Price competition and reputation in credence goods markets: Experimental evidence*

Preliminary

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Abstract

Experts have better information about the appropriate quality of treatment or surplus from trade than their customers. Providing both diagnosis and treatment, this leaves scope for fraud. In a credence good set-up, we experimentally investigate how intensity of price competition and the level of customer information about past expert behavior influence an expert’s incentive to defraud his customers when the expert can build up reputation. We apply a $2 \times 2$ factorial design where experts either engage in price competition or operate under regulated prices and customers have information about their own history with the expert or all customers’ past histories (private vs. public histories). We show that price competition has a strong impact on fraud: both the level of undertreatment and the level of overcharging are significantly higher when experts compete in price than when prices are regulated. We also find some evidence that the level of undertreatment and the level of overcharging are higher under public than under private histories under price competition while the opposite holds when prices are regulated. Our results indicate that price competition may be detrimental in credence goods markets as it superimposes quality competition.

JEL classification: D82; L15.

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1 Introduction

In the US, up to 10% of the 2.3 trillion USD of yearly health expenditures are estimated to be due to fraud (Federal Bureau of Investigation, 2007). Fraud comprises upcoding of services, providing and charging unnecessary services, and the willingness to risk patient harm by supplying an insufficient treatment. Similarly, according to the Statistisches Bundesamt (Ed.) (2012), expenditures in the health care market in Germany amounted to 264 billion Euro in the year 2008 of which Transparency International estimates up to 20 billion Euro to be due to fraud (Transparency International - Deutschland e.V. (Ed.), 2008). In car repair, Europe’s largest automobile club, the German Automobile Association ADAC (Allgemeiner Deutscher Automobil-Club e. V.), reports that about 5% of the car repair shops tested charge for more repairs than actually provided. According to a joint survey by the Consumer Federation of America, the National Association of Consumer Agency Administrators, and the North American Consumer Protection Investigators, customer complaints about fraud in the auto repair market rank among the top ten customer complaints (Consumer Federation of America et al., 2011).

Scope for fraud in these markets exists due to asymmetric information between provider and customer: the provider is an expert on the quality of the good the customer needs or on the surplus from trade and, in most cases, performs both the diagnosis and the treatment. The customer, however, does not know which quality he needs or might not be able to verify all relevant aspects of trade. Goods with these properties are termed credence goods as the customer has to rely on the expert’s advice. Whether the expert can and will exploit his informational advantage thereby crucially depends on the market environment and financial incentives. Providing an insufficient treatment but charging a high price for his services might be profitable for the expert if he cannot be made (fully) liable and does not risk losing future business. Besides the health care and car repair markets many service markets such as legal assistance, cab rides, and other repair services exhibit credence good properties which means that it is important to get a better understanding as to which market environments effectively constrain fraudulent expert behavior.

Typically, customers can identify the expert they interact with and possess some information about expert behavior, either from their own past interaction with the expert or public information such as friends’ recommendation or public rating de-
The fact that parties interact repeatedly may give the expert an incentive to build up a good reputation to gain a competitive advantage vis-à-vis his competitors.

An important further observation is that some credence goods markets are subject to price regulation. The most important example is the health care market: in most developed countries, fees for physician or hospital services are regulated. A possible rationale behind price regulation in these credence goods markets might be that price competition is harmful to consumers as it impedes the provision of (sufficient) quality and induces fraudulent behavior by experts as a result of low profits from price competition.

In this paper, we experimentally investigate an expert’s incentive to defraud his customers under price competition vs. price regulation when experts can build up reputation. In our set-up, experts can both undertreat, i.e., provide an insufficient quality/treatment, and overcharge, i.e., charge the price for a treatment that was not provided. While overcharging cannot be verified, the customer can observe ex post whether the treatment was sufficient. We vary the degree of customer information about past expert behavior, implementing private histories and public histories (see Table 1). Under private histories, customers are able to identify the experts they trade with and know their own history with each expert, i.e., whether previous treatments were sufficient and what prices were charged, whereas under public histories, customers can observe all customers’ histories with experts regarding undertreatment and prices charged.

We find that the level of undertreatment is significantly higher under price competition than when prices are regulated. Under regulated prices, customers return

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1A prime example of a public feedback platform is the Arztnavigator ("physician navigator") in Germany. The Arztnavigator was established by the three largest statutory health insurance companies in order to assist the insuree in finding a good doctor. More than 90% of the general practitioners are listed in the physician directory. As displayed in Figure 4 in the appendix, the Arztnavigator polls patients with a standardized questionnaire about their last physician visit. It allows patients to rate their physician in four dimensions: appeal of the practice, quality of communication between the patient and the physician, quality of the treatment, and overall impression. Open comments are not allowed in order to prevent customers from insulting doctors. The feedback information from different patients is pooled for each doctor and made available to other insurees. Insurees can then search for good doctors by weighting the results in each feedback dimension. Note that the Arztnavigator allows customers to compare the (perceived) quality provided by an expert. In contrast to the implementation of public histories in our experiment, the Arztnavigator does not provide any charging information.

2This is the case in several countries for taxi rides as well. Services of other liberal professions, such as legal assistance, have been recently deregulated in many European countries so that experts are free to choose prices.

3In our market, verifiability does not hold such that it is not profitable for the expert to overtreat instead of simply overcharge.
significantly less often to undertreating experts than under price competition in the first periods where reputational concerns play a role. Furthermore, under price competition, we observe a price pressure that undermines reputation building in the first periods: experts who undertreated in previous periods offer lower prices in the following periods. Taken together, our results suggest that a reputation equilibrium in which experts build up reputation on treatment quality is played under regulated prices whereas under price competition, the market coordinates on an equilibrium without reputation on treatment quality and fierce price competition. With respect to customer information, we find that public histories go along with lower levels of undertreatment compared to private histories when prices are regulated whereas the opposite is true under price competition, although differences are not significant. Under public histories the observed price decline over time is larger than under private histories. These results indicate that public information might help strengthen reputation building on treatment quality when prices are regulated whereas it might intensify price competition with negative feedback on treatment quality when prices are not regulated. Results on the second dimension of fraud, overcharging, mirror the results on undertreatment: the level of overcharging is significantly higher under competitive than under regulated prices. Furthermore, under price competition, the level of overcharging is significantly higher under public than private histories. Our results suggest that when customers are price-sensitive, price competition in credence good markets undermines reputation building on the quality of the provided service and induces higher levels of fraud than when experts cannot compete in prices. More customer information about experts’ past behavior hence does not necessarily lead to an improvement in treatment quality.

**Table 1:** Conditions.

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**Related literature**

The seminal experimental paper on credence goods is Dulleck et al. (2011). The authors analyze experts’ fraudulent behavior in markets with price competition and different institutional features. They show that while liability reduces the fraud level, verifiability and reputation with private histories hardly improve the market
outcome. We complement and extend the analysis in two important directions: firstly, we analyze regulated prices in a market where reputational concerns play a role. As pointed out before, this is motivated by the fact that the largest credence goods market in most economies—the health care market—is characterized by price regulation and non-anonymous experts. Secondly, we implement public histories where customers do not only observe their own but all customers’ histories. This reputation mechanism mirrors the frequently observed online feedback platforms.

The follow-up paper Dulleck et al. (2012) implements a credence goods experiment with regulated prices but without reputational concerns. The authors investigate whether good experts who always treat sufficiently post high prices or whether it is the high prices which induce a sufficient treatment. They show that good experts signal their type using the price but high prices do not induce sufficient treatment. In their setting, endogenous prices lead to a more efficient market result. We show that if customers can at least identify the expert they are trading with, i.e., experts can build up reputation by not undertreating or by charging the price for the minor treatment, regulated prices lead to a more efficient market outcome than under price competition. The reason is that price competition reduces experts’ mark-ups which in turn makes it less attractive to provide sufficient quality.

Another experimental paper investigating the impact of reputation on expert fraud is Grosskopf and Sarin (2010). Customers have incomplete information about the type of project that maximizes their payoff and the type of expert they are facing. The good expert has payoffs in line with the customer, the bad expert does not. In contrast to customers, experts know which type they are of and which type of project maximizes the customer’s payoff. Customers meet each expert once in a randomly determined order, observe the expert’s past actions if reputation is in place, and decide whether they want to interact. Grosskopf and Sarin (2010) find that reputation always increases the expert’s payoffs—even when theory predicts that reputation might be harmful to the expert’s payoff. While in Grosskopf and Sarin (2010) experts do not compete in prices for customers, we are specifically interested in how the intensity of price competition changes experts’ fraudulent incentives. Also, we allow customers to choose the expert they want to interact with based on the expert’s reputation. Interestingly, we find indicative evidence that under price competition, more customer information does not lead to less but to more fraud because lower prices reduce the experts’ incentive to act honestly.
The first field experiment in a credence goods market is by Schneider (2012). He analyzes whether reputational concerns reduce a mechanic's incentive to defraud his customer. The author manipulates a car with defects and submits the car to garages for repair. He leaves a home address close to the garage and states that he was looking for an ongoing relationship in order to signal repeated interaction. In contrast, he announces to be moving away in order to signal a one-time interaction. While Schneider (2012) finds both widespread over- and undertreatment, he finds no evidence that reputation might alleviate these problems.

Balafoutas et al. (2013) present a comprehensive field experiment on the influence of consumer characteristics on the expert's defrauding incentive. The experimenters take a taxi from the airport of Athens, Greece, to the city and find that taxi drivers take a shorter detour when the experimenters pretend to be well-informed about the route. Customers that taxi drivers perceive to be rich are defrauded more often than regular customers. In contrast to Balafoutas et al. (2013), our paper focuses on the impact of market rather than customer characteristics on the expert's incentive to defraud.

The remainder of this paper is organized as follows. The next section provides the market description. In section 3, we present the experimental set-up including the parameterization. In section 4, we identify market equilibria for the given parameterization and derive predictions. In section 5, we describe the econometric methods used before turning to the results in section 6. The last section concludes.

2 Market

We model a credence goods market with scope for undertreatment and overcharging as in Dulleck et al. (2011). There are four experts and four customers in the market. We assume that each of the customers either suffers from a minor or a major problem. Each customer knows that she has a problem but does not know which type of problem she suffers from. A customer's ex-ante probability of suffering from a major problem is \( h \), the probability of suffering from a minor problem \( 1 - h \). These ex-ante probabilities are common knowledge. An expert is able to identify the problem by performing a costless diagnosis.\(^4\) Treating the minor problem costs an expert \( c_L \) whereas treating the major problem costs an expert \( c_H \) (with \( c_H > c_L \)). The

\(^4\)We assume zero diagnosis costs in order to make our results comparable to those in Dulleck et al. (2011).
treatment for the major problem \( t_H \) heals both types of problems. The treatment for the minor problem \( t_L \) only heals the minor problem. Experts are not liable, i.e., they may treat a customer with a major problem with a minor treatment. The customer cannot observe the treatment but she can verify the treatment’s outcome, i.e., the customer notices whether the expert undertreated her.\(^5\) Observing undertreatment is feasible because the customer notices whether her problem has been fixed or not (Dulleck and Kerschbamer, 2006, p. 11). The prices for the treatments are denoted by \( p_L \) and \( p_H \), respectively.

