

# The role of diagnostic ability in markets for expert services\*

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## Abstract

In credence goods markets, an expert has better information about the appropriate quality of treatment than his customers. An expert may exploit this informational advantage by defrauding the customer. Market institutions have theoretically shown to mitigate fraudulent expert behavior. We analyze whether this positive result carries over when experts are heterogeneous with respect to their diagnostic abilities. Indeed, efficient market outcomes are always possible. However, depending on the probability of a major problem and the probability with which a low-ability expert performs the accurate diagnosis, inefficient equilibria can also exist. When such equilibria are played, better diagnostic abilities result in greater inefficiencies relative to the efficient equilibrium.

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# 1 Introduction

We analyze whether and how an expert's diagnostic errors change the market outcome in a credence goods market.<sup>1</sup> A credence good is a good for which the customer does not know which type of quality he needs. The expert, in contrast, learns the necessary quality after performing a diagnosis. As experts often both perform the diagnosis and the treatment, an expert may exploit his informational advantage when treating in three different ways. First, when an expert overtreats his customers, he provides more or more expensive treatments than necessary. Second, when an expert undertreats his customers, he provides an insufficient treatment. Third, when an expert overcharges his customers, he charges for a more expensive treatment than provided. In this paper, we focus on the first two forms of fraudulent behavior and the thereby caused inefficiencies.

Dulleck and Kerschbamer (2006) develop a unifying model of a credence goods market that allows to analyze market efficiency. They highlight that experts serve customers efficiently, i.e., fraudulent behavior does not occur, when customers are homogeneous with regard to the probability of major problem, they are committed to undergoing treatment after receiving a diagnosis, and when either the treatment is verifiable (i.e., overcharging is not possible), or experts are liable (i.e., undertreatment is not possible).

However, these predictions appear to contradict (real-life) observations. In the healthcare market, for example, the FBI estimates that up to 10% of the 3.3 trillion US\$ of yearly health expenditures in the United States are due to fraud (Federal Bureau of Investigation, 2007).<sup>2</sup> In car repair services, Taylor (1995), Schneider (2012) and Rasch and Waibel (forthcoming) report fraud by garages. Fraud in computer repair services has been documented by Kerschbamer et al. (2016). Balafoutas et al. (2013) and Balafoutas et al. (2017) document fraud in the market for taxi rides. Moreover fraudulent behavior has been reported in several lab experiments on credence goods (see, e.g., Dulleck et al., 2011; Mimra et al., 2016a,b).<sup>3</sup>

One explanation for fraud in expert markets under verifiability has been brought forward by Kerschbamer et al. (2017). The authors show theoretically and by experimental evidence that inefficient market outcomes with fraud may arise due to the heterogeneity in experts' social preferences. In particular, experts with a strong inequity aversion are observed to over- or undertreat

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<sup>1</sup>The seminal article on credence goods markets is by Darby and Karni (1973). For a comprehensive survey of the literature and a unifying model, see Dulleck and Kerschbamer (2006) (see also below).

<sup>2</sup>For an overview on physician-induced demand (PID) McGuire, 2000).

<sup>3</sup>For an overview on the experimental literature in credence goods markets, see Kerschbamer and Sutter (2017).

customers in order to reduce differences in payoffs.

We suggest a different explanation for why (inefficient) over- and/or undertreatment can be observed: heterogeneity in experts' diagnostic abilities. Experts may be of low or high diagnostic ability type but customers do not observe the type of experts they interact with. We are interested in how such differences in diagnosis quality affects expert behavior and market efficiency, and whether better diagnostic abilities yield better outcomes. In contrast to previous contributions<sup>4</sup>, we assume that diagnosis outcomes are exogenous, i.e., more effort or investments do not affect diagnostic quality. This has important welfare implications, as over- or undertreatment may now be socially optimal. Our model thus captures situations that require talent, experience, or specific knowledge (e.g., mathematical skills) which is hard to be extended in the short term. Also capacity or time constraints may limit an expert's possibilities to invest into his diagnostic abilities in the short run.

One area in which our assumptions with respect to differences in diagnostic abilities and the impossibility to change these in the short term appear to be realistic are medical diagnoses. Brush et al. (2017) provide an overview of research which analyzes diagnostic decision-making by expert clinicians. According to the so-called dual process theory, two definable systems of thinking can be distinguished: Whereas "System 1" thinking is intuitive, automatic, quick, and effortless (i.e., non-analytical), "System 2" thinking is analytic, reflective, slow, and effortful. The authors highlight the importance of expertise and experience when they conclude that "[t]he ability to rapidly access experiential knowledge is a hallmark of expertise. Knowledge-oriented interventions such as self-explanation, deliberate reflection, and checklists may improve diagnostic accuracy, but there is no substitute for experience gained through broad clinical exposure and regular feedback on patient outcomes" (pp. 632–633).

