Credence goods markets with heterogeneous experts

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Abstract

We analyze a credence goods market with regulated prices and heterogeneous experts. Experts are assumed to differ in the cost of treating a minor problem. We investigate the effect of this heterogeneity on the market level of fraud and amount of second opinions (and consequently consumer search cost) considering different distributions of high- and low-cost experts in the market. We show that a cost reduction always increases welfare but in some cases only because of the raised expert surplus and not due to fewer second opinions. Furthermore, there is only a positive effect on consumer welfare if the cost of sufficient many experts are reduced. The fraud level remains the same as before the cost reduction in all cases despite lower fraud incentives for the more efficient experts as a consequence of their lowered treatment cost.

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1 Introduction

A customer in a credence good market cannot estimate which quality of the traded good he actually needs whereas experts in credence goods market can exactly tell which kind of quality a customer needs. The expert’s information advantage compared to the customer may induce incentives for an expert to defraud a customer by selling him the wrong quality or charging him an inappropriate price (Darby and Karni, 1973). There are different factors and characteristics that may influence the experts’ fraud incentives and in the previous literature on credence goods several of them have been analyzed: Wolinsky (1993) shows that in credence good markets with endogenous prices experts may not have incentives to cheat at all, but in a market with exogenous prices there is no market equilibrium without fraud. Sülzle and Wambach (2005) illustrate that an increase in co-insurance rate in a market with regulated prices can lead to less fraud and higher welfare or to a higher level of fraud and lower welfare but can also have no effect on the market equilibrium. Dulleck and Kerschbamer (2006) find that the experts’ fraudulent behavior might be prevented by the market mechanism given endogenous prices if certain conditions such as large economies of scope between diagnosis and treatment are fulfilled. Dulleck et al. (2011) observe with a large-scale experiment that experts in credence good markets may trade-off between honest and fraudulent behavior considering the financial incentives and the degree of transparency.

In most of the credence goods literature experts are assumed to be homogeneous with respect to different characteristics whereas in reality they are heterogeneous. For example, Mehrotra et al. (2012) find empirical evidence that more experienced physicians have a lower cost profile than less experienced physicians considering patients’ treatments. The market for medical services is often regarded a prime example for a credence market. Intuitively one could expect that more efficient experts have lower incentives to defraud customers because they may earn higher profits by treating customers honestly than the less efficient experts. Therefore, we develop a theoretical model in which we distinguish between two types of experts, low-cost and high-cost experts, in order to analyze how the experts’ heterogeneity considering treatment efficiency affects the market level of experts’ overcharging and the amount of second opinions in the market. The number of second opinions determine the level of social welfare in our model.

Further, we assume that the prices for treatments are exogenously given. That is, our model generates implications for markets like the health care market in the USA or in Germany where prices are regulated (Sülzle and Wambach, 2005). Hilger (2012) also investigates a credence good market with experts that differ in their performance cost but with endogenous price setting by experts. The experts’ costs in his model are not observable and this might lead to mistreatment since prices are determined by experts but do not signal markups.

In the following section 2 we describe the model. In section 3 we analyze customers’ and

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1 The two types of experts in our model may also be seen as less experienced and more experienced experts.
experts’ behavior and perform an equilibrium analysis. Section 4 discusses different degrees of a cost reduction. Section 5 concludes.

2 Model

Our analysis is based on Wolinsky (1993). There is a continuum of customers in the market. Each customer has a problem but cannot observe whether it is a major or minor problem. However, he knows that the probability of having a major problem $H$ is $\pi$ and the probability of having a minor problem $L$ is $1 - \pi$. To fix their problems, each customer visits an expert to get a diagnosis and then decides whether to receive treatment from this expert or to consult another one. A customer derives the utility $B$ from getting his problem fixed. With each visit to an expert, search and waiting costs $k$ arise.

There is a large but limited number of experts in the market. An expert is able to correctly diagnose and fix a customer’s problem, however, she cannot observe if a customer has visited other experts before. After diagnosing a customer’s problem the expert recommends a minor or major treatment. If the customer accepts this recommendation, he pays according to the expert’s recommendation and she fixes the problem. Market prices are regulated. The prices for minor and major treatments are given by $p_L$ and $p_H$, respectively. It holds $p_H > p_L$.

A customer observes if his problem is fixed but not which type of treatment he received. This causes an informational disadvantage of customers compared to experts. In particular, an expert can recommend a major treatment but conduct a minor treatment instead. This gives the expert the opportunity to defraud her customers by overcharging. We do not consider overtreatment due to a lack of financial incentives for the experts. Undertreatment is ruled out because we assume experts to be liable for not fixing a customer’s problem successfully once an agreement between customer and expert was made, especially because we want to derive implications for health care markets. Customers know that they can only be overcharged.