The stage game depends on the experimental condition. In the following, we outline the stage game for a market with price competition and a market with regulated prices. In both cases, we discriminate between private and public histories by denoting these situations in the stage game by ‘ and ”, respectively. The stage game is played repeatedly for \( n \) periods for each condition. The stage game for a market with price competition is as follows:

1. For each of the customers, nature independently draws the type of problem the customer faces. With probability \( h \) a customer suffers from a major problem, with probability \( 1 - h \) she suffers from a minor problem.

2. Each expert posts a price menu \( \{p_L, p_H\} \) for the minor and major treatment.

3.' Each customer observes each expert’s price menu posted in the current period and her private history\(^6\) as specified below.

3.” Each customer observes each expert’s price menu posted in the current period and the public histories as specified below.

4. Each customer chooses an expert or decides not to interact.

5. Each expert observes the type of problem for each customer that chose to interact with him in step 3. Each expert either performs a minor treatment \( t_L \) or a major treatment \( t_H \) for (each of) his customer(s).

6. Each expert with an interaction charges (each of) his customer(s) the price \( p_L \) or the price \( p_H \).

\(^5\)Remember that undertreatment refers to a situation where the customer has a major problem but obtains a minor treatment.

\(^6\)Note that a rational customer builds up her private history in the course of the game and is always aware of her history. Participants in the experiment, however, might forget parts of their history. Therefore, we display the private history in step three of the stage game as a reminder.
7. Each expert observes his payoff and each customer observes her payoff from the current period.

The stage game under regulated prices only differs from the above stage game in that experts cannot post prices in step 2. Instead, the exogenously given prices are common knowledge among the players before the first stage game starts.

The expert’s per-period payoff $\pi_e$ is determined by the price $p_i$ charged less the costs $c_j$ for the treatment $t_j$ applied ($i,j \in \{L,H\}$) where $i$ and $j$ do not have to coincide:

$$\pi_e = p_i - c_j \quad i,j \in \{L,H\}$$

(1)

If no customer decides to interact with the expert, the expert’s payoff amounts to $\sigma$. If the customer decides to interact and is not undertreated, the customer derives a utility of $v$. If she decides to interact and is undertreated, she derives a utility of zero. In either case, the customer has to pay the price for the treatment charged by the expert. The customer’s per-period payoff $\pi_c$ therefore amounts to

$$\pi_c = \begin{cases} v - p_i & \text{if not undertreated, } i \in \{L,H\} \\ -p_i & \text{if undertreated, } i \in \{L,H\} \end{cases}$$

(2)

if the customer decides to interact. If the customer decides not to enter the market, her payoff amounts to $\sigma$.

The information customers observe in step 3 of the above stage game depends upon the experimental condition.\(^7\)

**Private histories**

Under private histories, each customer observes for each of the previous periods the expert she interacted with, the prices posted by this expert, whether this expert charged the price for the minor or the major treatment, whether this expert undertreated her, and her profit.

**Public histories**

Under public histories, each customer observes for each of the previous periods and each of the customers, the expert the customer interacted with, the prices posted by this expert, whether this expert charged the price for the minor or the major treatment, whether this expert undertreated her, and her profit.

\(^7\)Note that the categories of information that customers observe are the same as in Dulleck et al. (2011).
treatment, whether the expert the customer interacted with undertreated her, and what the customer’s profit was.

3 Experiment

3.1 Design

We apply a $2 \times 2$ factorial design. In all four conditions, the parameters are fixed and are the same as in the experiment by Dulleck et al. (2011): the ex-ante probability of a customer having a major problem is $h = 0.5$. The expert’s costs for providing a minor treatment are $c_L = 2$ and $c_H = 6$ for a major treatment. The customer derives a utility of $v = 10$ if her problem is solved. Otherwise, the customer’s utility amounts to $v = 0$. In case no interaction takes place, customers and experts receive a payoff of $\sigma = 1.6$ (outside option).

The stage game is repeated for 16 periods. In all conditions, we use matching groups of eight players. The assignment of the eight players to a matching group does not change throughout the experiment. Four of the players take the role of a customer. The remaining four take the role of an expert. The roles are randomly assigned at the beginning of the experiment and do not change throughout the 16 periods. Across conditions, we vary the reputation mechanism between private and public histories and the pricing regime between regulated prices and price competition.

In the conditions with price competition, experts announce prices $\{(p_L, p_H) \in \mathbb{N}^2 | 1 \leq p_L, p_H \leq 11, p_L \leq p_H\}$ in step 2 of the stage game. In the regulated-price conditions, we set the exogenously given prices $\{(p_L, p_H) = \{4, 8\} \text{ in periods 1–9, and } \{p_L, p_H\} = \{0, 3\} \text{ in periods 10–16. In periods 1–9, there is no obvious way to choose the regulated prices. We use the price vector of } \{p_L, p_H\} = \{4, 8\} \text{ for four reasons: firstly, equal mark-ups ensure that experts’ profits do not differ between the two treatments if experts treat and charge honestly. Secondly, equal mark-up prices are observed in several credence goods markets with price regulation.}^8$ The third

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8An example is the remuneration of short counseling interviews at general practitioners in Germany. Although the content of the counseling interviews and thus the service usually varies widely, the remuneration for the physician is always the same. Assuming that the general practitioner has similar costs for a short counseling independent of the content, he faces equal mark-ups for different services. Another example is the market for taxi rides. Once the passenger has paid the flat fee for taking a taxi, the taxi driver earns the same mark-up for each additional kilometer he drives the passenger (assuming that traffic is similar).
reason to choose \( \{p_L, p_H\} = \{4, 8\} \) is based on an observation when first conducting the conditions under price competition: the two equal mark-up vectors \( \{4, 8\} \) and \( \{3, 7\} \) are the most frequently posted price vectors under price competition. Thus, by choosing one of the two equal mark-up vectors, we approximate the expert pricing behavior observed under price competition. Among the two most often posted price vectors, we fourthly choose to implement the vector \( \{4, 8\} \) as this is one of the vectors used in the related study by Dulleck et al. (2012) that we will compare our results to.\(^9\)

In periods 10–16, the price for the major treatment \( p_H = 3 \) is derived from the predicted expert pricing behavior.\(^{10}\) The level of \( p_H \) ensures that customers still interact although they expect to be undertreated and overcharged in equilibrium. Theory does not provide a prediction for the price \( p_L \) as it is never charged in equilibrium. As we implement equal mark-up prices in the first nine periods, we approximate the equal mark-up price by setting \( p_L \) to the minimum of \( p_L = 0 \) in periods 10–16. Note that experts under price competition also posted a price for the minor treatment in periods 10–16 that was on average slightly below costs.

### 3.2 Procedure

The experimental sessions were conducted in the Cologne Laboratory for Economic Research between March and November 2012. 256 participants took part in the experiment. Participants were equally allocated to the four conditions so that in each condition there were 64 participants. Hence, there were eight matching groups (markets) per condition. We used ORSEE (Greiner, 2004) to recruit participants. We ran the experiments using z-Tree (Fischbacher, 2007). None of the participants took part in more than one session. The instructions were read aloud at the beginning of each session. A detailed set of control questions followed the instructions in order to ensure that all participants understood the experiment. After the experiment, players’ social preferences were determined by the choice of payoff pairs for oneself and a randomly assigned other person. Additionally, we used a questionnaire

\(^9\)Under price competition, theory predicts that experts post a price \( p_H \) that is below marginal costs for the major treatment. Thus, experts make losses if they do not undertreat a customer with a major problem. Inducing expert losses exogenously by setting a price that is below costs for the major treatment may increase experts’ undertreatment compared to a situation where the price choice is endogenous. Thus, we fix the price above the costs for a major treatment.

\(^{10}\)Note that a price below marginal costs does not alter the experts’ incentive to provide a sufficient treatment in the last periods because experts undertreat independent of the price vector posted.
to control for gender and age. The average time each session lasted was two hours. Participants earned on average 20.07 Euro.

4 Market: Theoretical analysis and predictions

In this section, we first provide a theoretical analysis of the above outlined market before deriving predictions for the experimental outcomes.

4.1 Theoretical analysis

In our theoretical analysis, we look for perfect Bayesian equilibria of the game described in section 2.\textsuperscript{11} Two types of equilibria might emerge: no-reputation equilibria and reputation equilibria (see Dulleck et al., 2011). In the no-reputation equilibria the one-shot Bayesian equilibria are played repeatedly over all 16 periods while reputation equilibria are based on the players’ repeated interaction. In what follows, we will characterize both types of equilibria for the conditions under price competition and regulated prices.

4.1.1 Price competition

The equilibria under price competition are adapted from Dulleck et al. (2011). In the following Lemmata we outline the outcomes in terms of fraud level and prices posted. For both—reputation and no-reputation equilibria—we do not need to distinguish between private and public histories as although strategies differ, there is no difference in outcomes when a particular type of equilibrium is played.

Lemma 1. No-reputation equilibria

In a market with price competition, there exist equilibria for private and public histories with the following characteristics: all experts post a price menu \{n.d., 3\}\textsuperscript{12} with probability \(x = 0.84398\) and an unattractive price menu \{n.d., \(p_H\)\} where \(p_H > 3\) with probability \(1 - x\). If an expert posts \{n.d., 3\}, the expert under treats customers

\textsuperscript{11}Note that the outlined equilibria are not exhaustive. There exist, for example, also equilibria with asymmetric expert behavior as pointed out by Dulleck et al. (2011). In line with their analysis, we restrict our analysis to equilibria with symmetric expert behavior.

\textsuperscript{12}’n.d.’ denotes ‘not determined’.
with a major problem and always overcharges his customers. If no expert posts \{n.d.,3\}, there is no interaction.

Proof. See Duldeck et al. (2011).

In a market with price competition, there exist the above described no-reputation equilibria in which experts strongly compete in the price dimension. The competitive price \(p_H = 3\) for the major treatment is so low that experts would even make losses in expectation if they always overcharged but did not undertreat customers with a major problem. Thus, it does not pay for experts to build up reputation. Hence, experts always undertreat customers with a major problem and always overcharge.

Experts are indifferent between posting a competitive price vector \{n.d.,3\} with probability \(x = 0.84398\) and posting an unattractive price vector where \(p_H > 3\) with probability \(1-x\). The reason experts play mixed strategies is that in case an expert only serves one customer, his profit amounts to 1 while the outside option yields a payoff of 1.6. Thus, it only pays for the expert to offer the competitive price if he can expect more than one customer on average.

We next turn to the reputation equilibria which are characterized as follows:

Lemma 2. Reputation equilibria

In a market with price competition, there exist equilibria for private and public histories with the following characteristics: each expert posts a price menu \{n.d.,5\} in the first nine periods and a price menu \{n.d.,3\} afterwards. Experts always overcharge customers with a minor problem. Experts do not undertreat customers with a major problem in the first nine periods with sufficiently high probability. Experts undertreat customers with a major problem in periods 10–16 and overcharge all customers.

Proof. See Appendix 8.1.

