Credence Goods, Costly Diagnosis, and Subjective Evaluation*

Short Title: Credence Goods and Subjective Evaluation

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We study contracting between a consumer and an expert in a credence goods model when (i) the expert's choice of diagnosis effort is not observable, (ii) the expert might misrepresent his private information about the adequate treatment, and (iii) payments can depend only on the consumer's subjective evaluation of treatment success. We show that the first–best solution can *always* be implemented if the parties' discount factor is equal to one; a decrease in the discount factor makes obtaining the first–best more difficult. The first–best is also always implementable if separation of diagnosis and treatment is possible.

This paper analyses the optimal design of contracts between a consumer and an expert in a credence goods environment, where the consumer relies on the expert's private information in order to choose one of two services (or treatments). There are three incentive problems: First, there is a *moral hazard problem* because the expert's diagnostic effort is not observable.

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Therefore, the contract should induce the expert to invest in costly information acquisition. Second, only the expert knows the diagnosis information and so the contract has to provide the expert with incentives for *truthful reporting*. Third, there is a *problem of subjective evaluation*. As success and failure are only observed by the consumer and not publicly verified, payments for treatments can only rely on the consumer's subjective evaluation, which might be misrepresented. Large parts of the credence goods literature focus on problem of truthful reporting by the expert in the absence of the moral hazard problem of diagnosis effort and the problem of subjective evaluation by the consumer. We provide conditions under which the first–best can be reached in the presence of these two additional incentive problems. We show that this is possible if the parties' discount factor is close enough to one so that the consumer does not care too much about a delay in the solution of the problem. Interestingly, independently of the discount factor, the first–best can *always* be obtained if it is possible to separate diagnosis and treatment by employing different experts for each task.

The environment considered is the by now standard credence good problem.[1] In such a situation there is an important information asymmetry between the consumer and the expert. Even if the consumer can determine which service he received, he does not know whether he really needed an expensive high quality service or whether a less costly service of lower quality would have been sufficient. Consequently, incentives for opportunistic behaviour arise, because a self-interested expert who also provides the service might give inappropriate advice and remain undetected. Two types of inefficiencies can appear. On one hand, the quality of the treatment can be too low and not solve the consumer's problem; we refer to this as *undertreatment*. On the other hand, *overtreatment* might occur, because when only low quality is needed, high quality is not valued higher than low quality.

These inefficiencies have potentially important implications. As many other countries, over recent years the U.S. experienced large increases in health care spending that many

[1]The concept of credence goods was introduced by Darby and Karni (1973). Unlike experience goods, a credence good has important properties that the consumer cannot detect even after consumption and the consumer relies on the advice of the seller. Classical examples include medical and legal advice, a variety of repair services, real estate services or taxi services. More recent applications of the concept of credence goods include technologically advanced consumption goods with many options (Dulleck and Kerschbamer, 2009), the newspaper industry (Gabszewicz and Resende, 2012), auditing services (Causholli *et al.*, 2013; Knechel 2013), financial services (Brown and Minor, 2012), contracting for infrastructure projects (Dulleck *et al.*, 2015), and fiscal restraints in public finance (Dulleck and Wigger, 2015).

think are unsustainable. Dr. Donald M. Berwick, a former administrator of the Centers for Medicare and Medicaid Services, listed overtreatment as one of the key reasons for 'waste' in health care, saying that: 'Much is done that does not help patients at all, and many physicians know it'.[2] In fact, in Berwick and Hackbarth (2012, p. 1514) he writes that overtreatment is 'the waste that comes from subjecting patients to care that, according to sound science and the patients' own preferences, cannot possibly help them—care rooted in outmoded habits, supply-driven behaviors, and ignoring science. Examples include excessive use of antibiotics, use of surgery when watchful waiting is better, and unwanted intensive care at the end of life for patients who prefer hospice and home care. We estimate that this category represented between $ 158 billion and $ 226 billion in wasteful spending in 2011'.[3]

It is well known that in the credence good problem the first–best can be reached, provided the expert can determine the consumer's type of problem without incurring any cost to himself (Dulleck and Kerschbamer, 2006). In order to do so the contract has to establish equal markup payments, which make the expert indifferent between treatments. Unequal markups would bias the expert towards one alternative, precluding truthful reporting. We depart from this credence good setting in three ways.

First, we depart from much of the credence goods literature by endowing the expert with a potentially less efficient diagnosis technology. First of all, we suppose that becoming informed before choosing a treatment requires exerting costly diagnosis effort. This creates a *moral hazard problem* because whether effort has been exerted is not observable. As a result, equal markup contracts no longer provide effort incentives. The reason is that the expert gains the markup if he chooses based on prior information, while this markup is reduced by the effort cost when he exerts diagnostic effort. Moreover, we allow the expert's

[2] See e.g. Robert Pear, 'Health Official Takes Parting Shot at Waste', The New York Times 3, December 2011. For a discussion of the conceptual difficulties in identifying wasteful health care spending see Fuchs (2009). The ABIM Foundation (established by the American Board of Internal Medicine, an organization certifying physicians specializing in internal medicine) has started the initiative Choosing Wisely that aims to reduce overuse of tests and procedures, see www.choosingwisely.org, accessed on 26/10/2016.

[3] Kale *et al.* (2011) look at that the top 5 overused clinical activities across 3 primary care specialties (pediatrics, internal medicine, and family medicine) and report that these activities are common in primary care although they provide little benefit to patients. They conclude that the associated costs of these activities exceed $ 5 billion.

signal to be noisy. Under- and overtreatment might thus occur, even if the expert invests in information and reports it truthfully, as his signal is not always correct.

Second, we follow Dulleck and Kerschbamer (2009) and consider sequential treatments. In addition, we allow for delay costs. Usually, the game ends when the consumer experiences undertreatment. In reality, however, the interaction between the consumer and the expert is unlikely to end if the consumer's problem is not solved. A patient, for instance, whose health problem persists after a non-invasive intervention (say knee injections) might well revisit the expert and ask for a surgical procedure. We assume that after the low-cost treatment failed, the consumer's problem may be solved by applying the high-cost treatment in a second period. Undertreatment causes therefore two types of costs. On one hand, the first period low–cost treatment is wasteful, and, on the other, it delays the solution of the consumer's problem. We measure this delay cost by $1-\delta$, where δ is the parties' common discount factor. When the discount factor is close to zero, undertreatment involves substantial delay cost, and in the extreme $\delta = 0$ we recover the standard setting considered in the survey by Dulleck and Kerschbamer (2006). The other extreme is reached for $\delta = 1$, so that undertreatment involves no delay cost at all.[4]

Third, we connect the credence good problem to the literature on contracting with subjective evaluation. As already mentioned, we assume that treatment choices are verifiable and contractible. This assumption is likely to hold when the consumer needs no specific expertise to identify treatments, as in the aforementioned examples of knee injections and surgical procedures (when informed consent must be given).[5] In addition, we suppose that

[4]To the best of our knowledge only Dulleck and Kerschbamer (2009) consider a model of credence goods and allow for sequential treatments. Liu and Ma (2013) provide a model of medical treatment decisions with treatments potentially applied in sequence. Both papers consider only the extreme case in which the discount factor is one. This precludes delay costs, which – as we will see – play an important role in our setting. There are also credence goods models in which the expert is liable to solve the problem of the consumer; see Dulleck and Kerschbamer (2006) for references. This is related to our model, because we assume that after failure of the low-cost treatment the consumer can request the high-cost treatment from the expert. Following Hilger (2016), who notes that liability can be defined as infinite punishment, our setting appears to be a weak form of liability.