Our results can be summarized as follows. As a benchmark, we analyze the situation in which types are known. In this case, we find that a low-ability expert—just like a high-ability expert—always efficiently serves the market. In contrast to a high-ability type, however, such efficient behavior can require over- or undertreatment. Turning to the case with unobservable types, it turns out that for some parameter constellations, multiple pooling equilibria can exist. In one of these pooling equilibria, the market is served inefficiently, and types choose too much over- or undertreatment. Now when experts coordinate on the inefficient equilibria, then an improved diagnostic ability of the low-ability type and/or a higher probability for the high-ability type can aggravate market inefficiencies.

The literature on heterogeneity in credence goods markets is very scarce. There is some evidence that the efficiency benchmark result with homoge-

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<sup>4</sup>See the literature overview below.

neous experts and customers and liability or verifiability breaks down once heterogeneity is introduced. The paper closest to ours is Schneider and Bizer (2017a), which offers an extension of the setup in Pesendorfer and Wolinsky (2003). Whereas Pesendorfer and Wolinsky (2003) assume that experts are homogenous and must decide whether they exert high or low diagnosis effort, Schneider and Bizer (2017a) consider two types of experts. Again, both types must decide whether to exert high or low diagnosis effort, and both types perform an accurate diagnosis when they choose high effort. However, experts differ when they decide to only exert low effort: In this case, the low-ability type always misdiagnoses a customer’s problem, which is drawn from a continuum of problems, whereas the high-ability type recommends the accurate treatment with some probability. In contrast to the present setup, customers can search for multiple opinions. The authors find that with a sufficient number of high-ability experts, there is the possibility for a second-best equilibrium in which welfare is maximized even without a policy intervention of fixing prices. Moreover, in line with Pesendorfer and Wolinsky (2003), given a small share of high-ability experts, a second-best equilibrium requires fixed prices.

Schneider and Bizer (2017b) experimentally test this model. They find that experimental credence goods markets with expert moral hazard with regard to the provision of truthful diagnoses are more efficient than predicted by theory. With regard to better expert qualification—in the sense that the share of high-ability experts increases—the authors find that market efficiency increases with fixed prices but remains unaffected or even declines with price competition.

In his generalization of the credence-good model by Dulleck and Kerschbamer (2006), Hilger (2016) assumes that heterogenous experts differ in their treatment costs, and that customers do not observe the experts’ cost functions.<sup>5</sup> As a consequence, experts cannot credibly signal that they will always provide the efficient treatment. Then, experts can take advantage of their expert status, resulting in equilibrium mistreatment in a wide range of price-setting and market environments.

The remainder of the paper is organized as follows. In the next section, we describe the model setup. In Section 3, we derive the equilibria distinguishing

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<sup>5</sup>In their unifying framework, Dulleck and Kerschbamer (2006) analyze the case in which customers differ in their expected costs of efficient treatment. Customers know their costs, but this is their private information: The expert only knows the distribution of types. In such a situation in which the expert cannot price-discriminate, inefficient rationing where high-cost customers are not served occurs when the difference in expected cost between the best and the worst type is large relative to the efficiency gain of treating the worst type. When the expert can price-discriminate, all customers are served, but high-cost consumers always receive the major treatment—even though it may not be necessary (overtreatment).

between the cases of observable types (Subsection 3.1) and unobservable types (Subsection 3.2). Section 4 concludes.

## 2 Model

Consider the following credence good market with a mass one of customers and a monopolistic expert. Each customer is aware that they have a problem and that they need a major treatment with probability  $h$  or a minor treatment with probability  $1 - h$ . Each customer decides whether to visit an expert. When customers decide to do so, they are committed to undergoing the recommended treatment and paying the price charged for that treatment. Customers can observe the treatment performed and whether the treatment is sufficient to heal the problem. As such, customers can observe undertreatment but not overtreatment. When the problem is healed, a customer receives a gross payoff equal to  $v$ . When it is not healed, a customer receives a gross payoff of zero. By assumption, a customer who is indifferent between visiting an expert and not visiting an expert, decides for a visit.