Treating a customer’s problem is costly for the experts. We assume the experts to be heterogeneous in the cost of treating a minor problem. Treating a customer with a minor problem induces costs of $c^h_L$ for the high-cost experts and costs of $c^l_L = c^h_L - \Delta$ for the low-cost experts, where $\Delta$ is the low-cost experts’ cost advantage. The share of high-cost experts in the market is defined by $q_h$ and the share of low cost experts by $1 - q_h$. The cost of treating a major problem is $c_H > c^h_L$ for all experts. The relation between prices and costs is given by $p_H = c_H$ and $p_L = c^h_L + e$, where $e$ is the high-cost experts’ mark-up for treating a customer honestly. It holds $0 < e < c_H - c^h_L$, i.e. for both types of experts the profit that can be earned by defrauding a customer with a minor problem (in case of acceptance by the customer) is always higher than the profit that can be received by treating the customer honestly.
3 Analysis

3.1 Customer behavior

A customer’s utility is given by $U = B - p_i - nk$, where $n$ is the number of experts he visits. We assume that $B > k + p_H$ and that $k < p_H - p_L$ such that each customer gets his problem fixed and such that second opinions may be beneficial. A customer maximizes her expected utility by choosing his optimal acceptance strategy $y$, i.e. the acceptance of a major diagnosis on his first visit. Assuming that all experts in the market overcharge customers with minor problems with probability $X = q_h x_h + (1 - q_h) x_l$, where $x_h$ is the high-cost experts’ average level of fraud and $x_l$ is the low cost experts’ average level of fraud, then a customer’s cost function is given as

$$\begin{align*}
C(y = 1) &= k + (1 - \pi)(1 - X)p_L + (\pi + (1 - \pi)X)p_H \\
C(y = 0) &= k + (1 - \pi)(1 - X)p_L + (\pi + (1 - \pi)X)p_H (1 - X)X \pi + (1 - \pi)X^2 p_H \pi
\end{align*}$$

when accepting a $H$-diagnosis and as

$$(1)$$

$$C(y = 1) = k + (1 - \pi)(1 - X)p_L + (\pi + (1 - \pi)X)p_H$$

when rejecting it.

A customer’s first visit leads to search cost $k$. A customer with a minor problem (which occurs with probability $1 - \pi$) receives an honest recommendation with probability $1 - X$, always accepts such a recommendation, and pays price $p_L$.

A customer receives a major diagnosis with probability $\pi + (1 - \pi)X$. If she accepts the recommendation, she has to pay $p_H$ for the treatment. If the customer rejects the recommendation from the first expert, she will consult a second expert. Getting a second opinion leads to additional search costs of $k$ but also leads to the possibility of receiving a minor diagnosis. On a second visit, a customer accepts any diagnosis.

A comparison of equations (1) and (2) yields customers’ optimal behavior, which we record in the following Lemma, due to Wolinsky (1993).

Lemma 1. For a given $X \in [0, 1]$ the customers’ symmetric best response is given as:

$$y^*(X) = \begin{cases} 
0 & \text{if } X \in (X_1, X_2) \\
1 & \text{if } X \in [0, X_1) \cup (X_2, 1] \\
[0, 1] & \text{if } X \in \{X_1, X_2\}
\end{cases}$$

where

$$(2)$$

The expected treatment costs weigh the prices for a major and minor treatment with their conditional probabilities given that the first expert recommended a major treatment (Sülzle and Wambach, 2005).
\[ X_{1,2} = \frac{1}{2} \left( 1 - \frac{k}{p_H - p_L} \right) \pm \sqrt{\frac{1}{4} \left( 1 - \frac{k}{p_H - p_L} \right)^2 - \frac{\pi}{1 - \pi} \frac{k}{p_H - p_L}}. \] (3)

Lemma 1 shows that customers only get a second opinion if the level of fraud is neither too high nor too low. If the level of fraud is low, the first diagnosis is correct with a large probability, while if the level of fraud is high, the second diagnosis is an \( H \)-diagnosis as well. The customers’ best response correspondence is shown in Figure 1.

![Figure 1: Customers’ best response correspondence](image)

### 3.2 Expert behavior

In this section we analyze the experts’ optimization problems. In the following, we assume \( e < (p_H - c^h_L)/2 \) in order to concentrate on the effects of a cost reduction on the level of fraud and welfare. If \( e \geq (p_H - c^h_L)/2 \) then are no fraud incentives for experts given customers’ reject a major diagnosis on their first relatively often (Sülzle and Wambach, 2005).

