

Jost, Peter-J.; Reik, Steffen; Ressi, Anna

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Information in a Monopolist's Credence Good Market

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The Information Paradox in a Monopolist's Credence Goods Market

Peter-J. Jost, Steffen Reik and Anna Ressi*
WHU – Otto Beisheim School of Management

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Abstract

Credence goods markets, such as those for car repairs and medical treatments, are generally characterized by an ex-ante and ex-post information asymmetry between the uninformed buyer and the informed seller. Previous literature demonstrates that efficiency and fraud in a monopolist credence goods market are crucially determined by two key assumptions concerning the verifiability of the quality provided and the expert's liability. In this paper, we identify the information distribution among customers as a third important determinant. Contrary to basic intuition, we find that improving the level of customers' information might actually lead to welfare losses. Further, we highlight the supremacy of the assumption regarding the expert's liability for determining whether informed customers have real effects on market outcomes. On the other hand and in contrast to traditional models, the verifiability of the quality provided is only of secondary importance.

Keywords: Credence Goods; Liability; Verifiability; Information.

JEL Classification: D42, D82, L0, L10, L15, I11.

*Corresponding author: Anna Ressi, Lehrstuhl für Organisationstheorie, WHU – Otto Beisheim School of Management, Burgplatz 2, 56179 Vallendar, Germany; anna.ressi(at)whu(dot)edu. The second author gratefully acknowledges support by the Friedrich-Ebert-Stiftung.

1 Introduction

Credence goods markets are an important part of daily life, as they encompass common transactions such as medical treatments, repair works, financial consulting, or taxi rides. Often, these markets are plagued by asymmetric information. The seller is usually better informed about the customer's need and the quality that is necessary to satisfy it. The asymmetric information usually persists even after consumption and creates incentives for fraudulent behavior. This might lead to large inefficiencies from inappropriate treatments as well as from customers anticipating to be defrauded and leaving the market.¹

While it has always been the case that some buyers have more information than others, recent technological developments, in particular, have reinforced the difference in customers' level of information.² In the past few years, it has become increasingly common to conduct online research before trading in markets for expert services. For example, online navigation applications, incorporating real-time traffic situations, provide taxi passengers with an idea of the shortest route and the approximate travel time. The internet provides potential investors with sophisticated tools for creating their own portfolio strategies. It also enables people to get a better understanding of the severity of an electronic or mechanical damage and how to repair it. Online information seeking is particularly common for medical treatments. A survey by Pew Research Center found that more than one in three Americans self-diagnose their symptoms online (Fox and Duggan, 2017). According to Agrawal et al. (2018), curated information sources offer reliable and credential information and second opinions for health diagnoses. However, preliminary evidence suggests that the Web is skewed towards a more educated population and as such contributes to creating inequalities in health information accessibility (Weaver, 2013; Jacobs et al., 2017). This implies that nowadays experts should be more prepared than ever before to face customers with different levels of information.

¹For an overview of recent field and lab experiments on credence goods and the extent of fraudulent behavior, see Kerschbamer and Sutter (2017).

²For example, there have always been other experts in the same field (see, e.g., Domenighetti et al., 1993) or natives and foreigners in a given country (see, e.g., Balafoutas et al., 2013).

While some customers may be completely uninformed about their need and therefore reliant on the seller's diagnosis expertise, others know exactly which product or service they require.

Up to now, the existing theoretical literature is relatively silent on how heterogeneously informed customers affect the functioning of credence goods markets. This is not surprising since information asymmetry is the fundamental source of distortion in credence goods markets. Therefore, basic intuition suggests that an improved level of information will always benefit social welfare. In our model, we introduce two types of customers in a market with a monopolist expert: the first type of customers has full information about the service required to fulfil their need, the other one remains uninformed. This is a simple, yet straightforward way to capture information differences among buyers and examine the influence on the expert's pricing decision, the incentive to commit fraud as well as market efficiency.

Our results show that the existence of informed customers may indeed help to discipline experts and reduce corruption and fraud. However, contrary to intuition, the resulting equilibrium may actually prove to be less efficient than in the case of exclusively uninformed customers, as some potential buyers may choose to leave the market. While previous literature demonstrates that efficiency and fraud in monopolist credence goods markets are determined by two key assumptions concerning the verifiability of the quality provided and the expert's liability, we identify the information distribution among customers as a third crucial determinant. We find that only if the expert cannot be held liable for unsatisfactorily treating the customer and the treatment is not verifiable, an increased level of information may improve social welfare. Otherwise, it leaves social welfare unaffected at best and may even be harmful. Hence, we strikingly demonstrate that policy measures aimed at improving customers' level of information to improve social welfare might actually backfire. Importantly, the missing liability of a seller proves to be a necessary condition for heterogeneously informed customers to affect the players' payoffs and social welfare. On the other hand and in contrast to traditional models, the verifiability of the credence good's quality is only of secondary importance.

The remainder of the paper looks as follows. The next section gives an overview of the relevant literature. We then introduce our model in section 3 and derive the equilibrium outcomes under four different institutional settings. Thereafter, we discuss our findings in section 4 before we conclude with a short summary and prospects for further research.

2 Related Literature

In this paper we contribute to the literature on markets for credence goods with a monopolist seller. The notion of credence goods traces back to Darby and Karni (1973). According to their definition, customers do not know ex-ante which quality of a good or service they actually require for satisfying their need. Ex-post, they are only able to identify whether their need was satisfied, but not whether the expert provided the appropriate quality. Sellers can take advantage of this lack of information and defraud the customer. Three types of fraud are possible, which will also be important for the purpose of our paper: (1) If the expert performs and charges for an expensive treatment even though a cheaper treatment would have been sufficient to satisfy the customer's need, this is called *overtreatment*. (2) If the expert only provides a cheap treatment even though the customer's problem would require an expensive one, *undertreatment* occurs. (3) If the customer's problem requires only a cheap treatment, but the expert charges for an expensive treatment while performing only the cheap treatment, we speak of *overpricing*. While the first two types of fraud lead to inefficiencies, the last type merely represents a monetary transfer from the customer to the expert.