[5]Dulleck and Kerschbamer (2006, p. 16) write that 'The verifiability assumption is likely to be satisfied in important credence goods markets, including dental services, automobile and equipment repair, and pest control. For more sophisticated repairs, where the customer is usually not physically present during the treatment, verifiability is often secured indirectly through the provision of ex post evidence. In the automobile

- even though the consumer might be able to observe the outcome of treatment as private information - it is impossible to verify treatment success in court.[6] As already mentioned, however, the interaction between the consumer and the expert is unlikely to end if the consumer experiences undertreatment. We therefore assume that undertreatment can have consequences for the expert. More precisely, we assume that payments for the low-cost treatment can be made contingent on the consumer's subjective report of the outcome, that is, on whether he reports success or failure. Since this report might potentially be misrepresented, a *problem of subjective evaluation* arises.

We analyse whether the consumer can choose the payments for treatments in such a way that delegating the choice of treatment to the expert avoids the two-sided incentive problem.[7] The motivation for this approach is the following. In our model treatments are contractible. Following the Revelation Principle, the contracting problem can then be stated as a direct mechanism design problem, where the consumer's and the expert's payoffs are derived from the basic credence goods problem described in Dulleck and Kerschbamer (2006, Table I, p. 11). Consequently, it is optimal to specify contract terms depending on the expert's reports, subject to the requirement that it must be incentive compatible for him to reveal his information truthfully. Therefore, it is also optimal to delegate the choice of treatment to the expert. A second feature implied by our approach is similar to Liu and Ma (2013) in that contractual payments are specified over the entire diagnosis and treatment relation. This specification allows the payment for the high-cost treatment in the second period (after failure of the low-cost treatment) to differ from the payment for using high-cost treatment directly in the first period.

It is not unrealistic that payments are specified over the entire diagnosis and treatment

repair market, for instance, it is quite common that broken parts are handed over to the customer to substantiate the claim that replacement, and not only repair, has been performed. Similarly, in the historic car restoration market the type of treatment is usually documented step by step in pictures'. See also Dulleck and Kerschbamer's discussion on p. 31.

[6]This difficulty has been recognised in the literature. Dulleck and Kerschbamer (2006, p. 32) write that '...treatment success is often impossible or very costly to measure for a court, while still being observed by the consumer (how can one prove the presence/absence of pain, for instance). In such a situation, a patient may misreport treatment success ...'.

[7]There is evidence that financial incentives affect professional recommendations, including studies on health services (Donaldson and Gerard, 1989; Henning-Schmidt *et al.*, 2011; Clemens and Gottlieb, 2014) and financial services (Brown and Minor, 2012; Mullainathan *et al.*, 2012).

relation. For example, Berenson *et al.* (2012, p. 1365) discuss hospital readmissions of Medicare beneficiaries and propose to create 'a single-episode price for all services associated with a surgical procedure, such as coronary-artery bypass grafting, including the initial hospitalization and all related services for 90 days, including any rehospitalizations — in essence, a warranty' in order to improve care and reduce spending. They report that similar programs are in place Britain, Germany and Maryland. Similarly, it is not unrealistic that payments to healthcare providers might depend on performance measures including patient satisfaction data that can be interpreted as subjective evaluation. Salisbury (2009) discusses the quality and outcomes framework in the United Kingdom in which the pay of general practitioners is partly based on performance, including patient experience.

Our main result highlights the importance of delay costs. If $\delta = 1$ so that undertreatment involves no delay cost, then the first–best is *always* implementable by a contract. If, however, $\delta < 1$, then the first–best is still implementable when effort costs are either high or low. For situations with intermediate effort costs in combination with a relatively uninformative prior, however, only a second–best outcome is implementable. The intuition for this result is based on the interplay of the problems of *moral hazard* and *subjective evaluation*. On the one hand, avoiding the former and endowing the expert with efficient information acquisition incentives requires that his reward in the event of failure of the low–cost treatment should be small enough in order to reflect delay cost. On the other hand, if payments after failure are too low, then the consumer has no incentive to reveal the success of the low-cost treatment truthfully and the latter problem cannot be avoided. Consequently, the conflict between the requirements grows with delay costs and the requirements can only be reconciled when these costs vanish.

We turn then to an extension of our model in which it is possible to separate diagnosis and treatment. This is a reasonable assumption in situations in which diagnosis and treatment are to a large extent two independent procedures. For example, prescribing and vending of drugs are independent activities and can therefore be carried out by different agents (doctors and pharmacies). In other situations, however, such a separation is not reasonable, as when treatment is more or less a by-product of diagnosis (like some surgical procedures).[8] We show that when separation is possible, then the first–best is always im-

[8]Dulleck and Kerschbamer (2006) provide further examples for situations in which separation is likely to be feasible and when it is not. Emons (1997) relates the feasibility of separation to the existence of economies

plementable. The intuition is that separate payments for diagnosis and treatment allow for more flexibility to cope with the joint problems of *diagnosis incentives* and *subjective evaluation*. The trade-off between both problems can be solved in the following way. In the event of failure, the expert making the diagnosis can receive a small payment so that information acquisition is induced, while the expert providing the treatment receives a large amount so that total payments to both experts are high enough to give the consumer incentives for truthful reporting.