An expert with cost \( c^i_L, i \in \{l, h\} \) maximizes her profit by choosing her optimal defrauding strategy \( x^i \). The profit function when facing a patient with a minor problem is given by

\[ \pi^i(x^i = 0) = p_L - c^i_L \] (4)

when treating the patient honestly and by

\[ \pi^i(x^i = 1) = \frac{y + X(1 - y)}{1 + X(1 - y)} (p_H - c^i_L) \] (5)
when defrauding the patient.

By diagnosing honestly, the expert gains a certain profit of $p_L - c^i_L$. If the expert defrauds the patient, the expected profit depends on patients’ acceptance rate $y$ and the market level of fraud $X$. Comparing (4) and (5) gives the expert’s best reply given $y$ and $X$.

**Lemma 2.** An expert’s best reply is given by

$$x^i(y, X) \in \begin{cases} 
{0} & \text{if } X < \frac{p_L - c^i_L - y(p_H - c^i_L)}{(1-y)(p_H - p_L)} \text{ and } y \leq \frac{p_L - c^i_L}{p_H - c^i_L} \\
[0, 1] & \text{if } X = \frac{p_L - c^i_L - y(p_H - c^i_L)}{(1-y)(p_H - p_L)} \text{ and } y \leq \frac{p_L - c^i_L}{p_H - c^i_L} \\
{1} & \text{else.}
\end{cases}$$

*Proof. *We distinguish between three cases which differ with regard to the customers’ acceptance probability $y$.

1. Suppose each customer accepts a major diagnosis from an expert on his first visit ($y = 1$). From substituting $y = 1$ in (5), it follows that (4) $<$ (5). Therefore, the expert strictly prefers to defraud her customers.

2. Suppose customers always reject a major diagnosis on their first visit ($y = 0$). From substituting $y = 0$ in (5), it follows that

$$\pi^i(x^i = 1) = \frac{X}{1 + X} (p_H - c^i_L).$$

(6)

The comparison between (4) and (6) depends on the market level of fraud, $X$. We consider three different cases:

a) Assume all other experts in the market treat customers with minor problems honestly ($X = 0$). Setting $X = 0$ reduces (6) to 0. It follows that an expert strictly prefers treat her patients honestly.

b) Suppose all other experts in the market always defraud customers with a minor problem ($X = 1$). From setting $X = 1$ in (6), comparing (4) and (6), and using the assumption $e < (p_H - c^i_L)/2$ it follows that

$$p_L - c^i_L < \frac{1}{2} (p_H - c^i_L) \text{ for all } i.$$

(7)

Hence, the expert strictly prefers to defraud her patients.

c) Consider that some experts defraud their customers while others diagnose honestly ($X \in (0, 1)$). Equalizing (4) and (6) yields the market level of fraud, $\tilde{X}$, where the expert is indifferent between defrauding her patients and treating them honestly:

$$\tilde{X}(y = 0) := \frac{p_L - c^i_L}{p_H - p_L} \in [0, 1].$$

(8)
It follows that the expert strictly prefers to defraud (treat honestly) if $X > \tilde{X}$ ($X < \tilde{X}$).

3. Suppose some customers accept a major diagnosis from the first expert, while others go for a second opinion ($y \in (0, 1)$). Given $y \in (0, 1)$, the comparison between (4) and (6) depends on the market level of fraud, $X$. Again, we consider three different cases:

a) Assume all other experts in the market are honest to customers with minor problems ($X = 0$). Substituting $X = 0$ in (5), and comparing (4) and (5) leads to the acceptance probability $\tilde{y}$ which makes the expert indifferent between defrauding her patients and treating them honestly:

$$\tilde{y}(X = 0) := \frac{p_L - c_i^L}{p_H - c_i^L} \in [0, 1].$$

That is, for $y > \tilde{y}$ ($y < \tilde{y}$), the expert strictly prefers to defraud her patients (treat them honestly).

b) Suppose all other experts in the market defraud customers with minor problems ($X = 1$). A comparison of (4) and (5) leads to

$$p_L - c_i^L < \frac{1}{2-y}(p_H - c_i^L),$$

which is always satisfied given $e < (p_H - c_i^L)/2$.