In our paper we follow the seminal theoretical work on credence goods, which is provided by Pitchik and Schotter (1987) and Wolinsky (1993). We further build upon Dulleck and Kerschbamer (2006). The authors introduce a single model that generalizes the analysis of credence goods markets and identify four key assumptions that explain and unify the findings of preceding contributions. Particularly important for our analysis are the assumptions

concerning *verifiability* and *liability*.³ If the type of treatment is verifiable, the customer knows whether he received the low- or high-quality treatment. Therefore, overpricing may not occur. This assumption is reasonable if no special expertise is necessary to evaluate the treatment’s quality. For instance, in the case of metered taxis, a longer route might be taken but the price per kilometer cannot be changed. If the expert is liable for solving the customer’s problem, undertreatment is unlikely to occur. This is relevant in situations where the outcome of the treatment is observable and verifiable (Bester and Quyang, 2018). In the context of the previous example, without any due justification, the taxi driver will not be able to charge money for dropping a customer at any destination other than the one stipulated at the beginning.⁴

In addition to verifiability and liability, we identify the distribution of information among customers as a third important factor that influences efficiency and fraud in a monopolist credence goods market. Further, the crucial finding of Dulleck and Kerschbamer (2006) is that given customers are homogeneous and are committed to an expert once she carried out her diagnosis, the monopolist market is non-fraudulent and hence efficient if *either* verifiability *or* liability holds. This is in stark contrast to our results, which suggest that even under the assumption of verifiability the market may be inefficient if the expert is not liable. Hence, different to Dulleck and Kerschbamer (2006), our paper highlights the supremacy of an expert’s liability, whereas the verifiability of the quality provided is only of secondary importance.

We thus advance the existing literature on credence goods in that we account for informational heterogeneity among customers. In our model, customers differ with respect to the level of information about the quality required for solving their problem. Only a few authors consider some kind of customer heterogeneity. Their focus, however, is on very spe-

³The other two assumptions concern the commitment of customers to a specific expert and the homogeneity of customers. While we already assume—although in a different interpretation—heterogeneity among customers, we abstain from analyzing the commitment assumption, as it is mainly interesting for markets with competition.

⁴While most studies assume unlimited liability on part of the expert, Bester and Quyang (2018) examine the case with limited liability.

cific dimensions that crucially differ from our approach. Dulleck and Kerschbamer (2006), for example, consider a monopolist market where customers vary in their expected costs of an efficient treatment. Depending on the available degrees of price discrimination, inefficient rationing or inefficient treatments may exist. In Fong (2005), customers vary in their willingness to pay and in their cost of treatment, both of which is private information. Experts, on the other hand, know what the efficient treatment would be, but the customer's willingness to pay is unknown to them. The resulting equilibrium is an inefficient one, in which neither customers nor sellers reveal their private information.

While up to now research on informational heterogeneity remains absent, there are some scholars who are concerned with the possibility that potential buyers acquire information. In Pesendorfer and Wolinsky (2003), customers may ask and pay several experts for their diagnosis before undergoing a treatment. In most cases, they do so until two diagnoses match, which consumers interpret as a sign of seller honesty. In combination with flexible prices, a Pareto-optimal equilibrium may not be achieved. Feddersen and Gilligan (2001) introduce a third party, "an activist", who may inform customers about the product's quality. The activist focuses on minimizing total product consumption by consumers, while at the same time maximizing the ratio of overall consumed good products to bad products. The authors shows that activists may help to increase social welfare and achieve an efficient equilibrium. However, the role of information per se and its effect on the market remains unknown, as the authors focus on the activist's role, and assume that customers are homogeneous and that they receive the activist's message simultaneously. A very recent theoretical as well as experimental contribution on information acquisitions is provided by Agrawal et al. (2018). In their model, the expert chooses whether or not to exert effort for diagnosing the customer's true condition. If he exerts effort, then the diagnosis will be correct and the customer obtains a positive utility. The customer himself can also exert effort in acquiring information. He has two options: Either he conducts personal research, in which case he obtains an informative but noisy signal about his condition. The other option is to obtain a second opinion, which is

modelled as being an independent draw from the distribution with which the expert invests. While assuming a fixed fee for the expert’s treatment, the authors show that in contrast to the personal research case, inefficiencies always arise in the second opinion case. All in all, if we assume that customers are marked by different costs of conducting information acquisition, this stream of literature can be regarded as an antecedent with respect to our analysis of heterogeneously informed customers.

3 Model

Similar to Pitchik and Schotter (1987), Wolinsky (1993) and Dulleck and Kerschbamer (2006) we consider a situation, where a customer (he) has a problem which is either of major or minor severity. The probability of major severity, $h \in [0, 1]$, is common knowledge.

The customer chooses to visit an expert (she) for treatment. His outside option is to receive no treatment. If the expert is consulted, she (but not the customer) learns the type of the problem and carries out a treatment.⁵ The expert can then choose between two different kinds of treatments: a major treatment costs the expert c_H and solves both the minor as well as the major problem, while the minor treatment costs her c_L , but solves only the minor problem. The expert charges prices p_H and p_L . These are posted prior to the customer’s decision to visit. If the customer’s problem is treated satisfactorily, he obtains a utility of v . We assume $v > c_H > c_L \geq 0$.

