Where are the Problems with Credence Goods?*

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Abstract

With credence goods consumers cannot judge the quality they receive compared to the quality they need. The needed quality can only be observed by an expert seller who may exploit the information asymmetry by cheating. In recent years various contributions have analyzed the credence goods problem under a wide variety of assumptions yielding equilibria exhibiting various degrees of inefficiencies and fraud. The present paper presents conditions under which market institutions solve the fraudulent expert problem at no cost and characterizes the inefficiencies that arise if at least one of these conditions is violated. Our analysis not only permits a clearer discrimination between situations in which markets prevent fraud and those in which they do not; it also helps to identify the forces driving the different inefficiency results derived in the literature.

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1 Introduction

Credence goods have the characteristic that, even when consumers can observe the utility they derive from the good *ex post*, they cannot judge whether the quality they received is the *ex ante* needed one. Thus, with credence goods customers need to trust sellers. Darby and Karni (1973) added this type of goods to Nelson's (1970) classification in ordinary, search and experience goods. Darby and Karni mention provision of repair services, execution of taxicab rides and removal of appendixes as typical examples.

The credence goods problem gave rise to a number of contributions which, taken together, yield no general picture regarding the inefficiencies arising from the information asymmetry; rather, the results seem to depend sensitively on the specific assumptions of the models.

The assumptions made by the authors vary along several dimensions: The analyzed market conditions range from experts having some degree of market power (Pitchik and Schotter 1987, Emons 1995) to competitive frameworks (Wolinsky 1993 and 1995, Emons 1997). Also, some authors consider models where the right treatment fixes the problem for sure (Pitchik and Schotter 1987, Wolinsky 1993 and 1995), others focus on frameworks where success is a stochastic function of service input (Darby and Karni 1973, Emons 1995 and 1997). Some authors assume that experts can serve arbitrarily many customers at in quantity constant (Wolinsky 1993 and 1995) or increasing (Darby and Karni 1973) marginal cost, in other contributions experts are capacity constrained (Emons 1995 and 1997). Also, in some contributions experts are able to post take-it-or-leave-it prices (Wolinsky 1993, Emons 1995 and 1997), in others prices are determined in a bilateral bargaining process (Wolinsky 1995), still others consider models where prices are exogenously given (Darby and Karni 1973, Pitchik and Schotter 1987).

Finally, there is not even consensus among the authors on what constitutes the main aspect of the credence goods problem: Some authors analyze experts' incentive to under- or overtreat customers (i.e., to provide treatment of an inappropriate low or high quality) as, e.g., Emons (1995 and 1997), others their temptation to overcharge the clientele (that is, to charge for a treatment quality not provided), as for instance Wolinsky (1993 and 1995), and in still other contributions it is not clear at all which of these two problems is really considered (Darby and Karni 1973, Pitchik and Schotter

1987)[1].

Given the wide variety in the analyzed problems it is not surprising that the proposed solutions exhibit a broad range of different equilibrium behavior: There are pure strategy equilibria in which experts overtreat consumers (Darby and Karni 1973), and pure strategy equilibria in which the credence goods information asymmetry gives rise to excessive search and diagnosis costs (Wolinsky 1993). There are mixed strategy equilibria where the market outcome involves fraud in the form of overcharging of consumers (Pitchik and Schotter 1987, and Wolinsky 1995). And there are also equilibria where the only inefficiencies in the credence goods market are experts' inefficient capacity levels (Emons 1997). Thus, for the non-expert reader the overall picture is rather blurred, i.e., it is fairly difficult to judge which set of conditions drives the presented results.

The present paper provides a very simple model of credence goods. The analysis of this simple framework not only permits a clearer discrimination between situations in which market institutions solve the fraudulent expert problem without any cost and those where they do not; it also helps to identify the forces driving the various inefficiency results in the literature. First we present conditions leading to an efficient solution for the credence goods problem regardless of all other parameters. Then we show that virtually all existing results on inefficiencies in the credence goods market can be obtained by relaxing one of these conditions. The conditions leading to an efficient solution are (i) that expert sellers face homogeneous customers, (ii) that there exist large economies of scope between diagnosis and treatment, and (iii) that either the type of treatment is verifiable, or a liability rule is in effect protecting consumers from obtaining an inappropriate inexpensive

[1] If the cost of treatment is increasing in quality - an assumption typically made in the credence goods literature - then overcharging a customers in strictly more profitable than overtreating him. So overtreatment can only be a problem if overcharging is impossible because the quality of the treatment is verifiable. Emons (1995 and 1997) explicitly assumes that the quality of treatment is verifiable and studies the problem of over- and undertreatment. Wolinsky (1993, 1995) analyses experts' temptation to overcharge their customers, implicitly assuming that the type of treatment is unobservable. Pitchik and Schotter (1987) specify the payoffs in a way that makes it impossible to disentangle the two phenomena. And in Darbi and Karni (1983) the implicit assumption regarding observability/verifiability varies according to whether capacity exceeds demand or *vice versa*. For the former case they analyze experts' incentive to overtreat customers, implicitly assuming that the type of treatment is verifiable. For the latter case they discuss the incentive to charge for treatments not provided, implicitly assuming non-verifiability.

treatment, or both.

Ad (i) That consumers are homogeneous is a standard assumption in the formal literature on credence goods.[2] This assumption is obviously unrealistic. However, it serves as a useful benchmark.

Ad (ii) Economies of scope between diagnosis and treatment are often seen as a constituent feature of credence goods since they make separate provision of these services by independent experts unattractive. The magnitude of these economies depends upon the good or service considered. Clearly, the assumption of large economies of scope is more plausible in environments where diagnosis is a by-product of the actual repair process and where a repair expert who learns the diagnosis from a diagnosis expert does not gain much because the recommendation does not reveal anything that would not have been revealed during the repair process anyway. For example, in surgery and in complicated repairs this assumption is appropriate[3], whereas for simple repairs and prescription and preparation of drugs it is not. Profound economies of scope between diagnosis and treatment have the effect that customer and expert are tied together once the diagnosis is made.

Ad (iii) Without exception all contributions to the credence goods literature implicitly or explicitly assume either verifiability or liability (but never both) to hold. The assumption that the type of treatment is verifiable is more plausible in environments where the customer is physically and mentally present during the treatment than for the alternative case where he is not.[4] For example, for dental services and minor car- or appliance-repairs this assumption is likely to be appropriate, whereas for more sophisticated repairs (where the customer is unlikely to wait for the repair to be performed in his sight) and surgery (where the patient is often in a coma during the treatment) it is not. Under verifiability the expert cannot charge the customer for a treatment not provided. Whereas for the verifiability assumption

[2] The only contribution with heterogeneous consumers is the more verbal paper by Darby and Karni (1973).

[3] As Darby and Karni (1973, FN 2) have put it, "..it is easier to repair any damage while the transmission or belly is open to see what is wrong, than to put everything back together and go elsewhere to repeat the process for the actual repair."

[4] There are, of course, exceptions to this rule. For instance, a customer is likely to be able to verify whether the muffler of his car has been replaced or only repaired even if he has taken the car to the mechanic in the morning and picked it up in the evening. For repairs concerning interior parts, on the other hand, the rule seems to apply: The customer is able to evaluate only the result but not the typ of treatment if he was not physically present during the repair process.

to hold the type of treatment has to be verifiable, for liability we need verifiability of results. Thus, liability rules are more likely to be in force for repair services than for medical treatments where the result is often very subjective, i.e. only observed by the patient. Under the liability assumption the expert is prevented from providing an inexpensive treatment when a more expensive one is needed.[5]

We shall show that inefficient rationing and inefficient treatment of some consumer groups may arise if condition (i) fails to hold, that equilibria involving overcharging of customers, or duplication of search and diagnosis costs may result if condition (ii) is violated, and that the credence goods market may break down altogether if condition (iii) doesn't hold.

The rest of the paper is organized as follows. The next section introduces the model. In Section 3 we show that market institutions solve the fraudulent expert problem at no cost when conditions (i), (ii) and (iii) hold. In the subsequent section we characterize the inefficiencies that arise if at least one of these conditions is violated. Section 5 concludes. Some proofs are relegated to the Appendix.

2 A Basic Model of Credence Goods

In this section, we first introduce a simple model of credence goods, characterized by their quality (or cost) and the utility they generate for customers. Then we specify the market for these goods.

With credence goods, even when customers can observe the utility they derive from the good *ex post,* they cannot tell whether the quality of the good or service they received is the *ex ante* needed one. Furthermore, depending on the concrete framework, consumers may also be unable to observe which quality they actually received. Thus, with credence goods customers need to trust expert sellers. To refer to examples, consider personal computers. An expert seller can help to find the right quality that fits customers' needs. A customer will not be able to tell whenever he received a too high quality. Only an inappropriate low quality is detected. Similarly, a car with a new muffler will work as well as with the repair of the old muffler when a repair would

[5]An alternative to a general liability rule (introduced by law) is a warranty (drawn up by the expert) in which the expert promises to pay the customer a sufficiently large amount of money if the treatment fails. As for the liability rule, verifiability of results is required for enforcement of the rule.