The logic of a reputation equilibrium is the following: experts do not undertreat customers in the first periods as this implies future profits from returning customers. In contrast to the no-reputation equilibrium, in the reputation equilibrium experts post higher prices in the first periods allowing them to build up reputation by not undertreating. A customer observes her own history (under private histories) respectively all customers’ histories (under public histories) regarding undertreatment and prices charged. The customer conditions her choice of expert on whether she
respectively any of the four customers has been undertreated by the expert in previous periods. If the expert did not undertreat in the first periods, the customer stays with this expert even in the later periods where experts will undertreat (periods 10–16). With this customer strategy, experts do not undertreat customers with a major problem in the first periods because the payoff from future business is larger than the additional current payoff from undertreating. Experts always overcharge customers. Customers still interact in periods 10–16 because the price for the major treatment is sufficiently low. Thus, the expected payoff from interacting exceeds the outside option.

The reasoning why experts only build up reputation in the treatment but not the charging dimension under price competition is as follows: customers cannot observe whether an expert overcharged. Thus, customers’ strategy can only condition on whether the price for the minor or the major treatment was charged. If an expert tried to build up the reputation of not overcharging by always charging the price for the minor treatment (with \( p_L < p_H = 5 \)) in the first periods, his payoff would be lower than the outside option. In later periods, the expert who built up reputation by charging the price for the minor treatment would have to return to charging the price for the major treatment in order to make positive profits. Due to price competition, the competitors would slightly undercut the higher price in later periods though and still offer a sufficient treatment. Hence, the competitors would attract all customers. Thus, charging \( p_L \) in the first periods is not profitable under price competition.

4.1.2 Regulated prices

In contrast to a market with price competition, the experts’ action space reduces to the treatment and charging choice if prices are fixed. In the following, we present equilibria that have a similar structure as the equilibria in a market with price competition. Under regulated prices, there exist no-reputation equilibria with the following properties:

**Lemma 3. No-reputation equilibria**

In a market with regulated prices, there exist equilibria for private and public histories in which there is no interaction in periods 1–9. In periods 10–16, experts always overcharge customers and undertreat those customers with a major problem.

*Proof. See Appendix 8.2.*
In contrast to the no-reputation equilibria under price competition, prices are not low enough for customers to interact in periods 1–9. Their outside option of 1.6 is larger than the expected payoff from interacting which amounts to −3 given that experts always overcharge and undertreat customers with a major problem. Thus, customers do not interact in the first nine periods. In the last periods, prices in the fixed price set-up are low enough so that although experts always overcharge and always undertreat customers with a major problem, customers interact.

With prices given by \( \{p_L, p_H\} = \{4, 8\} \) in periods 1–9 and by \( \{p_L, p_H\} = \{0, 3\} \) in periods 10–16, customers would not interact in the first nine periods if they randomized between experts. If interaction is still observed, customers must hence coordinate on experts. The reputation equilibria in a market with regulated prices are characterized by:

**Lemma 4. Reputation equilibria**

In a market with regulated prices, there exist equilibria for private and public histories in which experts do not undertreat customers with a major problem in periods 1–9 but always overcharge customers with a minor problem. In periods 10–16, experts always overcharge and undertreat customers with a major problem.

**Proof.** See Appendix 8.3. \( \square \)

Analogous to the case with price competition, the reputation equilibria outlined above are characterized by experts building up a reputation by not undertreating in periods 1–9. Experts always undertreat in periods 10–16. Experts overcharge customers with a minor problem in all periods. The equilibria described in Lemma 4 hold for both information structures: private and public histories.

Under public histories, there exists an additional reputation equilibrium in which experts build up reputation in the first periods by not undertreating and always charging \( p_L \) in periods 1–7. The expert serving the customers makes zero profits in the first periods. In periods 8 and 9, the expert makes positive profits by charging the customers the major treatment and not undertreating. In periods 10–16, experts always overcharge customers and undertreat those customers with a major problem.\(^{13}\) The equilibrium is characterized as follows:

\(^{13}\)As outlined before, a reputation equilibrium without overcharging does not exist under price competition. This is because competitors would slightly undercut the price of the expert not overcharging in periods 8 and 9.
Lemma 5. Reputation equilibrium without overcharging

In a market with regulated prices and public histories, there exists an equilibrium in which experts do not undertreat in periods 1–9. In periods 10–16, experts always undertreat customers with a major problem. In periods 1–7, experts charge $p_L$; in periods 8–16, experts always overcharge customers with a minor problem.

Proof. See Appendix 8.4.

If the expert serving customers deviated in periods 1–7 by undertreating a customer, by charging a customer $p_H$, or both, all customers would observe the deviation. Consequently, all customers would visit a different expert. This in turn disciplines the experts not to deviate. Note that the punishment mechanism for charging $p_H$ only works under public but not under private histories. If a customer under private histories observed that he was charged $p_H$, visiting a different expert would not be a credible threat because being the only customer at the other expert would mean that she would be undertreated and overcharged, yielding a payoff of $-3$.\textsuperscript{14} If the customer did not interact after the deviation instead of switching to a different expert, her payoff amounted to 1.6 while staying with the expert charging $p_H$ yields a payoff of 2. Thus, customers charged $p_H$ would still visit the same expert after being charged $p_H$. Thus, the deviation is profitable for experts under private histories.

4.2 Predictions

In the following, we derive predictions for the differences in the level of undertreatment and the level of overcharging between the four conditions. We also shortly describe experts’ price posting behavior.

4.2.1 Level of undertreatment

The first hypothesis is concerned with the difference between the conditions with price competition and those with regulated prices. There is no trade in the first nine periods under regulated prices if the no-reputation equilibrium is played. Thus, if we observe interaction, theory predicts that experts and customers behave according to the reputation equilibrium. Then, none of the customers is undertreated in

\textsuperscript{14}Remember that under private histories customers do not observe how many customers an expert had in the previous period.
periods 1–9. Under price competition and observed trade, however, players might either coordinate on the reputation equilibrium or the no-reputation equilibrium. Hence, undertreatment is possible in periods 1–9. Independent of which equilibrium players coordinate on under price competition, the equilibrium price for the major treatment in the price-competition condition is lower than the exogenously set price in the regulated-price conditions. Thus, we can state the following hypothesis:

**Hypothesis 1** (Price competition vs. regulated prices: undertreatment). *If interaction between experts and customers is observed in periods 1–9, the level of undertreatment in periods 1–9 is equal or lower under regulated prices than under price competition. The price \( p_H \) experts post under price competition is lower than the exogenously set price \( p_H \) in the regulated-price conditions.*

Next, we turn to the difference in the level of undertreatment if price competition is in place and histories are either private or public. Whether the level of undertreatment is lower or higher under private than under public histories depends on whether experts and customers coordinate on the no-reputation or reputation equilibrium. Thus, theory does not provide a direct prediction about the treatment comparison. The intuition why we expect less undertreatment under public than under private histories is the following: each customer observes the sufficiency of all treatments provided and not only the sufficiency of her own treatment under public histories. Hence, the customer may condition the choice of expert on whether any of the customers has been undertreated by the expert in any of the previous periods under public histories. This additional information under public histories helps customers coordinate on experts based on treatment histories. Thus, we expect that more information serves as a coordination device for customers such that the reputation equilibrium is played—even when it is not played right from the beginning as theory would require. Prices, however, do not differ between the two reputation mechanisms. Thus, we can state the following hypothesis:

**Hypothesis 2** (Private vs. public histories under price competition: undertreatment). *If players play a reputation equilibrium in a market with price competition, we expect the level of undertreatment in periods 1–9 to be equal or lower for public than for private histories. The price \( p_H \) posted by experts does not differ between the conditions.*

The above-outlined reasoning for why we expect less fraud under public than under private histories also applies to a market with regulated prices. We still distinguish
in the hypotheses for the difference between private and public histories with respect to the price regime because results differ across price regimes as shown below.

**Hypothesis 3** (Private vs. public histories under regulated prices: undertreatment). *If experts and customers play the reputation equilibrium outlined in Lemma 4 or in Lemma 5 in a market with regulated prices, we expect the level of undertreatment in periods 1–9 to be equal or lower for public than for private histories.*

### 4.2.2 Level of overcharging

Next, we turn to the hypotheses concerning overcharging. Under price competition, customers are always overcharged. If experts charged $p_L$ instead of $p_H$ in the first periods, experts would have lower payoffs in expectation compared to a situation with no interaction. Thus, charging $p_L$ might only be rational if higher prices in later periods compensated the forgone profit in the first periods. Due to price competition, the competitors would undercut the higher price in later periods though and still offer a sufficient treatment. Thus, charging $p_L$ in the first periods is not profitable under price competition. Under regulated prices and public histories, however, there exists a reputation equilibrium in which customers are not overcharged in the first seven periods. Therefore, we state the following hypothesis with respect to the expected difference in overcharging in the two price regimes:

**Hypothesis 4** (Price competition vs. regulated prices: overcharging). *If interaction between experts and customers is observed in periods 1–9, the level of overcharging in periods 1–9 is equal or lower in a market with regulated prices than in a market with price competition.*

Under price competition, experts cannot build up reputation by treating sufficiently and charging $p_L$. This insight holds independent of the information structure in the market. The reason is that experts’ possibility to undercut competitors’ prices is sufficient for the non-existence of no-overcharging equilibria in the markets we consider. Thus, we expect no difference in the level of overcharging between public and private histories:

**Hypothesis 5** (Private vs. public histories under price competition: overcharging). *If interaction between experts and customers is observed in periods 1–9, the level of overcharging in periods 1–9 does not differ between public and private histories in a market with price competition.*
In a market with regulated prices and public histories, experts can build up reputation with respect to the sufficiency of a treatment and the charging decision. The equilibrium outlined in Lemma 5 shows that experts charge customers $p_L$ in periods 1–7. Customers can credibly threaten to switch to a different expert if an expert undertreats or charges $p_H$. This is because all customers observe an expert's deviation. Losing all customers induces a sufficiently high reduction in expert profits such that experts will not charge $p_H$ in the first periods. Under private histories, however, customers cannot credibly threaten to switch to a different expert because other customers would not observe the deviation and thus would not punish the expert.\textsuperscript{15} Visiting an expert who only serves one customer is not rational for the customer as she would be undertreated. Thus, visiting a different expert is not a credible threat. Hence, we can state the following prediction with respect to the difference between private and public histories under regulated prices:

**Hypothesis 6** (Private vs. public histories under regulated prices: overcharging). *If interaction between experts and customers is observed in periods 1–9, the level of overcharging in periods 1–9 is equal or lower under public than under private histories in a market with regulated prices.*

5 Methodology

This section provides an overview and a discussion of the methods used. In light of the theoretical considerations above, we restrict our analysis to the first nine periods where reputational concerns may play a role.

All non-parametric test results reported in the following are based on two-tailed Mann-Whitney $U$ tests. Test results are reported to be (weakly) significant if the two-tailed test’s $p$-value is smaller than 0.05 (0.1). We consider the average per market over individuals and over the first nine periods as one independent observation. Thus, our non-parametric test results are based on eight independent observations per condition.