We further assume that there is a probability, $k \in [0, 1]$, that the customer is informed. This implies that he has the necessary expertise to evaluate whether his problem is a minor or a major one, as well as whether the expert provides the minor or the major treatment. With probability $1 - k$, he is not informed. Consumers are therefore heterogeneous if $0 < k < 1$. We assume that the customer’s knowledge can be observed by the expert. This is realistic for two

⁵At this point, we abstain from assuming a costly diagnosis because this is mainly relevant for a non-monopolistic market. An exception is Bester and Dahm (2017), who consider a monopolist framework with costly diagnosis where the outcome of a treatment can only be subjectively evaluated by the customer.

reasons: First, experts in a given field are likely known to one another.⁶ Secondly, informed customers may be able to credibly disclose their knowledge to an expert by using specialized terminology.⁷ What this assumption implies is that it is only uninformed customers that can be treated fraudulently. As already mentioned in the previous section, three types of fraud are possible: 1) overtreatment, 2) undertreatment, and 3) overpricing. Since, $c_H > c_L$, any equilibrium involving over- or undertreatment is inefficient while overpricing simply implies a monetary transfer from the customer to the expert.

The timing of the game is as follows: First, the expert sets prices p_H and p_L . Then, “nature” determines the customer’s information and the severity of his problem.⁸ In a third step, the customer decides whether to visit the expert. If he declines the visit, the game ends, in which case he and the expert receive zero utility. If the customer decides to visit the expert, the latter observes the customer’s type. She then chooses a treatment, bears the corresponding cost c_H or c_L , and charges price p_H or p_L from the customer. The customer then receives v if his problem is solved and zero otherwise. Both actors are assumed to be risk-neutral. If the customer is indifferent between visiting and not, he visits the expert. If the expert is indifferent between fraud and no fraud, she chooses not to commit fraud.

In the next few subsections, we successively analyze the implications of heterogeneously informed customers in four institutional settings, which vary in two key assumptions concerning the *verifiability* of the treatment and the *liability* of the expert. If verifiability is assumed, overpricing may not occur. Without verifiability, the expert always has an incentive to overprice the treatments for uninformed customers, because $p_H - c_L > p_H - c_H$. If the expert can be made fully liable for insufficient treatment, the option to undertreat ceases

⁶See, for example, Domenighetti et al. (1993) who analyze medical and surgical services among consumers in a Swiss canton. They find that doctors and their families had significantly less surgeries than the population average.

⁷As local versus foreign dialects also fit in this category, the findings of Balafoutas et al. (2013) support this assumption by demonstrating that taxi drivers react differently depending on whether they face a native or a foreigner. We assume that an informed customer will always disclose his type. In an earlier version of this model where this disclosure was voluntary, results prove to be identical.

⁸We assume this order of seller’s price setting before nature’s determination, as it allows us to work with proper subgames. The model’s results are not affected by that decision.

to be relevant. If there is no liability, undertreating uninformed customers may occur.

We describe the market equilibria with respect to whether it is non-fraudulent, i.e. whether the expert refrains from undertreatment, overtreatment and overpricing and with respect to whether it is efficient. In addition to the absence of over- and undertreatment, the latter also requires that both customer groups choose to participate in the market and visit the expert. Thus, efficiency entails a maximum social welfare of $SW_{max} = v - c_L - h(c_H - c_L)$. Note that even if the expert overcharges the uninformed customer and therefore the market is fraudulent, it is still efficient, as overpricing only constitutes a monetary transfer from the customer to the expert.

3.1 Markets with Verifiability but without Liability

Let us first consider a market where the expert cannot be held liable for insufficient treatment but the treatment is verifiable. Therefore, uninformed customers do not face the risk of being overcharged but may fear over- or undertreatment.

To begin with, assume for a moment that all customers are uninformed, $k = 0$. As shown by Dulleck and Kerschbamer (2006), the only equilibrium in the market satisfies the following conditions with regard to the expert's pricing decision:

$$hp_H + (1 - h)p_L = v \tag{1}$$

and

$$p_H - c_H = p_L - c_L. \tag{2}$$

With the latter condition, the monopolist sets equal mark-ups and can therefore credibly signal not to under- or overtreat the customer but to sufficiently and efficiently solve the problem. Nevertheless, the first condition implies that she sets prices such as to extract all of the customer's expected rent. All in all, $p_L = v - h(c_H - c_L)$, $p_H = v + (1 - h)(c_H - c_L)$ and

the seller's expected profit will be $\Pi_{max} = v - c_L - h(c_H - c_L)$. The market is non-fraudulent and efficient since the optimal welfare $SW_{max} = \Pi_{max}$ is achieved. Note, that $c_H > c_L$ together with condition (2) implies $p_H > p_L$. Hence, by condition (1) $p_H > v > p_L$.

Now assume that some share of uninformed customers becomes informed. As we will shortly see, the expert essentially chooses between three pricing strategies. The first strategy (strategy *a*) is to stick to her prices such that conditions (1) and (2) are fulfilled. In this case, however, an informed customer will refrain from visiting the expert if his problem is a major one, as $p_H > v$. The seller's expected profits decreases to $\Pi_a = (1 - hk)(v - c_L - h(c_H - c_L))$.

The higher the share of informed customers is, the more profits the expert continues to lose by adhering to strategy *a*. As uninformed customers already receive their reservation utility, the only option to compensate for the losses is to keep informed customers with a major problem from leaving the market. She can do that by decreasing p_H to $p'_H = v$. However, because $p'_H - c_H < p_L - c_L$ she would then have an incentive to undertreat uninformed customers. Anticipating this incentive, the uninformed customers would in turn leave the market. The expert now has two options, which leads to two additional strategies: The second strategy (strategy *b*) is to counteract the uninformed customer's incentive to leave the market by reducing p_L to $p'_L = v - (c_H - c_L)$, resulting in total profits of $\Pi_b = v - c_H$. This leads to higher profits than sticking to her prices if $k > k_{ab} = \frac{(1-h)(c_H-c_L)}{h(v-c_L-h(c_H-c_L))}$. For the third strategy (strategy *c*), the expert accepts the fact that she will only treat informed customers. In this case, she will fully abolish the undertreatment constraint and maximizes her profits on informed customers by increasing p_L to $p'_L = p'_H = v$. If the share of informed customers is sufficiently high, i.e. $k > k_{ac} = \frac{1}{1+h}$, the resulting profit of $\Pi_c = k(v - c_L - h(c_H - c_L))$ is higher than the profit from strategy *a*. Lastly, there exists a threshold $k_{bc} = \frac{v-c_H}{v-c_L-h(c_H-c_L)}$, such that for any $k < k_{bc}$ the expert's profit from strategy *b* is higher than from strategy *c* and lower otherwise.