The expert can be one of two types which is common knowledge. When the expert has high diagnostic ability, which happens with commonly known probability  $x$ , he performs an accurate (costless) diagnosis with certainty, i.e., he identifies the necessary treatment without making mistakes. When the expert has low ability, which happens with probability  $1 - x$ , he performs an accurate diagnosis with commonly known probability  $q \in [1/2, 1]$ .<sup>6</sup> A low-ability expert can hence make two types of errors, which occur both with probability  $1 - q$ : When the expert makes a false positive error, he diagnoses a major problem, although the customer only faces a minor problem. Under a false negative error, the expert diagnoses a minor problem, but the customer has a major problem. The expert has costs of  $\bar{c}$  and  $\underline{c}$  for providing the major and minor treatment, respectively (with  $\underline{c} < \bar{c}$ ). The major treatment fixes any of the two problems, whereas the minor treatment only fixes the minor problem. It is assumed that  $v > \bar{c}$  holds, which means that it is always (i.e., even ex post) efficient to treat a customer. Furthermore, the expert sets prices  $\bar{p}$  and  $\underline{p}$  for the major and minor treatment, respectively, and charges the customer for the recommended (verifiable) treatment. An expert's profit then amounts to the price-cost margin per customer treated. When customers do not visit the expert, he makes zero profit. Note that it is assumed that an expert cannot be held liable when providing an insufficient treatment.

The timing of events is as follows:

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<sup>6</sup>Note that a probability lower than one half does not make sense, as in this case, the expert could provide better services by performing the treatment that was *not* diagnosed.

1. Nature determines whether the expert type has high ability (with probability  $x$ ) or low ability (with probability  $1 - x$ ).
2. The expert learns his type and chooses a price vector  $\mathbf{P} = (\bar{p}, \underline{p})$ , which specifies a price for each of the two treatments.
3. Customers observe the prices, form beliefs  $\mu(\mathbf{P})$  that an expert setting a price vector  $\mathbf{P}$  is a high-ability expert, and decide whether to visit the expert. When customers do not visit the expert, the game ends, and both players receive payoffs of zero.
4. When customers visit the expert, nature determines whether they have a major problem (with probability  $h$ ) or a minor problem (with probability  $1 - h$ ).
5. In case the expert has low ability, nature determines the outcome of the diagnosis, which is accurate with probability  $q$ . A low-ability expert has beliefs  $\bar{\mu}$  ( $\underline{\mu}$ ) that a customer indeed faces the major (minor) problem when the diagnosis points to a major (minor) problem. A high-ability expert always performs an accurate diagnosis.
6. The expert recommends and performs a treatment and charges the price for that treatment. Then, payoffs realize.

*Figure 1* illustrates the structure of the game.

### 3 Analysis and results

We now derive the (non-trivial) equilibrium outcomes in our credence goods market. We distinguish between two cases in which types are (i) observable and (ii) unobservable. We start by analyzing the benchmark case with observable types.

#### 3.1 Benchmark: Observable types

In order to analyze the optimal pricing and treatment decisions by the two expert types, we look at the relative price-cost margins for the two treatments.

##### Price-cost margins

Three scenarios are possible: (i)  $\bar{p} - \bar{c} \geq \underline{p} - \underline{c}$ , (ii)  $\bar{p} - \bar{c} \leq \underline{p} - \underline{c}$ , and (iii)  $\bar{p} - \bar{c} = \underline{p} - \underline{c}$ . Scenario (iii) is a special case of the other two scenarios, but for brevity, we will not repeat the analyses of (i) and (ii) when analyzing (iii),

