect beliefs into correct ones. If such campaign entailed no cost, one could suppose that a government would decide to always air it, while when it is costly,

[38] See Alchourrón et al. (1985) for a discussion on the logic of theory change.

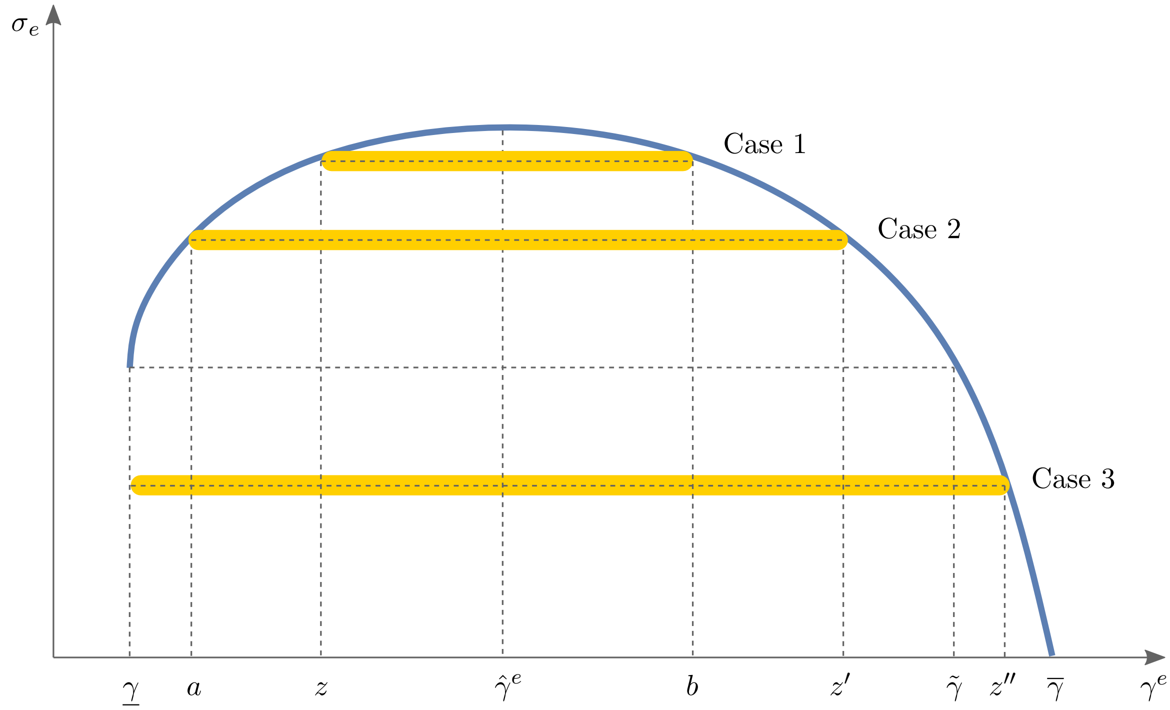


Figure 6: Information campaign maximizing honest behavior (Proposition 5 illustrated).

it would be aired only if beliefs are "sufficiently incorrect". For example, in the introduction, we conjectured that The Lonely Planet chooses to devote some lines of its guide to taxi drivers' behavior in one country only when such behavior differs in a substantial way from the one that is expected by their readers. This should also be true for a government in all decision theory problems that do not involve externalities. However, in decision theory problems with externalities and in games, a government might wish that people have incorrect beliefs. This is exactly what happens in our model (Propositions 2 and 4). As a consequence, such government might prefer that people maintain their initial beliefs, even when correcting them would entail no cost.

Proposition 5 says that an information campaign will be aired if and only if the true value of γ is "closer" to γ^{e*} than the belief γ^e.[39] The degree of "incorrectness" of beliefs plays therefore no role whatsoever. For example, in Figure 6, if $\gamma^e = z$, any value of γ between z and b (which could also be very close to z) would be revealed, while any value above b (a clearly "more incorrect" belief) would *not* be revealed.

Introducing in the model a positive cost for the information campaign would call for the government to be able to compare in some way an increase in the equilibrium level of honesty with a monetary cost. Whatever the modeling choice, it is clear that such extension would lead the set I_r^* to shrink. The

[39] The term "closer" must be interpreted in a literal way in two cases: (i) when $I_r^* = [l, \gamma^e)$; (ii) when $\beta = 1$. In the other cases, the intervals $I_r^* = (a, \gamma^e)$ and $I_r^* = (\gamma^e, b)$ contain γ^{e*}, but they are not exactly centered around it. In these cases, the term "closer" must be interpreted in a looser way.

degree of "incorrectness" would now play a role: shares that are sufficiently close to the believed ones would not be revealed, since the benefit of a campaign would fall short of the cost. However, shares that are sufficiently distant from the believed ones would also not be revealed. Hence, interpreting the revelation set with a costly information campaign in terms of how much initial beliefs are "incorrect" is misleading. What really matters is whether the actual world is "sufficiently closer" to the optimally believed world as compared to the initially believed one.

6.2 Consumer's expected utility

We now analyze the case where the government is interested in consumer's expected utility. Figure 7 refers to the case where $\beta \in (\beta_2, 1)$. Similar figures can be drawn for the other values of β.

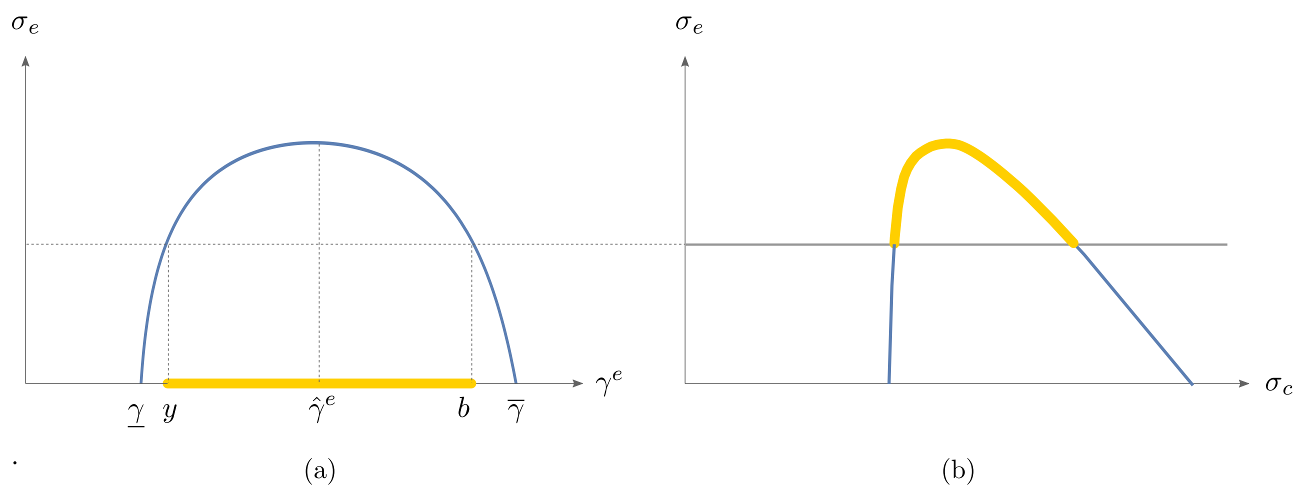


Figure 7: Information Campaign maximizing consumer welfare.

Suppose that the *actual* share of honest experts is $\gamma = y$ in Figure 7a. If such share was revealed by the government, consumers would reach the horizontal isoutility line drawn in Figure 7b. All the values of γ^e that lead to a point on the bold part of the equilibrium curve would let consumers reach a higher isoutility curve. Hence, a government interested in maximizing consumer's expected utility would choose *not* to reveal the value of γ if γ^e leads to a point on the bold part of the equilibrium curve (Figure 7b), *i.e.*, if $\gamma^e \in (y, b)$, with b such that $\sigma_e(b) = \sigma_e(y)$ (Figure 7a), and to reveal it otherwise. This conclusion can be rephrased as follows. A government interested in maximizing consumer's expected utility would choose to *reveal* the value of γ if and only if this raises the equilibrium level of honesty. This explains the following proposition.

Proposition 6. *Let I_r^{**} be the set of values of γ which, whenever observed, would be revealed by a government interested in maximizing consumer's expected utility. Then $I_r^{**} = I_r^*$.*

Proposition 6 says that the revelation set is the same with both government's objectives. Hence, a government might deem it optimal to hide an available information, because revealing it would damage the consumer. An authority that pursues the interest of consumers may thus legitimately withhold relevant information.

It is worth concluding the section with a brief remark on how the parameters of the models, in particular prices, affect the revelation set. In case 3, which always obtain when $\beta < \beta_0$, an information campaign is aired if and only if $\gamma < \gamma^e$. Hence, somehow paradoxically, all the parameters of the model, which have a great influence on the degree of overtreatment, do not play any role in government's decision, at least if one takes γ and γ^e as given. However, we think that, for example, an increase in $\bar{p} - \underline{p}$ should lead both γ and γ^e to decrease. It is then possible that an information campaign is aired in a country with a larger markup and not in a country with a smaller markup. This may occur, for example, if the belief γ^e is not quite different among countries, as we suggested it might be the case for people who take a taxi in a foreign country on which they have no detailed information [on taxi drivers' behavior.] More generally, it may occur if γ is more sensitive than γ^e to an increase in the difference in prices. This could not be an unreasonable assumption in the health sector: many consumers tends to be reluctant to believe that a doctor could provide an unnecessary treatment just to earn more money, while more doctors might be willing to violate the Hippocratic Oath for a larger monetary stake. Of course, we do not have a theory of how beliefs are formed, so it is fair to say that our model also allows for the possibility that an information campaign is aired in a country with a smaller markup and not in a country with a larger markup. Interestingly, in cases 1 and 2, which always obtain when $\beta > \beta_2$, the parameters of the model affect the revelation set. For example, if $\beta = 1$, it is easy to see that if $\gamma^e < \hat{\gamma}^e$ (case 1), an increase in $\bar{p} - \underline{p}$ leads the revelation set to shrink, while the opposite is true if $\gamma^e > \hat{\gamma}^e$ (case 2).[40] This result suggests that even for given γ and γ^e, it is possible that an information campaign is aired in one country but not in another country, simply because the two countries have a different price structure. It is not however possible to draw clearcut conclusions on the countries where an information campaign is more likely to occur, unless we know how the belief γ^e relates not only to the actual world γ, but also to the optimally believed world $\gamma^{e*} = \hat{\gamma}^e$.

7 Evidence

This section discusses the campaign carried out in Canton Ticino. It also reinterprets experimental data from Mimra et al. (2016), providing a first raw empirical test of our theory.

[40] These results follow immediately from the following two facts: (i) $\hat{\gamma}^e$ is decreasing in $\bar{p} - \underline{p}$; (ii) if $\beta = 1$, then $\sigma_e(\gamma^e)$ is symmetric around $\gamma^e = \hat{\gamma}^e$.

7.1 The Swiss campaign.

Domenighetti et al. (1988) claim that their study yields the first convincing evidence that publicity by the mass media can change professional practices and reduce overtreatment rates.

In 1982, the hysterectomy rate per 100 000 women in Canton Ticino, Switzerland, was almost double that of the West Midlands in the UK, and 74% of hysterectomies had related cancer indications (stage II-IV). Moreover, hysterectomy rates in the zones within the canton were highly correlated with the number of gynaecologists and surgical beds. This seems to suggest that not all hysterectomies were really needed. From February to October 1984, a public information campaign was run in the mass media in Canton Ticino. Some newspaper headlines were: "Too many uteri removed in Ticino?" and "Is the number of hysterectomies in Ticino exaggerated?". One daily newspaper advised women to seek a second opinion. These suggestive messages were generally complemented by data initially presented at a scientific conference in Zürich by Domenighetti and colleagues and later to the press. In some cases, the information was restricted to the presentation of the data. The public information campaign proved to be very effective. After the start of the campaign and during the following year the annual rate of operations per 100 000 women of all ages dropped by 25.8%, whereas in the reference area (Canton Bern, Switzerland), where no information was given to the public, hysterectomy rates increased by 1%. Domenighetti et al. (1988) conclude that such campaign may have compelled doctors, who can usually manipulate demand, to be more careful in their evaluation and possibly to better perform their natural role, which should be that of an agent and trustee of the patient.