Importantly, it is only strategy *b* that leads to an efficient market, as the expert serves both customer groups in a non-fraudulent way. While the other two strategies *a* and *c* are

also non-fraudulent, they are inefficient as under strategy a informed customers with a major problem and under strategy c uninformed customers leave the market.

Lemma 1 *There exists a threshold $k' > 0$, such that for a sufficiently low share of informed customers, $k < k'$, the market is non-fraudulent but inefficient as informed customers with a major treatment will leave the market.*

Lemma 1 states that for a sufficiently low share of informed customers, strategy a will dominate the other two strategies. As explained above, this will be the case if $k < k_{ab}$ and $k < k_{ac}$. Hence, it has to hold that $k < \min\{k_{ab}, k_{ac}\}$. Note that there exists a threshold $h^* = \frac{c_H - c_L}{v - c_L}$, such that $k_{ab} = k_{ac}$. For any $h < h^*$, $k_{ab} > k_{ac}$. If $h > h^*$, $k_{ab} < k_{ac}$. We can now define a function k' with $k' = \min\{k_{ab}, k_{ac}\} > 0$, such that for $h \geq h^*$, $k' = k_{ab}$. Otherwise, $k' = k_{ac}$. If $k < k'$, the expert sets her prices in a way such that informed customers with major problems leave the market while all other customers are treated in a non-fraudulent way (see also the light-gray area in Figure 1). This leads to several implications: while uninformed customers remain unaffected when compared to the case where $k = 0$ and obtain their outside utility of zero, the expected surplus of informed customers increases to $(1 - h)(v - p_L) = h(1 - h)(c_H - c_L) > 0$, while the seller's expected profits Π_a decreases to $(1 - hk)(v - c_L - h(c_H - c_L))$.⁹ As the seller's loss exceeds the informed customers' expected benefit social welfare is lost. Also, it can easily be shown that $\partial SW_a / \partial k < 0$, which implies that social welfare decreases in the share of informed customers.

Lemma 2 *There exists an efficient and non-fraudulent market if the share of informed customers is neither too high nor too low, $k \in [k_{ab}, k_{bc}]$, and if the probability of a major problem is sufficiently high, $h \geq h^*$.*

Remember that it is only under strategy b that both customer groups are served in an efficient and non-fraudulent way. Hence, in order for the market to be efficient and non-fraudulent, the monopolist's prices have to fulfil condition 2, that is, $p_H - c_H = p_L - c_L$, since

⁹These results are obtained by using the respective prices under strategy a , $p_L = v - h(c_H - c_L)$, $p_H = v + (1 - h)(c_H - c_L)$.

any deviation would trigger either under- or overtreatment. Additionally, in order to keep informed customers in the market, it has to hold that $p_H \leq v$. Under these two conditions, the expert's profit maximizing prices are $p_H = v$ and $p_L = v - (c_H - c_L)$. Customers would then be served efficiently and obtain an expected utility of $(1 - h)(c_H - c_L)$, regardless of whether they are informed or uninformed, while the expert's profit is $v - c_H$. Interestingly, with this pricing strategy the expert's profit is independent of h and k and social welfare always sums up to SW_{max} . Further, it is only in this efficient equilibrium that uninformed customers may obtain a positive expected utility.

Note that there is no way for the expert to increase profits on both types of customers at the same time. If she increases p_H , she will lose the informed customers with major problems since the treatment's cost would exceed the benefit, i.e. $p_H > v$ (strategy a). As stated above, this is only beneficial for $k < k_{ab}$. If on the other hand the expert solely increases p_L , she will lose the uninformed customers since they rightfully fear to be undertreated (strategy c). This strategy is only beneficial for $k > k_{bc}$. All in all, in order for strategy b to be sustained in equilibrium, it must dominate the two alternative strategies. Note that for any $h < h^*$ strategy b is always dominated by one of the other two strategies. Hence, in order for the efficient and non-fraudulent equilibrium to exist, the share of informed customers has to be in an intermediate range, $k \in [k_{ab}, k_{bc}]$, and the probability of a major problem has to be sufficiently high, $h \geq h^*$ (see also the gray area in Figure 1).

Lemma 3 *For a sufficiently high share of informed customers, $k \geq k''$, the market is non-fraudulent but inefficient. Uninformed customers leave the market because they fear the potential fraud of undertreatment.*

Assume for a moment that all customers in the market are informed, so $k = 1$. In this case, the expert can easily extract the whole rent by setting $p_H = p_L = v$ (strategy c). Even though customers know the type of their problem, they have to accept the expert's pricing decision in order for their problem to be treated. Note that because $p_H - c_H < p_L - c_L$, the expert would have an incentive to undertreat the customer. However, she cannot do so as all

customers are informed. This is different, if there exist at least some uninformed customers in the market, $k < 1$. Since these uninformed customers fear that only minor problems are being solved and major ones are being undertreated, their willingness to pay now declines to $(1 - h)v$. As $h > 0$, prices exceed their willingness to pay. Therefore, uninformed customers decline to visit the expert, which in turn renders the market inefficient.

If the share of informed customers k decreases further, the expert continues to lose profits by sticking to strategy c as she drives more and more customers out of the market. As shown before, adjusting prices to fulfil conditions (1) and (2) yields higher profits than abandoning uninformed customers if $k < k_{ac}$. Also, we know that treating both customer groups with prices of $p_H = v$ and $p_L = v - (c_H - c_L)$ yields higher profits than abandoning informed customers if $k < k_{bc}$. Strategy c hence dominates the other two strategies for $k \geq \max\{k_{ac}, k_{bc}\}$. As before, if $h = h^*$, then it holds that $k_{ac} = k_{bc}$. For any $h < h^*$, $k_{ac} > k_{bc}$. If $h > h^*$, $k_{ac} < k_{bc}$. We can again define a function k'' with $k'' = \max\{k_{ac}, k_{bc}\} > 0$, such that for $h \geq h^*$, $k'' = k_{bc}$. Otherwise $k'' = k_{ac}$. If $k \geq k''$, equilibrium prices will induce informed customers with minor and major problems to visit the expert while uninformed customers will exit the market (see also the dark-gray area in Figure 1). Therefore, the market will be non-fraudulent but inefficient.