c) Consider the case in which some experts defraud their customers, while others treat them honestly ($X \in (0, 1)$). Equalizing (4) and (5) gives a condition such that an individual expert is indifferent between defrauding customers with minor problems and treating them honestly:

$$\tilde{X}(y) := \frac{p_L - c_i^L - y(p_H - c_i^L)}{(1-y)(p_H - p_L)}.$$  

We now derive conditions guaranteeing that $\tilde{X}(y) \in [0, 1]$. First note that $\partial \tilde{X}/\partial y < 0$. An upper bound for $\tilde{X}(y)$ is given by substituting $y = 0$:

$$\bar{X} := \frac{p_L - c_i^L}{p_H - p_L}.$$  

Setting $\tilde{X}(y) = 0$, and solving for $y$ gives the upper bound on $y$ above which the expert strictly prefers to defraud independent of $X$:

$$\bar{y} := \frac{p_L - c_i^L}{p_H - c_i^L}.$$  

For $X > \tilde{X}(y)$, the expert prefers to defraud her patients, for $X < \tilde{X}(y)$, she prefers...
An expert has an incentive to honestly diagnose his patients if the market level of fraud and the acceptance rate are relatively low. A low acceptance rate implies that a customer is unlikely to accept a $H$-diagnosis when visiting the first expert. Additionally, because of a low level of fraud, most customers are consulting an expert for the first time. It follows that fraud is unprofitable. If the level of fraud is high fraud is profitable for an expert despite a low acceptance rate because many customers are on their second visit and would accept a fraud diagnosis with certainty. Given a high acceptance rate and/or a high fraud level the expert defrauds his customers. If the acceptance rate is relatively low, then there is region where experts are indifferent between their pure strategies, i.e. defrauding and treating a customer with a minor problem honestly.

Observe that the lower an expert’s cost for the minor treatment, the larger are the incentives to truthfully diagnose his patients. Intuitively, if treating patients honestly, a cost reduction translates into a larger mark-up with probability 1. When defrauding his patients, however, a lower cost is only beneficial in case of acceptance. This effect is displayed in Figure 2.
3.3 Equilibria

Equilibria of the model are obtained by combining the experts’ best response with the customers’ best response. As a point of reference, we first consider equilibria in a market with homogeneous experts and then turn to the equilibrium analysis of a market with heterogeneous experts.

3.3.1 Homogenous experts

In this section, we assume $c^l_L = c^h_L = c_L$. In this case the following result (due to Sülzle and Wambach, 2005) holds.

**Lemma 3.** There always exists an equilibrium in pure strategies in which all experts always defraud the customers with minor problems and all customers always accept any diagnosis (denoted as equilibrium $A$). In addition, there exist two equilibria in mixed strategies where the experts defraud customers with a minor problem with a positive probability and customers sometimes reject a major diagnosis on their first visit (denoted as equilibria $B$ and $C$, respectively).

**Proof.** See Lemma 3 and the proof thereof in Sülzle and Wambach (2005).

![Figure 3: Equilibria in a market with homogenous experts](image)

The results of Lemma 3 are illustrated in Figure 3. In equilibrium $A$, all experts defraud their customers and customers always accept the diagnosis from the first expert. Since all customers always accept a major diagnosis from the first expert, it is an expert’s best response to recommend a major treatment to all customers. A customer anticipates that in such a situation
it would be the best strategy to accept any diagnosis from the first expert because the second expert would cheat as well. Equilibria B and C are mixed strategy equilibria where experts are indifferent between honest and fraudulent behavior and customers are indifferent between accepting and rejecting.

3.3.2 Heterogeneous experts

In the following, we consider heterogeneous experts. In the following Lemma, we structure experts’ equilibrium behavior by characterizing cases consistent with equilibrium play.

Lemma 4. Depending on the acceptance rate \( y \) and the market level of fraud, \( X \), the following combinations of experts’ best responses can arise:

1. Both types treat customers honestly.
2. All low-cost types treat customers honestly while all high-cost types are indifferent.
3. All low-cost types treat customers honestly while all high-cost types defraud their customers.
4. All low-cost types are indifferent while all high-cost types defraud their customers.
5. Both types defraud their customers.

Proof. For a given market environment \((X, y)\), the Lemma directly follows from (11). Define \( c^0_L \) as the cost level where an expert is indifferent between defrauding and honest diagnoses. Suppose such a \( c^0_L \) exists: If \( c^L_L < c^0_L < c^h_L \), both types prefer to treat honestly. If \( c^L_L < c^0_L = c^h_L \), all low-cost experts treat honestly and high-cost experts are indifferent. If \( c^L_L < c^0_L < c^h_L \), all low-cost types treat honestly and all high-cost experts defraud. If \( c^L_L = c^0_L < c^h_L \), all low-cost types are indifferent and all high-cost types defraud. Finally, if \( c^L_L < c^0_L < c^h_L \), both types always defraud. If no \( c^0_L \) exists such that an expert is indifferent, then all experts always defraud their customers.