In order to separate the mechanisms at work and to account for individual heterogeneity, we complement the non-parametric test results by parametric tests in form of regressions. The data structure, however, is challenging for regression analysis

\textsuperscript{15}Note that under private histories, customers cannot observe how many other customers visit an expert.
for the following reasons: firstly, the stage game is repeated which imposes a serial correlation between the observations per individual over time. Secondly, eight individuals interact within a market which potentially leads to correlated observations within the market. And thirdly, our dependent variables—whether a customer was undertreated and/or overcharged in a period—are binary.

We follow Dullec et al. (2011) and make use of the random-effects panel probit regression with standard errors clustered on the individual level. The panel probit model accounts for the fact that the stage game is repeated for 16 periods and that the dependent variable is binary. In contrast to the fixed-effects estimator, the random-effects estimator allows us to estimate the treatment effect although the condition does not vary within an individual. Note that current implementations of binary panel regressions do not allow clustering on a different level than the individuals’ level nor is it possible to use robust standard errors. Thus, we may not be capturing the correlation within markets. Introducing market dummies to control for the different markets is not an option for two reasons: firstly, the dummies introduce high collinearity. Secondly, results would be relative to the reference market.

Therefore, we also present the results of a random-effects panel OLS regression with robust standard errors clustered on the market level (for the methodology of robust clustered standard errors, see Huber, 1967; White, 1980; Rogers, 1993). This alternative approach has been previously used by Dullec et al. (2012) in the same set-up as ours. In contrast to the implementation of the panel probit regression, the implementation of the panel OLS regression does explicitly allow to cluster standard errors on the market level. There are two more advantages of the panel OLS results: firstly, the panel OLS regression eases the interpretation of coefficients. Secondly, the interaction term cannot be misleading (for a methodological discussion on the interpretation of interaction terms in non-linear response models, see Ai and Norton, 2003). The drawback of the panel OLS regression is that it does not account for the binarity of the dependent variable and hence suffers from out-of-bound predictions and built-in heterogeneity (Wooldridge, 2009).

Our main results hold independent of the choice of method. Whenever the panel OLS estimates deviate from the panel probit estimates, we indicate the deviation in a footnote.
Table 2: Percentage of undertreatment in periods 1–9.

<table>
<thead>
<tr>
<th>Reputation mechanism</th>
<th>This paper</th>
<th>Dulleck et al. (2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Private histories</td>
<td>Public histories</td>
</tr>
<tr>
<td>Price system</td>
<td>Regulated</td>
<td>31.43%</td>
</tr>
<tr>
<td></td>
<td>Competitive</td>
<td>58.47%</td>
</tr>
</tbody>
</table>

6 Results

In this section, we present the result of the experimental study. We first comment on the level of undertreatment observed before we anylze experts’ overcharging behavior.

6.1 Level of undertreatment

The descriptive experimental results for the level of undertreatment are presented in Table 2. As our design is the same as in Dulleck et al. (2011), we present their corresponding results. The additional data allows us to compare the level of undertreatment under private and public histories with a situation in which the customer cannot even identify the expert she is interacting with (condition None), i.e., a market without reputational concerns.

In our regressions on the level of undertreatment, we control for the period in which an interaction takes place, the conditions and the interaction effect between the conditions. The basic specification is as follows

$$\text{undertreatment}_{it} = \beta_0 + \beta_1 \text{period}_{it} + \beta_2 \text{private_histories}_{it} + \beta_3 \text{fixed_prices}_{it} + \beta_4 \text{private_histories}_{it} \cdot \text{fixed_prices}_{it} + c_i + u_{it}$$  \hspace{1cm} (3)$$

where $c_i$ denotes the random intercept of individual $i$ and $u_{it}$ denotes the idiosyncratic error term for individual $i$ in period $t$. Table 3 displays our regression results. We report the random-effects panel OLS estimation with robust standard errors clustered on the market level in the last two columns.
Table 3: Random-effects panel regressions on undertreatment in periods 1–9.

<table>
<thead>
<tr>
<th>Undertreatment</th>
<th>Panel probit</th>
<th></th>
<th>Panel OLS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Period</td>
<td>0.046*</td>
<td>0.047*</td>
<td>0.044*</td>
<td>0.044*</td>
</tr>
<tr>
<td></td>
<td>(0.027)</td>
<td>(0.027)</td>
<td>(0.026)</td>
<td>(0.026)</td>
</tr>
<tr>
<td>Private histories</td>
<td>0.134</td>
<td>0.068</td>
<td>−0.133</td>
<td>−0.020</td>
</tr>
<tr>
<td></td>
<td>(0.187)</td>
<td>(0.155)</td>
<td>(0.216)</td>
<td>(0.271)</td>
</tr>
<tr>
<td>Fixed prices</td>
<td>−0.955***</td>
<td>−1.161***</td>
<td>−0.333***</td>
<td>−0.393***</td>
</tr>
<tr>
<td></td>
<td>(0.160)</td>
<td>(0.227)</td>
<td>(0.072)</td>
<td>(0.114)</td>
</tr>
<tr>
<td>Private histories · fixed prices</td>
<td>0.415</td>
<td>0.125</td>
<td>0.415</td>
<td>0.125</td>
</tr>
<tr>
<td></td>
<td>(0.312)</td>
<td>(0.141)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>−0.375**</td>
<td>−0.446**</td>
<td>0.064</td>
<td>0.171</td>
</tr>
<tr>
<td></td>
<td>(0.161)</td>
<td>(0.190)</td>
<td>(0.187)</td>
<td>(0.204)</td>
</tr>
<tr>
<td>$R^2_{M&amp;Z}$</td>
<td>0.029</td>
<td>0.033</td>
<td>0.184</td>
<td>0.190</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.033</td>
<td>0.184</td>
<td>0.190</td>
<td>0.190</td>
</tr>
<tr>
<td>Observations</td>
<td>454</td>
<td>454</td>
<td>454</td>
<td>454</td>
</tr>
</tbody>
</table>

Standard errors are clustered on the individual level for panel probit regressions (Note: clustering for panel probit regressions on a different level than the individuals' level has not yet been implemented). Standard errors are robust and clustered on the market level for panel OLS regression. Standard errors are reported in parentheses. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. p-values are based on two-tailed tests.

Result 1 (Price competition vs. regulated prices: undertreatment). The level of undertreatment is significantly higher under price competition than under regulated prices. Prices posted by experts under price competition are significantly lower than the exogenously given prices in the regulated-price condition.

Our experimental results are in line with our first hypothesis: the level of undertreatment is significantly higher in the price-competition regime than in the regulated-price regime (see models (3) and (5) in Table 3; Mann-Whitney $U$ test: $p < 0.001$). According to the OLS estimates, this difference in the level of undertreatment amounts to 33.3 percentage points. Prices posted by experts under price competition are significantly lower than the exogenously given prices in the regulated-price condition (Mann-Whitney $U$ test: $p < 0.001$ for both treatment prices).16

16Note that this difference in the level of undertreatment holds for both types of reputation mechanisms: private (Mann-Whitney $U$ test: $p = 0.009$) and public histories (Mann-Whitney $U$ test: $p = 0.006$).
Players coordinate on the reputation equilibrium under regulated prices. Experts build up reputation by treating customers sufficiently in the first periods. The average rate of undertreatment under regulated prices amounts to 27.59% in the first nine periods (and even only to 22.97% in the first eight periods). In later periods, experts exploit their reputation by undertreating. The average rate of undertreatment rises to 86.70% in periods 10–16 under regulated prices. Figure 1 illustrates the average rate of undertreatment for each of the four conditions over time. As an indication that under regulated prices, the reputation equilibrium is played, we observe that customers punish experts who undertreat more often under regulated prices than under price competition: customers return significantly less often to the undertreating expert under regulated prices than under price competition in the first periods (Mann-Whitney U test: $p < 0.001$).

Under price competition, players rather coordinate on the competitive than the reputation equilibrium. The average rate of undertreatment amounts to 60.81% in the first nine periods and rises to 77.78% in periods 10–16. We observe a price pressure that undermines reputation building in the first nine periods: experts do not only compete in quality (treatment) under price competition but also in the prices posted. Figure 2 visualizes the decline in the price posted for the major treatment over time in the two conditions with price competition. Experts who undertreated in previous periods try to balance their bad reputation by offering low prices in the following periods. In fact, we find that the average price posted for the major treatment prior to an expert’s first undertreatment amounts to 7.30 while the price significantly declines to 6.04 on average after an expert’s first undertreatment.
(Mann-Whitney $U$ test: $p < 0.001$). Concerning the customer behavior under price competition, our results show that customers return significantly more often to an expert that has undertreated the customer in one of the previous periods under the flexible- compared to the regulated-price conditions (Mann-Whitney $U$ test: $p < 0.001$). Thus, the decline in the price posted for the major treatment by an expert who undertreated seems to be sufficiently large to attract customers in future periods. Hence, price competition undermines reputation on quality and thereby leads to a higher level of undertreatment if price competition is in place.

A possible concern with respect to the lower level of undertreatment under regulated prices than under price competition might be that the level of the exogenous prices drives the results. Under price competition, the price vectors observed most often were $\{p_L, p_H\} = \{4, 8\}$ and $\{p_L, p_H\} = \{3, 7\}$. The average price posted for the major treatment under price competition was 7.39 in the first period. To check whether the level of regulated prices drove the result, we implement exogenous prices of $\{p_L, p_H\} = \{3, 7\}$ and thus reduce the experts’ profit in case of a sufficient treatment from 2 to 1.\(^{17}\) We find that the level of undertreatment remains similar to the set-up with prices $\{p_L, p_H\} = \{4, 8\}$ (see Table 4). The level of undertreatment under regulated prices $\{p_L, p_H\} = \{3, 7\}$ is again significantly lower than under price competition (Mann-Whitney $U$ test: $p = 0.011$). Hence, our Result 1 is robust to changes in the exogenously given prices. In fact, we do not even find a significant

\(^{17}\)Note that these robustness checks are based on four markets in the $PH$ Reg condition and four markets in the $PUH$ Reg condition.

---

**Figure 2:** Development of prices posted over time in conditions with price competition.
increase in the level of undertreatment when changing prices from \( \{p_L, p_H\} = \{4, 8\} \) to \( \{p_L, p_H\} = \{3, 7\} \) (Mann-Whitney U test: \( p = 0.186 \)).

\[ \text{Table 4: Robustness in the percentage of undertreatment in periods 1–9.} \]

<table>
<thead>
<tr>
<th>Reputation mechanism</th>
<th>Private histories</th>
<th>Public histories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price system</td>
<td>( {p_L, p_H} = {4, 8} )</td>
<td>31.43%</td>
</tr>
<tr>
<td></td>
<td>( {p_L, p_H} = {3, 7} )</td>
<td>28.07%</td>
</tr>
<tr>
<td></td>
<td>Competitive</td>
<td>58.47%</td>
</tr>
</tbody>
</table>

The lower level of undertreatment under regulated prices leads to a significantly higher rate of efficiency (Mann-Whitney U test: \( p = 0.008 \)). Undertreatment decreases market efficiency because the expert’s treatment induces costs while no customer benefit is generated. As the rate of undertreatment does not increase when lowering the regulated prices to \( \{p_L, p_H\} = \{3, 7\} \), efficiency remains on a significantly higher level under regulated than under competitive prices. Thus, price competition may not only be detrimental to the quality provided but also to market efficiency in expert markets.

\[ \text{Table 5: Efficiency in periods 1–9.} \]

<table>
<thead>
<tr>
<th>Reputation mechanism</th>
<th>Private histories</th>
<th>Public histories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price system</td>
<td>( {p_L, p_H} = {4, 8} )</td>
<td>70.30%</td>
</tr>
<tr>
<td></td>
<td>( {p_L, p_H} = {3, 7} )</td>
<td>76.80%</td>
</tr>
<tr>
<td></td>
<td>Competitive</td>
<td>58.59%</td>
</tr>
</tbody>
</table>

Efficiency is normed to the interval \([0, 1]\) on the market level. 0 corresponds to the (minimum surplus per market - outside option) while 1 corresponds to the (maximum surplus per market - outside option).