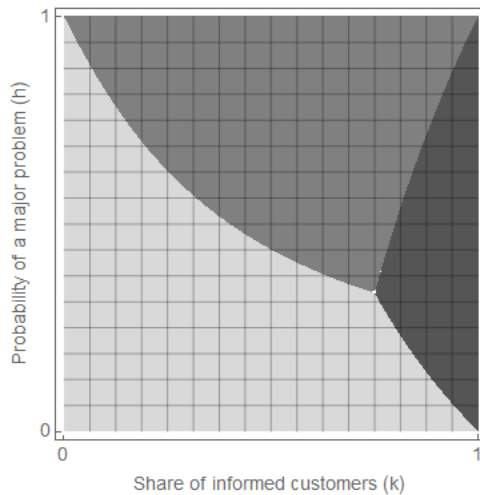


Figure 1: Parameter regions where pricing strategy a (light-gray), b (gray) or c (dark-gray) will prevail in equilibrium ($v = 1$, $c_L = 0.25$, $c_H = 0.5$).

Lemma 4 *For $c_L = 0$, $h < h^*$ and $k = k_{ac}$, there exists a weakly-dominated, inefficient equilibrium with undertreatment, where all customers enter the market.*

Lemma 4 suggests that the expert actually has a forth pricing strategy that he may adopt in equilibrium. In this strategy the expert sets her prices in a way such that the uninformed customers choose to visit the expert even though they anticipate to be undertreated. We will refer to this strategy as strategy d .

In order to prove Lemma 4, recall that the expert has an incentive to undertreat the uninformed customer if $p_H - c_H < p_L - c_L$. While the willingness to pay of the uninformed customer is $(1 - h)v$, it is still v for the informed customer as he cannot be defrauded. To ensure that the uninformed customer participates in the market, the price for the minor treatment has to be $p_L \leq (1 - h)v$. This means that the expert maximizes profits by setting $p_L = (1 - h)v$. As she cannot defraud the informed customer, p_H may be higher than $(1 - h)v$, but two constraints still have to hold. First, p_H cannot exceed v , as this would push informed customers with major problems out of the market. At the same time, p_H has to be smaller than $(1 - h)v + (c_H - c_L)$, since otherwise it would be the case that $p_H - c_H \geq p_L - c_L$, which implies that her incentive to undertreat would be lost. Under these restrictions, the profit of the expert is $kh(\min[v, (1 - h)v + (c_H - c_L)] - c_H) + (1 - kh)((1 - h)v - c_L)$.

Given that $hv > c_H - c_L$, it is easy to see that the expert's profit of $(1 - h)v - c_L$ is smaller than the profit of the efficient and non-fraudulent equilibrium in Lemma 2 with $v - c_H$. So, we focus the further analysis on cases where it holds that $hv < c_H - c_L$ and the corresponding profits are $kh(v - c_H) + (1 - kh)((1 - h)v - c_L)$.

In comparison to the equilibrium's profit of strategy a , where only informed customers with a major problem decline the expert's service, the expert is better off with strategy d for any $k > \frac{c_H - c_L - v}{c_H + c_H h - c_L h - v - hv}$. In comparison to the equilibrium's profit of strategy c , where uninformed customers leave the market, the expert is better off with strategy d for any $k < \frac{c_L - v + hv}{c_L - v + h^2 v}$. Therefore, strategy d will be the equilibrium strategy if the conditions $hv < c_H - c_L$ and $\frac{c_H - c_L - v}{c_H + c_H h - c_L h - v - hv} \leq k \leq \frac{c_L - v + hv}{c_L - v + h^2 v}$ are satisfied. The only possibility for

these conditions to simultaneously hold is for $c_L = 0$, $h < h^*$ and $k = k_{ac}$. In this case, the expert's profit of undertreating uninformed customers (strategy d) exactly matches her profits in the two other inefficient equilibria of Lemma 1 and Lemma 3.

We can now summarize our previous discussion in our first proposition:

Proposition 1 *Under the assumptions of verifiability and missing liability, the market is only efficient if the probability of severe problems is sufficiently high with $h > h^*$ and the share of informed customers is in an intermediate range, $k_{ab} < k < k_{bc}$. In this case, heterogeneously informed customers leave social welfare unaffected. Otherwise, the market is inefficient and therefore heterogeneously informed customers lead to a loss in social welfare.*

Proposition 1 directly follows from Lemma 1-4. Consider first the second part of Proposition 1. With heterogeneously informed customers, $0 < k < 1$, and for a sufficiently low probability of a major problem, $0 < h < h^*$, the two existing equilibria – and, if $c_L = 0$, the three existing equilibria – are all inefficient. Either some customers decide to leave the non-fraudulent market (see Lemma 1 and 3), or the market is plagued by undertreatment (see Lemma 4). Remember that in a market where all customers are uninformed, $k = 0$, social welfare is at its maximum. Therefore, heterogeneously informed customers always lead to a loss in social welfare, given that h is sufficiently low.

The first part of Proposition 1 implies the following. Assume now that $h > h^*$ and take $k = 0$ as the starting point. If some of the previously uninformed customers now become informed, Lemma 1 counter-intuitively implies that efficiency declines as long as $k < k'$. This is because informed customers with a major problem will decline the expert's visit. If the share of informed customers increases further, efficiency can be re-established given that $k' \leq k \leq k''$ (see Lemma 2). Both customer groups will be served in a non-fraudulent way. If the level of information in the market improves further, $k > k''$, social welfare decreases once more, as now uninformed customers fear to be undertreated and leave the market. All in all, if $h > h^*$, the existence of heterogeneously informed customers will either reduce or not have any effect on social welfare.