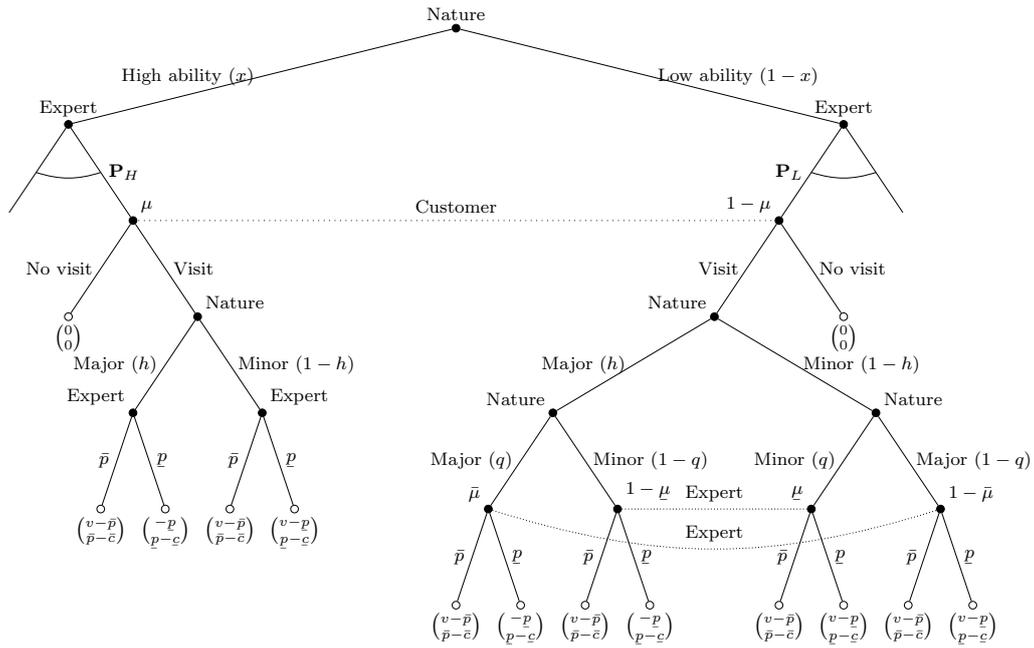


Figure 1: Timing of events in the expert market.

Note: We refrain from explicitly stating the treatment choice in the game tree, because due to verifiability, an expert's price choice implies the respective treatment. Note further that the first (second) entry in the payoff vector represents customer (expert) payoff.

even though they also apply. We focus on the equilibria that yield the highest profits in each (sub-)scenario.

In scenario (i), an expert—independent of his type (and hence observability)—finds it optimal to always overtreat his customers. In this case denoted by superscript o, an expert appropriates all surplus from trade, and hence optimal prices are given by

$$\bar{p}^o = v$$

and

$$\underline{p}^o \leq v - \Delta c,$$

where  $\Delta c := \bar{c} - \underline{c}$ . The resulting profit is given by

$$\pi^o = v - \bar{c}. \quad (1)$$

In the second scenario, an expert—again independent of his type—finds it optimal to always undertreat his customers. In this case denoted by superscript u, optimal prices are given by

$$\bar{p}^u \leq (1 - h)v + \Delta c$$

and

$$\underline{p}^u = (1 - h)v.$$

The profit in this case amounts to

$$\pi^u = (1 - h)v - \underline{c}. \quad (2)$$

The pricing decision in scenario (iii) (denoted by superscript e) depends on the expert's type, as different abilities result in different expected gains from trade for customers. Then, for a high-ability expert, the combination of the customers' binding participation constraint and equal markups leads to prices of

$$\bar{p}_H^e = v + (1 - h)\Delta c$$

and

$$\underline{p}_H^e = v - h\Delta c.$$

The profit for this type equals

$$\pi_H^e = v - \underline{c} - h\Delta c. \quad (3)$$

Similarly, the prices set by the low-ability expert amount to

$$\bar{p}_L^e = (1 - h + hq)v + (h - 2hq + q)\Delta c$$

and

$$\underline{p}_L^e = (1 - h + hq)v - (1 - h + 2hq - q)\Delta c.$$

The profit for this type equals

$$\pi_L^e = (1 - h + hq)v - \bar{c} + (h - 2hq + q)\Delta c. \quad (4)$$

Note that it holds that

$$\frac{\partial \pi_L^e}{\partial q} = hv + (1 - 2h)\Delta c > 0, \quad (5)$$

where the latter is due to the fact that  $v > \bar{c}$ . Not surprisingly, as customers' expected benefit from visiting an expert increases with the probability of receiving the accurate (sufficient) treatment, profits increase with better abilities.

Before characterizing the two types' optimal pricing behavior, let us briefly comment on efficiency. An expert is interested in maximizing customer surplus, because customer surplus can be fully appropriated by the expert through those prices, which are actually charged in equilibrium. As a consequence, whenever an expert opts for a certain regime given observability of the type, this is also optimal from a social welfare point of view. As just mentioned, profits under equal markups increase with better abilities, which means that the same is true for welfare.

Let  $\mathbf{P}^o := (\bar{p}^o, \underline{p}^o)$ ,  $\mathbf{P}^u := (\bar{p}^u, \underline{p}^u)$ , and  $\mathbf{P}_i^e := (\bar{p}_i^e, \underline{p}_i^e)$  (with  $i \in \{H, L\}$ ). We can now analyze the pricing and treatment decisions by the two types. We start with the high-ability type.