The Canton Ticino campaign can be read through the lenses of our model as follows. Let

$$H(g) = \eta + (1-\eta)(1-g)(1-\sigma_e)\Big(1-\sigma_c+\sigma_c(1-g)\big(\beta+(1-\beta)(1-\sigma_e)\big)\Big), \tag{11}$$

decreasing in g. $H(\gamma)$ and $H(\gamma^e)$ represent, respectively, the actual and the believed hysterectomy rate. The information campaign described above seems to suggest that $H(\gamma) > H(\gamma^e)$, which obtains if and only if $\gamma < \gamma^e$. According to our model, the implicit message of the information campaign was therefore that doctors were less honest than people believed.

The information campaign in Canton Ticino was very effective in reducing the hysterectomy rate. From Proposition 5, revealing that $\gamma < \gamma^e$ can actually "help doctors become better doctors" (Domenighetti et al. (1988)) only if $\gamma^e > \gamma^{e*}$ (case 2 or case 3). Moreover, in case 2, the value of γ should also not be too low. Hence, our analysis suggests that an information campaign, even if costless, should not always be implemented, because it might even magnify the overtreatment inefficiency.

7.2 Taking our theory to Mimra et al. (2016)'s data.

Mimra et al. (2016) test the predictions of Süzle and Wambach (2005)'s model under the additional assumption of liability, which turns the inefficiency from overcharging into overtreatment and otherwise changes none of the predictions in terms of equilibrium behavior. This amounts to test exactly our model under the parameter restrictions $\beta = 0$ and $\gamma^e = 0$, the latter descending from the fact that there are no honest types in Süzle and Wambach (2005) ($\gamma = 0$ is common knowledge).

In one control treatment, coded as $SO_7^{\text{Obs.}}$, the authors inform experts about their visit order ($\beta = 1$ in our setting) and test the equilibrium prediction that the rate of overtreatment in the second visit is 100%, *i.e.*, $\sigma_e = 0$ in our notation.[41] However, they experimentally find that such rate is only 58.16%, which, according to our theory, implies that the share of honest experts is $\gamma = 0.4184$. Such a high amount of honest behavior seems therefore to contradict the hypothesis of pure self-interest and justify our assumption that $\gamma > 0$. If we assume that $\gamma = 0.4184$, we can further ask to what extent adding (possibly incorrect) beliefs about honesty enhances the predictive power of the model.

To see the importance of beliefs, turn to session SO_7. The data presented by the authors display a degree of overtreatment in strategy of 0.527, meaning that physicians facing a minor problem overtreat patients roughly half of the times. According to our theory, only dishonest types overtreat light-ill patients, and they do so with probability $1 - \sigma_e$. This implies $0.527 = (1 - \gamma)(1 - \sigma_e)$. Note that a dishonest physician's strategy, σ_e, depends in a crucial way on the belief about honest types, γ^e (see Figure 2). We then ask, given γ from the control session $SO_7^{\text{Obs.}}$, which belief, if any, would satisfy the above equation and predict the overtreatment in strategy observed in the lab. This exercise shows that the only equilibrium of our model generating such rate is the low-fraud mixed strategy equilibrium with belief $\gamma^e = 0.9139$.[42] This value is way above zero, suggesting that the assumption of commonly known pure selfishness heavily constraints the theory's ability to explain real behavior.

8 Large markup

We have so far analyzed the case of a small markup (Assumption (A2)). In this model, prices are given, so the case of a larger markup cannot easily be dismissed. For example, in the case of taxi drivers, the extra profit from overtreatment clearly depends on the tariff system, which is often determined by public authorities at a national level, but also on the waiting time for the next passenger, which greatly varies between cities and hours of the day. For a given tariff system, when the waiting time is sufficiently long, the markup might well exceed the threshold we have considered so far. In fact, such possibility cannot easily be dismissed even when prices are determined by market forces. For example, it seems almost unavoidable that the profit for an hospital from an unnecessary surgery,

[41] In the main treatment SO_7, as well as in the control treatment $S_7^{\text{Obs.}}$, they assume (our notation): $\eta = 0.25$, $t = 7$, $\overline{p} = 117$, $\underline{p} = 75$, $\overline{c} = 80$, $\underline{c} = 60$. Hence $x = 0.5714 < 0.5724 = \frac{1}{2-\underline{\gamma}}$ (low mark-up) with $\underline{\gamma} = 0.2531$ and $\overline{\gamma} = 0.9219$.

[42] Note that this value is lower than $\overline{\gamma}$. It is also larger than $\underline{\gamma}$, which, according to our theory (see Lemma 1 and Footnote 20), implies that that the high-fraud equilibrium does not exist.

which also implies a series of medical examinations, far outweighs the profit of a single examination that leads to the prescription of some drugs. The case of a larger markup is actually interesting: in some circumstances it better fits the real world, and sometimes it leads to "more realistic" results, as we will show below.

In this section, we assume that the markup on the major intervention is sufficiently larger than the markup on the minor intervention (henceforth, *large* markup case):

$$x > \frac{1}{2-\overline{\gamma}} \tag{A3}$$

This assumption guarantees that if $\beta = 0$ (implicit standard assumption in the literature), then σ_c given by (7) is greater than one for any γ^e, and the unique equilibrium of the game is $\sigma_e = 0$ and $\sigma_c = 0$.[43] The mixed strategy equilibrium might however still exist for larger values of β. Transparency might therefore induce experts to behave in a more honest way.

The next proposition characterizes the equilibrium that maximizes σ_e in the large markup case.

Proposition 7. *Let $\tau < \tau_{\max}$ and $x > \frac{1}{2-\overline{\gamma}}$. There exist $0 < \beta_1' < \beta_2' < 1$ and $\underline{\gamma} < \underline{\underline{\gamma}}' < \overline{\gamma}$ such that $(\beta, \gamma^e) \in S'$ if and only if*[44]

$$\gamma^e \in \begin{cases} \left[\underline{\underline{\gamma}}', \overline{\gamma}\right] & \text{if} \quad \beta \in \left(\beta_1', \beta_2'\right) \\ \left[\underline{\gamma}, \overline{\gamma}\right] & \text{if} \quad \beta > \beta_2' \end{cases} \tag{12}$$

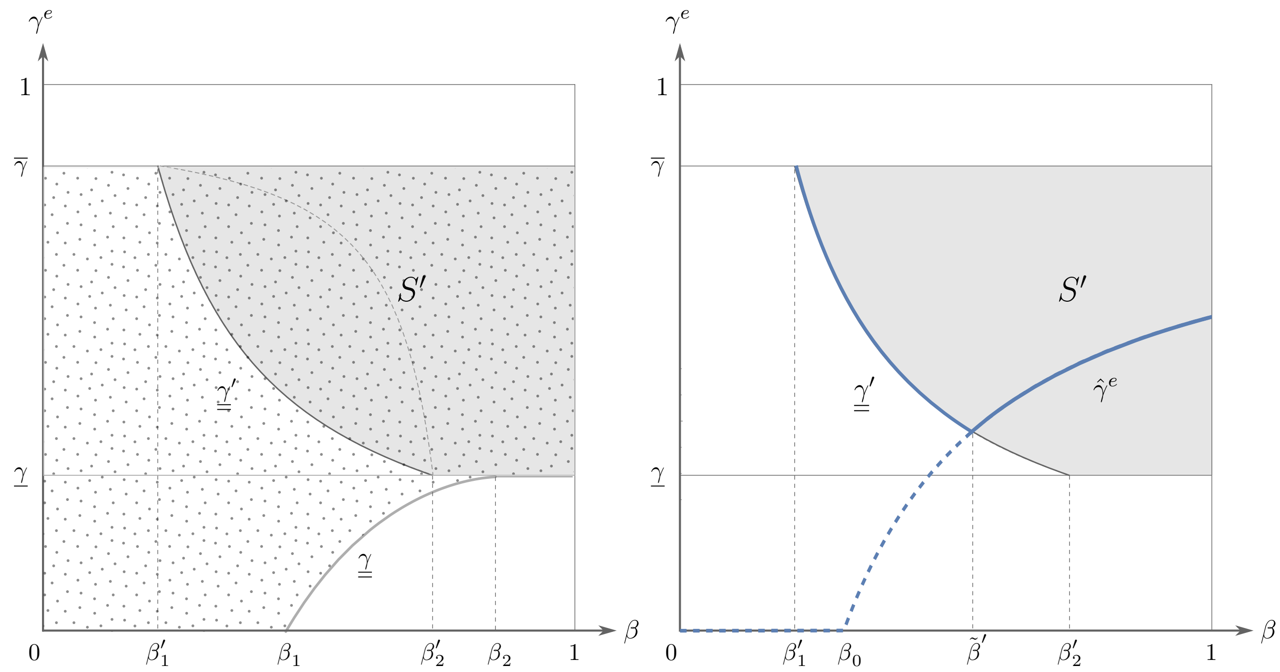
1. *If $(\beta, \gamma^e) \in S'$, the equilibrium that maximizes σ_e is the mixed strategy equilibrium given by equations (3) and (7).*
2. *If $(\beta, \gamma^e) \notin S'$, the unique equilibrium of the game calls for $\sigma_e = 0$, with $\sigma_c = 0$ if either $\gamma^e < \underline{\gamma}$ or $\gamma^e > \overline{\gamma}$, and $\sigma_c = 1$ if $\gamma^e \in \left(\underline{\gamma}, \overline{\gamma}\right)$.*

The shaded area of Figure 8a illustrates the set S', while the dotted area represents set S (Lemma 1).[45] From Lemma 1, the mixed strategy given by (3) exists if and only if $(\beta, \gamma^e) \in S$. In the small markup case, if $(\beta, \gamma^e) \in S$, then σ_c given by (7) is lower than one. Hence, the condition $(\beta, \gamma^e) \in S$ is both necessary and sufficient for the existence of the mixed strategy equilibrium. In the large markup case, the condition $\sigma_c < 1$ puts additional constraints on the set of parameters that allow for the mixed strategy equilibrium to exist: $S' \subset S$. In particular, such equilibrium does not

[43] The remaining case, characterized by an *intermediate* markup, is only treated in the Appendix.

[44] The mathematical expressions are in the Appendix. Note that $\underline{\gamma}$ and $\overline{\gamma}$ only depend on τ and η, β_1' and β_2' also depend on x, and $\underline{\underline{\gamma}}'$ also depends on β, with $\underline{\underline{\gamma}}'(\beta_1') = \overline{\gamma}$, $\underline{\underline{\gamma}}'(\beta)$ decreasing in β and $\underline{\underline{\gamma}}'(\beta_2') = \underline{\gamma}$ (see Figure 8a).

[45] As in Figure 1, we let $\tau = 0.1$ and $\eta = 0.48$. Moreover, in Figure 8a, we let $x = 0.92$, so that $\beta_1' = 0.26$ and $\beta_2' = 0.89$. In the shaded area to the right of the dotted concave curve, (3) and (7) is the unique equilibrium of the game, while in the remaining part of the shaded area, in addition to such equilibrium, there exist two other equilibria, which are characterized by a lower value of σ_e: a pure strategy equilibrium $\sigma_e = 0$ and $\sigma_c = 1$ and a semi-mixed strategy equilibrium $\sigma_e \in (0, 1)$ and $\sigma_c = 1$. To the best of our knowledge, these equilibria are new to the literature, but since they are Pareto dominated by the equilibrium (3)–(7), we focus on the latter.



(a) Set S' and S (dotted area)

(b) γ^e that maximizes σ_e

Figure 8: Existence region and most disciplining equilibrium belief under large markup.

exist if γ^e and/or β are small. When γ^e and/or β are small, it is relatively likely that the unaware expert is the second expert (eq. (5)), so the expert has a great incentive to try to obtain the much larger markup by overtreating the consumer. Hence, $\sigma_e = 0$. As a consequence, the consumer benefits from a second opinion only if the issue is minor and the second expert is honest (first motive). If $\gamma^e < \underline{\gamma}$, it is relatively unlikely that the second expert is honest, so $\sigma_c = 0$. On the other hand, if $\gamma^e \in \left(\underline{\gamma}, \overline{\gamma}\right)$, the value of the second opinion is relatively high, so $\sigma_c = 1$.