3.2 Markets without Verifiability and Liability

In a market without verifiability and liability the monopolist has the possibility to overcharge as well as to undertreat uninformed customers. While the expert can generally also overtreat the uninformed customer, this strategy is always dominated by overpricing. In turn, uninformed customers legitimately fear to be defrauded. Even if the expert sets her prices such as to fulfill condition $p_H - c_H = p_L - c_L$, she always has an incentive to offer the minor treatment at the price of the major one, irrespective of the problem's severity she observes.

Given this behavior, it is sufficient to consider the case in which the monopolist sets only one price in equilibrium, $p_H = p_L$. In the case with uninformed customers only, $k = 0$, their expected utility of visiting the expert is $(1 - h)v - p_L$. Hence, the expert will set $p_H = p_L = (1 - h)v$ in order to maximize profits. Note that if $(1 - h)v < c_L$, her profit will be negative. Hence, if $h > h^0$, with $h^0 = \frac{v - c_L}{v}$, a market with only uninformed customers will necessarily break down and social welfare is at its minimum. In all other cases, the expert extracts the uninformed customers' surplus and obtains profits of $(1 - h)v - c_L$. As either the market breaks down or uninformed customers will be undertreated, both equilibria are inefficient.

Let us now turn to a market with heterogeneously informed customers, $0 < k < 1$. Similar to the last section, the expert faces the decision between two options: either she chooses a price that is sufficiently low such that uninformed costumers still participate in the market or she chooses to serve informed costumers only, in which case the price she charges will be higher than in the first case.

In the first case, an uninformed costumer is willing to visit the expert if his expected value of a minor problem being treated is higher than the charged price. Hence, if the expert decides to serve both customer groups, she optimally sets $p_H = p_L = (1 - h)v$ and always undertreats uninformed customers with a major problem. We will refer to this strategy as strategy e . Her profit in this scenario is $\Pi_e = (1 - h)v - khc_H - (1 - kh)c_L$ and the utility of

informed consumers is hv , which is strictly greater than the uninformed customer's utility of 0. Note that with this pricing strategy, the expert's profit decreases in k .

In the second case, the expert focuses on informed customers only. The maximal price she can charge is $p_H = p_L = v$, which is equivalent to strategy c introduced in the previous subsection. Hence, the resulting profits are $\Pi_c = k(v - hc_H - (1 - h)c_L)$. While uninformed customers leave the market and informed customers visit the expert, both customer groups obtain their reservation utility of 0. Note that in this case, the market is actually fraud-free.

Lemma 5 *Under the assumptions of missing verifiability and missing liability, the market is always inefficient. For a sufficiently high share of informed customers, $k \geq k_{ce}$, the market is also non-fraudulent as uninformed customers leave the market. Otherwise, uninformed customers will always be undertreated.*

According to Lemma 5, there exists a critical value $k_{ce} = \frac{(1-h)v-c_L}{v-c_L}$ such that for $k < k_{ce}$ the expert is better off with the first strategy e of serving both customer groups. Otherwise, for $k \geq k_{ce}$, the expert's profit is higher under pricing strategy c that pushes uninformed customers out of the market. To sum up, under this institutional setting, the monopolist expert cannot credibly signal to refrain from defrauding uninformed customers. Hence, inefficiencies necessarily arise either because uninformed customers will be undertreated or because they leave the market.

Proposition 2 *While under the assumptions of missing verifiability and missing liability the existence of heterogeneously informed customers generally improves social welfare, it is harmful if the share of informed customers is neither too low nor too high, i.e. $k_{ce} < k < k'_{ce}$, and if the probability of a major problem is sufficiently low, $h < h^0$.*

Proposition 2 suggests that social welfare is not monotone in k . To see this, let us compare the social welfare of our two equilibria. If $k \leq k_{ce}$, social welfare is $SW = (1 - h)v - khc_H - (1 - kh)c_L + khv$. If $k > k_{ce}$, social welfare is $SW = k(v - c_L - h(c_H - c_L))$. Note

that both functions increase in k . However, although the expert's profits and the uninformed customer's utility are the same under both pricing strategies for $k = k_{ce}$, social welfare is not. This is because the informed customer obtains a positive utility of hv under the first strategy, but only his reservation utility of 0 under the second strategy. Since social welfare with only uninformed customers, $k = 0$, is equal to social welfare with heterogeneously informed customer, $0 < k < 1$, for $k'_{ce} > k_{ce}$, with $k'_{ce} = \frac{(1-h)v-c_L}{v-c_L-h(c_H-c_L)}$, there exist intermediate values of k between k_{ce} and k'_{ce} , where the existence of heterogeneously informed customers reduces social welfare when compared to the same market with uninformed customers only.

3.3 Markets without Verifiability but with Liability

We now turn to the scenario, where due to unverifiable treatments, the expert is able to overprice uninformed customers. She will, however, refrain from undertreatment, as she is liable for insufficient treatments. Again, overtreatment is possible but will always be dominated by overpricing.

Lemma 6 *Under the assumptions of missing verifiability but with liability, the existence of heterogeneously informed customers has no effect on the market's equilibrium and hence does also not affect social welfare. The market remains efficient and fraud-free.*

In this case, the expert always has an incentive to charge uninformed customers p_H , irrespective of the treatment she performed. She will, however, always choose the efficient treatment, as she can be held liable for an unsatisfactory treatment and hence has no incentive to undertreat. Also, there is no need to overtreat, because overpricing is more profitable. Even though uninformed customers anticipate that they will be defrauded by overpricing, they still know that their problem will definitely be solved and hence their overall willingness to pay is v . What this implies is that with uninformed customers only, $k = 0$, there basically exists a continuum of equilibria. Since the expert will charge p_H for the major as well as for the minor treatment, p_L is not really relevant. The expert therefore maximizes profits

by setting $p_H = v$ and hence extracts all of the customers' surplus. At the same time, any $p_L \leq p_H$ can be sustained in equilibrium. However, since we assume that if indifferent the expert will resort to the fraud-free strategy, a market characterized by prices $p_L = p_H = v$ will therefore be efficient and fraud-free.