### High-ability type

The pricing behavior by the high-ability type, if he can commit to a strategy, has been studied before and can be characterized as follows:

**Lemma 1** (Dulleck and Kerschbamer, 2006). *An observable high-ability type efficiently serves all customers and sets a price vector  $\mathbf{P}_H^e$ .*

*Proof.* Follows from a comparison of expression (3) with expressions (1) and (2), respectively, and the assumption that  $v > \bar{c}$ .  $\square$

We can thus point out that the high-ability benefits from offering equal-markup prices. By doing so, the expert can charge higher markups, as he credibly commits to treating customers honestly. At the same time, any problem is healed at the cheapest cost, i.e., welfare is maximized.

### Low-ability type

In order to specify the optimal prices set by a low-ability expert, note that

$$\pi^\circ \begin{matrix} \leq \\ > \end{matrix} \pi_L^e \Leftrightarrow h \begin{matrix} \leq \\ > \end{matrix} \frac{q\Delta c}{(1-q)v - (1-2q)\Delta c} =: h_L^\circ$$

and

$$\pi^u \begin{matrix} \leq \\ > \end{matrix} \pi_L^e \Leftrightarrow h \begin{matrix} \geq \\ < \end{matrix} \frac{(1-q)\Delta c}{qv + (1-2q)\Delta c} =: h_L^u.$$

We can thus state the following proposition:

**Proposition 1.** *Given that a low-ability expert makes diagnosis errors, an observable low-ability type efficiently serves his customers and sets the following prices:*

$$\mathbf{P}_L = \begin{cases} \mathbf{P}^u & \text{if } h \in [0, h_L^u] \\ \mathbf{P}_L^e & \text{if } h \in (h_L^u, h_L^\circ] \\ \mathbf{P}^\circ & \text{else} \end{cases}$$

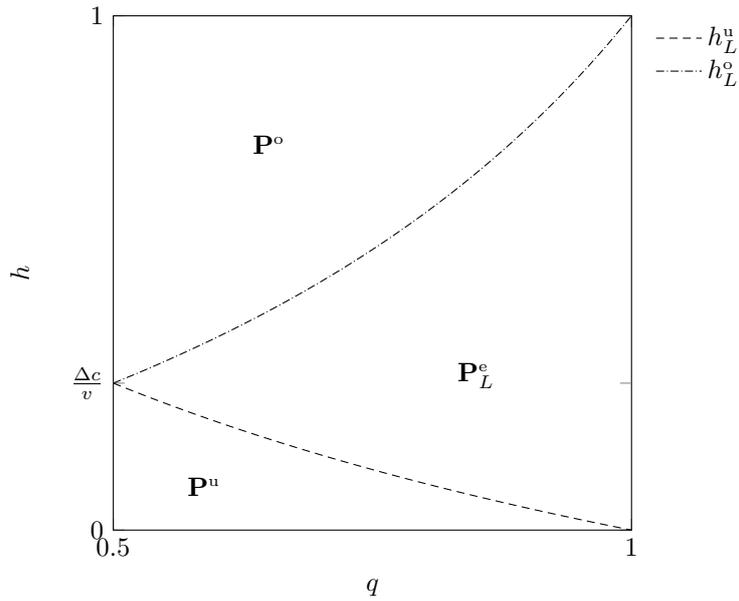


Figure 2: Pricing by an observable low-ability expert.

As argued above, the expert's and the social planner's incentive are fully aligned. Hence, over- or undertreatment can be optimal also from a welfare perspective. For example, when the probability of a major problem is relatively/very high, and the probability of an accurate diagnosis is relatively/very

low, then it is optimal to always recommend and perform the major treatment, as the likelihood of failing to heal the customer's problem is (much) greater than that of unnecessarily paying the higher costs for the major treatment.

### 3.2 Unobservable types

We start with a very general feature of equilibria in our setup:

**Lemma 2.** *In any equilibrium, both expert types make the same profit.*

*Proof.* If one expert type made a higher profit in an equilibrium by posting a certain price menu, the other type could easily mimic this offer and make a higher profit himself. As a matter of fact, both types make the same profit as long as they charge the same prices given the treatment incentives as a result of relative price-cost margins (see the three cases above). This is due to the observation that ability does not directly affect profits here.  $\square$

From the proof it is clear that identical profits, however, can only be achieved when experts offer the same price menu. Hence, we have:

**Corollary 1.** *There are no separating equilibria.*

Thus, we focus on non-trivial pure-strategy perfect Bayesian Nash pooling equilibria. Among those, we focus on the ones which yield the highest profits in each subcase. There are more equilibria in which all players play the same actions, but experts post uniformly lower prices because customers hold off-equilibrium beliefs such that they would not visit the experts for higher prices.