The first important difference between small and large markup cases is the role of transparency in the existence of the mixed strategy equilibrium. From Proposition 1 (see Figure 1), in the small markup case, transparency plays a role only when $\gamma^e < \underline{\gamma}$, in which case the desired equilibrium obtains only if β is sufficiently low. On the other hand, from Proposition 7 (see Figure 8a), in the large markup case, transparency plays a role only when $\gamma^e \in \left(\underline{\gamma}, \bar{\gamma}\right)$, in which case the mixed strategies equilibrium obtains only if β is sufficiently high. Transparency can therefore play both a negative and a positive role, according to the degree of transparency. In particular, notice that in the stark choice between the two polar cases considered in the literature, no transparency ($\beta = 0$) is preferred in the small markup case, while full transparency ($\beta = 1$) is preferred in the large markup case. Notice also that in the large markup case, the possibility of a second opinion has a positive disciplining effect on experts only when $\gamma^e > \underline{\gamma}$. If consumers and experts think that it is very unlikely that experts are honest, consumers will never ask for a second opinion and, accordingly, experts will always overtreat them. Hence, the existence of both transparency and honest experts are necessary in the large markup case in order to avoid such uninteresting outcome.

Lemma 2 characterizes the value of γ^e that maximizes σ_e. In the large markup case, there are however values of γ^e where σ_e exists, but the mixed strategy equilibrium does not obtain (set $S - S'$). The results of Lemma 2 applied to the set S' say that as long as $(\beta, \hat{\gamma}^e) \in S'$ (condition $\beta > \tilde{\beta}'$ in Proposition 2 below), the belief that maximizes the equilibrium level of honesty is $\hat{\gamma}^e$, while when $(\beta, \hat{\gamma}^e) \notin S'$, the value that maximizes σ_e (*i.e.*, $\hat{\gamma}^e$) exceeds the minimum value of γ^e such that the mixed strategy equilibrium exists (*i.e.*, $\underline{\underline{\gamma}}'$).[46] In the latter case, the belief that maximizes the equilibrium level of honesty $\underline{\underline{\gamma}}'$, since σ_e is decreasing in γ^e for all $\gamma^e > \hat{\gamma}^e$.

Proposition 8. *Let $\tau < \tau_{max}$, $x > \frac{1}{2-\overline{\gamma}}$, $\tilde{\beta}' \in (\beta_1', \beta_2')$ be the unique value such that $\underline{\underline{\gamma}}' = \hat{\gamma}^e$ and γ^{e*} be the belief that maximizes the equilibrium value of σ_e.*

1. *If $\beta < \beta_1'$, then $\gamma^{e*} = [0, 1]$, since $\sigma_e = 0$ for any γ^e.*
2. *If $\beta \in \left(\beta_1', \tilde{\beta}'\right)$, then $\gamma^{e*} = \underline{\underline{\gamma}}'$.*
3. *If $\beta > \tilde{\beta}'$, then $\gamma^{e*} = \hat{\gamma}^e$.*

Figure 8b describes the optimal belief γ^{e*} in both the small markup case (dotted line for $\beta < \tilde{\beta}'$, continuous increasing curve for $\beta > \tilde{\beta}'$) and the large markup case (continuous curve, decreasing for $\beta \in \left(\beta_1', \tilde{\beta}'\right)$ and increasing for $\beta > \tilde{\beta}'$). The second important difference between small and large markup cases is therefore that in the latter case, γ^{e*} is not monotone in β.

In this paper, we have considered β as a parameter and we have characterized the belief γ^e that maximizes either the equilibrium level of honesty or the consumer's expected utility. Assume now just for a moment that the government could choose both β and γ^e. In the small markup case, it is easy to see that a government that maximizes the equilibrium level of honesty would choose $\beta = 0$ and $\gamma^e = 0$, a quite stark but not too "realistic" conclusion that would lead us to the assumptions that are often made in the literature. Interestingly, this is no more true in the large markup case, where such government would always choose a positive value of both β and γ^e.

9 Conclusion

We have built a model of credence goods where people might have incorrect beliefs on the share of honest experts and have shown that the belief that maximizes social welfare, measured by consumer's expected utility, generically differs from the actual share. We have also studied when a government, in the interest of consumers, chooses either to reveal or to conceal some verifiable information and we have shown that this does not depend on how wrong beliefs are, but rather on whether the additional

[46] In fact, this calls for $\beta > \beta_1'$, since otherwise, in equilibrium, $\sigma_e = 0$ for all $\gamma^e \in [0, 1]$, so beliefs have no effects on the equilibrium level of honesty.

information induces more or less discipline by the experts. We think that these two features of the model are not only relevant in credence goods market. For example, a government might deem it optimal to let people think that smoking damages health more than it actually does, or that it is more likely to be affected by Covid-19 than it actually is. An interesting extension of our model, as well as of these potentially similar models, would be to study the decision of the government, or of the mass media, to choose between possibly competing verifiable information. For example, if two articles on the same topic are recently published on *Nature*, the government or the mass media could choose to publicize both of them, or only one, or none of them.

A second topic that could deserve further investigation is transparency. In our model, the role of transparency, although very important, was somehow indirect and instrumental. On the one hand, it allowed us to obtain the quite realistic conclusion that the optimal belief need not necessarily be zero. On the other hand, in the large markup case, the possibility of seeking a second opinion has a disciplining effect on dishonest experts only if there is some transparency. However, we think that there could be other channels that would lead consumers to benefit from the expert being aware that they have already obtained a first opinion. For example, if experts have only a limited knowledge of the action needed to fix a problem, or if such knowledge depended on the level of some costly effort, this might improve their diagnosis. A suggestive way of praising for complete transparency is to modify the tie-breaking rule used in the literature and in our model that if the consumer receives the same diagnosis from two experts, she will hire the second consulted expert. If it is common knowledge that she will come back to the first expert, when the second expert is aware to be the second, he will always propose the correct treatment. Indeed, if the problem is major, he will propose the major treatment in order to fix the problem, while if it is minor, he will propose the minor treatment in order not to lose the customer. Hence, the higher is transparency, the more likely is a honest behavior by the second expert. Of course, coming back to the first expert might be costly and the possibility of commitment is hardly realistic. However, we think that the analysis of transparency in credence good markets might give additional interesting insights.

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Appendix

To prove Lemma 1 and subsequent results we proceed by proving first a series of lemmas.

Lemma 1.1. *Recall τ_{max} from (A1) and let*

$$\underline{\gamma} \equiv \tfrac{1+\tau}{2} - \sqrt{\left(\tfrac{1+\tau}{2}\right)^2 - \tfrac{\tau}{1-\eta}} \quad \text{and} \quad \overline{\gamma} \equiv \tfrac{1+\tau}{2} + \sqrt{\left(\tfrac{1+\tau}{2}\right)^2 - \tfrac{\tau}{1-\eta}}. \tag{A1}$$

There exists an equilibrium in which $\sigma_e = \sigma_c = 0$ if

1. *$\tau > \tau_{max}$, in which case it is the unique equilibrium of the second opinion game.*
2. *$\tau < \tau_{max}$ and $\gamma^e \notin \left(\underline{\gamma}, \overline{\gamma}\right)$.*

Proof of Lemma 1.1. Consider first $\tau > \tau_{max}$. Since the maximum benefit attainable from hearing a second opinion falls short of the cost, it must be $\sigma_c = 0$. As a consequence, an unaware dishonest expert infers that no second opinion will be asked and sets $\sigma_e = 0$.
Consider now the opposite case $\tau < \tau_{max}$. As argued above, if $\sigma_c = 0$, then it must be $\sigma_e = 0$ in equilibrium. But then, plugging $\sigma_e = 0$ into (2) and rearranging, the consumer is willing not to hear a second opinion if, and only if,

$$\tau > \frac{\gamma^e \left(1-\gamma^e\right)\left(1-\eta\right)}{1-\gamma^e\left(1-\eta\right)} \Longleftrightarrow \gamma^e \notin \left(\underline{\gamma}, \overline{\gamma}\right).$$

Lemma 1.2. *Let $\tau < \tau_{max}$ and $\sigma_c = 1$ in equilibrium. Then it must be $\sigma_e < 1$.*

Proof of Lemma 1.2. Suppose not, that is $\sigma_e = 1$ in equilibrium. Then, using (1), $\Pr\left(\text{min.}|\overline{p}\right) = 0$ so that the consumer expects no good from hearing a second opinion and sets $\sigma_c = 0$, contradicting the assumed equilibrium behavior. Hence, it must be $\sigma_e < 1$.

Lemma 1.3. *Let $\tau < \tau_{max}$ and $\sigma_c = 1$ in equilibrium. Then $\sigma_e = 0$ is an equilibrium if, and only if,*

$$x > \frac{1}{2-\underline{\gamma}} \wedge \gamma^e \in \left(\underline{\gamma}, \overline{\gamma}\right) \wedge \beta < \beta'' \quad \text{with} \quad \beta'' \equiv 1 - \frac{1}{1-\gamma^e}\frac{1-x}{x}. \tag{A2}$$

Proof of Lemma 1.3. From (2) with $\sigma_e = 0$ and τ as defined in (A1), the consumer asks for a second opinion with certainty as long as $\tau < \frac{(1-\eta)\gamma^e(1-\gamma^e)}{1-\gamma^e(1-\eta)}$, which is true if, and only if, $\gamma^e \in \left(\underline{\gamma}, \overline{\gamma}\right)$. Note that $\max\limits_{\gamma^e} \frac{(1-\eta)\gamma^e(1-\gamma^e)}{1-\gamma^e(1-\eta)} = \tau_{max}$ so that the expressions in (A1) are well defined as long as $\tau < \tau_{max}$. From (6) taken with $\sigma_c = 1$ and $\sigma_e = 0$, the unaware expert's benefit from cheating is larger than that from honest reporting — i.e., the RHS exceeds the LHS of (6) — as long as $\gamma^e < 1 - \frac{1}{1-\beta}\frac{1-x}{x}$. (A2) follows from joining the constraints.

Lemma 1.4. *Let $\tau < \tau_{max}$ and $\sigma_c = 1$ in equilibrium. Then there exists an equilibrium in which the expert randomizes with*

$$\sigma_e = 1 - \frac{1}{\left(1-\gamma^e\right)\left(1-\beta\right)}\frac{1-x}{x} \tag{A3}$$

if, and only if,

$$\beta \begin{cases} < \beta' & \text{if} \quad x \in \left(\frac{1}{2-\underline{\gamma}}, \frac{1}{2-\overline{\gamma}}\right) \wedge \gamma^e < \underline{\gamma} \\ < \beta'' & \text{if} \quad x \in \left(\frac{1}{2-\underline{\gamma}}, \frac{1}{2-\overline{\gamma}}\right) \wedge \gamma^e > \underline{\gamma} \\ \in \left(\beta', \beta''\right) & \text{if} \quad x > \frac{1}{2-\overline{\gamma}} \end{cases} \tag{A4}$$

with

$$\beta' \equiv 1 - \frac{\gamma^e - \left(\frac{1-x}{x} + \tau\right)}{\gamma^e - \left(1 - \tau\frac{\eta}{1-\eta}\frac{x}{1-x}\right)} \quad \textit{and} \quad \beta'' \equiv 1 - \frac{1}{1-\gamma^e}\frac{1-x}{x}. \tag{A5}$$

Proof of Lemma 1.4. From (6) taken with $\sigma_c = 1$, (A3) follows immediately. Strategy σ_e is clearly below one and it is positive as long as

$$\beta < \beta'' \quad \text{with} \quad \beta'' > 0 \Longleftrightarrow \gamma^e < \gamma_3 \equiv 2 - \frac{1}{x}. \tag{A6}$$