The five combinations of experts’ best responses given in Lemma 4 lead to different levels of fraud \( X \) as illustrated in Figure 4. It holds \( X = 1 \) given all experts cheat and \( X = 0 \) given all experts treat honestly. We have \( X = q_h \) if all high-cost experts defraud and all low-cost experts treat customers honestly.

The average level of fraud is \( X = \frac{p_L - c^L_L - y(p_H - c^L_L)}{(1-y)(p_H - p_L)} \) given all high-cost experts randomize and all low-cost types diagnose honestly. But, the distribution of high- and low-cost experts in the market influences the maximal fraud level for this setting: If \( q_h \leq \left( > \right) \frac{p_L - c^L_L}{p_H - p_L} \), then the market level of fraud \( X \) lies between 0 and \( q_h \left( 0 \right. \text{ and } \frac{p_L - c^L_L}{p_H - p_L} \). In a situation, where the low-cost experts are indifferent and the high-cost experts always cheat the fraud level is given by
X = \frac{p_L - c_L^I - y(p_H - c_L^I)}{(1-y)(p_H - p_L)}. As Figure 4 shows in this case the fraud level X can lie between q_h and \( \frac{p_L - c_L^I - q_H(p_H - p_L)}{p_H - c_L^I - q_H(p_H - p_L)} \).

We next characterize the stable market configurations given the five combinations of the experts’ best responses. For each case in the lemma, we derive the experts’ cumulative best response from the individual best response functions.

**Proposition 1.** A stable market configuration for experts is given by the high-cost experts’ best response for \( X < q_h \) and by the low-cost experts best response for \( X > q_h \). For \( X = q_h \), a stable market configuration is given by, if it exists, \( \lambda \tilde{y}^l(q_h) + (1-\lambda)\tilde{y}^h(q_h) > 0 \) where \( \lambda \in [0,1] \).

**Proof.** For a double \((X,y)\) such that both types prefer to treat honestly, the only consistent market level of fraud is \( X = 0 \), which corresponds to the best response of a high-cost type.

For a double \((X,y)\) such that all low-cost types treat customers honestly while all high-cost types are indifferent, the maximum market level of fraud is given by \( q_h \). This is because all low-cost experts never defraud such that the market level of fraud is bounded from above by \( q_h \). Furthermore, indifference of high-cost types in connection with case 2 of Lemma 4 implies that the cumulative best response is given by the high-cost types’ best response.

For a double \((X,y)\) such that all low-cost types treat customers honestly while all high-cost types defraud their customers, the only consistent level of fraud is \( X = q_h \). It follows that a stable market configuration is given by \( \lambda \tilde{y}^l(q_h) + (1-\lambda)\tilde{y}^h(q_h) > 0 \) where \( \lambda \in [0,1] \). Existence is guaranteed if \( q_h \leq \tilde{X}(y=0) \). For \( y \leq \tilde{y}^l(q_h) \) implies that low-cost types want to be honest, \( y > \tilde{y}^h(q_h) \) guarantees that high-cost types want to defraud.
For a double \((X, y)\) such that all low-cost types are indifferent while all high-cost types defraud their customers, the minimum market level of fraud is given by \(q_h\). In that case, the high-cost experts always cheat so that the market level of fraud is bounded from below by \(q_h\). Also, low-cost experts’ indifference in connection with case 4 of Lemma 4 implies that the experts’ cumulative best response is determined by the low-cost experts’ best response.

For a double \((X, y)\) such that both types defraud their customers, the only consistent market level of fraud is \(X = 1\), which corresponds to a low cost expert’s best response.

Combining the proposition with the patients’ best response which is not affected by experts’ costs leads to the following equilibrium characterization. We first establish the existence of a qualitatively equivalent pure-strategy equilibrium compared to the case of homogenous experts.

**Proposition 2.** Independent of experts’ costs, an equilibrium exists where all experts always defraud their customers and where all customers always accept any diagnosis.

*Proof.* Suppose all customers accept any diagnosis. Then, all experts strictly prefer to defraud as \(p_H > p_L\). Given that all experts defraud, customers do not consult a second expert because \(k > 0\).

A cost reduction will not prevent an expert from cheating, if all other experts defraud customers. In case all experts cheat customers never look for a second opinion. Thus, the fraud profit is made with certainty and is even higher for the low-cost experts than for the high-cost experts. Consequently, the market equilibrium \(A\) is always a potential equilibrium in a market with low and high-cost experts independent of experts’ costs and the distribution of high- and low-cost experts in the market.