**Result 2** (Private vs. public histories under price competition: undertreatment).

*Under price competition, the level of undertreatment is non-significantly higher under public than under private histories.*

In contrast to Hypothesis 2, we find that more customer information does not lead to a decrease in the expert’s incentive to undertreat his customer under price com-
petition. The descriptives even suggest that more customer information might lead to a higher level of undertreatment in periods 1–9. However, this difference is not statistically significant (see models (4) and (6) in Table 3; Mann-Whitney $U$ test: $p = 0.916$). The higher undertreatment rate under public histories comes along with a lower average price paid by the customer in the public-history condition (5.15) compared to the private-history condition (5.38). Figure 3 illustrates the average price paid by customers over time and shows that for all except for two periods, the average price paid is lower under public than under private histories.

Price competition under public histories is more intense than under private histories as customers observe all customers’ histories. Comparing prices posted by experts in period 1 and 10 shows that the decline in the prices is larger under public than under private histories (Mann-Whitney $U$ test: $p = 0.145$ for the minor treatment and $p = 0.045$ for the major treatment). Also, the decline in the average price posted before and after the first undertreatment is larger under public than under private histories (1.54 vs. 1.23). Hence, we conclude that the additional customer information provided under public histories intensifies price competition and thus makes it less profitable for the expert to treat sufficiently.

**Result 3** (Private vs. public histories under regulated prices: undertreatment).
*Under regulated prices, the level of undertreatment is non-significantly lower under public than under private histories.*

In contrast to the price-competition treatments, the level of undertreatment is lower under public than under private histories if prices are fixed but differences are not
Table 6: Percentage of overcharging in periods 1–9.

<table>
<thead>
<tr>
<th>Price system</th>
<th>Reputation mechanism</th>
<th>Private histories</th>
<th>Public histories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulated</td>
<td></td>
<td>71.11%</td>
<td>41.24%</td>
</tr>
<tr>
<td>Competitive</td>
<td></td>
<td>77.84%</td>
<td>86.54%</td>
</tr>
</tbody>
</table>

significant (Mann-Whitney U test: $p = 0.103$). The additional customer information under public histories seems to serve as a coordination device. Customers observe not only their own treatment history but all customers’ treatment histories. Thus, public histories ease customers’ coordination on the reputation equilibrium even if it is not played from the very beginning as theory would predict.

The additional customer information about whether other customers receive a sufficient treatment increases the rate of interaction significantly (Mann-Whitney U test: $p = 0.042$). Whereas under private histories, customers interact in 73.26% of the cases, the rate of interaction amounts to 96.18% in the public-history condition.

Thus, we can conclude that the additional customer information provided by public histories tends to increase the provision of a sufficient treatment when experts do not compete in prices. However, if there is price competition, the additional information from public histories tends to intensify price competition which in turn makes it less profitable for experts to treat sufficiently.

6.2 Level of overcharging

In the following, we present the results concerning the level of overcharging. *Table 6* provides an overview of the level of overcharging across conditions.

Following the analysis for the level of undertreatment, we specify our regression function as follows:

$$
overcharging_{it} = \beta_0 + \beta_1 period_{it} + \beta_2 private\_histories_{it} + \beta_3 fixed\_prices_{it} \\
+ \beta_4 private\_histories_{it} \cdot fixed\_prices_{it} + c_i + u_{it}.
$$

*Table 6* displays our regression results.
Table 7: Random-effects panel regressions on overcharging in periods 1–9.

<table>
<thead>
<tr>
<th>Overcharging</th>
<th>Panel probit</th>
<th></th>
<th>Panel OLS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Period</td>
<td>0.043∗</td>
<td>0.042∗</td>
<td>0.041∗</td>
<td>0.046∗</td>
</tr>
<tr>
<td></td>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.022)</td>
<td>(0.022)</td>
</tr>
<tr>
<td>Private histories</td>
<td>0.301</td>
<td>0.240</td>
<td>−0.425∗</td>
<td>0.094</td>
</tr>
<tr>
<td></td>
<td>(0.191)</td>
<td>(0.162)</td>
<td>(0.213)</td>
<td>(0.073)</td>
</tr>
<tr>
<td>Fixed prices</td>
<td>−0.882***</td>
<td>−1.492***</td>
<td>−0.259***</td>
<td>−0.440***</td>
</tr>
<tr>
<td></td>
<td>(0.163)</td>
<td>(0.213)</td>
<td>(0.213)</td>
<td>(0.078)</td>
</tr>
<tr>
<td>Private histories, fixed prices</td>
<td>1.324***</td>
<td></td>
<td>0.388***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.305)</td>
<td></td>
<td>(0.137)</td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.486***</td>
<td>0.340**</td>
<td>0.759***</td>
<td>1.045***</td>
</tr>
<tr>
<td></td>
<td>(0.146)</td>
<td>(0.170)</td>
<td>(0.176)</td>
<td>(0.186)</td>
</tr>
<tr>
<td>R²_M&amp;Z</td>
<td>0.022</td>
<td>0.035</td>
<td>0.151</td>
<td>0.211</td>
</tr>
<tr>
<td>R²</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>705</td>
<td>705</td>
<td>705</td>
<td>705</td>
</tr>
</tbody>
</table>

Standard errors are clustered on the individual level for panel probit regressions (Note: clustering for panel probit regressions on a different level than the individuals' level has not yet been implemented). Standard errors are robust and clustered on the market level for panel OLS regression. Standard errors are reported in parentheses. ∗p < 0.1, ∗∗p < 0.05, ∗∗∗p < 0.01. p-values are based on two-tailed tests.

Result 4 (Price competition vs. regulated prices: overcharging). Under price competition, the level of overcharging is significantly higher than under regulated prices.

In line with Hypothesis 4, overcharging is significantly lower under regulated prices than under price competition (see models (3) and (5) in Table 7; Mann-Whitney U test: p = 0.019). Following the OLS estimates, this difference in the probability of being overcharged amounts to 25.9 percentage points. As can be seen in Figure 2, the average price posted for the major treatment declines over time under price competition. The average price posted for the minor treatment declines from 3.95 in period 1 to 2.90 in period 9.

A possible explanation why experts overcharge more often under price competition may be that experts try to compensate lower profits due to lower prices through

18Note that the difference in the level of overcharging between price competition and regulated prices is driven by the difference between the public-history conditions (Mann-Whitney U test: p = 0.006). The difference between the private-history conditions is not statistically significant (Mann-Whitney U test: p = 0.834).
overcharging. Furthermore, our hypothesis is confirmed that under price competition, there is no reputation building on the charging dimension.

Note that Result 4 is robust against reducing the regulated prices to \( \{p_L, p_H\} = \{3, 7\} \) (Mann-Whitney U test: \( p = 0.050 \); see also Table 8). However, the reduction in regulated prices leads to a considerable increase in the level of overcharging under public histories.

**Table 8:** Robustness in the percentage of overcharging in periods 1–9.

<table>
<thead>
<tr>
<th>Price system</th>
<th>Reputation mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Private histories</td>
</tr>
<tr>
<td>Regulated ( {p_L, p_H} = {4, 8} )</td>
<td>71.11%</td>
</tr>
<tr>
<td>Regulated ( {p_L, p_H} = {3, 7} )</td>
<td>68.42%</td>
</tr>
<tr>
<td>Competitive</td>
<td>77.84%</td>
</tr>
</tbody>
</table>

**Result 5** (Private vs. public histories under price competition: overcharging). Under price competition, the level of overcharging is significantly higher under public than under private histories.

We find evidence that the level of overcharging is higher under public than under private histories if experts compete in prices (Mann-Whitney U test: \( p = 0.093 \)).

Under public histories, a customer observes the price each customer was charged in the previous periods and not only the price she was charged herself which results in stronger price competition (compare Figure 2). The lower prices are compensated by higher frequencies of overcharging thus leading to an increased level of overcharging under public histories.

**Result 6** (Private vs. public histories under regulated prices: overcharging). Under regulated prices \( \{p_L, p_H\} = \{4, 8\} \), the level of overcharging is weakly significantly lower under public than under private histories. The difference diminishes if prices are regulated at \( \{p_L, p_H\} = \{3, 7\} \).

This result on overcharging again follows the pattern we find for the level of undertreatment: in a regulated-price regime, there is less overcharging under public

\(^{19}\)Note that the panel probit regression supports this result on a 5% significance level whereas the panel OLS regression does not find a statistically significant difference.
than under private histories. According to the Mann-Whitney $U$ test, the level of undertreatment is different on a significance level of $p = 0.066$.\footnote{Although the difference in the descriptives between the two conditions amounts to almost 25 percentage points, the significance level is rather low as there are three markets under public histories that show a high level of overcharging.}

The difference in the level of overcharging between public and private histories is due to the fact that customers can observe whether other experts charged the price for the minor or the major treatment in previous periods under public histories. If the experts' mark-up is sufficiently high as under prices $\{p_L, p_H\} = \{4, 8\}$, experts charge honestly in the first periods. However, if the experts' mark-up is low, such as under prices $\{p_L, p_H\} = \{3, 7\}$, the experts' incentive to charge honestly vanishes even under public histories.

Note that we virtually find no undercharging under public histories which is in contrast to the predicted expert behavior in the reputation equilibrium without overcharging (see Lemma 5).

### 7 Conclusion

There is scope for fraud in credence goods markets: If e.g. experts cannot be made (fully) liable and the provided service is not verifiable, they might undertreat and overcharge their customers. Experts compete mainly on two dimensions: posted prices to attract customers and the observable part of trade or surplus from trade when reputation plays a role. In this paper, we analyze the level of fraud in a credence goods market with repeated interaction both when experts can compete in prices or when this dimension of competition is shut down by regulating prices.

Our main result is that the level of fraud—both undertreatment and overcharging—is significantly lower under regulated than under competitive prices. Under regulated prices, customers return significantly less often to undertreating experts than under price competition in the first periods where reputational concerns play a role. Furthermore, under price competition, we observe a price pressure that undermines reputation building in the first periods: experts who undertreated in previous periods offer lower prices in the following periods. Taken together, our results suggest that a reputation equilibrium in which experts build up reputation on treatment quality is played under regulated prices whereas under price competition, the mar-
ket coordinates on an equilibrium without reputation on treatment quality and fierce price competition.