Hence, the equilibrium exists only if $\gamma^e < \gamma_3$, a condition which will be exploited later in the proof. As to the consumer, plugging (A3) into (1) and (2), since in the candidate equilibrium she strictly prefers to ask for a second opinion, it must hold

$$\tau < \frac{1 - \beta\left(1-\gamma^e\right) - \frac{1-x}{x}}{1 + (1-\beta)\frac{\eta}{1-\eta}\frac{x}{1-x}} \Longleftrightarrow \beta \begin{cases} < \beta' & \text{if} \quad \gamma^e < \gamma_1 \\ > \beta' & \text{if} \quad \gamma^e > \gamma_1 \end{cases} \quad \text{with} \quad \gamma_1 \equiv 1 - \tau\frac{\eta}{1-\eta}\frac{x}{1-x}, \tag{A7}$$

where the implications follow from tedious algebra. Hence, provided $\gamma^e < \gamma_3$, the necessary and sufficient conditions for the equilibrium to exist are

$$\beta \begin{cases} < \min\left\{\beta', \beta''\right\} & \text{if} \quad \gamma^e < \gamma_1 \\ \in \left(\beta', \beta''\right) & \text{if} \quad \gamma^e > \gamma_1 \end{cases}$$

We still need to show when the above conditions can be satisfied and how they map into the domain of x. We begin with characterizing the parametric restrictions under which (A7) is void, trivial or biting. To this end we shall rewrite

$$\beta' \equiv 1 - \frac{\gamma_2 - \gamma^e}{\gamma_1 - \gamma^e} \quad \text{with} \quad \gamma_2 \equiv \frac{1-x}{x} + \tau. \tag{A8}$$

Figure 9a depicts γ_1 and γ_2 in the unit square (x, γ^e). One shall notice that, if $\tau < \tau_{max}$, then γ_1 and γ_2 cross in the well defined interior points $\left(\frac{1}{2-\underline{\gamma}}, \overline{\gamma}\right)$ and $\left(\frac{1}{2-\overline{\gamma}}, \underline{\gamma}\right)$ as depicted in Figure 9a. Based on (A7), for pairs (x, γ^e) in areas with subscript 1 (resp. 2) it must be $\beta < \beta'$ (resp. $>$) since $\gamma^e < \gamma_1$ (resp. $>$). Using (A8), in A areas (white) condition (A7) is always satisfied ($\beta' > 1$ in A_1 and $\beta' < 0$ in A_2). In C areas (dark grey) condition (A7) is never satisfied ($\beta' < 0$ in C_1 and $\beta' > 1$ in C_2). Finally, in B areas the condition is binding since $\beta' \in (0, 1)$.

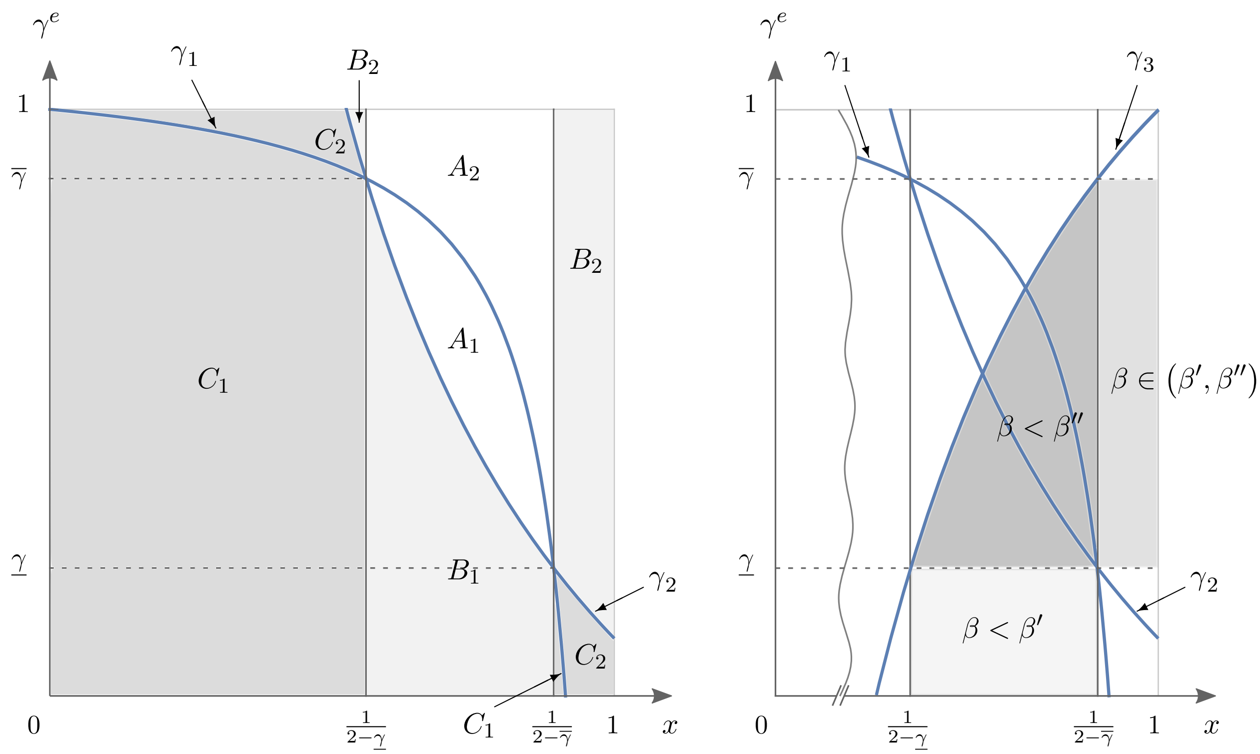
We shall now compare β' to β'' to evaluate conditions (A6) and (A7) in A and B areas. Simple algebra yields

$$\beta' < \beta'' \Longleftrightarrow \frac{\left(\gamma^e\right)^2 - (1+\tau)\gamma^e + \frac{\tau}{1-\eta}}{\gamma_1 - \gamma^e} > 0. \tag{A9}$$

It can be easily shown that the numerator of (A9) is positive if, and only if, $\gamma^e \notin \left(\underline{\gamma}, \overline{\gamma}\right)$.

To proceed with the proof it is convenient to plot γ_3 along with γ_1 and γ_2. Figure 9b plots the three curves and the surrounding areas slicing out the left hand side areas of Figure 9a in which (A7) never holds, to concentrate on the relevant areas in which it may hold. We shall notice that, for any admissible value of the parameters, $\gamma_3 = \underline{\gamma}$ (resp. $\gamma_3 = \overline{\gamma}$) when $x = \frac{1}{2-\underline{\gamma}}$ (resp. $x = \frac{1}{2-\overline{\gamma}}$). Notice further that the names of the areas in Figure 9b are the same as those of Figure 9a and are omitted for clarity.

Consider area A_1, where $\gamma^e < \gamma_1$ so that by (A7) it must be $\beta < \beta'$, trivially satisfied since $\beta' > 1$.



(a) Condition (A7).

(b) Conditions (A7) and (A6).

Figure 9: Parametric restrictions with $\tau = 0.1$ and $\eta = 0.48$.

Clearly, $\min\{\beta', \beta''\} = \beta''$. To satisfy $\beta < \beta''$ it must be $\beta'' > 0$, that is $\gamma^e < \gamma_3$. See dark grey part of area A_1 in Figure 9b.

Consider area A_2, where $\gamma^e > \gamma_1$ so that by (A7) it must be $\beta > \beta'$ trivially satisfied since $\beta' < 0$. To satisfy $\beta < \beta''$ it must be that $\beta'' > 0$, which requires $\gamma^e < \gamma_3$. See dark grey part of area A_2 in Figure 9b.

Consider area B_1, where $\gamma^e < \gamma_1$ so that by (A7) it must be $\beta < \beta' \in (0,1)$. Using (A9),

$$\min\{\beta', \beta''\} = \begin{cases} \beta' & \text{if} \quad \gamma^e < \underline{\gamma} \\ \beta'' & \text{if} \quad \gamma^e > \underline{\gamma} \end{cases}$$

So, taking into account the constraint (A6) ($\beta'' > 0$), in B_1 above $\underline{\gamma}$ and below γ_3 it must be $\beta < \beta''$ (dark grey part of area B_1) while below $\underline{\gamma}$ it must be $\beta < \beta'$ (pale grey part of area B_1).

Consider now B_2 areas, where $\gamma^e > \gamma_1$ so that by (A7) it must be $\beta > \beta' \in (0,1)$. Since it must also be $\beta < \beta''$, it has to be that $\beta'' > \beta'$, which, according to (A9), mandates $\gamma^e \in (\underline{\gamma}, \overline{\gamma})$, which excludes the top left part of area B_2 and the top (above $\overline{\gamma}$) and bottom (below $\underline{\gamma}$) slices of the rightward part of area B_2. See the medium grey part of area B_2 in Figure 9b.

Hence, the results summarized in Figure 9b imply that the equilibrium with $\sigma_c = 1$ and σ_e given by (A3) exists if, and only if, (A4) holds.

We now proceed to characterize fully mixed strategy Nash equilibria of the second opinion game. We assume $\tau < \tau_{max}$ throughout. If the consumer mixes in equilibrium, then (2) holds. If $\beta < 1$ the latter can be expressed as a second degree polynomial in γ^e which admits the solutions

$$\sigma_e = 1 - \frac{f \pm \sqrt{f^2 - g}}{2(1-\gamma^e)(1-\beta)} \quad \text{with} \quad f \equiv 1 - \beta\,(1-\gamma^e) - \tau \quad \text{and} \quad g \equiv 4\tau\,(1-\beta)\,\frac{\eta}{1-\eta}. \tag{A10}$$

If $\beta = 1$ (A10) is not defined, and solving for (2) yields the unique solution

$$\sigma_e = 1 - \frac{\tau}{(1-\gamma^e)\,(1-\eta)\,(\gamma^e - \tau)}, \tag{A11}$$

which is the limit for $\beta \to 1$ of the higher solution in (A10). Because of this, in what follows we will treat the case $\beta = 1$ together with the case of the higher solution in (A10), for all values of β.

Lemma 1.5. *Suppose an equilibrium with $\sigma_c \in (0,1)$ and $\sigma_e \in (0,1)$ exists. Then, a necessary and sufficient condition for σ_e to be well defined and lower than 1 is*

$$\gamma^e > \underline{\underline{\gamma}} \equiv 1 - \frac{1 - \tau - \sqrt{4\tau\,(1-\beta)\,\frac{\eta}{1-\eta}}}{\beta}. \tag{A12}$$

Proof of Lemma 1.5. From (A10), if $f^2 > g$, then $\sigma_e < 1$ exists if, and only if, $f > 0$. But then, from $f \in (0,1)$ and $g > 0$, we must have $f > f^2 - g > 0$. Note now that $f^2 - g$ can be expressed as a quadratic function of γ^e with positive coefficient on the second degree term. Hence, since f is positive and increasing in γ^e, the only solution to $f^2 - g > 0$ which satisfies $f > f^2 - g > 0$ calls for γ^e to exceed the larger solution to $f^2 - g = 0$, which is $\underline{\underline{\gamma}}$.