In what follows, we concentrate on equilibria where at least one agent plays a mixed strategy. Let \(B^i\) and \(C^i\) denote equilibria \(B\) and \(C\) in the homogenous case if all experts are of type \(i\). Because the cumulative best response with heterogeneous experts is defined by the individual best responses of both cost types, the mixed-strategy equilibrium candidates are given by \(B^i, C^i\), and convex combinations of \(B_h, B_l, C_h, C_l\).

**Proposition 3.** Mixed-strategy equilibria are given by

- \(B^h\) and \(C^h\) if \(q_h > X_2\),
- \(B^h\) and \(\{\lambda C^l + (1 - \lambda)C^h|\lambda \in [0, 1]\}\) if \(q_h = X_2\) and \(\tilde{y}^h(X_2) > 0\),
- \(B^h, C^h,\) and \(\{\lambda C^l + (1 - \lambda)(X_2, 0)|\lambda \in [0, 1]\}\) if \(q_h = X_2\) and \(\tilde{y}^h(X_2) \leq 0\),
- \(B^h\) and \(C^l\) if \(X_1 < q_h < X_2\),
- \(\{\lambda B^l + (1 - \lambda)B^h|\lambda \in [0, 1]\}\) and \(C^l\) if \(q_h = X_1\), and
\[ \text{• } B^l \text{ and } C^l \text{ if } q_h < X_1. \]

**Proof.** The only combinations in which at least one agent plays a mixed strategy are given by the cases 2 and 4 of Lemma 4. The market level of fraud in case 2 (4) is bounded from above (below) by \( q_h \). Thus, it depends on the size of \( q_h \) in when the experts’ combined best response function, where at least one type of expert is indifferent, intersects with the customers’ best response function, where the customers play a mixed strategy (illustrated in Figure 5). The existence of \( B^h \) and \( C^h \) is guaranteed by the assumption \( e < \frac{p_H - c_h}{p_H - p_L} \) and a sufficient large value of \( \frac{p_L - c_h}{p_H - p_L} \) (i.e., \( \frac{p_L - c_h}{p_H - p_L} > X_1 \)). If \( X_1 < \frac{p_L - c_h}{p_H - p_L} < X_2 \), then there would be an equilibrium \( C^h \) where all customers look for a second opinion after having received a major diagnosis on their first visit. We assume \( \frac{p_L - c_h}{p_H - p_L} > X_2 \) in the following. We consider five cases concerning the size of \( q_h \):

(a) \( q_h > X_2 \): This case is portrayed by Figure 5a. The experts’ combined best response function, that illustrates the situation in which all high-cost experts randomize between their pure strategies and all low-cost types always treat honestly, has two intersection with the customers’ best response function at the the customers’ indifference level generating two mixed-strategy equilibria, denoted \( B^h \) and \( C^h \).

(b) \( q_h = X_2 \): As Figure 5b shows in this situation the experts’ combined best response correspondence that emerges if the high-cost cheat and the low-cost experts randomize also intersects with the customers’ best response function and this leads to a continuum of equilibria described by the convex combination \( \{ \lambda C^l + (1 - \lambda)C^h | \lambda \in [0, 1] \} \), in which the high-cost experts cheat and the low-cost experts are honest. This is a special case since in \( C^l \) the low-cost experts are always honest here and in \( C^h \) the high-cost experts always cheat.

(c) \( X_1 < q_h < X_2 \): Here, we have two intersections of the experts’ combined best response functions and the customers’ best response function that lead to two mixed-strategy equilibria, \( B^h \) and \( C^l \) (as illustrated in Figure 5c). In \( C^l \) the high-cost experts defraud and the low-cost experts are indifferent. There is no equilibrium \( C^h \) because the experts’ combined best response function for that case of honest low-cost experts and indifferent high-cost experts ends at \( q_H \) which lies between \( X_1 \) and \( X_2 \) and thus only intersects once with the customers’ best response function. The combined experts’ best response function given the high-cost types cheat and the low-cost experts randomize begins at \( X = q_H \) and therefore we have no continuum of equilibria.

(d) \( q_h = X_1 \): Figure 5d shows that the experts’ combined best response correspondence given the high-cost experts cheat and the low-cost experts are indifferent intersects with the customers’ best response function twice, at \( X_1 \) and \( X_2 \), leading to an additional mixed-strategy equilibrium \( B^l \) besides the equilibria \( B^h \) and \( C^l \). If \( q_h = X_1 \) then we again have
a continuum of equilibria described by the convex combination \( \{ \lambda B^l + (1 - \lambda)B^h | \lambda \in [0, 1] \} \), in which the high-cost experts defraud customers but the low-cost types are honest with certainty.