#### Pooling equilibria

Given the comparison of the two price-cost margins, there are three types of equilibria, which can be classified as follows: pooling with (i) overtreatment, (ii) undertreatment, and (iii) equal markups. The prices and profits for the first two scenarios are the same as in Subsection 3.1.

$$\bar{x}^u := \frac{-hqv + (1-q-h+2hq)\Delta c}{(1-q)(hv - (1-2h)\Delta c)}$$

$$\bar{x}^o := 1 - \frac{(1-h)\Delta c}{(1-q)(hv + (1-2h)\Delta c)}$$

We can therefore define these equilibria as follows:

**Definition 1** (Undertreatment pooling equilibria). *Undertreatment pooling equilibria are characterized as follows:*

- Both types choose the price vector  $\mathbf{P}^u$ .
- Both types always recommend the minor treatment.

- The low-ability type has beliefs  $\bar{\mu} = \underline{\mu} = q$ .
- Customers' beliefs equal  $\mu(\mathbf{P}^u) = x$ ,  $\mu(\mathbf{P}) \in [0, 1] \forall \mathbf{P} < \mathbf{P}^u$ , and  $\mu(\mathbf{P}) \in [0, \bar{x}^u] \forall \mathbf{P} > \mathbf{P}^u$ .
- Customers always visit the expert.

**Definition 2** (Overtreatment pooling equilibria). *Overtreatment pooling equilibria are characterized as follows:*

- Both types choose the price vector  $\mathbf{P}^\circ$ .
- Both types always recommend the major treatment.
- The low-ability type has beliefs  $\bar{\mu} = \underline{\mu} = q$ .
- Customers' beliefs equal  $\mu(\mathbf{P}^u) = x$ ,  $\mu(\mathbf{P}) \in [0, 1] \forall \mathbf{P} < \mathbf{P}^\circ$ , and  $\mu(\mathbf{P}) \in [0, \bar{x}^\circ] \forall \mathbf{P} > \mathbf{P}^\circ$ .
- Customers always visit the expert.

Let us now come to equal-markup equilibria. In those, each type of expert may choose to either follow the diagnosis or to always perform one of the two treatments. Thus, special cases of the undertreatment and overtreatment pooling equilibria can be equal markup equilibria. When both types of experts follow the diagnosis, prices and profits for equal markups are given by

$$\bar{p}^e = (1 - h + hq - hqx + hx)v + (h - 2hq - 2hqx - 2hx + q - qx + x)\Delta c$$

and

$$\underline{p}^e = (1 - h + hq - hqx + hx)v - (1 - h + 2hq - 2hqx + 2hx - q + qx - x)\Delta c.$$

Then, let  $\mathbf{P}^e := (\bar{p}^e, \underline{p}^e)$ . The profit for each type equals

$$\begin{aligned} \pi^e &= (1 - h + hq - hqx + hx)v \\ &\quad - \underline{c} - (1 - h + 2hq - 2hqx + 2hx - q + qx - x)\Delta c. \end{aligned} \quad (6)$$

Again, both types make identical profits, because ability does not play any role under equal-markup prices: Even when a low-ability type recommends the wrong treatment, he receives the same mark-up as the high-ability type.

A comparison of profits reveals that

$$\pi^\circ \stackrel{\leq}{\geq} \pi^e \Leftrightarrow h \stackrel{\leq}{\geq} \frac{(q - qx + x)\Delta c}{(1 - 2q + 2qx - 2x)v - (1 - q + qx - x)\Delta c} =: h^\circ$$

and

$$\pi^u \lesseqgtr \pi^e \Leftrightarrow h \gtrless \frac{(1 - q + qx - x)\Delta c}{(q - qx + x)v + (1 - 2q + 2qx - 2x)\Delta c} =: h^u$$

Note that it holds that

$$\frac{\partial h^e}{\partial q}, \frac{\partial h^e}{\partial x} > 0, \quad (7)$$

and

$$\frac{\partial h^u}{\partial q}, \frac{\partial h^u}{\partial x} < 0. \quad (8)$$

Thus, we can point out that both probabilities have a very similar effect on the two thresholds. This is due to the fact that over- and undertreatment are not affected by either of the two probabilities, because the two expert types do not differ in their diagnosis. Under equal mark-up pricing, customer surplus is affected by diagnostic quality. From an ex-ante point of view, however, it does not make a difference for the customer whether he faces a high-ability expert with probability  $x$  and gets the accurate treatment or whether he faces a low-ability type and gets the accurate treatment with probability  $q$ .