With respect to customer information, we find that public histories go along with lower levels of undertreatment compared to private histories when prices are regulated whereas the opposite is true under price competition, although differences are not significant. Under public histories the observed price decline over time is larger than under private histories. These results indicate that public information might help strengthen reputation building on treatment quality when prices are regulated whereas it might intensify price competition with negative feedback on treatment quality when prices are not regulated. Results on the second dimension of fraud, overcharging, mirror the results on undertreatment: the level of overcharging is significantly higher under competitive than under regulated prices. Furthermore, under price competition, the level of overcharging is significantly higher under public than private histories. Our results suggest that when customers are price-sensitive, price competition in credence good markets undermines reputation building on the quality of the provided service and induces higher levels of fraud than when experts cannot compete in prices.

Our results could be interpreted as giving a rationale for why we observe regulated prices in several credence goods markets. In terms of customer information about expert behavior, in markets with regulated prices feedback platforms such as the Arztnavigator seem to be an adequate instrument to reduce the fraud level. In markets with price competition, however, more customer information might focus attention (too) strongly on price with adverse effects on treatment quality.
8 Appendix A: Proofs

In the following proofs, we assume that if customers are indifferent between visiting and not visiting an expert, the customer opts for the visit. Experts who are indifferent between undertreating and not undertreating do not undertreat.

For each class of equilibria (no-reputation and reputation equilibria) two types of equilibria may exist: an equilibrium where customers randomize with equal probability among experts and an equilibrium where customers coordinate on an expert in the first period. We outline both types of equilibria in the following if they exist.

8.1 Proof of Lemma 2

8.1.1 Reputation Equilibria in which Customers Randomize

We first comment on the reputation equilibria in which customers randomize between experts in the first period.

Public Histories The strategies and beliefs as well as the corresponding proof for the reputation equilibrium under public histories in which customers randomize are outlined in Dullecck et al. (2011). Note that the strategies and beliefs presented below partially build upon this equilibrium.

Private Histories Under private histories a reputation equilibrium where customers randomize between experts does not exist. This is because customers cannot coordinate on the expert with the strict majority of customers because customers do not observe how many customers an expert serves. Without customers observing which expert serves the most customers and without customer coordination, it is optimal for experts to undertreat customers unless they face four customers. If experts post prices as outlined in Lemma 2 and an expert serves three customers, his maximum additional future payoff from treating customers sufficiently amounts to $7(3 - 1.6) = 9.8$ in period 9 (which is the last period where reputational concerns may play a role), while the maximum additional current payoff from deviating amounts to $3((5 - 2) - (5 - 6)) = 12$. Thus, experts always provide the minor treatment if they serve three or less customers. The expected payoff from interacting
(0.5+)5 − 0.5(1 − 1/64) · 5 = 0.078125 is lower than the outside option of 1.6 (where 1/64 is the probability that all customers choose the same expert in the first period).

8.1.2 Reputation Equilibrium in which Customers Coordinate

In the following, we assume that customers coordinate on one of the experts in the first period. We refer to the four experts as expert $A$, $B$, $C$, and $D$.

Public Histories The strategies and beliefs in the reputation equilibrium with customers coordinating under public histories are as follows.

Customers’ beliefs: Each customer believes that experts always charge $p_H$. Each customer believes to be treated sufficiently if and only if (i) she is treated under a price menu \{$n.d., 5\} and the expert has at least two customers, (ii) the expert has only undertreated a customer in situation where all experts served exactly one customer, and (iii) the game is in periods 1–9. Otherwise, each customer believes to get the minor treatment.

Customers’ strategy: Each customer visits among the experts posting a price menu \{$n.d., 5\} the same expert as all other customers (in the following expert $A$) in the first period. In periods 2–9, if expert $A$ did not undertreat any of the customers in the previous period and expert $A$ posts a price menu a \{$n.d., 5\} in the current period, customers return to expert $A$. If expert $A$ undertreated any of the customers in the previous period or posts a price menu different from \{$n.d., 5\} in the current period, all customers coordinate to another expert (in the following expert $B$) among the experts posting a price menu \{$n.d., 5\}. If there is no expert posting \{$n.d., 5\}$, customers randomize between those experts posting \{$n.d., 3\}. If there is no expert posting \{$n.d., 3\}$, customers do not interact. Customers’ strategy when visiting experts $B$, $C$ and $D$ is according to the above strategy at expert $A$. If there is no expert who never undertreated, customers do not interact. In periods 10–16, customers choose expert $A$ if he never undertreated in periods 1–9. If expert $A$ undertreated in any period 1–9, customers visit expert $B$ if he never undertreated in any period 1–9; and so forth. If there is no expert who never undertreated, customers randomize between experts with equal probability in periods 10–16.

Expert Strategy: In the first nine periods, all experts post \{$n.d., 5\}. Each expert serves his customers sufficiently if he has two or more customers and provides the mi-
nor treatment otherwise. In periods 10–16, all experts post the price menu \{n.d., 3\}
and always provide the minor treatment if one seller had strictly the most customers
in period 9. Otherwise all experts play the strategy described *Lemma 1*.

**Verification:**
We now verify that the given strategies and beliefs form a perfect Bayesian equi-
librium. We first show that customers’ strategies are rational. In periods 10–16, if
customers interact, they receive an expected payoff of $0.5(10 - 3) + 0.5(0 - 3) = 2$
which is larger than their outside option of 1.6. In periods 1–9, given expert
behavior, it is optimal to interact as the expected payoff of $10 - 5 = 5$ is larger than
the one from not interacting (1.6). If customers return to play the above described
randomization equilibrium, customers’ strategy off-equilibrium is optimal as shown
in the public histories reputation equilibrium with randomization.

In the following, we show that experts’ strategy is rational. In periods 10–16 it is
optimal to always provide the minor treatment because the maximum additional
future payoff of treating sufficiently $6 \cdot 2.4 = 14.4$ (in period 10) is lower than
the maximum current payoff from deviating $4((5 - 2) - (5 - 6)) = 16$. In period 9,
if the expert serves four customers, the expert’s maximum additional future payoff
of treating customers sufficiently amounts to $7 \cdot 2.4 = 16.8$ whereas the maximum
additional current payoff from deviating is $4((5 - 2) - (5 - 6)) = 16$. If the expert
serves three customers, his maximum additional future payoff of treating customers
sufficiently also amounts to $7(4 - 1.6) = 16.8$ (because the single customer will
visit this expert in periods 10–16) whereas the maximum additional current profit
from deviating is $3((5 - 2) - (5 - 6)) = 12$. If an expert serves two customers in
period 9, the maximum current payoff from deviating amounts to $2((5 - 2) - (5 - 6)) = 8$. Whether the expert will serve all four customers in periods 10–16 depends
on whether the expert serves the strict majority of customers in period 9. Given
customers’ strategies, an expert should never serve only two customers. Hence,
Bayes’ rule cannot be applied to calculate the probability with which an expert
expects to be the expert with the strict majority of customers. We assume that the
expert believes to serve the strict majority of customers with probability 1. Given
these beliefs, the expert’s maximum additional future payoff of treating sufficiently
amounts to 16.8 because all customers will choose this expert in periods 10–16. In
periods 1–8, future payoff of treating customers sufficiently is larger so that deviation
incentives are lower. Hence, the expert will treat customers sufficiently if he serves
at least two customers under the above beliefs. In case the expert only serves one
customer, the maximum additional future payoff from treating sufficiently amounts to $7(1 - 1.6) = -2.8$ while the maximum current payoff from deviating is 4. Thus, the expert always provides the minor treatment if he serves a single customer. Given that all other experts charge the price $p_H$ for both treatments in all 16 periods, it is optimal for the individual expert to also charge $p_H$. Consequently, experts’ strategies are rational.

**Private Histories** The strategies and beliefs in the reputation equilibrium with customers coordinating under private histories are as follows.

*Customers’ beliefs:* Each customer expects to be charged $p_H$ in any of the periods. Each customer believes to be treated sufficiently if and only if (i) she is treated under a price menu \{n.d., 5\} and the expert has four customers, (ii) if the expert has never undertreated the customer before, and (iii) the game is in periods 1–9. Otherwise, each customer believes to get the minor treatment.

*Customers’ strategy:* Each customer visits among the experts that post a price menu \{n.d, 5\} the same expert as all other customers (in the following expert A) in the first period. In periods 2–9, if expert A did not undertreat the customer in the previous period and posts \{n.d, 5\}, the customer returns to expert A. If expert A undertreated the customer in the previous period or posts a price vector different from \{n.d, 5\}, the customer refrains from interacting. In periods 10–16, if expert A did not undertreat the customer in any period 2–9, the customer stays with expert A. If expert A undertreated the customer in any period 2–9, the customer randomizes between the remaining three experts with equal probability in periods 10–16.

*Experts’ strategy:* Experts post price vectors \{n.d, 5\} in periods 1–9 and \{n.d, 3\} in periods 10–16. Each expert treats his customers sufficiently in periods 1–9 if he serves all four customers and provides the minor treatment otherwise. In periods 10–16, experts always provide the minor treatment. Experts always charge $p_H$.

*Verification:* We now verify that the given strategies and beliefs form a perfect Bayesian equilibrium. We first show that customers’ strategies are rational. In periods 10–16, if customers interact, they receive an expected payoff of $0.5(10 - 3) + 0.5(0 - 3) = 2$ which is larger than their outside option of 1.6. In periods 1–9, given expert behavior, i.e., always sufficient treatment, it is optimal to interact as the expected payoff of $10 - 5 = 5$ is larger than the one from not interacting (1.6). If expert A undertreats,
it is optimal for the customer to refrain from interacting because the outside option of 1.6 is larger than the expected payoff from interacting \((0.5(10-5)+0.5(0-5) = 0)\).

In the following, we show that experts' strategies are rational. In periods 10–16 it is optimal to always provide the minor treatment because the maximum additional future payoff of treating sufficiently \(6 \cdot 2.4 = 14.4\) (in period 10) is lower than the maximum current payoff from deviating \(4((5 - 2) - (5 - 6)) = 16\). In period 9, if the expert serves four customers, the expert’s maximum additional future payoff of treating customers sufficiently amounts to \(7 \cdot 2.4 = 16.8\) whereas the maximum additional current payoff from deviating is \(4((5 - 2) - (5 - 6)) = 16\). In periods 1–8, future payoff of treating customers sufficiently is larger so that deviation incentives are lower. If the expert serves three or less customers, his maximum additional future payoff of treating customers sufficiently amounts to \(7(3 - 1.6) = 9.8\) (in case he serves three customers) which is less than the maximum additional current profit from deviating \(3((5 - 2) - (5 - 6)) = 12\). Thus, it is optimal for the expert to provide the minor treatment. Given that all other experts charge the price \(p_H\) for both treatments in all 16 periods, it is optimal for the individual expert to also charge \(p_H\). Hence, experts’ strategy is rational.