Although our model is very stylised, it allows us to draw policy implications. In situations in which diagnosis and treatment are jointly provided, it recommends contracts that resemble a *prospective payment system* and contributes hence to the discussion whether a retrospective or a prospective payment system is optimal.[9] Under a prospective system payments have no link to the real costs of treatments, while under a retrospective system reimbursement is based on real treatment costs. The standard argument in favour of a prospective payment system is that a fixed budget contains health care costs, because it breaks the link between the expert's income and the number of treatments provided. Our argument focuses on a moral hazard problem in providing diagnosis and is therefore different. Our analysis also recommends that contractual payments should be based on treatment protocols, rather than on each treatment in isolation. Payments for the low-cost treatment should include a reimbursement for a potentially necessary high-cost treatment. This mimics the so-called *payments per case* to both individual providers, like general practitioners, or institutional providers, like hospitals.[10] In addition, our model recommends equal markup payments on treatment protocols that are based on the expected costs of a sequence of

of scope between diagnosis and treatment, while Pesendorfer and Wolinsky (2003) propose a formalization that is based on whether a recommendation identifies uniquely the service to be performed. Separation has already been discussed by Darby and Karni (1973) as a solution to the problem of fraud by experts, because an expert has only an incentive to recommend unnecessary treatment if he also provides it. As observed by Wolinsky (1993, p. 387), 'Such arrangements, however, would raise new problems regarding the proper incentives for the diagnostician and hence might not be easily sustainable'. In our setting the expert must not only be provided with incentives to give correct advice, but also to exert costly diagnostic effort in the first place.

[9]Much of the following discussion is based on the definitions provided in Jegers *et al.* (2002).

[10]An important example for payments per case to institutional providers are Diagnostic Related Groups Systems (DRG-system) for hospitals. This system has been used in the U.S. (Medicare), Canada, or Germany, among others (Jegers *et al.*, 2002). An example for payments per case to individual providers is a so-called integrated system, like the British general practitioner fundholder system. Here primary care doctors might

treatments. Prospective reimbursement systems with this feature are called *cost-neutral*. Cost-neutrality is usually justified by a concern to avoid that patents receive the least costly treatment option. Our argument is again different, since it recognises the existence of diagnosis costs and is based on a concern to provide incentives for information acquisition. Taking all together, our model provides support for a prospective reimbursement payment system in which reimbursement is per case and cost-neutral. This stands in stark contrast to the standard credence good model which recommends a retrospective payment system with equal markup payments for real treatment costs.

In some situations it is possible to separate diagnosis and treatment, because they are two largely independent procedures. In these cases our analysis provides novel theoretical support for separation, complementing existing explanations. For example, in their discussions of separation between doctors and pharmacies, Darby and Karni (1973) and Dulleck and Kerschbamer (2006, p. 8) focus on the incentive problem of revealing the diagnosis outcome and argue that breaking up the joint provision of diagnosis and treatment avoids overtreatment. In contrast, in our framework separation alleviates also moral hazard in investing in diagnosis effort and the tension between this problem and the problem of subjective evaluation.

Related Literature

The literature on credence goods focusses on the avoidance of fraud. Since the result of diagnosis is unobserved, opportunistic advice might result in inappropriate treatment. We follow a strand of the literature that assumes treatment decisions are observable. As mentioned earlier, fraud might then occur when treatments have different markups, as the expert might misrepresent the required treatment.[11] A second strand of literature assumes that the treatment provided is not observable. This gives rise to a different type of fraud, in which the low-cost treatment is provided but misrepresented as a high-cost one.[12] In addition, a social loss from the problem remaining insufficiently treated may arise.[13]

get a payment in advance and in return have to provide comprehensive health care that might require buying hospital care or drugs when needed.

[11] See Darby and Karni (1973), Emons (1997, 2001), De Jaegher and Jegers (2001), Frankel and Schwarz (2014), Fong *et al.* (2014), and Hilger (2016).

[12] See Darby and Karni (1973), Pitchik and Schotter (1987, 1993), Wolinsky (1993, 1995), Sülzle and Wambach (2005), Alger and Salanié (2006), Hyndman and Ozerturk (2011).

[13] See Fong (2005), Liu (2011).

These models assume that the expert is perfectly informed, without incurring any costs. Consequently, they abstract from the moral hazard problem we consider.[14] When such a moral hazard problem is considered, equal markups no longer achieve the first–best and the question how the credence good environment should be designed arises. The theoretical literature considering this question is very small.[15]

Similar to us, Pesendorfer and Wolinsky (2003) assume that success and failure of treatment are unobservable and unverifiable, but they do not consider the problem of subjective evaluation. In contrast to our model, in which treatments are vertically differentiated, in their setting differentiation is horizontal so that the problem of overtreatment cannot appear. In addition, treatments are equally costly and experts have no incentive to misrepresent the required treatment, once it is diagnosed. This isolates the problem to provide incentives to invest in costly diagnostic effort, when contrary to us the diagnostic signal is assumed to be perfectly precise. Pesendorfer and Wolinsky explore how competition between experts can allow consumers to obtain multiple diagnoses and whether this competition can provide experts with effort incentives. Their main result is that the equilibrium is inefficient. In contrast, we provide conditions under which the first–best can be reached. In an extension, Pesendorfer and Wolinsky (2003) also discuss briefly the case when it is possible to separate diagnosis and treatment. Interestingly, they show that the outcome remains inefficient, while our extension to such a setting shows that the first–best is always implementable. In this sense, our result emphasises the potential of multiple experts to *specialise* in diagnosis and treatment rather than to *compete* with one another, as in Pesendorfer and Wolinsky.[16]

[14]Dulleck and Kerschbamer (2006) review this literature in a unified model. Our model generalises their setting in the three dimensions explained above. The limiting case of our model when (i) the expert's signal is costless as well as perfectly precise; (ii) treatments cannot be applied in sequence (that is, the discount factor δ vanishes); and (iii) contractual payments are restricted to depend only on the choice of treatment, recovers the setting in Dulleck and Kerschbamer (2006) in which their assumptions H (Homogeneity), C (Commitment), and V (Verifiability) hold and their Lemma 1 applies.

[15]Bonroy *et al.* (2013) also analyse a credence good problem and look at incentives for costly diagnostic effort. The problem considered is different from ours, however, because effort is observable. The papers by Demski and Sappington (1987), Taylor (1995), and Malcomson (2004) investigate costly diagnostic effort in settings different from the credence goods environment with observable treatments that we consider.

[16]Notice that this specialization result is different from (vertical) specialization results in the second strand of literature mentioned above, in which treatment decisions are unobservable. In Wolinsky (1993) or Alger and Salanié (2006) some experts provide only the minor treatment, while others specialise in the major treatment.