Lemma 1.6. *Let (A12) hold. Then the higher solution in (A10) (with $-$ sign) is positive if, and only if, one of the conditions in (4) of Lemma 1 holds.*

Proof of Lemma 1.6. Rearranging the larger solution in (A10),

$$\sigma_e > 0 \iff \sqrt{\left(1 - \beta\,(1-\gamma^e) - \tau\right)^2 - 4\tau\,(1-\beta)\,\frac{\eta}{1-\eta}} > \gamma^e - (1-\gamma^e)\,(1-\beta) - \tau. \tag{A13}$$

By Lemma 1.5 the LHS of (A13) is well defined as long as $\gamma^e > \underline{\underline{\gamma}}$ — i.e., (A12) holds. The inequality (A13) is certainly satisfied if the RHS is negative, in which case $\sigma_e > 0$. If instead the RHS of (A13) is positive, that is

$$\gamma^e > \tilde{\gamma} \equiv \frac{1 + \tau - \beta}{2 - \beta}, \tag{A14}$$

then, taking squares and rearranging, (A13) is satisfied if, and only if,

$$\gamma^e \in \left(\underline{\gamma}, \overline{\gamma}\right). \tag{A15}$$

Hence

$$\sigma_e > 0 \iff \text{(A12)} \wedge \Big(\neg\text{(A14)} \vee \big(\text{(A14)} \wedge \text{(A15)}\big)\Big). \tag{A16}$$

Let

$$\beta_1 \equiv 1 - \frac{\tau}{\tau_{max}} \quad \text{and} \quad \beta_2 \equiv \frac{\overline{\gamma} - \underline{\gamma}}{1 - \underline{\gamma}} \quad \text{with} \quad 0 < \beta_1 < \beta_2 < 1. \tag{A17}$$

It is a matter of algebra to show that, within the range of admissible parameters,

1. $\max\left\{\tilde{\gamma}, \underline{\underline{\gamma}}, \underline{\gamma}, \overline{\gamma}\right\} = \overline{\gamma}$ for all $\beta \in [0,1]$

2. $\underline{\underline{\gamma}} < \underline{\gamma} < \tilde{\gamma} \iff \beta \in [0, \beta_2)$ with $\underline{\underline{\gamma}} \gtreqless 0 \iff \beta \gtreqless \beta_1$
3. $\underline{\underline{\gamma}} = \underline{\gamma} = \tilde{\gamma} \iff \beta = \beta_2$
4. $\tilde{\gamma} < \underline{\underline{\gamma}} < \underline{\gamma} \iff \beta \in (\beta_2, 1)$ with $\tilde{\gamma} = \underline{\underline{\gamma}} = \tau < \underline{\gamma} \iff \beta = 1$

Figure 10 illustrates constraints (A12), (A14) and (A15) and the points above in the plane (β, γ^e).

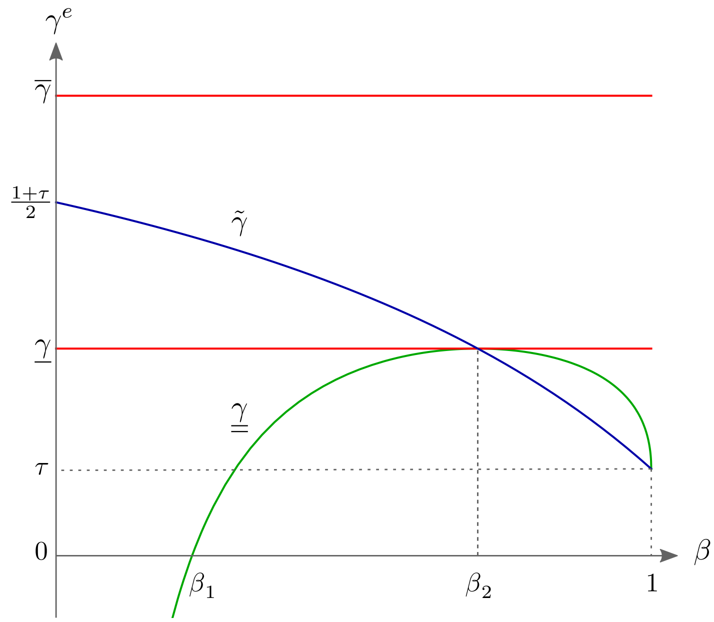


Figure 10: Existence of the higher solution $\sigma_e > 0$ with $\tau = 0.1$ and $\eta = 0.48$.

Consider first $\beta \in [0, \beta_1]$. Then by point 2, if (A12) is satisfied, either (A14) is not satisfied or, if it is, then also (A15) is satisfied provided that $\gamma^e < \overline{\gamma}$ (point 1). Hence, by (A16), $\sigma_e > 0$ exists for all $\gamma^e \in [0, \overline{\gamma})$.

Consider then $\beta \in (\beta_1, \beta_2)$. The same arguments as above hold except than now (A12) binds and thus $\sigma_e > 0$ exists for all $\gamma^e \in \left[\underline{\underline{\gamma}}, \overline{\gamma}\right)$.

Consider last $\beta \in [\beta_2, 1]$. Then by points 3 and 4, when (A12) holds, also (A14) does, thus requiring that (A15) holds as well, mandating $\gamma^e \in \left(\underline{\gamma}, \overline{\gamma}\right)$. Thus, (A16) implies that $\sigma_e > 0$ exists for all $\gamma^e \in \left(\underline{\gamma}, \overline{\gamma}\right)$.

Lemma 1.7. *Consider the lower solution to (A10) (with + sign) and let (A12) hold, so that σ_e is well defined and lower than 1. Then σ_e is positive if, and only if, $\beta < \beta_2$ and $\gamma^e \in \left(\max\left\{0, \underline{\underline{\gamma}}\right\}, \underline{\gamma}\right)$.*

Proof of Lemma 1.7. Rearranging (A10),

$$\sigma_e > 0 \iff \sqrt{\left(1 - \beta\left(1 - \gamma^e\right) - \tau\right)^2 - 4\tau\left(1 - \beta\right)\frac{\eta}{1-\eta}} < \tau - \gamma^e + \left(1 - \gamma^e\right)\left(1 - \beta\right), \tag{A18}$$

which requires $\neg$(A14) to hold as a necessary condition. By point 4 of Lemma 1.6, when $\beta > \beta_2$ the latter is not compatible with (A12) so there does not exist $\sigma_e \in (0, 1)$ (see Figure 10).

Consider now $\beta < \beta_2$. Once $\neg$(A14) is imposed, (A18) is easily seen to hold as long as $\neg$(A15) holds. Since when $\beta < \beta_2$ the latter is more restrictive than the former, $\sigma_e \in (0, 1)$ exists if, and only if, (A12) and $\neg$(A15) hold, that is $\beta < \beta_2$ and $\gamma^e \in \left(\max\left\{0, \underline{\underline{\gamma}}\right\}, \underline{\gamma}\right)$ (see Figure 10).

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To complete the characterization of the existence conditions for a fully mixed strategy Nash equilibrium of the second opinion game, we now focus on the consumer's strategy. As it is clear from (7), $\sigma_c > 0$. The next lemmas provide the parametric restrictions for $\sigma_c < 1$ in both solutions to (A10).

Lemma 1.8. *Let (A12) hold and consider the higher solution to (A10) (with $-$ sign). The strategy σ_c of the consumer is strictly below one if, and only if,*

$$\beta > \beta''' \vee \left(\beta < \beta''' \wedge \beta \begin{cases} < \beta' & \text{if} \quad \gamma^e < \gamma_1 \wedge x < \frac{1}{2-\bar{\gamma}} \\ > \beta' & \text{if} \quad \gamma^e > \max\{\gamma_1, \gamma_2\} \end{cases} \right) \tag{A19}$$

$$\text{with} \quad \beta''' \equiv \frac{1-\tau}{1-\gamma^e} - \frac{2}{1-\gamma^e}\frac{1-x}{x}, \tag{A20}$$

where β', γ_1 and γ_2 are defined in the proof of Lemma 1.4.

Proof of Lemma 1.8. Rearranging (7) replacing σ_e from (A10) with the $-$ sign one gets

$$\sigma_c < 1 \Longleftrightarrow f - 2\frac{1-x}{x} < \sqrt{f^2 - g},$$

where the RHS is well defined because of (A12). Clearly, the inequality above is satisfied if the LHS is negative, which occurs if $\beta > \beta'''$.

Suppose instead that $\beta < \beta'''$. Then, taking squares and rearranging, one obtains the very same condition as in (A7). As discussed at length in Lemma 1.4, $\beta' < 0$ when $\gamma^e < \gamma_1$ and $x > \frac{1}{2-\bar{\gamma}}$ (area C_1 in bottom right corner of Figure 9a), from which the qualifier that, when $\gamma^e < \gamma_1$, it must hold $x < \frac{1}{2-\bar{\gamma}}$ as well, else the condition $\beta < \beta' < 0$ is impossible. Similarly, $\beta' > 1$ when $\gamma^e \in (\gamma_1, \gamma_2)$, which makes the constraint $\beta > \beta'$ impossible (areas C_2 in Figure 9a). Hence, the qualifier that, when $\gamma^e > \gamma_1$ it also has to be that $\gamma^e > \gamma_2$.

A final note to clarify that, with reference to Figure 9a, $\beta < \beta'''$ implies $x > \frac{1}{2-\underline{\gamma}}$ so that for the last argument about the extra qualifier when $\gamma^e > \gamma_1$ only the bottom right C_2 area matters.

Lemma 1.9. *Let (A12) hold, consider the lower solution to (A10) (with + sign) and the restriction $x \notin \left[\frac{1}{2-\underline{\gamma}}, \frac{1}{2-\bar{\gamma}}\right]$. The pair of strategies (σ_e, σ_c) is a fully mixed strategy equilibrium if, and only if, $x < \frac{1}{2-\underline{\gamma}}$, $\beta < \beta_2$ and $\gamma^e \in \left(\max\left\{0, \underline{\underline{\gamma}}\right\}, \underline{\gamma}\right)$.*

Proof of Lemma 1.9. Rearranging (7) replacing σ_e from (A10) with the + sign one gets

$$\sigma_c < 1 \Longleftrightarrow 2\frac{1-x}{x} - f > \sqrt{f^2 - g},$$

where the RHS is well defined because of (A12). Clearly, the inequality above is not satisfied if the LHS is negative, which occurs if $\beta < \beta'''$ (as defined in (A20)).

Suppose instead that $\beta > \beta'''$. From tedious algebra one obtains

$$\sigma_c < 1 \Longleftrightarrow \beta \begin{cases} > \beta' & \text{if} \quad \gamma^e < \gamma_1 \\ < \beta' & \text{if} \quad \gamma^e > \gamma_1 \end{cases} \tag{A21}$$

with γ_1 defined in (A7) and β' as in (A8).

Recall now that, by lemmas 1.5 and 1.7, the lower solution σ_e is well defined as long as $\beta < \beta_2$ and $\gamma^e \in \left(\max\left\{0, \underline{\underline{\gamma}}\right\}, \underline{\gamma}\right)$. In particular, we must restrict our attention to $\gamma^e < \underline{\gamma}$.

Consider first the small markup case, $x < \frac{1}{2-\underline{\gamma}}$. Then, with reference to Figure 9a we are in the bottom rectangle of area C_1. There, according to the proof of Lemma 1.4, $\gamma^e < \gamma_1$ and $\beta' < 0$ so that (A21) is satisfied. Hence, the fully mixed strategy with small markup exists whenever $\beta < \beta_2$ and $\gamma^e \in \left(\max\left\{0, \underline{\underline{\gamma}}\right\}, \underline{\gamma}\right)$.

Consider now $x > \frac{1}{2-\overline{\gamma}}$. In this case it is a matter of algebra to show that, under the given constraints, the conditions $\beta > \beta'''$ and $\gamma^e < \underline{\underline{\gamma}}$ are mutually exclusive. In particular, one can show that $\gamma^e > \underline{\underline{\gamma}}$ for $\beta \in [\beta_1, \beta_2]$ if and only if $\beta < \underline{\underline{\beta}}$ for $\gamma^e \in \left[0, \underline{\gamma}\right]$ with

$$\underline{\underline{\beta}} = 1 - \frac{(\tau-\gamma^e)(1-\gamma^e)+2\frac{\eta}{1-\eta}\tau+2\sqrt{\frac{\eta}{1-\eta}\tau\left((\tau-\gamma^e)(1-\gamma^e)+\frac{\eta}{1-\eta}\tau\right)}}{(1-\gamma^e)^2} \tag{A22}$$

and that $\beta''' > \underline{\underline{\beta}}$ for all γ^e whenever $x > \frac{1}{2-\overline{\gamma}}$. Hence, with a large markup the conditions for the existence of a fully mixed strategy Nash equilibrium are not satisfied.

Proof of Lemma 1. The first statement follows straight from Lemmas 1.5 and 1.6. The second statement — that if (4) does not hold the unique equilibrium of the game is $\sigma_e = 0$ and $\sigma_c = 0$ — follows from two intertwined observations: (i) according to Lemma 1.9, the second (lower) solution to (2) exists in a subset of the parameter region, S, for which the higher solution exists; (ii) according to (2), the expected benefit from a second opinion falls short of the cost whenever $\gamma^e > \overline{\gamma}$ or $\gamma^e < \min\left\{\max\left\{0, \underline{\underline{\gamma}}\right\}, \underline{\gamma}\right\}$. In these cases it must be $\sigma_c = 0$ in equilibrium and, as a consequence, $\sigma_e = 0$.