### 8.2 Proof of Lemma 3

Both types of equilibria (with customer randomization and customer coordination) described in Lemma 3 are characterized as follows:

**Customers' beliefs:** Each customer believes to always receive the minor treatment and to always be charged \(p_H\).

**Customers' strategy:** Customers do not interact in periods 1–9. Customers randomize between experts in each period respectively coordinate in any (arbitrary) way on the experts in periods 10–16.

**Experts' strategy:** Experts always provide the minor treatment and always charge \(p_H\).

\(^{21}\)Note that the fourth customer in the market will be undertreated because she ends up as a single customer at an expert in period 9. As the fourth customer cannot observe whether the expert serving three customers undertreated his customers, her behavior in periods 10–16 is not changed by the treatment decision of the expert serving three customers in period 9. Hence, the fourth customer is irrelevant when determining whether the expert serving three customers deviates or sticks to the equilibrium strategy.
Verification:
We now verify that the above outlined strategies and beliefs form a perfect Bayesian equilibrium. Customers’ behavior is rational because their expected payoff from interaction in periods 1–9 amounts to $0.5(10 - 8) + 0.5(0 - 8) = -3$ which is less than the outside option of 1.6. In periods 10–16, if customers interact, they receive an expected payoff of $0.5(10 - 3) + 0.5(0 - 3) = 2$ which is larger than their outside option of 1.6. Given the customers’ behavior, experts’ strategies are optimal because their payoff from always providing the minor treatment at the price $p_H$ is larger than treating sufficiently. Note that the expert cannot decide not to participate.

8.3 Proof of Lemma 4
The players’ strategies and beliefs in the reputation equilibria without overcharging in a market with regulated prices are outlined below. The reputation equilibria require that customers coordinate on one expert in the first period. Given the strategies and beliefs of reputation equilibria under price competition in which customers randomize, customers would face a lower payoff than the outside option under regulated prices. Thus, if interaction is still observed, customers must coordinate on one of the experts. We refer to the four experts as expert $A$, $B$, $C$, and $D$.

Public Histories The strategies and beliefs in the reputation equilibrium with customer coordination under public histories are as follows.

Customers’ beliefs: Each customer expects to be charged $p_H$ in any of the periods. Each customer believes to be treated sufficiently if and only if (i) the expert serves at least two customers, (ii) the expert only undertreated a customer in situation where all experts served one customer, and (iii) the game is in periods 1–9. Otherwise, each customer believe to receive the minor treatment.

Customers’ strategy: Each customer visits the same expert (in the following expert $A$) as all other customers in the first period. In periods 2–9, if expert $A$ did not undertreat any of the customers in the previous period, customers return to expert $A$. If expert $A$ undertreated in the previous period, all customers visit expert $B$. If expert $B$ did not undertreat any of the customers in the previous period, customers return to expert $B$ whereas if he undertreated in the previous period, customers choose expert $C$; and so forth. If there is no expert who never undertreated, customers do not interact. In periods 10–16, customers choose expert $A$ if he never
undertreated. If expert A undertreated in any period 1–9, customers visit expert B if he never undertreated; and so forth. If there is no expert who never undertreated, customers randomize between experts with equal probability in periods 10–16.

*Experts’ strategy:* Each expert treats his customers sufficiently in periods 1–9 if he serves two or more customers and provides the minor treatment otherwise. In periods 10–16, experts always provide the minor treatment. Experts always charge $p_H$.

*Verification:* We now verify that the above described strategies and beliefs form a perfect Bayesian equilibrium. We first show that customers’ strategies are rational. In periods 10–16, if customers interact, they receive an expected payoff of $0.5(10 - 3) + 0.5(0 - 3) = 2$ which is larger than their outside option of 1.6. In periods 1–9, given expert behavior, i.e., always sufficient treatment, it is optimal to interact as the expected payoff of $10 - 8 = 2$ is larger than the one from not interacting (1.6).

In the following, we show that experts’ strategy is rational. In periods 10–16 it is optimal to always provide the minor treatment because the maximum additional future payoff of treating sufficiently $6 \cdot 2.4 = 14.4$ (in period 10) is lower than the maximum current payoff from deviating $4((8 - 2) - (8 - 6)) = 16$. In period 9, if an expert serves four customers, the expert’s maximum additional future payoff of treating customers sufficiently amounts to $7 \cdot 2.4 = 16.8$ whereas the maximum additional current payoff from deviating is $4((8 - 2) - (8 - 6)) = 16$. If the expert serves three customers, his maximum additional future payoff of treating customers sufficiently also amounts to $7(4 - 1.6) = 16.8$ (because the single customer will visit this expert in periods 10–16) whereas the maximum additional current profit from deviating is $3((8 - 2) - (8 - 6)) = 12$. If an expert serves two customers in period 9, the maximum current payoff from deviating amounts to $2((8 - 2) - (8 - 6)) = 8$. Whether the expert serving two customers in period 9 will serve all four customers in periods 10–16 depends on whether the expert serves the strict majority of customers in period 9. Given customers’ strategies, an expert should never serve only two customers. Hence, Bayes’ rule cannot be applied to calculate the probability with which an expert expects to be the expert with the strict majority of customers. We assume that the expert believes to serve the strict majority of customers with probability 1. Given these beliefs, the expert’s maximum additional future payoff of treating sufficiently amounts to 16.8 because all customers will choose this expert in periods 10–16. In periods 1–8, future payoff of treating customers sufficiently is
larger so that deviation incentives are lower. Hence, the expert will treat customers sufficiently if he serves at least two customers under the above beliefs. In case the expert only serves one customer, the maximum additional future payoff from treating sufficiently amounts to \(7(1 - 1.6) = -2.8\) while the maximum current payoff from deviating is 4. Thus, the expert always provides the minor treatment if he serves a single customer. Given that all other experts charge the price \(p_H\) for both treatments in all 16 periods, it is optimal for the individual expert to also charge \(p_H\). Consequently, experts’ strategies are rational.

**Private Histories** The strategies and beliefs in the reputation equilibrium with customers coordinating under private histories are as follows.

*Customers’ beliefs:* Each customer expects to be charged \(p_H\) in any of the periods. Each customer believes to be treated sufficiently if and only if (i) the expert has four customers, (ii) the expert has never undertreated the customer before, and if (iii) the game is in periods 1–9. Otherwise, each customer expects to receive a minor treatment.

*Customers’ strategy:* Each customer visits the same expert as all other customers (in the following expert \(A\)) in the first period. In periods 2–9, if expert \(A\) did not undertreat any of the customers in the previous period, customers return to expert \(A\). If expert \(A\) undertreated in the previous period, customers refrain from interacting. In periods 10–16, if expert \(A\) did not undertreat the customer in any period 2–9, customers stay with expert \(A\). If expert \(A\) undertreated the customer in any period 2–9, customers randomize between experts with equal probability in periods 10–16.

*Experts’ strategy:* Each expert treats his customers sufficiently in periods 1–9 if he serves all four customers and provides the minor treatment otherwise. In periods 10–16, experts always provide a minor treatment. Experts always charge \(p_H\).

**Verification:**
We now verify that the above described strategies and beliefs form a perfect Bayesian equilibrium. We first show that customers’ strategies are rational. In periods 10–16, if customers interact, they receive an expected payoff of \(0.5(10 - 3) + 0.5(0 - 3) = 2\) which is larger than their outside option of 1.6. In periods 1–9, given expert behavior, it is optimal to interact as the expected payoff of \(10 - 8 = 2\) is larger than the one from not interacting (1.6).
In the following, we show that experts’ strategy is rational. In periods 10–16 it is optimal to always provide the minor treatment because the maximum additional future payoff of treating sufficiently $6 \cdot 2.4 = 14.4$ (in period 10) is lower than the maximum current payoff from deviating $4((8 - 2) - (8 - 6)) = 16$. In period 9, if the expert serves four customers, the expert’s maximum additional future payoff of treating customers sufficiently amounts to $7 \cdot 2.4 = 16.8$ whereas the maximum additional current payoff from deviating is $4((8 - 2) - (8 - 6)) = 16$. In periods 1–8, future payoff of treating customers sufficiently is larger so that deviation incentives are lower. If the experts serve three or less customers, his maximum additional future payoff of treating customers sufficiently amounts to $9.8$ (in case he serves three customers) which is less than the maximum additional current profit from deviating $3((8 - 2) - (8 - 6)) = 12$.22 Thus, it is optimal for the expert to provide the minor treatment. Given that all other experts charge the price $p_H$ for both treatments in all 16 periods, it is optimal for the individual expert to also charge $p_H$. Hence, experts’ strategy is rational.

8.4 Proof of Lemma 5

The strategies and beliefs of the players in the reputation equilibrium without overcharging in a market with regulated prices are outlined below. We refer to the four experts as expert $A$, $B$, $C$, and $D$.

Customers’ beliefs: Each customer believes to be charged $p_L$ if (i) the expert serves at least two customers, (ii) the expert has never charged $p_H$ in any of the previous periods and (iii) the game is in period 1–7. Otherwise, each customer expects to be charged $p_H$. Each customer believes to be treated sufficiently if and only if (i) the expert serves at least two customers, (ii) the expert has never undertreated in any of the previous periods, and (iii) the game is in periods 1–9. Otherwise, each customer expects to receive the minor treatment.

Customers’ strategy: Each customer visits the same expert as all other customers (in the following expert $A$) in the first period. If expert $A$ did not undertreat any of the customers and did not charge $p_H$ in the previous period, customers return to expert $A$. If expert $A$ undertreated in the previous period or charged $p_H$, all customers visit expert $B$. If expert $B$ did not undertreat any of the customers and did not charge $p_H$ in the previous period, customers return to expert $B$; otherwise,

22Note that the single customer is again irrelevant for the above analysis.
all customers visit expert $C$. If expert $C$ did not undertreat any of the customers and did not charge $p_H$ in the previous period, customers return to expert $C$; otherwise, all customers visit expert $D$. If expert $D$ did not undertreat any of the customers and did not charge $p_H$ in the previous period, customers return to expert $D$; otherwise, all customers visit expert $A$ if expert $A$ has not undertreated in any of previous periods; otherwise, all customers visit expert $B$; and so forth. If there is no expert who has not undertreated, customers do not interact. In periods 10–16, customers choose expert $A$ if he has not undertreated customers in periods 1–9 and has only charged $p_L$ in periods 1–7. Otherwise, customers choose expert $B$ if he has not undertreated customers in periods 1–9 and has only charged $p_L$ in periods 1–7; and so forth. If there is no expert who never undertreated, customers randomize between experts with equal probability in periods 10–16.

Experts’ strategy: Each expert treats his customers sufficiently in periods 1–9 if he serves two or more customers and provides the minor treatment otherwise. Experts always provide the minor treatment in periods 10–16. In periods 1–7, each expert charges each customer $p_L$ if he serves at least two customers and charges $p_H$ otherwise. In periods 8–16, experts always charge $p_H$.

Verification:
We now verify that the above described strategies and beliefs form a perfect Bayesian equilibrium. We first show that customers’ strategies are rational. Customers interact in periods 1–8 because their expected payoff from interacting amounts to $10 - 4 = 6$ which is more than the outside option of 1.6. Customers interact in period 9 because $0.5(10 - 8) + 0.5(10 - 8) = 2 > 1.6$. Customers interact in periods 10–16 because $0.5(10 - 3) + 0.5(0 - 3) = 2 > 1.6$.