Customer's utility		Customer needs	
		$\underline{c}$	$\overline{c}$
Customer gets	$\underline{c}$	v	0
	$\overline{c}$	v	v

Table 1: Utility from a Credence Good

have been sufficient. The customer cannot tell whether the new part was really needed. The same problem arises when seeing a doctor: As long as the patient feels as healthy as he thinks it was possible, he cannot tell whether he was treated correctly or was overtreated. As in the other examples, customers are only able to detect too little treatment.

To model this situation, we assume that a customer (he) has either a (minor) problem requiring a cheap treatment $\underline{c}$, or a (major) problem requiring a more expensive treatment $\overline{c}$. The customer knows that he has a problem, but does not know how severe it is. He only knows that he has an *ex ante* probability of h that he has the major problem and a probability of $(1 - h)$ that he has the minor one. An expert (she), on the other hand, is able to detect the type of problem by performing a diagnosis. She can then provide the appropriate treatment. The cost of the more expensive treatment is $\overline{c}$ and the cost of the cheap treatment is $\underline{c}$, with $\overline{c} > \underline{c}$.[6] The more expensive treatment fixes either problem while the cheap one is only good for the minor problem.

Table 1 represents the gross utility of a customer given the type of treatment he needs and the type he gets. If the type of treatment is sufficient, a customer gets utility v. Otherwise he gets 0. The credence good characteristic stems from the fact that the customer is satisfied in three out of four cases. In general, he is satisfied whenever he gets a treatment quality at least as good as the needed one. Only in one case, where he has the major problem but gets the cheap treatment, he will discover *ex post* what he needed and what he got.

Two kinds of fraud have been the focus of research in the credence goods literature.[7] The first kind is the provision of an inefficient treatment. On the

[6] For convenience, both the type of treatment and the associated cost is denoted by c.

[7] There are, of course, a number of other potential problems (and therewith a number of other sources for fraud) in the credence goods market. For example, experts may differ in their ability to perform a diagnosis or a treatment, and this ability may be their own

one hand, it is inefficient if the customer gets the cheap treatment when he actually has the major problem. On the other hand, it is inefficient if the customer gets the expensive treatment when he only has the minor problem. We label the former inefficiency as under-, the latter as overtreatment. Overtreatment cannot be ruled out by law since it is never detected. Whether an expert may be tempted to undertreat customers depends on the institutional arrangements present in the market. Some contributions to the credence goods literature implicitly or explicitly assume that a liability rule is in effect, making experts liable for providing an inappropriate inexpensive treatment. Such a liability rule prevents undertreatment. We refer to this as the liability assumption (Assumption L).

Assumption L (Liability) *An expert cannot provide the cheap treatment $\underline{c}$ if the expensive treatment $\overline{c}$ is needed.*

An expert can defraud consumers in a second way. She might claim to have supplied the expensive treatment $\overline{c}$, even if he has only provided $\underline{c}$. This kind of fraud is labelled overcharging. Whether overcharging poses problems depends on the technical ability of customers.[8] We consider two settings. In the first, a customer is neither able to observe the type of treatment he needs nor the type he gets. He only observes *ex post* whether the type of treatment he got was sufficient to solve his problem. In this setting overcharging might be profitable. In the alternative case the customer can observe and verify the type of treatment he gets. Under this assumption an expert cannot charge for a treatment not provided. We refer to this as the verifiability assumption (Assumption V).

Assumption V (Verifiability) *An expert cannot charge for the high cost treatment $\overline{c}$ if she has provided the low cost treatment $\underline{c}$.*

private information. Or, the effort bestowed by an expert in the diagnosis stage may be unobservable. We ignore these problems here, not because we regard them as less important, but rather because they seem to be less specific to the credence goods market. For an analysis of a situation where effort is needed to diagnose the customer and where an expert's effort investment is unobservable see Pesendorfer and Wolinsky (1999).

[8] An undercharging incentive only exists if the price of the expensive treatment is such that customers reject if recommended this treatment, and if the price of the cheap treatment exceeds the cost of the expensive one. Such price combinations are not observed in equilibrium.

Let us now describe the market environment. There is a population of $n \geq 1$ identical risk-neutral experts in the credence goods market. Each expert can serve arbitrarily many customers. The experts simultaneously post take-it-or-leave-it prices. Let $\overline{p}^i$ denote the price posted by expert $i \epsilon \{1, ..., n\}$ for the high cost treatment $\overline{c}$, and $\underline{p}^i$ the price posted for the cheap treatment $\underline{c}$. An expert's profit is the sum of revenues minus costs over the customers she treated. By assumption, an expert provides the appropriate treatment if she is indifferent between providing the appropriate and providing the wrong treatment, and this fact is common knowledge among all players.

There is a population of $m \geq 1$ identical risk-neutral consumers in the market. Each consumer incurs a diagnosis cost d per expert he visits independently of whether he is actually treated or not.[9] That is, a consumer who resorts to r experts for consultation bears a total diagnosis cost of rd. The net payoff of a customer who has been treated by an expert is his gross valuation as depicted in Table 1 minus the price paid for the treatment minus total diagnosis cost. The payoff of a consumer who has not been treated is his reservation payoff, which we normalize to equal zero, minus total diagnosis cost.[10] By assumption, it is ex ante efficient that a consumer is treated when he has a problem. That is, $v - d - h\overline{c} - (1-h)\underline{c} > 0$. Also, getting the more expensive treatment $\overline{c}$ if needed is assumed to be more efficient than getting the cheap one, i.e., $v > \overline{c} - \underline{c}$. Finally, if a consumer is indifferent between visiting an expert and not visiting an expert, he is assumed to decide for a visit, and if a customer who decides for a visit is indifferent between two or more experts he is assumed to randomize (with equal probability) among them.

Consumers may differ in their "risk" h and in their gross valuation v. Following the rest of the literature on credence goods we assume in Section 3 that customers are identical. We refer to this as the homogeneity assumption (Assumption H).

Assumption H (Homogeneity) *All customers have the same probability h and the same valuation v.*

[9] Provision of treatment without diagnosis is assumed to be impossible. The diagnosis cost d is assumed to include the time and effort cost incurred by the customer and a fair diagnosis fee paid to the expert to cover her opportunity cost.

[10] Here, the implicit assumption is that the outside option is not to be treated at all. Dulleck (1999) discusses the alternative case where a discounter - offering no expertise - is an outside option for the provision of a credence good by an expert. In this context, the reservation payoff is the utility the customer gets if he is served by the discounter.

Regarding the magnitude of economies of scope between diagnosis and treatment there are two different scenarios to consider. If these economies are small, separation of diagnosis and treatment or consultation of several experts may become attractive. With profound economies of scope, on the other hand, expert and customer are in effect tied together once the diagnosis is agreed upon. We will determine the exact conditions under which this occurs in Section 4. In Section 3 we will work with the following short-cut assumption which we refer to as the commitment assumption (Assumption C).

Assumption C (Commitment) *Once the diagnosis is agreed upon, the customer is committed to undergo a treatment by the expert.*

The time and information structure is as follows. The variables $v, h, \overline{c}$ and $\underline{c}$ are common knowledge. At the outset the expert(s simultaneously) post prices $\underline{p}^i$ and $\overline{p}^i$ for $\underline{c}$ and $\overline{c}$, respectively. Consumers observe the quoted prices and then decide whether to undergo a diagnosis by an expert or not, and if yes, by which expert. An expert who gets visited by a customer diagnoses the customer. In the course of the diagnosis she learns the customer's problem and recommends either the cheap or the expensive treatment. Under the commitment assumption she then provides a treatment. Without commitment the customer can refuse to undergo a treatment; only if he agrees the expert provides a treatment.[11] The game ends with the expert charging for the recommended treatment.

With commitment the situation just described can be represented by a multi-stage game with observed actions and complete information (i.e., by a "game of almost-perfect information").[12] The natural solution concept for such a game is subgame-perfect equilibrium and we will resort to it in Section 3. Subgame-perfection looses much of its bite in the non-commitment case where the less-informed customer has to decide whether to stay or to leave without knowing whether the better-informed expert has recommended the

[11] Throughout we assume that an expert's agreement to perform the diagnosis means a commitment to provide a treatment even if treatment-provision is not profitable for the expert. This assumption is not important for our results and we mention in footnotes what changes if the expert is free to send off the customer after having conducted the diagnosis.