Dulleck and Kerschbamer (2009) investigate the incentives of experts to exert diagnostic effort and to report truthfully when they face competition from chain stores or discounters. Their analysis has thus a very different focus from ours. In their model, however, effort is costly and treatments can be applied in sequence. There are three main modeling differences. First, in their paper the expert's signal is perfectly precise, whereas we allow for noise. This generalization is not only realistic but also potentially important. Without noise the low-cost treatment is less attractive to the expert, because when the treatment fails one can infer that he did not exert diagnostic effort.[17] Second, in Dulleck and Kerschbamer (2009) success and failure of treatment are observable and verifiable. We will later explain that under this assumption the first-best can always be obtained in our model, even though diagnosis effort is not observable. Third, in their paper there are no delay costs and as a byproduct Dulleck and Kerschbamer describe contracts that provide effort incentives. This is consistent with our result that the first–best can be achieved when there are no delay costs. Our analysis goes beyond their result and shows that when failure is not verifiable and delay costs are introduced, a tension between the problems of *moral hazard* and *subjective evaluation* arises, so that the first–best can no longer be achieved for some parameter combinations.

Finally, our paper is related to the literature on subjective evaluation, which addresses the problem of providing of effort incentives for the agent in situations where only the principal privately observes some performance measure. This applies to our context because the expert has to invest effort in identifying the appropriate treatment, and only the consumer learns the outcome of the treatment. Some part of the literature studies subjective evaluations in models of repeated interactions, where intertemporal incentives play a key role.[18] Our model is more closely related to MacLeod (2003), who like us considers a single interaction between a principal and an agent. He shows that effort incentives can be created only if the contract specifies some ex post inefficiencies that are formally equivalent to 'money burning', i.e. payments to a passive third party. Such payments allow punishing the agent for poor performance without distorting the principal's truthful subjective evaluation. In contrast, our analysis is confined to budget balanced contracts and excludes third-party payments. Nonetheless, even under joint provision of diagnosis and treatment, the first–best

[17] Since the second treatment is observable, it becomes public that the expert has violated the contract by not acquiring information.

[18] See e.g. Baker *et al.* (1994), Pearce and Stacchetti (1998), Levin (2003), Fuchs (2007).

can be achieved at least for some range of parameter combinations. A main driver for this efficiency result is that the expert can be punished for failure by contractually obliging him to provide the high–cost service if the consumer reports failure of the low–cost service. The consumer, however, does not benefit from this punishment if his problem has been solved already by the low–cost treatment, because after a successful treatment he does not gain in utility from an additional treatment. These two properties of our model eliminate the tension between the consumer's truth-telling constraint and the expert's incentive constraint for $\delta = 1$, and soften it for $0 < \delta < 1$. Under separation of diagnosis and treatment the first–best can be obtained for all values of δ. As we explain in Section 4, the intuition for this efficiency result is that the expert for treatment acts as a budget breaker, in a similar way to the outside party in MacLeod (2003).

This paper is organised as follows. The next section describes the credence goods problem and our assumptions on observability and contracts. In Section 2 we characterise the first–best decision. Section 3 analyses optimal contracts and establishes our main result. In Section 4 we extend our model to a situation in which it is possible to separate diagnosis and treatment. Finally, we conclude in Section 5.

1 The Model

1.1 The Credence Good Problem

Consider the by now standard credence good problem. An expert potentially knows more about the quality of a good or service that a consumer needs than the uninformed consumer himself.[19] In terms of the principal–agent literature, the consumer is the principal and the expert the agent.

More precisely, the consumer needs one of two services (or treatments), depending on his type. If the consumer has the minor problem θ_L, then the low-cost treatment T_L is sufficient. The problem might, however, be important, denoted by θ_H. In this case the high-cost treatment T_H is needed, as the low-cost service does not help. This formalises one type of choice in health care that is often considered to lead to wasteful expenditures. Discussing waste in health care, Fuchs (2009) gives the following example for a choice between a high-cost procedure and a less expensive alternative: 'high-cost drug-eluting stents may be

[19] See the survey by Dulleck and Kerschbamer (2006).

the better choice for some patients, but others would do just as well with less expensive bare-metal stents' (p. 2481). Formally, the consumer's gross utility u^P depends on his type $\theta \in \{\theta_L, \theta_H\}$ and the treatment $T \in \{T_L, T_H\}$ according to[20]

$$u^P(\theta, T) = \begin{cases} 0 & \text{if } \theta = \theta_H \text{ and } T = T_L \\ v > 0 & \text{otherwise.} \end{cases}, \tag{1}$$

We refer to the combination (θ_H, T_L) as *undertreatment:* the consumer discovers ex post that he has the major problem and that the service T_L is insufficient. When the minor problem is solved through the high-cost treatment in the combination (θ_L, T_H), we speak of *overtreatment*, as the low-cost service would have been sufficient.

The consumer is uncertain as to which service is the correct one. But he knows the prior probability

$$\text{Prob}(\theta_L) = 1 - \text{Prob}(\theta_H) = q. \tag{2}$$

The outside option of the consumer is not to be treated at all, giving zero utility to both consumer and expert.

Also the expert a priori only knows (2). But he can acquire additional information about the consumer's problem to identify the appropriate treatment. To do so he needs to exert effort at a cost $c \geq 0$, which enables him to privately observe a signal $s \in \{s_L, s_H\}$ about the consumer's problem θ. The signal is correct with probability σ, i.e.

$$\text{Prob}(s_L|\theta_L) = \text{Prob}(s_H|\theta_H) = \sigma, \quad \text{Prob}(s_L|\theta_H) = \text{Prob}(s_H|\theta_L) = 1 - \sigma, \tag{3}$$

with $\sigma > 1/2$. If the expert exerts no effort, he incurs no cost but learns nothing. These assumptions generalise the previous literature on credence goods which assumed either $c = 0$ or $\sigma = 1$ or both. The effort cost c can also be interpreted as the opportunity costs of time. Physicians often complain that changes in reimbursement oblige them to see more patients per day, thereby making it more difficult to conduct proper diagnosis.[21]

[20]The assumption that when the problem is important the low-cost treatment never solves it, while the high-cost treatment solves it with probability one, is standard in the credence goods literature. It seems, however, stronger than needed. Suppose the low–cost treatment has a small and the high–cost treatment a high probability of solving the major problem respectively. Then it can be shown that our main result that the first–best can be reached, provided delay costs are absent, is still true.

[21]See e.g. Sandeep Jauhar, 'Busy Doctors, Wasteful Spending', The New York Times 20, July 2014.

Once the consumer was treated in the first period and experienced undertreatment, in a second period he can request the high-cost treatment, which will then solve his problem. We introduce the discount factor $\delta \in [0,1]$, in order to capture that the consumer prefers his problem to be solved in period 1 rather than in period 2. A special case is when $\delta = 0$ and only one treatment can be applied. This might be because the treatment is urgent (the consumer is extremely impatient) or the first treatment is irreversible. For simplicity we assume that the consumer and the expert share a common discount factor.

Abusing notation we indicate also the treatment costs by T_L and T_H. Unless explicitly stated otherwise, we assume that $v > T_H > T_L \geq 0$, $q \in (0,1)$, $c > 0$, $\delta > 0$, and $\sigma > 1/2$. The values of these parameters are common knowledge.