(e) \( q_h < X_1 \): This case is illustrated in Figure 5e: The experts’ combined best response function given honest low-cost experts’ and randomizing high-cost types does not intersect with the customers’ best response function since it ends at \( q_h < X_1 \). Thus, there are only the two equilibria, \( B^l \) and \( C^l \), that result from the intersections of the experts’ combined best response function for the situation in which the high-cost experts cheat and the low-cost experts randomize and which begins at \( q_H < X_1 \).

In the following we analyze different market equilibrium settings depending on the different distributions of high- and low-cost experts in the market. We consider the same possible distributions as in Figure 5. Note that if there are only high-cost experts in the market, i.e. \( q_h = 1 \), then the market configuration is equivalent to the market configuration in the market with homogeneous experts (compare Figure 3) and that the pure-strategy equilibrium \( A \) remains the same throughout for all possible distributions as explained above. We also compare the equilibrium configuration to the reference case.

If there is only a small share of low-cost experts (i.e. \( q_h > X_2 \)), then we have three potential equilibria (see Figure 5a). The market level of fraud \( X \) as well as the patients’ acceptance strategy \( y \) in \( B^h \) and \( C^h \) is the same as in \( B \) and \( C \), respectively, of the reference market. That is, an introduction of a cost reduction concerning a minor treatment for a low share of experts would not lead to any changes regarding the equilibrium outcome compared to the reference market. This is particular interesting since in \( B^h \) and \( C^h \) all low-cost experts are honest with certainty and only the high-cost experts defraud with a positive probability, whereas in the reference case all experts in the mixed-strategy equilibria randomize between cheating and treating honestly. That is, the high-cost experts compensate the low-cost experts’ honest behavior with defrauding more on average in \( B^h \) and \( C^h \) than all experts in \( B \) and \( C \), respectively. In that case, there are still sufficient customers on their second visit despite the low-cost experts’ honesty so that at a low or intermediate acceptance rate cheating may still be profitable for high-cost experts.
Figure 5: Equilibria with heterogeneous experts for different shares of high-cost experts.
Reducing the share of high-cost experts further eventually leads to the market configuration with \( q_h = X_2 \), where we have a continuum of equilibria including a new mixed-strategy equilibrium \( C^l \) (compare Figure 5b), in which (here) all low-cost experts diagnose honestly and all high-cost experts cheat. The continuum \( \{ \lambda C^l + (1 - \lambda) C^h | \lambda \in [0, 1] \} \) generates the same level of fraud as equilibrium \( C^h \), but might generate a higher acceptance rate \( y \) than in \( C^h \) with the highest possible rate in \( C^l \). That is, introducing a cost reduction for a share of \( 1 - X_2 \) experts might reduce the amount of second opinions if the market is in equilibrium \( C \) before the cost reduction, but would not change anything with respect to the equilibrium outcome if the market is in equilibrium \( B \) before. The equilibria \( B^h \) and \( C^h \) remain the unchanged for the same reason as in the previous case.

If we have an intermediate share of low-cost experts in the market (i.e. \( X_1 < q_h < X_2 \)), then there are three potential market equilibria, but no equilibrium \( C^h \) anymore (compare Figure 5c). Given a medium share of honest low-cost experts and a low acceptance rate \( y \) too many customers are on their first visit and would most likely reject a major diagnosis making fraud unprofitable for high-cost experts. Thus, equilibrium \( C^h \) is eliminated. In equilibrium \( C^l \) all high-cost experts cheat and the low-cost experts randomize between defrauding and diagnosing honestly. In \( C^l \) customers accept a major diagnosis on their first visit sufficiently often to generate incentives for low-cost experts to defraud with a positive probability given all high-cost experts cheat. Starting from equilibrium \( C \) in the reference market reducing the cost for a medium share of experts would increase the patients’ acceptance rate \( y \) of a major diagnosis on their first visit in the equilibrium. As in the previous cases, starting from \( B \) would not lead to any changes in the equilibrium outcome in this case.

A further reduction of the share of high-cost experts to \( q_H = X_1 \) generates another continuum of equilibria \( \{ \lambda B^l + (1 - \lambda) B^h | \lambda \in [0, 1] \} \) and a new equilibrium \( B^l \). Again, in the continuum (and given \( q_H = X_1 \) also in \( B^l \)) all high-cost experts cheat and all low-cost experts diagnose honestly we have the same level of fraud as in \( B^h \). The continuum might generate a lower search rate regarding second opinions than in the equilibrium \( B^h \) with the highest possible acceptance rate \( y \) in \( B^l \).