[12] To see this, note that the commitment scenario can be described by an extensive form game in which nature chooses the severity of the customer's problem after the customer has consulted the expert (but before the expert performs the diagnosis).

right or the wrong treatment. To extend the spirit of subgame-perfection to this game of incomplete information, we require that strategies yield a Bayes-Nash equilibrium not only for each proper subgame, but also for continuation games that are not proper subgames (because they do not stem from a singleton information set). That is, we focus on perfect Bayesian or sequential equilibria in the non-commitment case.[13]

3 No Problem with Credence Goods

In this section we show that market institutions solve the fraudulent expert problem at no cost if (i) expert sellers face homogeneous customers (Assumption H), (ii) expert and customer are committed to proceed with a treatment once a diagnosis is agreed upon (Assumption C), and (iii) either the type of treatment is verifiable (Assumption V), or a liability rule is in effect (Assumption L), or both. This result is recorded as Proposition 1 below. The proof for this result, as well as the intuition behind it, relies on three observations that are reported as Lemmas 1-3.

Lemma 1 discusses the result under the liability assumption. With liability alone (i.e., without verifiability) experts charge a uniform price for both types of treatment and serve customers honestly as the following result shows[14].

Lemma 1 *Suppose that Assumptions H, C and L hold, and that Assumption V is violated. Then, in any subgame-perfect equilibrium, expert(s) charge(s) a constant price for both types of treatment and efficiently serve(s) customers. The price charged in equilibrium is given by* $\widetilde{p} = \underline{c} + h(\overline{c} - \underline{c}) + \alpha\left[v - d - \underline{c} - h(\overline{c} - \underline{c})\right]$, *where* $\alpha = 1$ *for* $n = 1$ *and* $\alpha = 0$ *otherwise (i.e., for* $n > 1$*). Posted prices satisfy* $\underline{p} \leq \overline{p} = \widetilde{p}$.

Proof. First observe that with commitment the subgame starting immediately after the price-posting game among experts is a multi-stage game of perfect information and as such can be solved by backward induction. So we

[13] As Fudenberg and Tirole (1991) have shown, the concept of perfect Bayesian equilibrium is equivalent to sequential equilibrium for games in which the type space of each player has at most two elements as is the case in our present model.

[14] If the expert is not obligated to treat the customer after having conducted the diagnosis the price charged in equilibrium changes to $\widetilde{p} = \overline{c} + \alpha\left[v - d - \overline{c}\right]$. The rest of Lemma 1 remains unaffected.

start by solving for the expert's optimal provision policy for each possible situation she might face. Under the conditions of Lemma 1, liability prevents undertreatment, and the cost difference $\overline{c} - \underline{c} > 0$ prevents overtreatment. So each expert will efficiently serve her customers. Next consider the recommendation policy. If $\overline{p} > \underline{p}$ then the expert has incentives to overcharge, i.e., to always recommend $\overline{c}$ and charge $\overline{p}$. Only if $\overline{p} = \underline{p}$ the expert has no incentive to charge for the wrong treatment.[15] Customers' beliefs reflect experts' incentives. Thus, they visit the expert with the lowest $\overline{p}$, provided that the lowest $\overline{p}$ is such that $v - \overline{p} - d \geq 0$. The rest is trivial. In the monopoly case $(n = 1)$ the expert has all the market power. Thus, she posts $\underline{p} \leq \overline{p} = v - d$. With $n > 1$, the price-posting game is a standard Bertrand game without capacity constraints. Thus, $\underline{p} \leq \overline{p} = \underline{c} + h\left(\overline{c} - \underline{c}\right)$ by the usual price-cutting argument. ■

Liability solves the problem of undertreatment, the cost differential $\overline{c} - \underline{c} > 0$ that of overtreatment. Remains the overcharging incentive. This incentive is eliminated by posting a constant price independent of the type of treatment provided. This result offers an explanation for the frequently observed fixed prices for expert services in environments where experts have to provide reliable quality because otherwise they are punished either by law or by bad reputation. Examples are garages offering car check-ups at a fixed price and health maintenance organizations (HMOs) providing medical service to members at an individualized constant price per treatment. From the analysis it becomes clear that the schemes offered by the HMOs are cheaper than a health insurance system. Under insurance the customer does not care about the price after having paid the insurance premium. With the HMO, the company will make sure that the cheapest sufficient quality will be provided.

Let us turn now to the verifiability case. Under the verifiability assumption experts charge equal mark-up prices as the following result shows.

Lemma 2 *Suppose that Assumptions H, C and V hold, and that Assumption L is violated. Then there exists a unique subgame-perfect equilibrium for each n. In this equilibrium, expert(s) post(s) and charge(s) equal mark-up prices and efficiently serve(s) customers. Posted (and charged) equilibrium prices are given by* $\underline{p} = \underline{c} + \alpha\left[v - d - \underline{c} - h(\overline{c} - \underline{c})\right]$ *and* $\overline{p} = \underline{p} + (\overline{c} - \underline{c})$, *where* $\alpha = 1$ *for* $n = 1$ *and* $\alpha = 0$ *otherwise.*

[15] Throughout we assume that $\overline{p} \geq \underline{p}$. Allowing for $\underline{p} > \overline{p}$ burdens the analysis without changing the qualitative results.

Proof. First note that with observability the last two stages of the game coincide; that is, an expert's recommendation (and charging) policy equals her provision policy. If $\overline{p} - \underline{p} > \overline{c} - \underline{c}$ the expert will always recommend and provide the more expensive, if $\overline{p} - \underline{p} < \overline{c} - \underline{c}$ the less expensive treatment. Only if $\overline{p} - \underline{p} = \overline{c} - \underline{c}$ the expert is indifferent between the two types of treatment and, therefore, behaves honestly. Customers know that and visit the expert whose posted price-vector, together with the implied provision policy, generates the highest positive expected utility. A customer visiting an expert whose posted prices satisfy $\overline{p} - \underline{p} > \overline{c} - \underline{c}$ has an expected utility of $v - \overline{p} - d$. Similarly, a customer visiting a $\overline{p} - \underline{p} < \overline{c} - \underline{c}$ expert obtains an expected utility of $(1 - h) v - \underline{p} - d$. Finally, the expected utility from visiting an equal mark-up expert is $v - \underline{p} - h(\overline{c} - \underline{c}) - d$. Experts take consumers' expected utility into account in posting their prices. First, consider the monopoly case. The maximal profit per customer the monopolist can realize with equal mark-up prices is $v - d - \underline{c} - h(\overline{c} - \underline{c})$. The maximal obtainable profit with price vectors satisfying $\overline{p} - \underline{p} > \overline{c} - \underline{c}$ is $v - d - \overline{c}$, and the maximal profit with price vectors satisfying $\overline{p} - \underline{p} < \overline{c} - \underline{c}$ is $(1 - h) v - d - \underline{c}$. Thus, since $v > \overline{c} - \underline{c}$, the expert will post the proposed equal mark-up price-vector. Next suppose that $n > 1$. Further suppose that at least two experts post equal mark-up prices. Then these prices are given by $\overline{p} = \overline{c}$ and $\underline{p} = \underline{c}$ since this is the only equal mark-up price-vector consistent with Bertrand competition. Next suppose that at least one expert posts $\overline{p} = \overline{c}$ and $\underline{p} = \underline{c}$, while at least one other expert posts prices violating the equal mark-up rule. In order to attract customers the deviating expert must either post prices satisfying $\overline{p} \leq \underline{c} + h(\overline{c} - \underline{c})$ and $\overline{p} > \underline{p} + \overline{c} - \underline{c}$, or prices satisfying $\underline{p} \leq \underline{c} - h(v - \overline{c} + \underline{c})$ and $\underline{p} > \overline{p} + \underline{c} - \overline{c}$. The former price-vector results in a loss of at least $(1 - h)(\overline{c} - \underline{c})$ per customer, the latter in a loss of at least $h(v - \overline{c} + \underline{c})$ per customer. Next suppose that no expert posts equal mark-up prices. Then at least one expert can attract all customers and increase her profit by switching to equal mark-up prices. Finally suppose a single expert is able to attract some customers with equal mark-up prices exceeding the proposed equilibrium prices, while all other experts post prices violating the equal mark-up rule. Then one of those other experts has an incentive to switch to an equal mark-up price-vector, leading again to Bertrand competition. ■

Verifiability solves the problem of overcharging, i.e. the seller cannot claim to have supplied the expensive treatment when he actually has provided the cheap one. The incentive to provide the wrong treatment is eliminated by prices that yield a constant profit independent of the type of treatment sold.

Such an efficiency inducing pricing behavior is often seen in case of expert sellers. Computer stores are an obvious example. Customers can control which quality they receive. Our result provides a reason for a limitation of choice and a reputation for being expensive of expert shops. If (some) customers behave irrational in the sense that they care for a relative mark-up instead of expected prices, some (low) qualities will not be sold, because the needed - efficiency inducing - mark-up is high compared to costs. Other examples are pricing schemes of travel agents. The mark up the travel agent charges (the margin plus any bonuses to the agent offered by the provider) are similar for all products.