1.2 Observability and Contracts

We assume that the expert's choice of treatment is observable. As mentioned in the Introduction, this is likely to hold when no specific expertise is required to identify treatments. Therefore, a contract can stipulate that he selects treatment T_H for a payment p_H in the first period. Since it is commonly known that this solves the consumer's problem, under this contract the principal–agent relation ends at the end of the first period.

Also, a contract can specify that the expert selects treatment T_L in the first period. We assume, however, that success and failure are not publicly observable. The consumer privately learns whether this treatment has been successful or not at the end of the first period. Therefore, the payment for treatment T_L can only depend on a *subjective evaluation* $R \in \{S, F\}$ of the consumer, where S indicates 'success' and F 'failure'. Thus, if the expert selects treatment T_L, he receives the payment p_{LS} if the consumer reports S and p_{LF} otherwise. This captures for example health problems for which it is difficult to measure treatment success objectively. Dulleck and Kerschbamer (2006) mention the difficulty of proving the absence of pain as an example. It is less appropriate when an objective test exists, like in the case of cancer screening.

Since $v > T_H$, a contract optimally entitles the consumer to treatment T_H in the second period upon failure of treatment T_L in the first period. Without loss of generality, there are no additional payments for the second treatment. This means that the payment p_{LF} is the reimbursement for treatment T_L in the first period and T_H in the second period.[22] As the

[22]If the consumer has to pay p'_{LF} for the first and p'_2 for the second treatment, this is equivalent to a single

consumer can misreport a successful treatment, for completeness we also have to specify his utility for the case where he demands T_H even though his problem has been solved by T_L in the first period. We assume that in this case a second treatment in period 2 does not affect the consumer's gross utility, i.e. his gross payoff remains v at the end of period 1.[23]

Finally, the consumer may wish the expert to exert diagnosis effort before a treatment is selected. Yet, in addition to the problem that success and failure of the low–cost treatment are not publicly observable, this creates a *moral hazard problem*: neither the public nor the consumer observe whether the expert invests effort in information acquisition, and if so which signal he observes. Therefore, if the consumer prefers a costly diagnosis, he has to delegate the choice of treatment to the expert and to choose the payments

$$p \equiv (p_H, p_{LS}, p_{LF}) \tag{4}$$

in such a way that they provide the incentive to acquire information about θ. Indeed, under an optimal contract, the Revelation Principle requires the expert to report the observed signal truthfully and the consumer to commit himself to a treatment strategy contingent on the expert's report. In line with the Delegation Principle (see, e.g., Holmström, 1984; Alonso and Matouschek, 2008) this is equivalent to a contract that delegates the choice of treatment to the expert. Once the treatment decision is delegated to the expert, the client is committed to undergo the treatment selected by the expert and he cannot reject a treatment decision. This assumption is important because otherwise the client might want to leave without payment after hearing the diagnosis and request the treatment from another expert or remain untreated.

The contracting relation proceeds in the following stages:

1. Nature determines the consumer's type $\theta \in \{\theta_L, \theta_H\}$. Neither the consumer nor the expert observes the realization of θ. They both know only the a priori probabilities as given by (2).

payment $p_{LF} = p'_{LF} + \delta p'_2$ after the first treatment.

[23]Constant gross utility is the conservative assumption to make, as if the consumer's gross utility were to decline, incentives for misreporting were reduced. On the other hand, increasing gross utility is not in line with the basic assumptions of the credence goods problem, in which the high-cost treatment does not yield higher gross utility than the low-cost treatment given that both solve the problem.

2. The consumer signs a contract with the expert. This specifies some payments p. In addition, the consumer can either delegate the choice of treatment to the expert or he can demand some first–period treatment $T \in \{T_L, T_H\}$. Our assumptions ensure that a positive net surplus can be achieved by an appropriate contract, on which both parties will agree.

3. If the treatment is already specified in the contract, the expert selects the mandated treatment. Otherwise, if the choice of treatment is delegated, he decides whether or not to invest effort in information acquisition. After investing he privately observes a signal s, updates his prior beliefs according to (3), and then chooses some first–period treatment T. The expert's effort decision is not observable. Without information acquisition the expert directly selects T without observing a signal.

4. After a first–period treatment T_H the contracting relation ends and the consumer pays p_H. If treatment T_L has been selected, the consumer privately observes whether his problem has been solved. If he reports 'success' he pays p_{LS} and the relation ends; if he reports 'failure' he pays p_{LF} and receives treatment T_H in the second period.

Thus, the consumer can either keep authority over the selection of treatment or he can delegate the treatment decision to the expert. If he is confident that he can identify the appropriate treatment, he can follow his judgement. Otherwise he has the opportunity of letting the expert determine the treatment decision. This seems to be in line with patient preferences. When the choice of the appropriate treatment is uncertain patients prefer to delegate the final decision to their physician, rather than making the decision themselves.[24]

2 First–Best Treatment Strategies

Before analysing the optimal contract between the consumer and the expert, we consider the first–best outcome. This analysis is closely related to the characterization of efficient policies in Dulleck and Kerschbamer (2009).[25] Suppose the consumer is able to acquire

[24] See Pauline W. Chen, M.D., 'Letting Doctors Make the Tough Decisions', The New York Times 11, August 2011.

[25] There are, however, subtle differences. On one hand, we consider a more general setting with delay costs in which the expert's signal might be noisy. On the other hand, Dulleck and Kerschbamer assume that the consumer gets a per period utility.

information and to perform the appropriate treatment with the same cost as the expert. Since the consumer himself effectively takes over the role of the expert, both the problem of subjective evaluation and the incentive problems of investing effort and revealing the signal disappear. The consumer maximises the overall surplus and the result is the first–best decision.

As explained before, when treatment T_L fails in period 1, it is optimal to choose T_H in the second period. Therefore, the different combinations of treatments T and types θ imply the surplus net of treatment cost given in Table 1.

	θ_L	θ_H
T_L	$v - T_L$	$-T_L + \delta(v - T_H)$
T_H	$v - T_H$	$v - T_H$

Table 1: *Surplus Net of Treatment Cost*

At the beginning of the first period the consumer can either choose the treatment based on prior information only or he can invest in information before making his choice. Thus there are three possible treatment strategies. First, the consumer can choose treatment T_H without acquiring information. This yields the net surplus

$$S_H^* \equiv v - T_H, \tag{5}$$

because the treatment is always successful. Yet, with probability q it involves overtreatment.