Suppose now that there also exists a share of informed customers who cannot be defrauded. In this case, there is only one combination of prices that is feasible in equilibrium. Given that $p_L < p_H$, the expert could always boost profits on informed customers by increasing p_L to p_H . In equilibrium, $p_H = p_L = v$ and the expert treats both customer groups. The expert again extracts all of the market's surplus yielding profits of $\Pi_{max} = v - c_L - h(c_H - c_L) = SW_{max}$, which is independent of k . The resulting equilibrium is efficient and fraud-free, which is equivalent to the case where the market encompasses uninformed customers only, $k = 0$.

3.4 Markets with Verifiability and Liability

The last institutional setting is the one where treatments are verifiable and the expert can be held liable. Therefore, neither overpricing nor undertreating uninformed customers is feasible. The only possibility to defraud uninformed customers is to resort to overtreatment.

Lemma 7 *Under the assumptions of verifiability and liability, the existence of heterogeneously informed customers does not affect the expert's profit and the customers' utility and hence does also not affect social welfare. The market remains efficient and fraud-free.*

Let us first consider a market with uninformed customers only, $k = 0$. Under the liability assumption, customers know that they will always be satisfied, so their willingness to pay is v . As shown by Dulleck and Kerschbamer (2006), in equilibrium the expert may set prices to any $p_L + h(p_H - p_L) = v$ and $p_H - c_H \leq p_L - c_L$. While the latter condition ensures that the expert will not engage in fraud by overtreating minor problems, the first condition extracts the customer's expected rents and maximizes profits. The expert is then visited by

all customers and a welfare-optimal and fraud-free equilibrium is achieved.

Assume now the case with heterogeneously informed customers, $0 < k < 1$, and $p_L < p_H$. Similar to the previous section, the expert can now improve on informed customers by increasing p_L to $p_H = v$, thereby extracting the market's entire surplus, $\Pi_{max} = SW_{max}$. All in all, in contrast to the market with $k = 0$, there only exists one equilibrium. However, customers' expected utility and the expert's expected profit remain unaffected by introducing heterogeneously informed customers. Therefore, the market with homogeneously as well as with heterogeneously informed customers is always efficient and fraud-free.

4 Summary and Discussion of Results

Proposition 3 summarizes our main findings. We subsequently discuss the implications of informed customers for the functioning of monopolist credence goods markets.

Proposition 3 *Only if the expert cannot be held liable for an unsatisfactory treatment, the existence of heterogeneously informed customers affects the players' profits and utilities, market efficiency and fraud. In this case, the assumption regarding the treatment's verifiability determines whether informed customers may only harm or at best not affect social welfare, or whether informed customers may actually also improve social welfare.*

Basic intuition suggests that the existence of informed customers helps to discipline experts in their incentives to commit fraud and prove to be beneficial for social welfare. However, our analysis so far reveals that the consequences of informed customers significantly depend on the prevalent market institutions. Most importantly, from Lemma 6 and 7 it directly follows that if the expert is liable for solving the customer's problem satisfactorily, market outcomes regarding profits and social welfare in our model are the same as if all customers were uninformed ($k = 0$, see Dulleck and Kerschbamer, 2006). Irrespective of whether the expert's treatment is verifiable or not, the market remains efficient and no fraud

occurs. Hence, in a market with liability, an increase in the level of information actually lacks any influence on profits and social welfare (see the first part of Proposition 3).

These results change dramatically if the liability assumption is abolished, as now the existence of informed customers significantly affects market efficiency. If the expert's treatment is verifiable, the traditional model of $k = 0$ predicts that the market will always be efficient. In our model, both customer groups will be served in a non-fraudulent way only if there exists a relatively balanced share of informed to uninformed customers, $k' \leq k \leq k''$, and the probability of a major problem is sufficiently high, $h \geq h^*$ (see Proposition 1). Otherwise, the market is inefficient as uninformed customers fear undertreatment and hence decline the expert's service (only in a very special case will they accept undertreatment and nevertheless stay in the market). Therefore, in a market with verifiable treatments but without liability, the existence of informed customers may either leave social welfare unaffected or lead to welfare losses if compared to a market with uninformed customers only.

If the treatment is not verifiable, then the market is always inefficient (see Lemma 5). For sufficiently high levels of k , the expert increases prices such that uninformed customers leave the market. For low levels of k , the expert serves informed as well as uninformed customers but will always undertreat and overcharge the latter. Note that if $h > h^0$, a market with only uninformed customers $k = 0$ will necessarily break down. In the face of heterogeneously informed customers, $0 < k < 1$, the expert is able to ensure that at least informed customers will always be treated. In this case, the co-existence of informed customers will save the market from breaking down and hence improve efficiency. Given that $h < h^0$, the existence of informed customers also leads to higher social welfare if $k \notin (k^I, k^{II})$ and to welfare losses otherwise. Hence, under these market institutions, heterogeneously informed customers may improve or deteriorate social welfare (see Proposition 2). Also, since under $k = 0$ the market, if it exists, will always be fraudulent, heterogeneously informed customers will discipline experts and prevent them from committing fraud, given that $k \geq k_{ce}$ (see Lemma 5).

All in all, this discussion implies that the intuition regarding the beneficial effect of

informed customers only holds in the special case that the expert cannot be held liable, treatments are not verifiable, the probability of a major treatment, h , is sufficiently low and the share of informed customers in the market, k , is sufficiently low or sufficiently high. Under all remaining institutional configurations, informed customers either have no effect on the market's efficiency or may even harm social welfare. Note that this also contrasts the findings of existing literature that argues that the expert's liability and the treatment's verifiability are of equal importance for securing efficiency (Dulleck and Kerschbamer, 2006). This is because we find the assumption concerning the expert's liability in a market with at least a few informed customers to be most prominent.¹⁰ Even more tellingly, note that verifiability always leads to efficiency if $k = 0$. In a market where some customers are informed, we find that verifiable treatments are at best welfare-neutral but mostly lead to inefficiencies, while unverifiable treatments mainly imply welfare gains (although welfare losses are also possible).