The assumption that it is common knowledge among players that experts provide the appropriate treatment whenever they are indifferent plays an important role in Lemma 2 in generating a unique subgame-perfect equilibrium. Without this assumption there exist other subgame-perfect equilibria which are supported by the belief that all experts who post equal mark-up prices - or, that experts who post equal mark-up prices that are too low (in the monopoly case: too high) - deliberately mistreat their customers. We regard such equilibria as implausible and have therefore introduced the common knowledge assumption which acts as a restriction on consumers' beliefs.

Note that Lemma 2 encompasses the Emons (1997) result on the provision and pricing strategies of capacity constrained experts as a special case. Emons considers a model with a continuum of identical consumers and a finite number of identical potential experts. Each potential expert has a fixed capacity. She becomes an active expert by irreversibly devoting this capacity to the credence goods market. Once she has done this, she can use her capacity to provide two types of treatment at zero marginal cost up to the capacity constraint. One type of treatment uses up more units of capacity than the second. Total capacity over all potential experts exceeds the amount necessary to serve all customers honestly. Emons proposes a symmetric equilibrium in which all potential experts' entry decision is strictly mixed. Thus, active experts may either have to ration their clientele due to insufficient capacity, or they may end up with idle capacity. In the former case they charge prices such that (i) all the surplus goes to the experts and (ii) the price for the more capacity-consuming treatment exceeds the price of the second treatment by such an amount that the profit per unit of capacity consumed is the same for both types of treatment. In the latter case all experts charge a price of zero for both types of treatment. In both cases experts serve customers honestly. This is exactly what our Lemma 2 would predict: If demand exceeds total capacity experts have all the market power ($\alpha = 1$). Thus, all the surplus goes to the experts. Furthermore, with insufficient capacity, equal mark-up prices imply a higher price for the more capacity-consuming treatment since the opportunity cost in terms of units of capacity used is higher. By contrast, if capacity exceeds demand, the opportunity cost of both types of treatment is the same, namely zero. Thus, the price has to be the same for both types of treatment to yield equal mark-ups. Furthermore, with idle capacity, experts have no market power ($\alpha = 0$). Thus, prices are zero and customers appropriate the entire surplus. To summarize, our analysis shows that many specific assumptions made by Emons (e.g., that there is a continuum of customers, that capacity is needed to provide treatments, or that success is a stochastic function of the type of treatment provided) are not important for his efficiency result.[16] What is important, however, are the explicit assumptions that consumers are homogeneous and that the type of treatment is verifiable, and the implicit assumption that the fixed cost of consulting an expert (our diagnosis cost) is rather high.

Let us now consider the case where both, the liability and the verifiability assumption hold. In this case $\overline{p} \leq \underline{p} + (\overline{c} - \underline{c})$ is sufficient to induce nonfraudulent behavior as the following result shows.

Lemma 3 *Suppose that Assumptions H, C, L and V hold. Then, in any subgame-perfect equilibrium, expert(s) post(s) and charge(s) prices satisfying* $\overline{p} \leq \underline{p} + (\overline{c} - \underline{c})$ *and* $\underline{p} + h(\overline{p} - \underline{p}) = \underline{c} + h(\overline{c} - \underline{c}) + \alpha\left[v - d - \underline{c} - h(\overline{c} - \underline{c})\right]$, *where* $\alpha = 1$ *for* $n = 1$ *and* $\alpha = 0$ *for* $n > 1$. *With these prices customers are served honestly.*

Proof. The proof is similar to that of Lemma 2, the only difference being that the liability rule prevents the expert from profiting by providing the cheap treatment when the more expensive one is needed. ■

With liability and observability undertreatment and overcharging are both unattractive. The incentive to overtreat customers is eliminated by posting prices yielding a lower mark-up for the more expensive treatment.

Lemmas 1 - 3 can be summarized to the following result.

[16] The only inefficiency that remains in the Emons model are the suboptimal capacity levels. This inefficiency has nothing to do with the credence goods problem, however. It is rather a coordination failure type of inefficiency similar to that arising in the symmetric mixed strategy equilibrium of the grab-the-dollar game prominent in Industrial Organization.

Proposition 1 *Under Assumptions H, C, and either L or V or both, market institutions solve the fraudulent expert problem at no cost.*

4 Various Degrees of Inefficiencies and Fraud in the Credence Goods Market

4.1 Heterogeneous Customers: Inefficient Rationing and Inefficient Treatment of some Consumer Groups

Without exception the formal literature on credence goods assumes that consumers are homogeneous. In this subsection we show that new inefficiencies may arise if this assumption (our Assumption H) is violated. To show this it suffices to consider a simple example where $n = 1$, and where consumers differ only in their risk of needing the more expensive treatment. More precisely, we assume that consumer $j \in \{1, ...m\}$ has the major problem with probability h_j, and the minor problem with probability $(1 - h_j)$. Consumers' types (i.e., the probabilities h_j) are drawn independently from the same cumulative distribution function $F(\cdot)$, with differentiable strictly positive density $f(\cdot)$ on $[0, 1]$. $F(\cdot)$ is common knowledge, but a consumer's type is the consumer's private information.[17] If a customer gets the appropriate treatment he obtains a type-independent gross utility of v, and if not one of zero, exactly as in our basic model.[18] To rule out overcharging of customers we assume the type of treatment to be verifiable (Assumption V).

Our first result considers a setting in which the expert cannot price discriminate among consumers. Without price discrimination the expert chooses equal mark-up prices such that some consumers do not consult her even though serving them would be efficient. This is nothing but the familiar monopoly-pricing inefficiency: The monopolistic expert would like to appropriate as much of the net gain from treatment as possible but, because of asymmetric information, runs the risk of losing some consumers in order to

[17] Car owners know how they treat their vehicles and the associated risk of needing certain repairs, auto mechanics know only the distribution. Similarly, patients know their eating and smocking habits and the associated risk of getting certain diseases, doctors only the distribution.

[18] Similar results can be derived under the assumption that each customer is characterized by a vector (h_j, v_j), and that the types of different consumers are independently drawn from the same two-dimensional distribution.

get a higher price from the remaining ones. We record the monopoly pricing result in Lemma 4.

Lemma 4 *Suppose that Assumptions C and V hold, and that Assumptions H and L are violated. Further suppose that* $n = 1$ *and that consumers differ in their risk of needing the more expensive treatment only. Finally suppose that the expert can post a single price vector* $\left(\underline{p}, \overline{p}\right)$ *only. Then there exists a unique subgame-perfect equilibrium. In this equilibrium, the expert posts and charges equal mark-up prices* $\left(\overline{p} - \overline{c} = \underline{p} - \underline{c}\right)$ *such that (i) high risk consumer types decide to remain untreated* $(\overline{p} > v - d)$ *, and (ii) all other types visit the expert* $\left(\underline{p} < v - d\right)$ *and get the appropriate treatment.*

Proof. From the proof of Lemma 2 we know that, for given net utilities for the consumers, the monopolist's profit is highest with an equal mark-up price vector. Thus, the monopolist will choose such a vector and she will provide the appropriate treatment to all of her customers. With an equal mark-up price vector the monopolistic expert is interested in two variables only, in the magnitude of the mark-up and in the number of visiting consumers. The result then follows from the observation that the expert's problem is nothing but the familiar monopoly pricing problem for demand curve $D(\underline{p}) = mF((v - \underline{p} - d)/(\overline{c} - \underline{c}))$ and net revenue per customer $\underline{p} - \underline{c}$. ■

For our next result we allow the expert to price discriminate among consumers. That is, we let the monopolistic expert post a menu of price vectors. Consumers observe the menu and then decide under which vector, if any, they wish to be served.

Under standard conditions, second degree discriminatory pricing reduces the monopoly-pricing inefficiency. In the present model with credence goods, a new inefficiency appears.

Lemma 5 *Suppose that the general conditions of Lemma 4 hold, except that the expert can now price discriminate among consumers (rather than being restricted to a single price vector only). Then, in any subgame-perfect equilibrium, the expert posts two price vectors, one with equal mark-ups* $\left(\overline{p} - \overline{c} = \underline{p} - \underline{c}\right)$*, and one with a higher mark-up for the more expensive treatment* $\left(\overline{p} - \overline{c} > \underline{p} - \underline{c}\right)$[19]. *Both vectors attract customers and in total all consumers are served. Types*

[19] The menu may contain some redundant price vectors too, i.e., some vectors that attract no consumers.

served under the former vector always get the appropriate treatment, those served under the latter always get the more expensive treatment independently of whether they have the minor or the major problem.

Proof. See the Appendix. ■

Under the conditions of Lemma 5 the expert posts two price vectors, an equal mark-up vector to skim-off low risk consumers and a less profitable vector with a higher mark-up for the more expensive treatment to serve the rest. The equal mark-up in the vector posted under the conditions of Lemma 5 is strictly higher than that in the vector of Lemma 4. This follows from the observation that the expert's trade-off is between increasing the mark-up charged from the types in the segment of served customers and losing some types to the unprofitable segment of not served consumers in the latter case, while the trade-off here is between increasing the mark-up charged from the types served under the more profitable equal mark-up vector and losing some types to the segment of customers served under the less profitable second vector. So, some types that always get the appropriate treatment under the conditions of Lemma 4, get (with strictly positive probability) the wrong treatment when the expert can price discriminate among consumers. Thus, there is a trade-off between increasing the number of treated consumers and serving the treated customers efficiently. Overall efficiency might increase or decrease with price discrimination depending on the shape of the distribution function $F(\cdot)$, the valuation v (net of diagnosis costs d, of course) and the cost-difference $\overline{c} - \underline{c}$. An increase in efficiency is more likely the smaller is .., the larger is .., and the steeper is ... This is because a large .. and a small .. increases .., while a ...