Second, also based on prior information only, the consumer can first try the low-cost treatment and correct this choice later when needed. We call this the *trial-&-error* strategy. It yields the net surplus

$$S_{T\&E}^* \equiv q(v - T_L) + (1-q)\left[-T_L + \delta(v - T_H)\right], \tag{6}$$

because the problem is solved with the a priori probability q, whereas with probability $1 - q$ it turns out that T_L results in undertreatment so that the high-cost treatment becomes necessary in period 2. The trial-&-error strategy can be interpreted as risky experimentation, because failure of the treatment in period 1 reveals that the consumer has the major problem

θ_H. Thus the choice between T_H and the trial-&-error strategy can be viewed as a problem of deciding between a 'safe' and a 'risky' action.

Finally, if the consumer exerts effort in diagnosis he will choose treatment T_i upon observing signal s_i. With a binary signal and two treatments this choice is clearly optimal because investing in information acquisition and then ignoring the information cannot be optimal.[26] Therefore, the expected surplus from spending the cost c on diagnosis is

$$\begin{aligned} S_I^* \equiv\ & q\,[\sigma(v-T_L)+(1-\sigma)(v-T_H)] \\ & +(1-q)[\sigma(v-T_H)+(1-\sigma)(-T_L+\delta(v-T_H))]-c. \end{aligned} \tag{7}$$

Indeed, with probability q the problem is minor and overtreatment occurs only if the signal is incorrect. With probability $1-q$ the problem is major, and when the signal is incorrect the treatment decision must be corrected later. These expected benefits are reduced by the information cost c.

From the payoffs in (5)–(7) we can now derive the first–best treatment strategy. If treatment choice is based on prior information only, the trial-&-error strategy is at least as good as choosing the high-cost treatment if $S_{T\&E}^* \geq S_H^*$, which is equivalent to

$$q \geq q^* \equiv \frac{(1-\delta)(v-T_H)+T_L}{(1-\delta)(v-T_H)+T_H}. \tag{8}$$

Clearly, our assumptions imply that $q^* \in (0,1)$. Intuitively, the trial-&-error strategy is the more attractive, the more the consumer is concerned with overtreatment and the less he cares about undertreatment and the riskiness of experimenting by trial-&-error.

Investing in information is optimal if it is at least as good as choosing any of the two strategies based on prior information, i.e. if $S_I^* \geq S_H^*$ and $S_I^* \geq S_{T\&E}^*$. These two conditions are satisfied if and only if

$$\begin{aligned} c \leq c_I(q) \equiv\ & (T_H-T_L)\,[q(2\sigma-1)+1-\sigma] \\ & -(1-\sigma)(1-q)\,[v(1-\delta)+\delta T_H] \end{aligned} \tag{9}$$

and

$$\begin{aligned} c \leq c_{II}(q) \equiv\ & (T_H-T_L)\,[q(2\sigma-1)-\sigma] \\ & +\sigma(1-q)\,[v(1-\delta)+\delta T_H]. \end{aligned} \tag{10}$$

[26] For a formal proof and discussion of this argument see Lemma 3 below.

Therefore, as long as

$$c \leq \bar{c}(q) \equiv \min[c_I(q), c_{II}(q)], \tag{11}$$

the consumer optimally invests in information acquisition before taking a treatment decision.

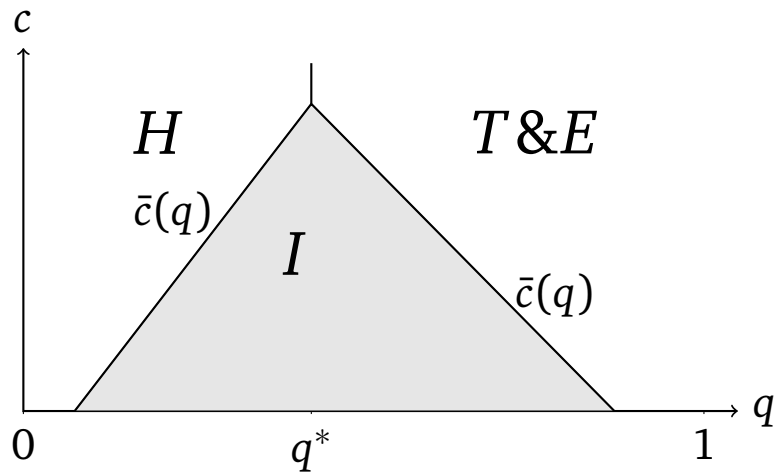


Fig. 1: *First–best Treatment Strategies*

It is easily verified, that $c_I(\cdot)$ and $c_{II}(\cdot)$ are linear in q with $\partial c_I(q)/\partial q > 0$ and $\partial c_{II}(q)/\partial q < 0$. Further, for q^* as defined in (8) we have

$$\bar{c}(q^*) = c_I(q^*) = c_{II}(q^*) = \frac{(2\sigma - 1)(T_H - T_L)[(1-\delta)(v - T_H) + T_L]}{v(1-\delta) + \delta T_H} > 0. \tag{12}$$

As illustrated in Figure 1, this implies that the critical level of information costs $\bar{c}(\cdot)$ is linearly increasing in q for $q < q^*$ and decreasing for $q > q^*$ so that $\bar{c}(\cdot)$ is maximised by q^*. Moreover, as $\bar{c}(q^*) > 0$, by (11) information acquisition is the optimal strategy for some interval $Q(c)$ of q-values with q^* in its interior whenever $c \leq \bar{c}(q^*)$. As c decreases, $Q(c)$ expands so that information acquisition becomes attractive for a larger range of parameter combinations.

The following proposition summarises the first–best treatment strategy:

PROPOSITION 1. *The first–best solution has the following properties:*

(a) If $c \geq \bar{c}(q)$ and $q \leq q^*$, it is optimal to choose the high-cost treatment without diagnosis.

(b) If $c \geq \bar{c}(q)$ and $q \geq q^*$, it is optimal to choose the trial-&-error strategy, i.e. the low-cost treatment without diagnosis, followed by the high-cost treatment in case of failure.

(c) If $c \leq \bar{c}(q)$, it is optimal to exert effort in diagnosis and choose the treatment contingent on the information revealed.

Figure 1 illustrates Proposition 1. Information acquisition before choosing a treatment constitutes the first–best strategy in the grey shaded area. Outside this area, the first–best outcome requires the high–cost treatment if $q \leq q^*$ and the trial-&-error strategy otherwise. As can be seen from the shape of the grey shaded area, the more diffuse the prior, the less is known about the success of treatments and the higher the incentives for diagnosis. As the prior becomes more precise, the risk of overtreatment with the high-cost treatment or of undertreatment with the trial-&-error strategy declines, because $\partial c_I(q)/\partial q > 0$ and $\partial c_{II}(q)/\partial q < 0$ respectively. Indeed, when the prior becomes perfectly precise as $q \to 0$ or $q \to 1$, the treatment decisions based on prior information entail no risk of over- or undertreatment and information acquisition is not needed to take the correct treatment decision. Moreover, the overall incentives to invest in information before choosing a treatment (measured e.g. by the altitude of the grey shaded triangle) are the higher, the more important it is to avoid over- and undertreatment and the more precise the signal is that can be acquired.