Proof of Proposition 1. Point 1 follows from Lemmas 1.1 and 1.3 through 1.9. Point 2 is trivial once uniqueness is proved (see Lemma 1).

Proof of Lemma 2. From (A10) with the $-$ sign (higher solution) and under the given parameter restrictions, it holds

$$\frac{\partial \sigma_e}{\partial \gamma^e} = \frac{\left(f-\sqrt{f^2-g}\right)\left(\beta(1-\gamma^e)-\sqrt{f^2-g}\right)}{2(1-\beta)(1-\gamma^e)^2\sqrt{f^2-g}} > 0 \quad \Longleftrightarrow \quad \beta\left(1-\gamma^e\right) > \sqrt{f^2-g} \quad \Longleftrightarrow \quad \gamma^e < \hat{\gamma}^e$$

where the first inequality follows from the first multiplier in the numerator and the denominator being positive and the second and third inequalities from simple algebra with $\hat{\gamma}^e$ defined in (9).

To establish concavity, let

$$\frac{\partial^2 \sigma_e}{\partial \left(\gamma^e\right)^2} = -\frac{1}{2}\left(f - \sqrt{f^2-g}\right) \frac{2\left(f^2-g\right)\sqrt{f^2-g}+(1-\gamma^e)\beta\left((1-\gamma^e)\beta\left(f+\sqrt{f^2-g}\right)-2\left(f^2-g\right)\right)}{\left(\sqrt{f^2-g}\right)^3(1-\beta)(1-\gamma^e)^3}$$

and notice that, since $f - \sqrt{f^2-g} > 0$, the second derivative is negative if and only if the numerator of the last multiplier is positive. Now define $y \equiv \left(1-\gamma^e\right)\beta$ and $z \equiv f^2 - g$ with $(y, z) \in (0,1)^2$. Then, using the fact that $f = \sqrt{g+z}$ and rearranging, one can write

$$\frac{\partial^2 \sigma_e}{\partial \left(\gamma^e\right)^2} < 0 \quad \Longleftrightarrow \quad \left(\sqrt{g+z} + \sqrt{z}\right) y^2 - 2yz + 2z\sqrt{z} > 0.$$

Further note that the above expression is increasing in g so that, if it is positive at $g = 0$, it is always positive. Substituting $g = 0$ and simplifying one obtains $2\sqrt{z}\left(\left(y-\sqrt{z}\right)^2 + y\sqrt{z}\right) > 0$.

Now notice that $\hat{\gamma}^e$ is increasing in β — from (9), it has to be $(1-\tau)^2 - 4\frac{\eta}{1-\eta}\tau > 0$, which is true since the expression decreases in τ and is positive at $\tau_{\max}$. In particular, $\hat{\gamma}^e(\beta = 0) = -\infty$ and $\hat{\gamma}^e(\beta = 1) = 1 + \tau > 0$. Hence,

$$\hat{\gamma}^e \gtreqless 0 \quad \Longleftrightarrow \quad \beta \gtreqless \beta_0 \equiv 1 - \frac{1}{2}\frac{1-\tau^2}{1-\tau\frac{1+\eta}{1-\eta}}. \tag{A23}$$

The above proves that σ_e as a function of γ^e is concave non-monotone with a maximum in $\hat{\gamma}^e$ when $\beta > \beta_0$ and is concave decreasing in γ^e when $\beta \leq \beta_0$ (with maximum in $\gamma^e = 0$).

Proof of Proposition 2. Point 1 follows from Lemma 2 once it is proven that $\beta_0 < \beta_1$ — which follows from simple algebra and is implied by $\tau < \tau_{\max}$ — and that $\hat{\gamma}^e > \underline{\underline{\gamma}}$ — which follows from

$$\hat{\gamma}^e - \underline{\underline{\gamma}} = \frac{4\tau\eta(1-\beta)+(1-\eta)(1-\tau)^2-4(1-\eta)(1-\tau)\sqrt{\tau(1-\beta)\frac{\eta}{1-\eta}}}{2\beta(1-\eta)(1-\tau)} > 0 \iff \left((1-\tau)^2(1-\eta) - 4\tau\eta(1-\beta)\right)^2 > 0.$$

To prove point 2 it is convenient to refer to Figure 8b and to work with the expression of $\underline{\underline{\gamma}}'$, that is to invert the expression of β', which yields

$$\underline{\underline{\gamma}}' = \frac{\gamma_2 - \gamma_1(1-\beta)}{\beta}.$$

Note that $\underline{\underline{\gamma}}'$ decreases in β since $\partial\underline{\underline{\gamma}}'/\partial\beta = \frac{\gamma_1-\gamma_2}{\beta^2} < 0$ because $\gamma_1 < \gamma_2$ under large mark-up (see Figure 9a). Moreover $\underline{\underline{\gamma}}' = \underline{\gamma} \iff \beta = \beta_2'$, with

$$\beta_2' \equiv 1 - \frac{1-x}{x}\frac{1}{\overline{\gamma}-\tau}.$$

Now recall $\hat{\gamma}^e$ is increasing in β and notice that $\hat{\gamma}^e = \underline{\gamma} \iff \beta = \hat{\beta}$ with

$$\hat{\beta} \equiv \frac{1}{1 - 2\frac{(1-\tau)(1-\eta)}{\eta(1+\tau)^2-(1-\tau)^2}\left(\overline{\gamma} - \frac{1+\tau}{2}\right)}.$$

Finally notice that

$$\beta_2' - \hat{\beta} = \frac{(3-\tau)x - 2}{2x(\overline{\gamma}-\tau)} > 0 \iff (3-\tau)x > 2 \iff \overline{\gamma} > \frac{1+\tau}{2},$$

where the latter inequality always holds (see (A1)). The facts exposed above, coupled with the observation that $\hat{\gamma}^e < \overline{\gamma}$ for all values of β, prove that the intersection between $\underline{\underline{\gamma}}'$ and $\hat{\gamma}^e$ always exists for some $\tilde{\beta}' \in (\beta_1', \beta_2')$ and is unique. In particular

$$\tilde{\beta}' = 1 - \frac{(1-x)(1-\eta)(1-\tau)}{2x\eta\tau}.$$

Equilibrium curve. To prove Propositions 3-6 it is convenient to previously characterize the *equilibrium curve* $\sigma_e(\sigma_c)$, that is the lucus of points in the plane (σ_c, σ_e) representing the optimal strategies corresponding to any γ^e such that the fully mixed strategy equilibrium (3)–(7) exists. To identify the curve one i) derives $\gamma^e(\sigma_e)$ as the inverse of σ_e from (3); and then ii) plugs it into σ_c from (7) and solves for σ_e to obtain the relation $\sigma_e(\sigma_c)$.

Point i) yields two solutions to a second degree equation. One of them, when plugged into (7), yields a σ_c increasing in σ_e, which is inconsistent with the equilibrium behavior described by (7). Hence,

$$\gamma^e(\sigma_e) = 1 - \frac{1}{2(1-\sigma_e(1-\beta))}\left(1-\tau+\sqrt{(1-\tau)^2 - 4\tau\frac{\eta}{1-\eta}\left(1+\beta\frac{\sigma_e}{1-\sigma_e}\right)}\right).$$

Point ii) using $\gamma^e(\sigma_e)$ above yields the equilibrium curve

$$\sigma_e(\sigma_c) = 1 - \frac{\beta}{1-\beta}\frac{(1-\eta)(x-\sigma_c)^2}{-\left((1-\eta)(1-(1-\tau)x)+\tau\eta(1-\beta)x^2\right)\sigma_c^2 + x(1-\eta)\left(2-x(1-\tau)\right)\sigma_c - x^2(1-\eta)} \tag{A24}$$

Note that (A24) has an economic meaning when the fully mixed strategy equilibrium exists and σ_e and σ_c are well defined. In particular, if $\beta \in (\beta_2, 1)$, the mixed strategy equilibrium exists if and only if $\gamma^e \in [\underline{\gamma}, \bar{\gamma}]$, with $\sigma_e(\underline{\gamma}) = \sigma_e(\bar{\gamma}) = 0$, so the equilibrium curve has two horizontal intercepts, as illustrated in Figure 4. Moreover, as γ^e grows, the equilibrium point moves counterclockwise along the curve (since σ_c decreases with γ^e in equilibrium) and the right-intercept corresponds to $\gamma^e = \underline{\gamma}$ while the left-intercept corresponds to $\gamma^e = \overline{\gamma}$ — if $\beta = 1$ the horizontal intercepts coincide since σ_c does not depend on γ^e and the equilibrium curve is a vertical line such that the equilibrium point moves from the bottom up as γ^e grows from $\underline{\gamma}$ to $\hat{\gamma}$ and from the top down as γ^e keeps growing until $\overline{\gamma}$. The remaining cases are illustrated in Figure 11 below. If $\beta \in (\beta_1, \beta_2)$, such equilibrium exists if and only if $\gamma^e \in \left[\underline{\underline{\gamma}}, \bar{\gamma}\right]$, with $\sigma_e\left(\underline{\underline{\gamma}}\right) > 0$ and $\sigma_e(\bar{\gamma}) = 0$ and the equilibrium curve has no right-intercept. Finally, if $\beta \in (\beta_0, \beta_1)$, the equilibrium exists if and only if $\gamma^e \in [0, \bar{\gamma}]$, with $\sigma_e(0) > 0$ and $\sigma_e(\bar{\gamma}) = 0$ so that, again, the curve crosses zero only in the left-intercept. In all three cases, σ_e is not monotone in γ^e (see Figure 2) so that the equilibrium curve is first increasing and then decreasing as illustrated in Figure 4 and Figures 11a and 11b. On the other hand, if $\beta \in (0, \beta_0)$, then σ_e, which is again defined in $\gamma^e \in [0, \bar{\gamma}]$ with $\sigma_e(0) > 0$ and $\sigma_e(\bar{\gamma}) = 0$, is decreasing in γ^e and the equilibrium curve, which as before crosses zero only in the left-intercept, is now strictly increasing — if $\beta = 0$ then again σ_c does not depend on γ^e and the equilibrium curve is a vertical line such that the equilibrium point moves from the top down as γ^e grows from zero to $\overline{\gamma}$. We further characterize the equilibrium curve by noticing that

$$\begin{aligned}\frac{\partial\sigma_e(\sigma_c)}{\partial\sigma_c} &= x^2(\sigma_c - x)\frac{\beta}{1-\beta}\frac{x(1-\tau)-\left(1-\tau-2x\frac{\eta}{1-\eta}\tau(1-\beta)\right)\sigma_c}{\left(-\left(1-(1-\tau)x+\tau\frac{\eta}{1-\eta}(1-\beta)x^2\right)\sigma_c^2 + x(2-x(1-\tau))\sigma_c - x^2\right)^2} \\ &= 0 \iff \sigma_c = \frac{1}{\frac{1}{x} - 2(1-\beta)\frac{\eta}{1-\eta}\frac{\tau}{1-\tau}},\end{aligned} \tag{A25}$$

which, since it can be shown (available upon request) that $\frac{\partial^2\sigma_e(\sigma_c)}{\partial\sigma_c^2} < 0$, defines the maximum of the equilibrium curve in the cases in which $\beta \in (\beta_0, 1)$ (Figure 4 and Figures 11a and 11b). In the case of $\beta \in (0, \beta_0]$ (Figure 11c) the maximum is obtained setting $\gamma^e = 0$ in the equilibrium values for σ_e and σ_c.

We shall further notice that the sign of (A25) depends uniquely on the numerator of the last factor (since σ_c can be easily shown to exceed x by manipulating (7)), which is decreasing in β. Evaluating the derivative in $\beta = \beta_0$ with σ_c calculated in $\gamma^e = 0$ (that is, the smallest γ^e such that the equilibrium exists) equates it to zero, confirming that, for any smaller β, the derivative of the equilibrium curve in the point corresponding to $\gamma^e = 0$ is strictly positive.