The result that the number of served customers increases with price discrimination carries over to a setting in which the type set is discrete, with the qualification that the increase is not necessarily strict in that case, since all types might already get served under the conditions of Lemma 4. It also extends to a setting where consumers differ in their valuation v, but have the same probability h of needing the more expensive treatment. It does not carry over to a model with a two-dimensional type space, however, as the (discrete) example below shows. In this example some types that always get the appropriate treatment under the conditions of Lemma 4, remain unserved when the expert can price discriminate among consumers: If the expert can post a single price vector only, she serves all consumers with equal mark-up prices. With prices discrimination she uses an equal mark-up vector to skim off low risk / high valuation consumers, and a price vector with a higher mark-up for the more expensive treatment to (mis-)treat medium risk / medium valuation consumers. High risk / low valuation consumers remain unserved with price discrimination although treating them would be efficient.

Example: There is an arbitrary number m of consumers. Each consumer $j \in \{1, ...m\}$ is characterized by his two-dimensional type (h_j, v_j). Consumers' types are independently drawn from an equal probability distribution on the discrete support $\{(.,.), (.,.), (.,.)\}$. There are no diagnosis costs $(d = 0)$. The cost of the more expensive treatment is one $(\overline{c} = 1)$, and the cost of the cheap treatment is zero $(\underline{c} = 0)$.
If the expert can post a single price vector only, then she serves all consumers with equal mark-up prices $(\underline{p}, \overline{p}) = (..,..)$. If the expert can price discriminate among consumers then she posts two price vectors, the equal mark-up vector $(\underline{p}, \overline{p}) = (..,..)$, and a second vector with $\overline{p} = .. > \underline{p} + (\overline{c} - \underline{c})$. High valuation consumers are served efficiently under the equal mark-up vector, medium valuation consumers mistreated under the second vector, and low valuation consumers remain unserved.

Before proceeding notice that the inefficiencies of Lemmas 4 and 5 disappear if the number of experts increases. With $n > 1$, price-competing experts provide both treatments at marginal cost leaving no leeway for inefficiencies of any kind. Thus, we can summarize the results of this subsection to the following proposition.

Proposition 2 *Suppose that Assumptions C and V hold, and that Assumptions H and L are violated. Further suppose that consumers differ in their risk of needing the more expensive treatment only. Then, with $n > 1$ the equilibrium outlined in Lemma 2 remains the only subgame perfect equilibrium. By contrast, with $n = 1$ there exists no subgame-perfect equilibrium in which all consumers get always the appropriate treatment. If the expert can post a single price vector only, then she always provides the right treatment, but she serves too few customers. If the expert can price discriminate among customers, then she serves all consumers but some consumer types get (with strictly positive probability) the wrong treatment.*

4.2 No Commitment: Overcharging and Duplication of Search and Diagnosis Costs

In this subsection we drop the commitment assumption. Under certain conditions this gives rise to two different types of equilibria, overcharging equilibria and specialization equilibria. In both, the credence good problem manifests itself in inefficiently high search and diagnosis costs as some consumers end up visiting more than one expert and being diagnosed more than once. We begin with the overcharging scenario.

Lemma 6 *Suppose that Assumptions H and L hold, and that Assumptions C and V are violated. Further suppose that* $n = 2$ *and that* $d < (\overline{c} - \underline{c})(1 - h)$*. Then there exists a symmetric sequential equilibrium scenario in which experts overcharge customers (with strictly positive probability). In this scenario experts post prices satisfying* $\underline{p} > \underline{c}$ *and* $\overline{p} > \underline{p}$*. Experts always recommend the expensive treatment if the customer has the major problem, and they recommend* $\overline{c}$ *with probability* $o \in (0, 1)$ *if the customer has the minor problem. Customers always accept a* $\underline{c}$ *recommendation, and they accept a* $\overline{c}$ *recommendation with probability* $a \in (0, 1)$ *on their first, and they accept it with certainty on their second visit. A customer who accepts to be treated always gets the appropriate treatment.*

Proof. See the Appendix. ■

In the overcharging equilibrium of Lemma 6 liability solves the problem of undertreatment and the cost differential $\overline{c} - \underline{c}$ that of overtreatment. Remains the temptation to overcharge consumers. Experts do not overcharge their customers all the time (but only with strictly positive probability) because recommending the cheap treatment guarantees a positive profit of $\underline{p} - \underline{c} = \Delta > 0$ for sure, while recommending the expensive treatment when only the cheap one is required is like playing in a lottery yielding a payoff of $\overline{p} - \underline{c} > \Delta$ if the consumer accepts, and zero otherwise. By construction, the expected payoff under the lottery equals Δ, making the expert exactly indifferent between recommending honestly and overcharging.

The overcharging equilibrium of Lemma 6 is essentially the equilibrium outlined by Pitchik and Schotter (1989) for a setting with exogenously given payoffs. Wolinsky (1993) argues that the equilibrium also exists with flexible prices, without giving conditions for existence, however. The "equilibrium with fraud" discussed by Darby and Karni (1973) is also similar in that it resembles a purified version of the overcharging equilibrium of Lemma 6. In their (in large parts verbal) analysis "...increasing the amount of services prescribed on the basis of the diagnosis, increases the probability of entering the customer's critical regions for going elsewhere [....] Taking this consideration into account, the firm will carry fraud up to the point where the expected marginal profit is zero" (p. 73). Adapting Lemma 6 to an environment where consumers are heterogeneous with respect to their search cost would yield an equilibrium with these properties. The analogy is not perfect, however, as the problem discussed by Darby and Karni is that of overtreating, and not that of overcharging customers. Overtreatment can only pose problems if the customer can observe and verify the type of treatment he gets (our Assumption V), since, if he can not, overcharging is always more profitable. But, with verifiability and flexible prices there are no equilibria exhibiting fraud, as Lemma 8 below shows. In other words, to support the Darby and Karni (1973) configuration with fraud as an equilibrium, payoffs need to be exogenously fixed, as they are in their environment.

Overcharging equilibria with the essential features as outlined in Lemma 6 cease to exist if sufficiently many experts compete for customers. With a continuum of experts, low economies of scope between diagnosis and treatment, and a certain 'reasonable' restriction on consumers' beliefs, the only sequential equilibria that survive when Assumptions H and L hold, while Assumptions C and V are violated are specialization equilibria similar to the one outlined in the next lemma. This has been shown by Wolinsky (1993).[20]

Lemma 7 *Suppose that Assumptions H and L hold, and that Assumptions C and V are violated. Further suppose that $n \geq 4$ and that $d < (\overline{c}-\underline{c})(1-h)$. Then there exists a sequential equilibrium scenario exhibiting specialization. In this scenario at least two experts post prices given by $\underline{p} = \underline{c}$ and $\overline{p} > \overline{c} + d$ (we call such experts "cheap experts"), and at least two other experts ("expensive experts") post prices given by $\underline{p} \leq \overline{p} = \overline{c}$. Cheap experts always recommend the appropriate treatment, expensive experts always the expensive one. Consumers first visit a cheap expert. If this expert recommends $\underline{c}$ the customer agrees and gets $\underline{c}$. If the cheap expert recommends $\overline{c}$ the customer rejects and visits an expensive expert who treats him efficiently.*

Proof. See the Appendix. ■

[20] If the expert is not committed to treat the customer after having conducted the diagnosis, the condition $d < (\overline{c} - \underline{c})(1 - h)$ changes to $d < (\overline{c} - \underline{c})(1 - h)/h$.

In the specialization equilibrium of Lemma 7 liability solves (again) the problem of undertreatment and the cost differential $\overline{c}-\underline{c}$ that of overtreatment. The incentive to overcharge customers is eliminated because cheap experts lose their customers if they recommend the expensive treatment.