More generally, let  $\mathbf{P}_{ij}^e := (\bar{p}_{ij}^e, \underline{p}_{ij}^e)$ , where  $i \in \{o, u, a\}$  specifies whether the high type always recommends the major or the minor treatment or follows his diagnosis, where  $j \in \{o, u, a\}$  does so for the low type, and where

$$\begin{aligned} \bar{p}_{ij}^e &= \underline{p}_{ij}^e + \Delta c = x[\mathbb{1}_{i=o}v + \mathbb{1}_{i=u}((1 - h)v + \Delta c) + \mathbb{1}_{i=a}(v + (1 - h)\Delta c)] \\ &+ (1 - x)[\mathbb{1}_{j=o}v + \mathbb{1}_{j=u}((1 - h)v + \Delta c) \\ &+ \mathbb{1}_{j=a}(v(1 - h(1 - q)) + ((1 - h)q + h(1 - q))\Delta c)]. \end{aligned} \quad (9)$$

The profits are  $\pi_{ij}^e = \bar{p}_{ij}^e - \bar{c}$ .

Given the above prices, we can define equal-markup pooling equilibria:

**Definition 3** (Equal-markup pooling equilibria in which experts follow their diagnosis). *Equal-markup pooling equilibria in which experts follow their diagnosis are characterized as follows:*

- Both types choose the price vector  $\mathbf{P}^e$ .
- Both types always recommend the necessary treatment (according to their abilities).
- The low-ability type has beliefs  $\bar{\mu} = \underline{\mu} = q$ .
- Customers' beliefs equal  $\mu(\mathbf{P}^e) = x$ ,  $\mu(\mathbf{P}) \in [0, 1] \forall \mathbf{P} < \mathbf{P}^e$ , and  $\mu(\mathbf{P}) \in [0, x] \forall \mathbf{P} > \mathbf{P}^e$ .
- Customers always visit the expert.

Using these definitions, we can characterize equilibrium existence in the following proposition:

**Proposition 2.** *The existence of pooling equilibria is characterized as follows:*

- (i) for  $h \in [0, h^u]$ , there exist undertreatment pooling equilibria;
- (ii) for  $h \in (h^u, h_L^u)$ , there exist undertreatment pooling equilibria and equal-markup pooling equilibria in which experts follow their diagnosis;
- (iii) for  $h \in [h_L^u, h_L^o]$ , there exist equal-markup pooling equilibria in which experts follow their diagnosis;
- (iv) for  $h \in (h_L^o, h^o)$ , there exist overtreatment pooling equilibria and equal-markup pooling equilibria in which experts follow their diagnosis; and
- (v) for  $h \in [h^o, 1]$ , there exist overtreatment pooling equilibria.

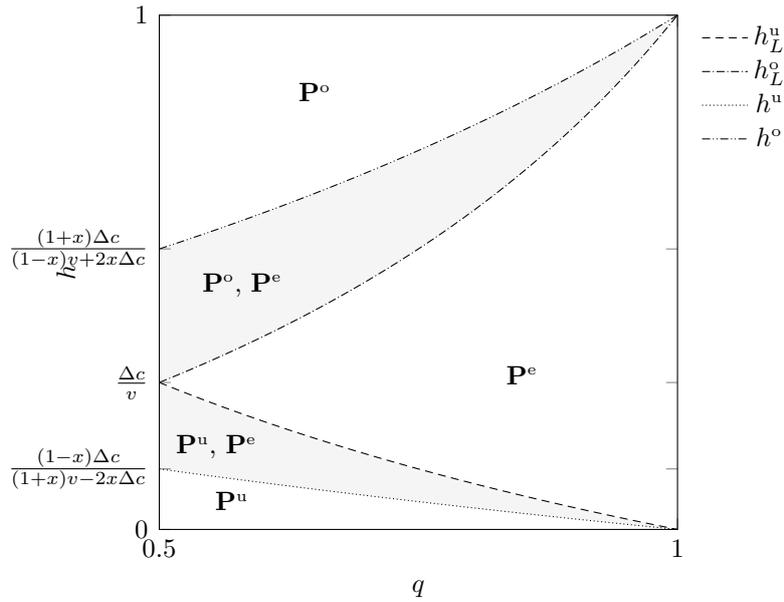


Figure 3: Existence of pure-strategy pooling equilibria (for off-equilibrium beliefs equal to zero).