Figure 1 also shows the trade–off between acquiring information by diagnosis versus experimentation by trial-&-error: The latter is costly because with probability $1-q$ the cost of treatment T_L is wasted and the solution of the consumer's problem is delayed. Therefore, experimentation is more attractive than diagnosis only if the cost of diagnosis exceeds $c_{II}(q)$. In the limit $T_L \to 0$ and $\delta \to 1$, however, $q^* \to 0$ and $\bar{c}(q^*) \to 0$ because the cost of experimentation tends to zero. In this limit, therefore, the first–best solution is always to experiment by applying the trial-&-error strategy.

Before analysing optimal contracts under the informational assumptions of Section 1, it may be useful to point out that despite the non–observability of diagnosis effort the first–best treatment strategy can easily be implemented by a contract as long as success and failure of a treatment are publicly observable. Payments then can be made directly contingent on the treatment outcome: If already the first–period treatment is successful, the expert receives the payment $p = v - k$ in period 1; otherwise the first period payment is reduced to $p = \delta v - k$ and the expert is contractually obliged to administer the high-cost treatment in

period 2. The parameter k is some constant that determines the division of expected surplus between both parties.

With these payments, the expert's expected profit net of expected treatment costs is $S_H^* - k$ if he chooses the high cost treatment in period 1. If he adopts the trial-&-error strategy, he gets $S_{T\&E}^* - k$; and if he invests in information before selecting the first–period treatment he gets $S_I^* - k$. Thus, by the above payments the expert becomes the residual claimant and he will choose the treatment strategy that maximises the first–best surplus.

3 Optimal Contracts

We now study the optimal contract between the consumer and the expert. Since both parties are risk–neutral, they agree at the contracting stage to maximise their joint surplus. To derive the optimal contract, we can therefore focus on contracts that maximise the net surplus. Under our assumptions a positive net surplus can be achieved by an appropriate contract, on which both parties will agree. The actual division of surplus depends on market conditions and can be determined by some upfront payments or by adjusting the payments p in (4) appropriately.[27] If, for example, there are several competing experts and the consumer has all the bargaining power at the contracting stage, he can appropriate the entire joint net surplus in this way.

We first investigate the possibility of implementing the first–best outcome through a contract. Trivially, this is possible for all parameter combinations described in part (a) of Proposition 1, where the first–best solution is to choose the high–cost treatment without prior diagnosis. In this situation the expert can simply be contractually obliged to select treatment T_H for a payment p_H. The consumer's and the expert's payoffs from such a contract are

$$U_H(p) \equiv v - p_H, \quad V_H(p) \equiv p_H - T_H. \tag{13}$$

The expert's reimbursement can be set equal to $p_H = T_H + k$, where k is some constant that

[27] As our analysis below shows, incentive effects depend only on payment differences for different treatments. Therefore, the *level* of payments can be adjusted to reflect market power. Our approach allows for alternative interpretations. For example, a benevolent social planner proposing the contract would also aim to maximise the joint net surplus but might wish to take into account some criterion of distributive justice when dividing the surplus between the agents.

can be adjusted to divide the joint surplus $S_H^* = U_H(p) + V_H(p) = v - T_H$. In the extreme cases, if the consumer has all the bargaining power, $k = 0$ and the expert's net payoff is zero; if the expert has all the bargaining power, $k = v - T_H$ and so the consumer's net payoff is zero.

Next consider the case where the trial-&-error strategy is optimal in the first–best, i.e. where part (b) of Proposition 1 applies. In this case contracting is slightly complicated by the fact that the consumer privately observes success or failure of the first–period treatment. Optimal contract design requires that he publicly reports his information (see Myerson, 1986). Further, by the Revelation Principle (Myerson, 1979) there is no loss of generality in considering only contracts under which reporting is truthful. The following lemma describes the restrictions that the *truthful reporting* requirement imposes on the payments p:

LEMMA 1. *The consumer reports success and failure truthfully after treatment T_L if and only if*

$$p_{LF} - \delta v \leq p_{LS} \leq p_{LF}. \tag{14}$$

PROOF: If treatment T_L was successful, the consumer's payoff from truthful reporting at the end of period 1 is $v - p_{LS}$. If he reports F, he gets $v - p_{LF}$. Therefore, the second inequality in (14) ensures that he reports truthfully. If the treatment T_L failed, the consumer's payoff from reporting F is $-p_{LF} + \delta v$ and his payoff from reporting S is $-p_{LS}$. By the first inequality in (14), he therefore reports truthfully. Q.E.D.

Intuitively, reporting success must be cheaper for the consumer than reporting failure. The difference, however, cannot be larger than the gains from receiving the high-cost treatment in the second period. Given that the condition for truthful reporting in (14) holds, at the contracting stage the consumer's and the expert's payoffs from the trial-&-error strategy are

$$\begin{aligned} U_{T\&E}(p) &\equiv q(v - p_{LS}) + (1-q)(\delta v - p_{LF}), \\ V_{T\&E}(p) &\equiv q(p_{LS} - T_L) + (1-q)(p_{LF} - T_L - \delta T_H), \end{aligned} \tag{15}$$

because with probability q the first–period treatment T_L is successful and with probability $1-q$ it fails, requiring the high-cost treatment in period 2. For any p satisfying (14), the contracting parties can achieve the first–best joint surplus $S_{T\&E}^* = U_{T\&E}(p) + V_{T\&E}(p)$.

Obviously, it is not problematic to write a contract complying with the incentive–compatibility constraint (14). Since the interval $[p_{LF} - \delta v, p_{LF}]$ is non–empty, it is always possible to choose a price p_{LS} within this interval. In particular, consider a contract with *equal markup* payments as in Dulleck and Kerschbamer (2006) so that the expert's net payoff is independent of treatment costs. Such a contract is defined by the property that

$$p_H - T_H = p_{LS} - T_L = p_{LF} - (T_L + \delta T_H) = k, \tag{16}$$

for some markup k that can be adjusted to determine the division of the joint surplus. As $v > T_H > 0$, it is easy to see that these payments satisfy (14). With equal markups the consumer fully bears the cost of an additional treatment, and therefore he always reports truthfully.