Note that the condition for the strategies described in Lemma 1 to constitute a sequential equilibrium scenario even if the commitment assumption (Assumption C) is not imposed and even if $n \geq 4$ is exactly that the restriction imposed by Lemma 7 (an by Lemma 6) on d is violated; that is, the diagnosis cost d must exceed $(1-h)(\overline{c}-\underline{c})$. To verify this, notice that a deviation that might jeopardize the equilibrium of Lemma 1 must have $\underline{p} < \underline{c} + h(\overline{c}-\underline{c})$ and $\overline{p} \geq \overline{c} + d$. The expected cost to a consumer who visits the deviator first, and, if recommended the expensive treatment, resorts to a non-deviating expert is $d + \underline{p} + h\left[\underline{c} - \underline{p} + h(\overline{c}-\underline{c}) + d\right]$. Consulting only a non-deviating expert, on the other hand, costs $d + \underline{c} + h(\overline{c}-\underline{c})$. Thus, to attract customers, the deviator must post a price vector with a $\underline{p}$ such that $d + \underline{c} + h(\overline{c}-\underline{c}) \geq d + \underline{p} + h\left[\underline{c} - \underline{p} + h(\overline{c}-\underline{c}) + d\right]$, which is equivalent to $\underline{p} \leq \underline{c} + h\left[(\overline{c}-\underline{c}) - d/(1-h)\right]$. But, if $d > (1-h)(\overline{c}-\underline{c})$, then such a price vector doesn't cover cost, and so no deviation is profitable.

The equilibrium outlined in Lemma 7 is essentially the specialization equilibrium of Wolinsky (1993), the only difference being that experts can reject to provide a treatment after having conducted the diagnosis in the Wolinsky model while they cannot reject in our present framework. What drives the Wolinsky result is the combination of two assumptions, the assumption that consumers are neither able to observe the type of treatment they need nor the type they get (our Assumption V is violated), and the assumption that experts are liable for providing the cheap treatment when the expensive one is needed (our Assumption L holds).[21] Both, specialization and overcharging equilibria cease to exist if Assumption L is violated, and they also cease to exist if Assumption V holds. We postpone the discussion of the case where neither liability nor verifiability holds to the next subsection and record the rest of the result as Lemma 8.

Lemma 8 *Suppose that customers are homogeneous (Assumption H) and that the type of treatment is verifiable (Assumption V). Then the equilibria summarized in Lemma 2 (for the case where Assumption L is violated) and*

[21] Wolinsky (1993) doesn't explicitly impose the liability assumption. This assumption is implicit in his specification of consumer payoffs, however.

Lemma 3 (for the case where Assumption L holds) remain the only sequential equilibria even if Assumption C is violated.

Proof. The proof is similar to that of Lemma 2 and therefore omitted. ■

For obvious reasons, sequential equilibria exhibiting specialization and sequential equilibria in which experts overcharge customers also cease to exist if there is a single expert only.[22] Thus, we can summarize the results of this subsection to the following proposition.

Proposition 3 *Sequential equilibria exhibiting specialization and sequential overcharging equilibria might exist if Assumption L holds while Assumption V is violated, and they do not exist if either Assumption L is violated or Assumption V holds. Such equilibria also do not exist if there are profound economies of scope between diagnosis and treatment (our Assumption C), or if there is a single expert only* $(n = 1)$. *Overcharging equilibria in addition cease to exist if sufficiently many experts compete for customers.*

4.3 Neither Liability Nor Verifiability: The Credence Goods Market Breaks Down

In this subsection we consider an environment in which consumers can neither observe the type of treatment they get (Assumption V is violated), nor punish the expert if they realize *ex post* that the type of treatment they received was not sufficient to solve their problem (Assumption L is violated too). Under these adverse conditions experts always provide the cheap treatment independently of whether the customer has the minor or the major problem.

Proposition 4 *Suppose that Assumption H holds, and that Assumptions V and L are violated. Then there is no sequential equilibrium in which expert(s) serve(s) customers efficiently. If* $\underline{c} + d \leq (1-h)v$ *then expert(s) charge(s) a constant price given by* $\widetilde{p} = \underline{c} + \alpha\left[(1-h)v - d - \underline{c}\right]$ *(where* $\alpha = 1$ *for* $n = 1$ *and* $\alpha = 0$ *otherwise), and always provide(s) the cheap treatment. If* $\underline{c} + d > (1-h)v$ *then the credence goods market ceases to exist.*

[22] Since the uniform price charged by the monopolistic expert under the conditions of Lemma 1 does not exceed consumers' gross utility v, they will not quit even if not committed, for their only alternative is to remain without any treatment.

Proof. Under the conditions of Proposition 4 the consumer is neither able to observe the type of treatment he needs nor the type he gets. Also, the consumer has no means to punish the expert if he observes *ex post* that the type of treatment he got was not sufficient to solve his problem. Given this, and since $\overline{c} - \underline{c} > 0$, the result follows from standard arguments. ■

The equilibrium of Proposition 4 is rather extreme and one is tempted to argue in favor of public intervention, e.g. the introduction of a legal rule that makes the expert liable for providing an inappropriate inexpensive treatment. In reality, liability rules are far from being perfect mechanisms, however. Problems arise, e.g., in cases in which it is hard to prove that the treatment provided was not sufficient to solve the problem. For instance, a toothache needn't prove that necessary treatment was not provided, and proving to have a toothache is by itself hard, if not impossible. Liability rules may also fail to do their job when there is consumer moral hazard *ex post*. Is there a way out? In practice, experts might be kept honest by their need to maintain reputation (if bad reputation spreads, reputation considerations might mitigate the problem even if consumers are expected to buy only once), or by their desire to retain customers who are expected to need a treatment repeatedly.[23]

5 Conclusions

Previous work has fostered the impression that the equilibrium behavior of experts and consumers in the credence goods market delicately depends on the details of the model. By contrast, the present paper has shown that the results for the majority of the specific models can be reproduced in a very simple unifying framework.

Our analysis suggests that market institutions solve the fraudulent expert problem at no cost if (i) expert sellers face homogeneous customers, (ii) there exist large economies of scope between diagnosis and treatment, and (iii) either the type of treatment is verifiable, or a liability rule is in effect protecting consumers from obtaining an inappropriate inexpensive treatment.

We have shown that inefficient rationing and inefficient treatment of some consumer groups may arise if condition (i) fails to hold, that equilibria involving overcharging of customers or duplication of search and diagnosis costs

[23] To our best knowledge Wolinsky (1993) is the only paper in the credence goods literature that studies the reputation mechanism. Wolinsky assumes liability, however.

may result if condition (ii) is violated, and that the credence goods market may break down altogether if condition (iii) doesn't hold.

Our model might be considered restrictive in several respects. It rests on the assumption that there are only two possible types of problem and only two types of treatment, that treatment costs are observable, that posted prices are take-it-or-leave-it prices, that experts can diagnose a problem perfectly, and so on. This is certainly a justified criticism. Nevertheless our simple model is sufficient to derive most results of that class of models that have been the focus of research in the credence goods literature.[24] Thus, our simple model provides a useful benchmark for the development of more general frameworks which allow for an assessment of the robustness of the results.

References

[1] Darby, M. and Karni, E. (1973), "Free Competition and the Optimal Amount of Fraud", *Journal of Law and Economics* **16**, 67-88.

[2] Dulleck, U. (1997), "Experts vs. Discounters - Competition when Customers have Limited Information about their Needs", mimeo, Department of Economics, Humboldt University.

[3] Emons, W. (1995), "Credence Goods Monopolists", Discussion Paper No 95/01, Department of Economics, University of Bern (revised 1998).

[4] Emons, W. (1997),"Credence Goods and Fraudulent Experts", *Rand Journal of Economics* ***28***, 107-119.

[5] Fudenberg, D. and Tirole, J. (1991), "Perfect Bayesian and Sequential Equilibrium", *Journal of Economic Theory* **53,** 236-260.

[6] Glazer, J. and McGuire, T. (1996), "Price Contracts and Referrals in Markets for Services", Working Paper No 10/96, Institute of Business Research, Tel Aviv University.

[7] Jelovac, I. (1997), "Physicians' Payment Contracts, Treatment Decisions and Diagnosis Accuracy", mimeo, Departament d'Economia i d'Història Econòmia, Universitat Autònoma de Barcelona.

[24] Our model is insufficient, however, to reproduce the Wolinsky (1995) result which relies on the assumption that posted prices are bargaining prices. It is also insufficient to cover some of the more specific results of Wolinsky (1993).

[8] Nelson, P. (1970), "Information and Consumer Behavior", *Journal of Political Economy* **78,** 311-329.

[9] Pesendorfer, W. and Wolinsky, A. (1999), "Second Options and Price Competition: Inefficiency in the Market for Expert Advice" mimeo, Department of Economics, Northwestern University.

[10] Pitchik, C. and Schotter, A. (1987), "Honesty in a Model of Strategic Information Transmission", *American Economic Review* **77**, 1032-1036; Errata (1988), *AER* **78**, 1164.

[11] Schils, R. (1998), "Gate-Keeping for Sequential Production", mimeo, Department of Economics, University of Bonn.

[12] Taylor, C. (1995), "The Economics of Breakdowns, Checkups, and Cures", *Journal of Political Economy* **103**, 53-74.

[13] Wolinsky, A. (1993), "Competition in a Market for Informed Experts' Services", *Rand Journal of Economics* **24**, 380-398.

[14] Wolinsky, A. (1995), "Competition in Markets for Credence Goods", *Journal of Institutional and Theoretical Economics* **151**, 117-131.