Isoutility curves. To prove Propositions 3-6 we need also to study isoutility curves, that is those combinations (σ_e, σ_c) which, for given true γ, yield the consumer the same expected utility (10). We already argued in the text that, given a true γ, the isoutility curve corresponding to the equilibrium value $\sigma_e(\gamma)$ which would obtain if $\gamma^e = \gamma$ is a straight horizontal line since any mixed strategy σ_c would yield the same utility to the consumer. To characterize the shape of all the other isoutility curves let us study first how (10) varies with the belief γ^e:

$$\frac{d\text{EU}_c}{d\gamma^e} = \frac{\partial \text{EU}_c}{\partial \sigma_e}\frac{\partial \sigma_e}{\partial \gamma^e} + \frac{\partial \text{EU}_c}{\partial \sigma_c}\frac{\partial \sigma_c}{\partial \gamma^e}.$$

We first notice that $\left.\frac{\partial \text{EU}_c}{\partial \sigma_c}\right|_{\gamma^e=\gamma} = 0$, that is the consumer is actually maximizing her objective expected utility when her belief is correct and equals the true state. This argument corroborates our earlier discussion on the straight isoutility curve going through $\sigma_e(\gamma)$. Conversely, when she has incorrect beliefs, that is $\gamma^e \neq \gamma$, the consumer would strictly prefer either to ask or not to ask a second opinion if she knew the true share of honest experts.

Similarly, note that $\left.\frac{\partial \sigma_e}{\partial \gamma^e}\right|_{\gamma^e=\hat{\gamma}^e} = 0$, that is the expert behaves honestly with the highest probability when the belief is $\hat{\gamma}^e$ (see Lemma 2 and recall that σ_e) is strictly concave in γ^e).

Moreover, we note that $\frac{\partial \sigma_c}{\partial \gamma^e} < 0$ and $\frac{\partial \text{EU}_c}{\partial \sigma_e} > 0$.

To characterize the slope of isoutility curves consider the following derivative

$$\frac{\partial \frac{\text{EU}_c}{p_h - p_l}}{\partial \sigma_c} = (1-\gamma)(1-\eta)(1-\sigma_e)(\gamma - \tau + \sigma_e(1-\gamma)(1-\beta)) - \tau\eta > 0 \iff \sigma_e \in \left(\sigma_e^-, \sigma_e^+\right), \quad \text{(A26)}$$

where σ_e^- and σ_e^+ are the lower and larger solutions to (A10) as a function of the true γ rather than γ^e (the scalar multiplier $(p_h - p_l)^{-1}$, generally omitted, is for readability). Hence, when $\sigma_e > \sigma_e^+$ the consumer's expected utility decreases as σ_c increases. To maintain the utility constant, σ_e must therefore increase (recall that $\frac{\partial \text{EU}_c}{\partial \sigma_e} > 0$). This establishes that all the isoutility curves above the straight horizontal one are upward sloped.

Indeed, relation (A26) makes clear that there are two straight horizontal isoutility curves, the one illustrated above which corresponds to $\sigma_e^+(\gamma)$ and the one corresponding to $\sigma_e^-(\gamma)$ — the latter being positive if and only if $\beta < \beta_2$ and $\gamma \in \left(\underline{\underline{\gamma}}, \underline{\gamma}\right)$. Moreover, all isoutility curves above $\sigma_e^+(\gamma)$ and below $\sigma_e^-(\gamma)$ are upward sloped, while those between them are downward sloped.

We shall further characterize isoutility curves establishing whether they are concave or convex. To do so, note that by the implicit function theorem we can write the slope of a generic isoutility curve as follows:

$$\frac{\partial \text{EU}_c}{\partial \sigma_c} d\sigma_c + \frac{\partial \text{EU}_c}{\partial \sigma_e} d\sigma_e = 0 \iff \frac{d\sigma_e}{d\sigma_c} = -\frac{\frac{\partial \text{EU}_c}{\partial \sigma_c}}{\frac{\partial \text{EU}_c}{\partial \sigma_e}} \quad \text{(A27)}$$

which is defined for all (σ_c, σ_e) since $\frac{\partial \text{EU}_c}{\partial \sigma_e} > 0$ and $\frac{\partial \text{EU}_c}{\partial \sigma_c}$ is always defined. Hence, the slope of a generic isoutility curve $\sigma_e(\sigma_c)$, $\frac{d\sigma_e}{d\sigma_c}$, depends on the sign of $\frac{\partial \text{EU}_c}{\partial \sigma_c}$ as discussed above. As to concavity/convexity, note that

$$\frac{d^2\sigma_e}{d\sigma_c^2} = -\frac{1}{\left(\frac{\partial \text{EU}_c}{\partial \sigma_e}\right)^2}\left(\frac{\partial^2 \text{EU}}{\partial \sigma_c^2}\frac{\partial \text{EU}_c}{\partial \sigma_e} - \frac{\partial \text{EU}_c}{\partial \sigma_c}\frac{\partial^2 \text{EU}_c}{\partial \sigma_e \partial \sigma_c}\right) = \frac{\frac{\partial \text{EU}_c}{\partial \sigma_c}\frac{\partial^2 \text{EU}_c}{\partial \sigma_e \partial \sigma_c}}{\left(\frac{\partial \text{EU}_c}{\partial \sigma_e}\right)^2}$$

since $\frac{\partial^2 \text{EU}_c}{\partial \sigma_c^2} = 0$ (see (A26)). The sign of $\frac{d^2\sigma_e}{d\sigma_c^2}$ depends on the signs of $\frac{\partial \text{EU}_c}{\partial \sigma_c}$ (characterized in (A26)) and $\frac{\partial^2 \mathrm{E}U_c}{\partial\sigma_e\partial\sigma_c}$. The latter can be shown to satisfy $\frac{\partial^2 \mathrm{E}U_c}{\partial\sigma_c\partial\sigma_e} < 0 \iff \sigma_e > \frac{\sigma_e^+ + \sigma_e^-}{2}$. Hence, wrapping up,

$$\frac{d^2\sigma_e}{d\sigma_c^2}\begin{cases} > 0 & \text{if} \quad \sigma_e > \sigma_e^+ & \text{with } \sigma_e' > 0 \Rightarrow \sigma_e\left(\sigma_c\right) \text{ convex increasing} \\ < 0 & \text{if} \quad \sigma_e \in \left(\frac{\sigma_e^+ + \sigma_e^-}{2}, \sigma_e^+\right) & \text{with } \sigma_e' < 0 \Rightarrow \sigma_e\left(\sigma_c\right) \text{ concave decreasing} \\ > 0 & \text{if} \quad \sigma_e \in \left(\sigma_e^-, \frac{\sigma_e^+ + \sigma_e^-}{2}\right) & \text{with } \sigma_e' < 0 \Rightarrow \sigma_e\left(\sigma_c\right) \text{ convex decreasing} \\ < 0 & \text{if} \quad \sigma_e < \sigma_e^- & \text{with } \sigma_e' > 0 \Rightarrow \sigma_e\left(\sigma_c\right) \text{ concave increasing} \end{cases}$$

where $\frac{\sigma_e^+ + \sigma_e^-}{2} = 1 - \frac{1-\beta(1-\gamma)-\tau}{2(1-\gamma)(1-\beta)}$ depends on the true γ as σ_e^+ and σ_e^-.

Since we are interested in maximizing the consumer expected utility we will focus on the highest class of isoutility curves, that is those above σ_e^+, which are increasing and convex.

Proof of Proposition 3. To prove the proposition consider our previous discussion and start focusing on $\beta \geq \beta_0$ so that $\gamma^* = \hat{\gamma}$. In this case the equilibrium curve is increasing concave from zero to its maximum. Now consider the horizontal isoutility curve $\sigma_e(\gamma)$ (the one corresponding to σ_e^+) and notice that the value of its intercept is increasing (resp. decreasing) in γ when $\gamma < \hat{\gamma}$ (resp. $\gamma > \hat{\gamma}$). When $\gamma = \hat{\gamma}$ the straight horizontal isoutility curve is tangent to the equilibrium curve in its maximum. In this case, clearly $\gamma = \gamma^* = \gamma^{**}$. Suppose instead that $\gamma \neq \hat{\gamma}$, then the straight horizontal isoutility curve crosses the equilibrium curve strictly below its maximum and the optimum is found at the point where the highest (convex increasing) isoutility curve is tangent to the equilibrium curve (see Figure 4). This point must lie to the left of the maximum on the increasing part of the equilibrium curve and thus corresponds to some $\gamma^e > \hat{\gamma}$ so that $\gamma^{**} > \gamma^*$.

Focus now on $\beta < \beta_0$ so that $\gamma^* = 0$ and the equilibrium curve is everywhere strictly increasing — *i.e.* it has no longer a decreasing branch. A similar argument to the one above applies with the caveat that now the straight horizontal isoutility curve which touches the equilibrium curve in its maximum is no longer tangent. Other than that, the reasoning is the same.

Proof of Proposition 4. Let first $\beta \in [\beta_0, 1)$. From (A27), the equation $\frac{d\sigma_e}{d\sigma_c} = k$, k constant, is a quadratic function of γ. Let $\gamma_1(k)$ and $\gamma_2(k)$ be the two solutions (either real or imaginary) to this equation. We know that (i) the point at the top of the equilibrium curve is optimal when $k = 0$. It is easy to show that, in this point (which obtains when $\gamma^e = \hat{\gamma}^e$), $\gamma_1(0) = \gamma_2(0) = \hat{\gamma}^e$; (ii) for any $\gamma \neq \hat{\gamma}^e$, the unique tangency point between an isoutility curve and the equilibrium curve obtains in the upward sloped part of the latter. This calls for $k > 0$ both when $\gamma < \hat{\gamma}^e$ and when $\gamma > \hat{\gamma}^e$. By continuity, if we consider a point on the equilibrium curve that is sufficiently close to the top, *i.e.,* with a slope $\bar{k} > 0$ not too high, there must exist two real solutions $\gamma_1\left(\bar{k}\right) < \hat{\gamma}^e$ and $\gamma_2\left(\bar{k}\right) > \hat{\gamma}^e$ that are admissible (*i.e.*, within the domain of the mixed strategy equilibrium). The point on the equilibrium curve with slope $\bar{k}$ is therefore optimal when either $\gamma = \gamma_1\left(\bar{k}\right)$ or $\gamma = \gamma_2\left(\bar{k}\right)$. Let us consider now another point on the equilibrium curve characterized by a larger slope (we are moving anticlockwise through the equilibrium curve): $k_1 > \bar{k}$. If there are admissible solutions, we must have that $\gamma_1(k_1) < \gamma_1\left(\bar{k}\right) < \hat{\gamma}^e$ and $\gamma_2(k_1) > \gamma_2\left(\bar{k}\right) > \hat{\gamma}^e$, since otherwise, by continuity, we would obtain that two different points on the equilibrium curve are optimal with the same value of γ, which is impossible (the equilibrium curve is concave, while the isoutility curves are convex). But then, if $k_2 > k_2$, we must have that $\gamma_1(k_2) < \gamma_1(k_1) < \gamma_1\left(\bar{k}\right) < \hat{\gamma}^e$ and $\gamma_2(k_2) > \gamma_2(k_1) > \gamma_2\left(\bar{k}\right) > \hat{\gamma}^e$, and so on. Moving anticlockwise through the equilibrium curve amounts to considering a larger value of γ^e. Hence, if $\beta \in [\beta_0, 1)$, we have that γ^{e**} is increasing in γ for all $\gamma > \hat{\gamma}^e$ and decreasing in γ for all $\gamma < \hat{\gamma}^e$.