Our results further point towards another counter-intuitive implication of a market comprising both uninformed as well as informed customers, which regards the advantageousness of the expert's liability for the different market participants. Let us first consider the expert. Not surprisingly, the existence of informed customers in well functioning markets is in general to the expert's disadvantage.¹¹ However, we strikingly find that in such a situation, the expert is always better off if she can be held liable for treating the customer's problem unsatisfactorily. The reason is that if liability is not institutionalized, she cannot credibly commit to refrain from mistreatment, which leads to smaller profits and inefficient markets.

In contrast to the expert, uninformed customers never suffer from the existence of informed customers. In most situations, their utility remains the same as in a market with no information ($k = 0$). Yet, if treatments are verifiable and the expert cannot be held liable,

¹⁰This finding is also in line with the experimental study of Dulleck et al. (2011). While they demonstrate the central importance of the liability assumption, they do not find any noteworthy effects of the assumption regarding the treatment's verifiability.

¹¹Only in or close to the trivial case of the prevention of market failure for missing verifiability and liability, her profits are positively affected by informed customers.

uninformed customers might even benefit from the existence of informed customers. This is the case if the share of informed customers is in an intermediate range, $k' \leq k \leq k''$, and the probability of a major problem is sufficiently high, $h > h^*$, such as to induce the expert to treat both types of customers.

5 Concluding Remarks and Further Research

While existing literature suggests that the expert's liability and the treatment's verifiability are the two crucial assumptions that influence efficiency in a monopolist credence goods market (see Dulleck and Kerschbamer; 2006), this paper reveals that the distribution of information among customers has to be considered as a third fundamental determinant. Specifically, we study how the existence of heterogeneously informed customers affects an expert's pricing decision, incentives to commit fraud as well as market efficiency. We find that the co-existence of informed and uninformed customers in a credence goods market may actually help to discipline experts and reduce fraud relative to a situation with uninformed customers only. However, contrary to intuition, informed customers do not always improve social welfare. If the expert can be held liable for an insufficient treatment, efforts to disseminate information among a broader customer base are actually redundant as they leave social welfare unaffected. If, on the other hand, the expert cannot be held liable, it depends on the assumption regarding the treatment's verifiability whether heterogeneously informed customers can actually improve social welfare. In contrast to existing literature that views both institutional assumptions as equally decisive for market efficiency, we thereby highlight the supremacy of an expert's liability relative to the treatment's verifiability, which is only of secondary importance.

More specifically, only if the expert is not liable and her treatment is not verifiable may informed customers improve efficiency in comparison to a market where all customers are uninformed.¹² The latter institutional setting is particularly relevant for repair works and

¹²Social welfare may, however, also decline.

certain medical treatments. As Dulleck and Kerschbamer (2006) discuss, it might be difficult to judge whether the expert replaced or only fixed a broken part, for example, if this part can only be revealed by using special equipment. Also, an insufficient repair might solve the problem for some time, but eventually the product will stop working again. In this case, the break-down cannot be unambiguously traced back to the expert's behavior as in the meantime other defects may have developed. Therefore, liability is difficult to enforce. Similarly, with regard to complex medical treatments, it is reasonable to assume that most patients lack the necessary education to evaluate the treatment's quality. Also, in many situations they are not physically able to do so. At the same time, it might be nearly impossible for a court to verify the success of a medical treatment, as for many diseases a full recovery is unlikely, the effectiveness of a treatment is affected by significant noise and symptoms like pain are impossible to objectively verify (Dulleck and Kerschbamer, 2006).

Importantly, if the expert is not liable but her treatments are verifiable, disseminating information is at best ineffective and may even be harmful. Consider, for example, a patient suffering from knee pain, which might simply be the result of physical overload, in which case rest will be sufficient, or might be due to out-of-position joints that cause ligaments and tendons to chafe, in which case surgery might be necessary. Obviously, the type of the treatment is observable by the patient. Still, in light of the aforementioned reasons, it remains doubtful that the expert can be made liable for suggesting rest rather than immediately starting a comprehensive treatment.

Given that the expert is not liable, our paper demonstrates that improving customers' level of information, for example through informational webpages for self-diagnostics or patient discussion forums, may be a desirable and worthwhile development for improving social welfare only if treatments are of a high complexity such that they are difficult to verify. However, it is exactly under these situations that providing information to customers will encounter its limits. Hence, efforts to improve the level of information – such as the project of the American Accreditation HealthCare Commission who work with health providers, re-

searchers, consumers organizations and search engines including Google, Yahoo! and AOL, on improving results for consumer health searches online (Weaver, 2013) – might at best prove to leave social welfare unaffected.

Our paper is the first to model different levels of information in context of a credence goods market and therefore allows for various potentially fruitful avenues for further research. Note that we focus on customers that cannot be defrauded. A different approach that is informally addressed in Dulleck et al. (2011) but that has been neglected in the theoretical literature so far is to consider customers who know their exact need, for example whether or not they demand eco-friendly products, but can still be defrauded. This might prove particularly insightful for investigating incentives for fraudulent behavior in certification markets. Further, our model assumes that the share of informed customers is exogenously given. This of course neglects the preceding question of why some customers choose to acquire information and others do not. Obviously, for obtaining a market where only a share of customers is informed and the other is uninformed, the costs of information acquisition have to differ. In this context, it might be reasonable to assume that the marginal costs of information acquisition decline the more customers are already informed. This promises interesting new insights with regard to the strategic information behavior of customers. Last but not least, our theoretical analysis provides various hypotheses that can be tested experimentally.

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