Note: In the shaded areas, an inefficiency arises when both types do not choose equal-markup prices.

## Improving diagnostic results

From a policy perspective, it is an important question whether better diagnostic abilities improve the market outcome—in particular when such an endeavor involves (substantial) costs. Such an improvement can come in two forms: First, the low-ability type may become better at supplying an accurate diagnosis (i.e.,  $q$  increases). Second, the probability that an expert is a high type increases (i.e.,  $x$  increases).

Recall that in our setup, changes in the two parameters have a similar effect (see expressions (7) and (8)). Moreover, as we have seen before (see equation (5)), profits for the low-ability type—and hence welfare—increases in the probability with which he can supply an accurate diagnosis. Equivalently, an observable high-ability expert makes higher profits than its low-ability counterpart. We can therefore state the following result:

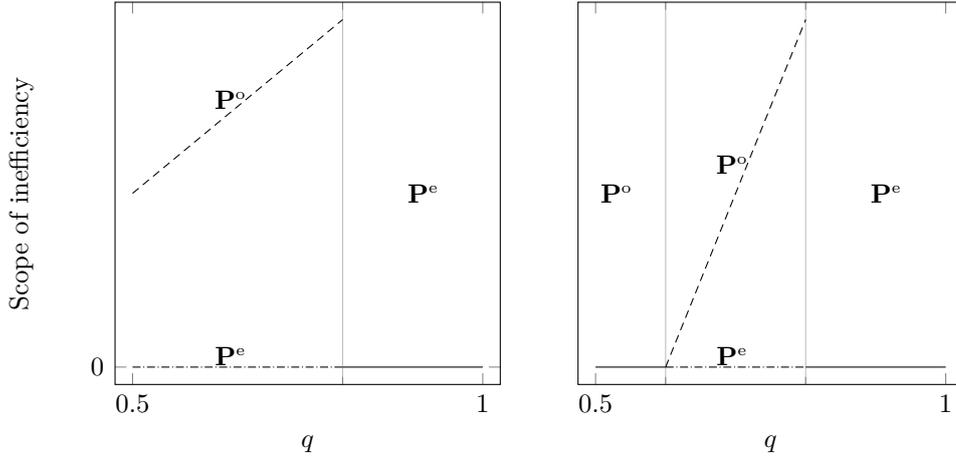
**Proposition 3.** *When both types do not choose an equal-markup price vector for  $h \in (h^u, h_L^u)$  or  $h \in (h_L^o, h^o)$ , better diagnostic abilities of the low-ability type and, equivalently, a higher probability for a high-ability type result in greater market inefficiencies.*

*Figure 4* illustrates the finding for a change in the low-ability type’s diagnostic accuracy (where  $h > \Delta c/v$ ).

We point out that an increase in any of the two probabilities imply that the areas in which more equilibria exist increase. This is due to the fact that a low-ability expert benefits from higher prices as its diagnostic precision or the probability for a high-ability expert increases. At the same time, however, the incentives in the under- and overtreatment equilibria do not change. This means that, from a social welfare point of view, there should be more equal-markup pricing. As a consequence, the potential scope for inefficient equilibria increases.

## 4 Conclusion

Our setup represents the opposite extreme of what has been analyzed in previous contributions: Whereas earlier analyses have assumed that it is sufficient for experts to incur (heterogenous) costs to perform accurate diagnoses, we consider a situation in which experts sometimes make diagnostic mistakes, but they cannot do anything about it. Both approaches have their merits and reflect different markets or expert services. Clearly, real-world markets are likely to display both features at the same time. It would therefore be interesting to include the two aspects in a single framework.



(a) Major problem occurs with medium probability ( $h \in (\Delta c/v, (1 + x)\Delta c/((1 - x)v + 2x\Delta c))$ ). (b) Major problem occurs with (very) high probability ( $h > (1 + x)\Delta c/((1 - x)v + 2x\Delta c)$ ).

Figure 4: Market (in)efficiency when major problem occurs with medium to very high probability ( $h > \Delta c/v$ ) and off-equilibrium beliefs equal to zero.

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