If the share of experts is very small (i.e. \( q_H < X_1 \)), then there is no equilibrium \( B^h \) in the market but the two mixed-strategy equilibria \( B^l \) and \( C^l \), in which the high-cost experts defraud customers with minor problem and the low-cost experts are indifferent. There is no equilibrium \( B^h \) due to the large share of honest low-cost experts in the market that make it unprofitable for high-cost experts to cheat at a medium acceptance rate \( y \). In equilibrium \( B^l \) and \( C^l \) the search rate for a second diagnosis is smaller than in \( B^h \) and \( C^h \), respectively. That means, if we have a large share of low-cost experts (\( 1 - q_H > 1 - X_1 \)), then the market with heterogeneous experts would provide an equilibrium outcome with a higher acceptance rate \( y \) than in the reference market if we start in one of the mixed-strategy equilibria (\( B \) or \( C \)). Obviously, this finding also holds for \( q_H = 0 \), i.e. if we reduce the cost of all experts even if it is only by a little.
4 Welfare

Welfare is defined as the sum of consumer and expert surplus. Besides the direct positive welfare effect of a cost reduction for treating a minor problem due to increased gains from trade which lead ceteris paribus to a higher expert surplus, welfare is only influenced by the number of visits per customer because the demand is inelastic and every patient is treated efficiently. Fraud just leads to a redistribution between experts and customers. The more the customer search the more search cost they bear and hence welfare is reduced with a lower search rate. We analyze how a cost reduction affects welfare by comparing the welfare in the market with heterogeneous experts with the welfare in the initial equilibrium before lowering the cost.

A cost reduction for a low share of experts leads to higher welfare due to the increased accumulated experts’ profit independent of the equilibrium state before the cost reduction. However, there are no additional welfare effects since we have no changes regarding the fraud level or the amount of second opinion. If the market is originally in equilibrium A, then are no further welfare effects due to the experts’ level of fraud $X$ and patients’ acceptance $Y$ remaining at the maximum in all possible distributions of high- and low-cost experts.

Given the market is initially in equilibrium $B$ or $C$ a cost reduction for a sufficient large share of experts would have additional positive effects on overall welfare. A cost reduction for at least a medium (large) share of experts would reduce the search rate if the initial market is in equilibrium $C (B)$ because in equilibrium $C^h (B^l)$ the patients’ acceptance rate $y$ is higher than in $C (B)$. Interestingly, reducing the cost of treating a minor problem for even half of the of experts does not generate additional welfare effects apart from the increased experts’ surplus if the market is originally in equilibrium $B$.

Consumer welfare is increased by a decreased level of fraud and/or an increased acceptance rate $y$. Consequently, a cost reduction has no effect on the consumer surplus in equilibrium $A$. It follows from the equilibrium analysis that the consumer rent in $C (B)$ is only affected by a cost reduction if the cost are reduced for at least a medium (large) share of experts. In equilibrium $B$ and $C$ the amount of fraud equals the amount in $B^h/B^l$ and $C^h/C^l$, respectively. Therefore, only the patients’ acceptance rate $y$ determines the changes in consumer welfare in our model. Consequently, a cost reduction for at least a medium (large) share of experts leads to a higher consumer rent with certainty if we start in equilibrium $C (B)$.

5 Conclusion

We analyze how a cost reduction for share (or all) experts in a credence goods market affects the degree of experts’ fraud and the amount of second opinions in the market. Some of our results are rather counter-intuitive, whereas some of our findings are consistent with intuition. We find that the effects of experts’ heterogeneity with respect to the efficiency in treating customers on equilibrium outcomes depend mainly on the distribution of low- and high-cost experts. If the
fraud level and the patients’ acceptance rate are already at their maximum, however, then there will be no changes regarding equilibrium outcomes independent of the distribution.

Further, the market level of fraud is neither increased nor decreased by a cost reduction even if it was originally not at its maximum: The possible new according market equilibria always generate the same level of fraud as the respective equilibrium before the cost reduction independent of the initial equilibrium. This result is somewhat surprising since the low-cost experts have lower incentives to cheat than the high-cost experts.

Besides, a cost reduction could reduce the search rate with respect to second opinions (if not at its minimum) compared to the market with homogeneous if there are sufficient many low-cost experts in the market with heterogeneous experts. A lower search rate means higher overall welfare. That is, welfare is not only increased by a higher accumulated experts’ profit as a consequence of a cost reduction for experts but also due to fewer second opinions in the market given the cost are reduced for a sufficiently large share of experts. Then, also consumer surplus is raised due to the cost reduction. If the cost of too few experts are lowered we do not observe any effects on consumer welfare.

Finally, taking into account the effects on consumer and overall welfare we can conclude that from a competition policy perspective a cost reduction for a large share of experts, even if the cost reduction would be small, would be a better option than lowering the treatment cost of a minor treatment by large for only a low share of experts

References


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