6 Appendix

■Proofs of Lemmas 5, 6, and 7 follow.

Proof of Lemma 5 First note that any arbitrary menu of price vectors can be represented by (at most) three variables, by the lowest $\overline{p}$ from those vectors in the menu which have $\overline{p} > \underline{p} + (\overline{c} - \underline{c})$ (we denote the lowest $\overline{p}$ in this class by $\overline{p}^l$), by the lowest $\underline{p}$ from those vectors in the menu which have $\underline{p} > \overline{p} - (\overline{c} - \underline{c})$ (we denote this $\underline{p}$ by $\underline{p}^l$), and by the lowest equal mark-up Δ from all equal mark-up vectors in the menu (denoted by Δ^l). To see this, divide the vectors in the menu in the mentioned three groups, i.e., in the group of $\overline{p} > \underline{p} + (\overline{c} - \underline{c})$ vectors, the group of $\underline{p} > \overline{p} - (\overline{c} - \underline{c})$ vectors, and the group of $\overline{p} - \overline{c} = \underline{p} - \underline{c}$ vectors. A consumer who decides for a vector in the first group has (by the arguments in the proof of Lemma 2) an expected utility of $v - \overline{p} - d$; thus, he chooses the vector with the lowest $\overline{p}$, and all other vectors in the group can safely be ignored since they attract no customers.[25] Similarly, the expected utility under a $\underline{p} > \overline{p} - (\overline{c} - \underline{c})$ vector is $(1 - h)\, v - \underline{p} - d$, and all vectors in the group but the one with the lowest $\underline{p}$ can be ignored since they are redundant. Finally, the expected utility under a vector with equal mark-ups of Δ is $v - \underline{c} - h(\overline{c} - \underline{c}) - \Delta - d$ and all vectors in the equal mark-up group but the one with the lowest Δ can be ignored. A first implication of this observation is that successful price discrimination requires that some types are mistreated with strictly positive probability. Why? Since at least two vectors must attract a positive measure of consumers and since only one of the two can be an equal mark-up vector. A second implication is that each menu of price vectors partitions the type-set into (at most) three subintervals (delimited by cut-off values $\widehat{h}$ and $\widetilde{h}$, with $0 \leq \widehat{h} \leq \widetilde{h} \leq 1$) such that (i) the optimal strategy of types in $[0, \widehat{h})$ is to choose the vector characterized by $\underline{p}^l$, (ii) the optimal strategy of types in $[\widehat{h}, \widetilde{h}]$ is to decide for the Δ^l vector, and (iii) the optimal strategy of types in $(\widetilde{h}, 1]$ is either to choose $\overline{p}^l$, or to remain untreated.[26] This follows from the fact that the expected utility under both, the Δ^l and the $\underline{p}^l$ vector, is strictly decreasing in h while the utility under $\overline{p}^l$ is a constant, and from $v > \overline{c} - \underline{c}$ (implying that the $\underline{p}^l$-function is steeper than the Δ^l function). Here, note that we allow for $\widetilde{h} = 1$ (all consumers are served and no consumer chooses $\overline{p}^l$), for $\widehat{h} = \widetilde{h}$ (no consumer is attracted by Δ^l), and for $\widehat{h} = 0$ (no consumer is attracted by $\underline{p}^l$). Price discrimination requires, however, that at lest two of the three relations hold as strict inequalities. Our strategy is now to show first that an optimal price-discriminating menu cannot have $\widehat{h} = \widetilde{h}$ (that is, there must be an equal mark-up vector which attracts a strictly positive measure of types), to show then that $\widehat{h} = 0$ whenever $\widehat{h} < \widetilde{h}$ (that is, the expert has never an incentive to post a menu where both an equal mark-up vector and a $\underline{p} > \overline{p} - (\overline{c} - \underline{c})$ vector attract types), and to show in the end that the expert has indeed always a strict incentive to cover a strictly positive interval $(\widetilde{h}, 1]$ by a $\overline{p}^l$ (that is, by a $\overline{p} > \underline{p} + (\overline{c} - \underline{c})$ vector). To see that $\widehat{h} < \widetilde{h}$, suppose to the contrary that $\widehat{h} = \widetilde{h}$. Then $\widehat{h} > 0$, since $\widehat{h} = \widetilde{h} = 0$ is incompatible with price-discrimination. But such a menu is strictly dominated, since the $\underline{p}^l$ vector can always be replaced

[25] Neither the consumer nor the expert cares about the associated $\underline{p}$. All vectors in the group that have the same $\overline{p}$ can therefore be thought off as being a single vector without any loss in generality.

[26] The borderline types $\widehat{h}$ and $\widetilde{h}$ are indifferent between the strategies of the types in the adjacent intervals (whenever such intervals exist).

by a vector with equal mark-ups of $\Delta = \underline{p}^l - \underline{c} + \widehat{h}(v - \overline{c} + \underline{c})$; the latter attracts exactly the same types as the replaced one and yields a strictly higher profit. To see that $\widehat{h} = 0$ whenever $\widehat{h} < \widetilde{h}$, suppose to the contrary that $0 < \widehat{h} < \widetilde{h}$. Then the expert's profit is strictly increased by removing all $\underline{p} > \overline{p} - (\overline{c} - \underline{c})$ vectors from the menu. This follows from the observation that all types in $[0, \widehat{h})$ switch to Δ^l when all $\underline{p} > \overline{p} - (\overline{c} - \underline{c})$ vectors are removed from the menu (by the monotonicity – in h – of the expected utility under Δ^l), and from the fact that the expected profit per customer is strictly higher under Δ^l than under $\underline{p}^l$ whenever $0 < \widehat{h} < \widetilde{h}$, since $\Delta^l \leq \underline{p}^l - \underline{c}$ is incompatible with the shape of expected utilities ($\Delta^l \leq \underline{p}^l - \underline{c}$ implies that $v - \underline{c} - h(\overline{c} - \underline{c}) - \Delta^l - d > (1-h)\, v - p^l - d$ for all $h > 0$ contradicting $\widehat{h} > 0$.) Thus, $\widehat{h} = 0 < \widetilde{h} \leq 1$. So, if price discrimination is observed in equilibrium it is performed via a menu that contains two price vectors, one with equal mark-ups, and one with a higher mark-up for the more expensive treatment.[27] We now show that the expert has always a strict incentive to post such a menu. Consider the equal mark-up price vector posted by the expert under the conditions of Lemma 4. With this one-vector menu all types in $[0, \widetilde{h})$ have a strictly positive expected utility under the equal mark-up vector and therefore opt for it. Type $\widetilde{h}$ is also treated since he is indifferent and since indifferent types choose to be served, by assumption. Types in $(\widetilde{h}, 1]$ would have a strictly negative expected utility under Δ^l and, therefore, decide not to visit the expert. Now, suppose the monopolist posts a menu consisting of two vectors, the one chosen under the conditions of Lemma 4 and a second with $\overline{p} = v - d$ and $\underline{p} < \overline{p} - (\overline{c} - \underline{c})$. This vector guarantees each type an expected utility equal to the reservation utility of 0. Thus, all types in $(\widetilde{h}, 1]$ will opt for it since they are indifferent. Also, all types in $[0, \widetilde{h}]$ still choose the equal mark-up vector since $v - \underline{c} - h(\overline{c} - \underline{c}) - \Delta^l - d \geq v - \overline{p}^l - d = 0$ for $h \leq \widetilde{h}$ (with strict inequality for $h < \widetilde{h}$). Hence, since $\overline{p} = v - d > \overline{c}$ (the strict inequality follows from our assumption that it is *ex ante* efficient to treat all types), and since all types in $[0, 1]$ have strictly positive probability, the expert's expected profit is increased. Furthermore, the expert can do even better by increasing Δ^l. This follows from the observation that the expert's trade-off under the conditions of Lemma 4 is between increasing the mark-up charged from the types in the segment of served customers and losing some types to the unprofitable segment of not served consumers, while

[27] The menue might contain some redundant vectors too, which can safely be ignored, however.

the trade-off here is between increasing the mark-up charged from the types in the segment of customers served under the more profitable equal mark-up vector and losing some types to the segment of customers served under the less profitable $\overline{p} > \underline{p} + (\overline{c} - \underline{c})$ vector. ■

Proof of Lemma 6 For the proposed strategy configuration to be a potential candidate for a sequential equilibrium scenario the probabilities o and a, and the prices $\underline{p}$ and $\overline{p}$ must satisfy

$$d = (\overline{p} - \underline{p})\frac{(1-o)\,o\,(1-h)}{h + (1-h)\,o}$$

and

$$(\underline{p} - \underline{c}) = (\overline{p} - \underline{c})\frac{a + o\,(1-a)}{1 + o\,(1-a)}.$$