In the following, we show that experts’ strategy is rational. In periods 10–16 it is optimal to always provide the minor treatment because the maximum additional future payoff of treating sufficiently $6 \cdot 2.4 = 14.4$ (in period 10) is lower than the maximum current payoff from deviating $4((8 - 2) - (8 - 6)) = 16$. In period 9, if the expert serves four customers, the expert’s maximum additional future payoff of treating customers sufficiently amounts to $7 \cdot 2.4 = 16.8$ whereas the maximum additional current payoff from deviating is $4((8 - 2) - (8 - 6)) = 16$. If the expert serves three customers, his maximum additional future payoff of treating customers sufficiently also amounts to $7(4 \cdot 1.6) = 16.8$ (because the single customer will visit this expert in periods 10–16) whereas the maximum additional current profit from deviating is $3((8 - 2) - (8 - 6)) = 12$. If an expert serves two customers in
period 9, the maximum current payoff from deviating amounts to \(2((8 - 2) - (8 - 6)) = 8\). Whether the expert will serve all four customers in periods 10–16 depends on whether the expert serves the strict majority of customers in period 9. Given customers’ strategies, an expert should never serve only two customers. Hence, Bayes’ rule cannot be applied to calculate the probability with which an expert expects to be the expert with the strict majority of customers. We assume that the expert believes to serve the strict majority of customers with probability 1. Given these beliefs, the expert’s maximum additional future payoff of treating sufficiently amounts to 16.8 because all customers will choose this expert in periods 10–16. In periods 8 and 9, future payoff of treating customers sufficiently is larger so that deviation incentives are lower. Hence, the expert will treat customers sufficiently if he serves at least two customers under the above beliefs. In case the expert only serves one customer, the maximum additional future payoff from treating sufficiently amounts to \(7(1 - 1.6) = -2.8\) while the maximum current payoff from deviating is 4.

Next, we consider check experts’ incentive to deviate from their strategy in periods 1–7. Note that experts’ incentive to deviate is largest in period 1 and not in period 7. This is because experts make zero profits if they play according to equilibrium strategy in periods 1–7 while a deviation leads to profits of 1.6 (outside option). In period 1, experts’ behavior is rational because the maximum additional current payoff from deviating—if all four customers have a major problem, the expert charges \(p_H\) but provides the minor treatment—amounts to \(4((8 - 2) - (4 - 6)) = 32\) while the maximum expected future payoff from charging \(p_L\) and treating sufficiently amounts to \(2 \cdot 4(0.5(8 - 6) + 0.5(8 - 2)) - 9 \cdot 1.6 + 7 \cdot 2.4 = 34.4\). For the case of three and two customers, the same reasoning applies for the deviation in period 9. Hence, experts charge \(p_L\) if they face at least two customers given the above outlined belief. In periods 2–7, the incentive to deviate is lower than in period 1. Thus, the experts’ behavior is rational.

\[23\] In periods 1–9, the expert sticking to the equilibrium strategy gives up the outside option of 1.6. In periods 8 and 9, the expert can charge all four customers the major treatment although in expectation only two customers need the major treatment. In periods 10–16, the expert’s additional expected future profit amounts to \(7(4 - 1.6)\).
9 Appendix B: Screenshots of Feedback Systems

9.1 Feedback System in a Fixed Price Market

Figure 4: Patient feedback at the Arztnavigator. Source: https://weisseliste.arzt-versichertenbefragung.tk.de/, accessed on July 18, 2012.
9.2 Feedback System in a Market with Price Competition

![Figure 5: Car repair shop rating at Google Maps.](https://plus.google.com/109459300714062123468/about?gl=US&hl=en), accessed on July 18, 2012.
10 Appendix C: Instructions

In the following, we present the instructions for the public histories under price competition condition. The instructions are taken from Dulleck et al. (2011) and have been adapted for our purposes.
ANLEITUNG ZUM EXPERIMENT
Herzlichen Dank für Ihre Teilnahme am Experiment. Bitte sprechen Sie bis zum Ende des Experiments nicht mehr mit anderen Teilnehmern.

2 Rollen und 16 Runden
Dieses Experiment besteht aus 16 Runden, die jeweils die gleiche Abfolge an Entscheidungen haben. Die Abfolge der Entscheidungen wird unten ausführlich erklärt.

Alle Experimentteilnehmer erhalten die gleichen Informationen bezüglich der Regeln des Spiels, inklusive der Kosten und Auszahlungen an beide Spieler.

Überblick über die Entscheidungen in einer Runde
Jede einzelne Runde besteht aus maximal 4 Entscheidungen, die hintereinander getroffen werden. Die Entscheidungen 1, 3 und 4 werden von Spieler A getroffen; die Entscheidung 2 wird von Spieler B getroffen.

Ablauf der Entscheidungen einer Runde (kurz gefasst)
1. Die Spieler A wählen Preise für die Aktionen 1 und 2.
3. Falls Spieler B mit einem Spieler A interagiert ...

Detaillierte Darstellung der Entscheidungen und ihrer Konsequenzen hinsichtlich der Auszahlungen

Entscheidung 1
Jeder Spieler A hat in Entscheidung 3 für den Fall einer Interaktion zwischen zwei Aktionen zu wählen, einer Aktion 1 und einer Aktion 2. Jede gewählte Aktion verursacht Kosten, die folgendermaßen fixiert sind:
Die Aktion 1 verursacht Kosten von 2 Punkten (= experimentelle Währungseinheit) für Spieler A. Die Aktion 2 verursacht Kosten von 6 Punkten für Spieler A.
Für diese Aktionen kann Spieler A von jenen Spielern B, die mit ihm interagieren wollen, Preise verlangen. In Entscheidung 1 muss jeder Spieler A diese Preise für beide Aktionen festlegen. Nur
(strikt) positive Preise in vollen Punkten von 1 Punkt bis maximal 11 Punkte sind möglich. D.h. die zulässigen Preise sind 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 oder 11. Beachten Sie, dass der Preis für die Aktion 1 den Preis für die Aktion 2 nicht übersteigen darf.

Entscheidung 2


Falls nein, dann endet diese Runde für diesen Spieler B und er erhält als Auszahlung für diese Runde 1,6 Punkte.

Falls keiner der Spieler B mit einem bestimmten Spieler A interagieren möchte, erhält auch der betreffende Spieler A als Auszahlung für diese Runde 1,6 Punkte.


In der unteren Hälfte des Bildschirms sehen Sie alle bisherigen Runden (aktuell ist Runde 3). Die Spalten bedeuten Folgendes:

- Runde: In welcher Runde etwas passiert ist
- Spieler: Um welchen Spieler B es sich handelt
- Verbindung zu: Hier sehen Sie, mit welchem Spieler A der jeweilige Spieler B interagiert hat (z.B. B4 in Runde 2 mit A3; „-“ falls keine Interaktion stattgefunden hat).
- Preis für Aktion 1: welchen Preis der jeweilige Spieler A für Aktion 1 festgesetzt hat (falls Sie eine Interaktion hatten; sonst steht „-“ wie z.B. bei B4 in Runde 1).
- Preis für Aktion 2: welchen Preis der jeweilige Spieler A für Aktion 2 festgesetzt hat.
- Aktion Spieler A: „ausreichend“ oder „nicht ausreichend“ (falls Interaktion stattgefunden hat) bzw. „-“ (falls keine Interaktion stattgefunden hat – wie in Runde 2 bei Spieler B2). (zur Erklärung siehe unten)
- Rundengewinn: Ihr Gewinn in Punkten in der betreffenden Runde. (zur Berechnung siehe unten)
Entscheidung 3


Eine **Aktion** ist unter folgenden Bedingungen für einen bestimmten Spieler B **ausreichend**:

- a) Spieler B hat die Eigenschaft 1 und Spieler A wählt entweder die Aktion 1 oder die Aktion 2.
- b) Spieler B hat die Eigenschaft 2 und Spieler A wählt die Aktion 2.

Eine Aktion ist **nicht ausreichend**, wenn Spieler B die Eigenschaft 2 hat, aber Spieler A die Aktion 1 wählt.

**Spieler B** erhält 10 **Punkte**, wenn die von Spieler A gewählte **Aktion ausreichend** ist. **Spieler B** erhält 0 **Punkte**, wenn die von Spieler A gewählte **Aktion nicht ausreichend** ist. In beiden Fällen ist noch der entsprechende Preis zu bezahlen (siehe unten bei „Auszahlungen“).

**Spieler B** wird zu **keiner Zeit** auf dem Computerbildschirm darüber informiert, ob er/sie in einer Runde die Eigenschaft 1 oder die Eigenschaft 2 hatte bzw. welche Aktion Spieler A gewählt hat.

Entscheidung 4

Die beiden letzten Zeilen sind dann für jene Spalten auszufüllen, in denen bei Interaktion „JA“ steht. In der vorletzten Zeile muss für jeden Spieler B eine Aktion gewählt werden (1 oder 2) und in der letzten Zeile muss angegeben werden, welchen Preis Spieler A verlangen möchte (1 steht für den Preis für die Aktion 1; 2 steht für den Preis für die Aktion 2). Auf dem Beispielsbildschirm wollte ein Spieler B mit dem betrachteten Spieler A interagieren und für diese Spalten muss Spieler A seine Entscheidungen eingeben (d.h. die „0“-en ersetzen).

In der/den Spalten mit „JA“ müssen Sie die letzten beiden Zeilen ausfüllen. In der Zeile unter „JA“ sehen Sie die Eigenschaft des jeweiligen Spieler B.

In Spalten mit „NEIN“ können Sie in den beiden letzten Zeilen nichts verändern.
**Auszahlungen**

**Keine Interaktion**
Wenn Spieler B in Entscheidung 2 mit keinem Spieler A interagiert (Entscheidung „Nein“ für alle 4 Spieler A), dann erhält er in dieser Runde **1,6 Punkte**.
Wenn kein Spieler B mit einem bestimmten Spieler A interagiert, dann erhält dieser Spieler A in dieser Runde auch **1,6 Punkte**.

Ansonsten (Entscheidung „Ja“ von Spieler B) sind die Auszahlungen wie folgt:

**Interaktion**

**Spieler A** erhält für jeden Spieler B, der mit ihm interagiert, seinen in Entscheidung 4 gewählten Preis (in Punkten) abzüglich der Kosten (siehe Seite 1 unten) für die in Entscheidung 3 gewählte Aktion. D.h. die Auszahlung eines Spielers A setzt sich aus allen Interaktionen zusammen, die ein Spieler A in einer bestimmten Runde hat.

Für **Spieler B** hängt die Auszahlung davon ab, ob die vom betreffenden Spieler A in Entscheidung 3 gewählte Aktion ausreichend war.


Für die Auszahlung werden die Anfangsausstattungen und die Gewinne aller Runden zusammengezählt und mit folgendem Umrechnungskurs am Ende des Experiments in bares Geld umgetauscht:

1 Punkt = 25 Euro-Cent
(d.h. 4 Punkte = 1 Euro).
References