Let now $\beta \in (0, \beta_0)$. The equilibrium curve is now upward sloped. Moreover, the slope of the curve at the top of it (which obtains when $\gamma^e = 0$) is positive. Let it be $\bar{k} > 0$. This implies that $\gamma^{e**} = 0$ if and only if the slope of the isoutility curve at the top of the equilibrium curve is lower or equal to $\bar{k}$. At the top of the equilibrium curve, we have that $\gamma_1(0) = 0$ and $\gamma_2(0) < 0$. The first solution ($0 < \bar{k}$) gives the economically meaningful result that $\gamma^{e**} = 0$ when $\gamma = 0$ (Proposition 3). However, by continuity, there must exist other values of γ such that $\gamma^{e**} = 0$. We have to consider two possibilities. The first one calls for the existence of a value $k_1 > \bar{k}$ such that $\gamma_1(k_1) < \bar{\gamma}$. This means that there exists a point on the equilibrium curve below the top of the curve that is optimal for an admissible value of γ. This point will be characterized by tangency between the equilibrium curve and an isoutility curve. The same reasoning seen in the case $\beta \in [\beta_0, 1)$ applies. Let us consider another point on the equilibrium curve characterized by a larger slope (we are moving anticlockwise through the equilibrium curve): $k_2 > k_1$. If there are admissible solutions, we must have that $\gamma_1(k_2) > \gamma_1(k_1) > 0$, since otherwise, by continuity, we would obtain that two different points on the equilibrium curve are optimal with the same value of γ, which is impossible (the equilibrium curve is concave, while the isoutility curves are convex). And so on. The first possibility calls therefore for $\gamma^{e**} = 0$ for low values of γ, while $\gamma^{e**} > 0$ increasing in γ for larger values of γ. This case is not empty. Indeed, it always occurs when β is sufficiently close to β_0, which implies that the slope of the equilibrium curve at the top is sufficiently close to zero, so $\gamma^{e**} = 0$ only when γ is sufficiently close to zero. The second possibility calls for $\gamma^{e**} = 0$ for all admissible values of γ. This case obtains when the slope of the isoutility curve at the top of the equilibrium curve is always lower than $\bar{k}$. It is also not empty. Indeed, it always occurs when β is sufficiently close to zero, which implies that $\bar{k}$ is sufficiently high ($\bar{k}$ tends to infinite as β tends to zero).

The cases $\beta = 0$ and $\beta = 1$ are discussed in the text.

Proof of Proposition 5. See main text in Section 6.1.

Proof of Proposition 6. See main text in Section 6.2.

Proof of Proposition 7. We first prove that, by Lemma 1.8 with large markup, the fully mixed strategy equilibrium with the higher σ_e only exists for $\gamma^e \in \left(\underline{\gamma}, \overline{\gamma}\right)$ and $\beta > \beta'$ (the equilibrium with the lower solution does not exist under large markup by Lemma 1.9).

Start noticing that, by Lemma 1, the mixed strategy equilibrium does not exist for $\gamma^e > \overline{\gamma}$. Consider instead $\gamma^e < \overline{\gamma}$. In this case, by Lemma 1.8, under large markup the existence of the equilibrium requires condition (A19) to be satisfied. In particular, it must be $\gamma^e > \max\{\gamma_1, \gamma_2\}$. Before proceeding note that $\max\{\gamma_1, \gamma_2\} < \underline{\gamma} \Leftrightarrow x > \frac{1}{2-\overline{\gamma}}$ (see Figure 9 for a quick reference). Hence, we analyze in turn $\gamma^e \in \left(\max\{\gamma_1, \gamma_2\}, \underline{\gamma}\right)$ and $\gamma^e \in \left(\underline{\gamma}, \overline{\gamma}\right)$.

Consider first $\gamma^e \in \left(\max\{\gamma_1, \gamma_2\}, \underline{\gamma}\right)$. Then by (A19) it must be $\beta > \beta'$ for σ_c to be lower than 1 and, by Lemma 1.6, a necessary condition for $\sigma_e > 0$ when $\gamma^e < \underline{\gamma}$ is that $\beta < \beta_2$ (see Figure 10 for a quick reference). Now, it can be shown that: (i) $\frac{\partial \beta'}{\partial \gamma^e} < 0$ under large markup; (ii) $\frac{\partial \beta'|_{\gamma^e = \underline{\gamma}}}{\partial x} > 0$; and (iii) $\lim_{x \to \frac{1}{2-\overline{\gamma}}} \beta'|_{\gamma^e = \underline{\gamma}} = \beta_2$. Hence, for any $\gamma^e < \underline{\gamma}$ and $x > \frac{1}{2-\overline{\gamma}}$ it holds $\beta' > \beta_2$ and the fully mixed strategy equilibrium does not exist.

Consider then $\gamma^e \in \left(\underline{\gamma}, \overline{\gamma}\right)$. In this case, by Lemma 1, σ_e is well defined and, by Lemma 1.8, $\sigma_c < 1$ as long as $\beta > \beta'$ ($\sigma_c > 0$ is trivial from (7)).

The above discussion defines the existence area S' for the fully mixed strategy with the larger solution to (A10) under large markup.

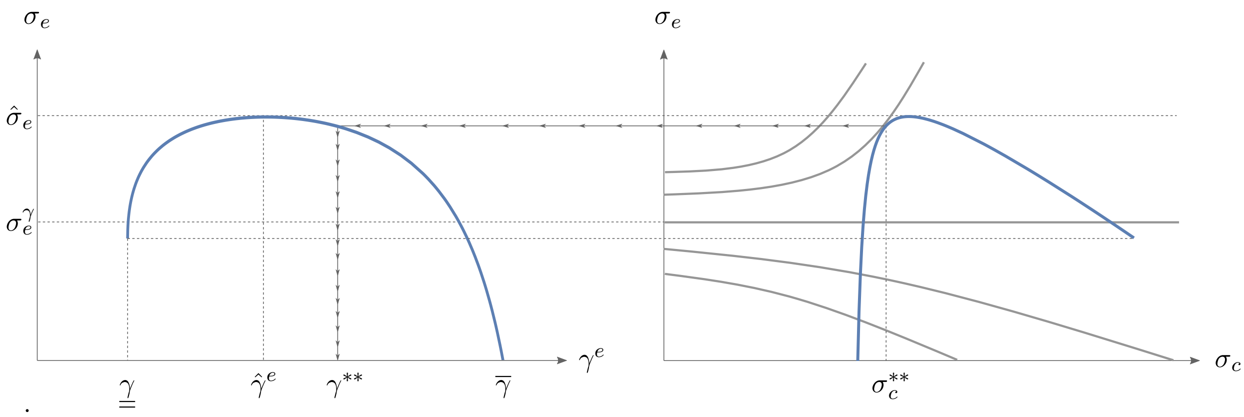
Next, we study the other equilibria which may arise under large markup and then compare them to the fully mixed strategy one.

By Lemma 1.4, the equilibrium with $\sigma_c = 1$ and $0 < \sigma_e < 1$ with large markup exists in a subarea of S' implicitly defined by (A9) as the area between the curves β' and β'' (see third line of (A4)).

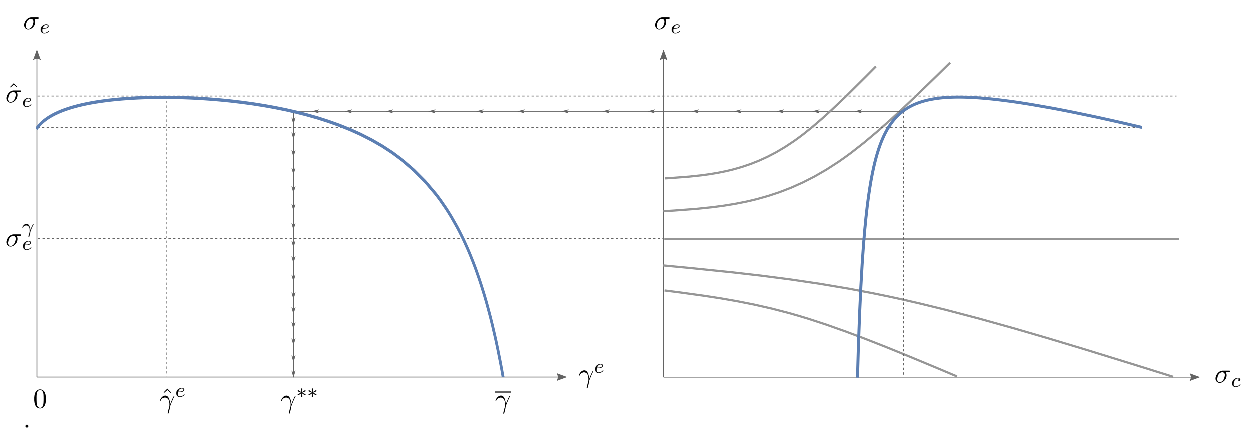
These curves cross in the points with coordinates $\left(\beta'_1, \overline{\gamma}\right)$ and $\left(\beta'_2, \underline{\gamma}\right)$ depicted in the plane (β, γ^e) in Figure 8a. In the figure the solid curve corresponds to β' (labeled $\underline{\underline{\gamma}}'$, the inverse of β' w.r.t. γ^e, for consistency with the axes orientation), the dashed (unlabeled) curve corresponds to β'' and (A9) is zero in the mentioned points.

Next, we shall notice that σ_e from Lemma 1 is larger than σ_e from Lemma 1.4. [Alternative 1] In fact, let's call the former σ_e^f and the latter σ_e^s, where f denotes the fully- while s the semi-mixed strategy equilibrium. By definition, σ_e^f is such that the expected benefit of hearing a second opinion equals the expected cost (equation (2) holds with equal sign). Notice that the expected benefit is concave in σ_e and decreasing at σ_e^f. Hence, if σ_e^s was larger than σ_e^f, the expected benefit from hearing a second opinion would be lower than the cost (condition (2) would hold with $<$ sign) and $\sigma_c = 1$ would not be an admissible equilibrium behavior. Therefore, it must be $\sigma_e^f > \sigma_e^s$. [Alternative 2] In fact, it is immediate to see from (7) that the larger σ_c is, the lower σ_e must be in equilibrium. In particular, when $\sigma_c = 1$ it cannot be that σ_e is higher than the value it takes when $\sigma_c < 1$, since in that case (7) would not hold.

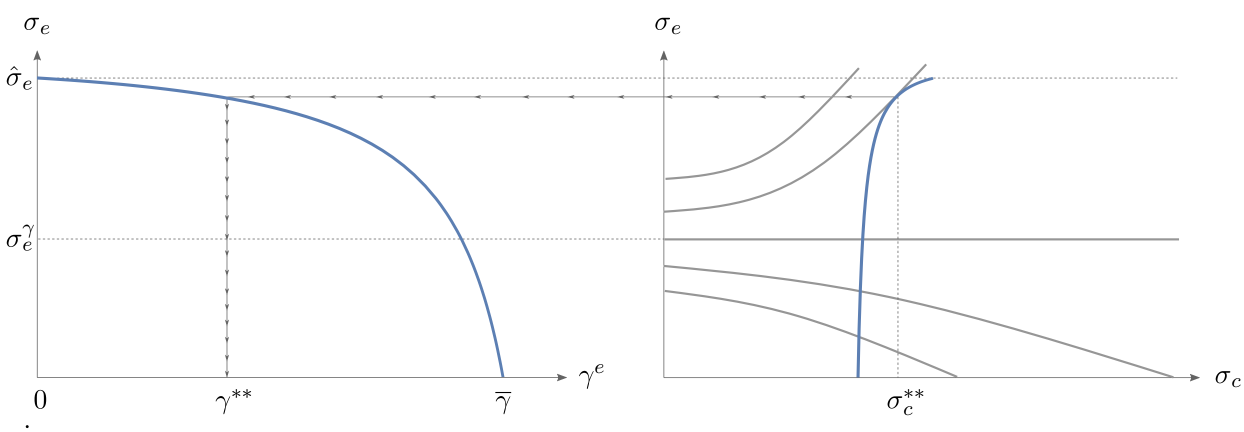
Lemmas 1.1 and 1.3, together with the previously mentioned lemmas jointly prove point 2 of the proposition. By the first lemma the equilibrium with $\sigma_c = \sigma_e = 0$ exists for $\gamma^e \notin \left(\underline{\gamma}, \overline{\gamma}\right)$, while by the second lemma the equilibrium with $\sigma_c = 1$ and $\sigma_e = 0$ exists for $\gamma^e \in \left(\underline{\gamma}, \overline{\gamma}\right)$. Lemmas 1.4, 1.8 and 1.9 prove uniqueness by exclusion.



(a) $\beta \in (\beta_1, \beta_2)$.



(b) $\beta \in (\beta_0, \beta_1)$.



(c) $\beta \leq \beta_0$.

Figure 11: Consumer welfare maximizing credence γ^{**}.