The first of these two equations guarantees that consumers who get a $\overline{c}$ recommendation are indifferent between accepting and rejecting: If they reject, they incur an additional diagnosis cost of d for sure. Their benefit is to pay less for the treatment on their second visit with probability $[(1-o)\,o\,(1-h)]/[h + (1-h)\,o]$ because they have the minor problem with probability $[o\,(1-h)]/[h + (1-h)\,o]$ given that the expert has recommended $\overline{c}$. The second equation guarantees that experts are indifferent between recommending $\underline{c}$ and recommending $\overline{c}$ when the consumer has the minor problem: Recommending the cheap treatment guarantees a profit of $\underline{p} - \underline{c} = \Delta > 0$ for sure, while recommending the expensive treatment when only the cheap one is required is like playing in a lottery yielding a payoff of $\overline{p} - \underline{c} > \Delta$ with probability $[a + o\,(1-a)]\,/[1 + o\,(1-a)]$, and zero otherwise. This probability takes into account that a fraction $1/[1 + o\,(1-a)]$ of customers is on their first visit (and hence, is accepting the $\overline{c}$ recommendation with probability a), while the remaining fraction $o\,(1-a)\,/[1 + o\,(1-a)]$ is on their second visit (accepting the $\overline{c}$ recommendation for sure). To show that the proposed candidate is really a sequential equilibrium scenario we have to specify reasonable (in the sense of being consistent with equilibrium play in the continuation game) out-of-equilibrium beliefs and strategies that support the equilibrium. Let k denote the expected cost to the customer if he follows the proposed equilibrium strategy; that is, $k = \underline{p} + (\overline{p} - \underline{p})[h + (1-h)\,o] + d$. Similarly, let π denote the profit per customer if experts follow the proposed equilibrium strategy; that is, $\pi = (1-h)[1+o(1-a)](\underline{p}-\underline{c})+h(\overline{p}-\overline{c})$. Rest of the proof still missing! ■

Proof of Lemma 7 The proof is very similar to that of Wolinsky (1993)'s Proposition 1, the only difference being that experts can reject to provide a treatment after having conducted the diagnosis in the Wolinsky model, while they cannot reject in our present framework. To show that the proposed scenario is part of a sequential equilibrium we have to specify reasonable (in the sense of being consistent with equilibrium play in the continuation game) out-of-equilibrium beliefs and strategies that support the equilibrium. Let k denote the expected cost to the customer if he follows the proposed equilibrium strategy; that is, $k = d + (1-h)\underline{c} + h(\overline{c}+d)$. Suppose that customers believe (i) that an expert always provides the appropriate treatment independent of her original treatment-recommendation; (ii) that an expert's recommendation (and charging) policy is honest if her posted prices satisfy either $\underline{p} = \overline{p} < \underline{c}+d$ or $\overline{p} > \overline{c}+d$ and $\underline{p} < \overline{c}$; (iii) that the expert always recommend $\underline{c}$, and that customers believe that they have the major problem if the expert recommends $\overline{c}$, if $\overline{p} > \overline{c}+d$ and $\underline{p} > \overline{c}$; (iv) that the expert recommends $\overline{c}$ if the customer has the major problem and that she randomizes between recommending $\underline{c}$ and recommending $\overline{c}$ if he has the minor problem (and that the randomization is such that a customer who gets a $\overline{c}$ recommendation is indifferent between accepting and rejecting) whenever $\overline{p} \in (k+d)$ and $\underline{p} \in (\underline{c}, \underline{c}+d)$; and (v) that the expert always recommends $\overline{c}$, and that customers believe that they have the minor problem if the expert recommends $\underline{c}$, in any other case. Further suppose that customers who visit an expert who has posted a price-vector where $\overline{p} > \overline{c}+d$ and $\underline{p} > \overline{c}$ accept a $\underline{c}$ recommendation if $\underline{p} \leq k$ and reject it otherwise, and that customers who visit other experts accept a $\underline{c}$ recommendation if $\underline{p} \leq \underline{c}+d$ and reject it otherwise. Also suppose that customers who visit an expert who has posted a price vector satisfying $\overline{p} < k$ accept a $\overline{c}$ recommendation with certainty; that customers who visit an expert who has posted a price vector satisfying $\overline{p} \in (k, \overline{c}+d)$ and $\underline{p} < \underline{c}+d$ accept a $\overline{c}$ recommendation with a strictly positive probability that keeps the expert indifferent between recommending $\underline{c}$ and recommending $\overline{c}$ whenever the customer has the minor problem; and that customers who visit other experts reject a $\overline{c}$ recommendation with certainty. Finally suppose that customers behave in accordance with the proposed sequential equilibrium scenario provided no deviating expert offers either $\underline{p} < \underline{c}$ and $\overline{p} > \overline{c}+d$, or $\overline{p} < \overline{c}$, and that experts behave in accordance with consumers' beliefs. First observe that customers beliefs reflect experts' incentives: Under the conditions of Lemma 7, liability prevents undertreatment and the cost difference $\overline{c}-\underline{c} > 0$ prevents overtreatment. So each expert will always provide the appropriate treatment if the customer agrees to proceed after the diagnosis. An expert might, however, recommend the wrong treatment in the hope to be able to charge a higher price. Whether an expert has an incentive to do this, depends on her posted prices and on customers' acceptance behavior. The expert recommends honestly if $\overline{p} < \underline{c}+d$ and $\underline{p} = \overline{p}$, and if $\overline{p} > \overline{c} + d$ and $\underline{p} < \overline{c}$, either since both recommendations are accepted and have the same price (in the former case), or since consumers prefer to leave after a $\overline{c}$ recommendation and recommending the cheap treatment to a customer who has the major problem is not profitable (in the latter case); the expert always recommends $\underline{c}$ if $\overline{p} > \overline{c}+d$ and $\underline{p} > \overline{c}$, since a $\overline{c}$ recommendation is always rejected and since the price of the cheap treatment exceeds the cost of the expensive one; the expert recommends $\overline{c}$ if the consumer has the major problem and she randomizes between recommending $\underline{c}$ and recommending $\overline{c}$ if he has the minor problem whenever $\overline{p} \in (k, \overline{c} + d)$ and $\underline{p} \in (\underline{c}, \underline{c} + d)$ since the $\underline{c}$ recommendation is always accepted while the $\overline{c}$ recommendation is rejected with such a probability that she is exactly indifferent between both recommendations (by construction); and the expert recommends the expensive treatment in all other cases, either because the expensive treatment is accepted with certainty and $\overline{p} > \underline{p}$, or because both types of treatment are rejected anyway. Next observe that customers' strategies are optimal given their beliefs: First consider consumers' acceptance strategies. If a single expert deviates the proposed equilibrium offers are still available since at least two experts make each offer. Thus, the above described acceptance strategies are optimal given consumers' beliefs. Next consider consumers' visiting strategy. If no expert deviates the relevant alternatives are (i) to visit a cheap expert first and to reject the $\overline{c}$ recommendation as proposed, or (ii) to visit an expensive expert first and to accept the $\overline{c}$ recommendation. The former strategy has an expected cost of $d + (1-h)\,\underline{c} + h\,(\overline{c} + d)$, the latter a cost of $\overline{c}+d$, while the benefit is the same. Since $(\overline{c} - \underline{c})\,(1-h)\,/h > (\overline{c} - \underline{c})\,(1-h) > d$ the former cost is strictly lower and customers' visiting strategy is optimal if no expert deviates. Given that the equilibrium offers are still available if a single expert deviates, and given the above specified beliefs, no customer has an incentive to visit a deviating expert if her posted prices exceed the respective marginal cost. Finally observe that no expert has an incentive to deviate: Deviations to prices satisfying $\underline{p} < \underline{c}$ and $\overline{p} > \overline{c} + d$ are unattractive since only the $\underline{c}$ recommendation is accepted. Deviations to price vectors where $\underline{p} \geq \underline{c}$ and $\overline{p} \geq \overline{c}$ are unattractive since they attract no customers. Price vectors where $\overline{p} < \overline{c}$ are unprofitable too, if they only attract customers who first visit a cheap expert, and, if recommended the expensive treatment, resort to the deviator. The expected cost to the customer of this latter strategy is $d + \underline{c} + h(\widehat{p} + d - \underline{c})$, where $\widehat{p}$ is the price posted by the deviator for the expensive treatment. Going directly to the deviator and accepting her recommendation, on the other hand, costs at most $\widehat{p}+d$. Thus, in order to avoid being visited only by $\overline{q}$ consumers, the deviation must satisfy $d + \underline{c} + h(\widehat{p} + d - \underline{c}) > d + \widehat{p}$, which is equivalent to $\widehat{p} < \underline{c} + dh/(1-h)$. To cover expected treatment cost the price $\widehat{p}$ must also satisfy $\widehat{p} \geq \underline{c} + h(\overline{c} - \underline{c})$. But, $\underline{c} + h(\overline{c} - \underline{c}) > \underline{c} + dh/(1-h)$, since $(1-h)(\overline{c} - \underline{c}) > d$. This proves that no deviation by an expert is profitable. ■