The efficient choice between the safe treatment T_H and risky experimentation by trial-&-error can be implemented because treatments are observable. Unlike in Bergemann and Hege (2005) and Hörner and Samuelson (2013), where the agent's experimentation effort is not observable, in our setting experimentation involves no problem of moral hazard. Since the remaining problem of truthful subjective evaluation by the consumer is solvable by the appropriate payments, we obtain the following conclusion:

PROPOSITION 2. *Let $c \geq \bar{c}(q)$, i.e. the first–best requires no investment in diagnosis. Then there exists an optimal contract that implements the first–best solution.*

We now turn to the more interesting and also more complicated case where the first–best treatment strategy involves diagnosis effort by the expert, as in part (c) of Proposition 1. Implementing this strategy by a contract requires not only that the consumer truthfully reports the outcome of the low–cost treatment, but also that the expert invests c in information acquisition and reports his private information truthfully. Consider a contract satisfying (14) so that the first of these requirements is fulfilled. Then, if the expert exerts effort and chooses treatment T_i upon observing signal s_i, the expected payoffs of the consumer and the expert are

$$\begin{aligned} U_I(p) \;\equiv\; & q\,[\sigma(v - p_{LS}) + (1-\sigma)(v - p_H)] \\ & + (1-q)[\sigma(v - p_H) + (1-\sigma)(\delta v - p_{LF})], \end{aligned} \tag{17}$$

$$\begin{aligned} V_I(p) \;\equiv\; & q\,[\sigma(p_{LS} - T_L) + (1-\sigma)(p_H - T_H)] \\ & + (1-q)\,[\sigma(p_H - T_H) + (1-\sigma)(p_{LF} - T_L - \delta T_H)] - c, \end{aligned} \tag{18}$$

and their joint surplus is $S_I^* = U_I(p) + V_I(p)$.

When the expert receives the authority to select a treatment, he will exert diagnosis effort only if this gives him a higher payoff than selecting a treatment based on prior information only. Thus the contractual payments have to satisfy the *effort incentive* constraints

$$V_I(p) \geq V_H(p), \quad V_I(p) \geq V_{T\&E}(p). \tag{19}$$

Actually, these constraints also imply that the expert will select treatment T_i after observing signal s_i. This is so because with a binary signal and two treatments it cannot be optimal to invest $c > 0$ in diagnosis and then to ignore the information.[28] Condition (19) is equivalent to requiring that p simultaneously solves

$$\begin{aligned} c \leq c_A(p,q) \quad \equiv \quad & (T_H - T_L - p_H)[q(2\sigma - 1) + 1 - \sigma] \\ & -(1-\sigma)(1-q)(\delta T_H - p_{LF}) + q\sigma p_{LS} \end{aligned} \tag{20}$$

and

$$\begin{aligned} c \leq c_B(p,q) \quad \equiv \quad & (T_H - T_L - p_H)[q(2\sigma - 1) - \sigma] \\ & +\sigma(1-q)(\delta T_H - p_{LF}) - q(1-\sigma)p_{LS}. \end{aligned} \tag{21}$$

Therefore, condition (19) can also be written as

$$c \leq \tilde{c}(p,q) \equiv \min[c_A(p,q), c_B(p,q)]. \tag{22}$$

In what follows we say that a treatment with diagnosis effort is *implementable* by a contract with payments p if these satisfy both the consumer's truthful reporting requirement (14) and the expert's effort incentive constraint (19), or equivalently (22). The following result characterises the parameter combinations under which such a contract is feasible.

PROPOSITION 3. *There exist payments p that implement diagnosis effort by the expert if and only if*

$$c \leq \hat{c}(q) \equiv q(1-q)(2\sigma - 1)\delta T_H. \tag{23}$$

If this condition holds, then diagnosis effort is implementable in particular by the payments

$$\hat{p}_H = T_H + k, \quad \hat{p}_{LS} = \hat{p}_{LF} = T_L + (1-q)\delta T_H + k, \tag{24}$$

for some constant k.

[28] For a formal proof and discussion of this argument see Lemma 3 below.

PROOF: Let $\hat{p}$ maximise $\tilde{c}(p,q)$, as defined in (22), subject to the truthful reporting condition (14). Then obviously, diagnosis effort is implementable if and only if $c \leq \tilde{c}(\hat{p},q) = \hat{c}(q)$.

If $c_A(p,q) > c_B(p,q)$ then $\tilde{c}(p,q) = c_B(p,q)$ is increasing in p_H by (21) because $q(2\sigma-1)-\sigma < 0$. If $c_A(p,q) < c_B(p,q)$ then $\tilde{c}(p,q) = c_A(p,q)$ is decreasing in p_H by (20) because $q(2\sigma-1)+1-\sigma > 0$. Therefore, $\tilde{c}(p,q)$ is maximised by p_H if $c_A(p_H,p_{LS},p_{LF},q) = c_B(p_H,p_{LS},p_{LF},q)$. This yields

$$\hat{p}_H = T_H[1-\delta(1-q)] - T_L + qp_{LS} + (1-q)p_{LF}. \tag{25}$$

Since

$$\tilde{c}(\hat{p}_H,p_{LS},p_{LF},q) = q(1-q)(2\sigma-1)(\delta T_H + p_{LS} - p_{LF}), \tag{26}$$

is increasing in p_{LS} and decreasing in p_{LF}, it is maximised subject to (14) by setting $\hat{p}_{LF} = \hat{p}_{LS}$. As $\tilde{c}(\hat{p}_H,\hat{p}_{LS},\hat{p}_{LF},q) = q(1-q)(2\sigma-1)\delta T_H$, this proves (23). Finally, we obtain from (25) for $\hat{p}_{LF} = \hat{p}_{LS}$ that

$$\hat{p}_H - \hat{p}_{LS} = \hat{p}_H - \hat{p}_{LF} = T_H[1-\delta(1-q)] - T_L, \tag{27}$$

which is equivalent to (24). Q.E.D.

Since the consumer reports truthfully and because T_L additionally requires T_H with probability $1-q$ in the next period, the prices $\hat{p}$ in (24) can be interpreted as equal markups on the *expected* treatment costs of choosing T_H or T_L before receiving information.[29] This has two implications. First, these payments make the consumer indifferent between reporting success and failure after a successful low-cost treatment inducing hence truthful reporting, as (14) holds. Second, they have the property that they equalise the expert's payoffs from treatment choices based on prior information alone, that is $V_{T\&E}(\hat{p}) = V_H(\hat{p})$. Thus, once the expert prefers information acquisition to one of the treatment choices based on prior information, he also prefers it to the other. More precisely, compared to recommending the high-cost treatment without diagnosis, information acquisition allows the expert to target the low-cost treatment correctly with probability $q\sigma$ and to gain $(1-q)\delta T_H$. This gain represents the part of the payment for the low-cost treatment that covers the expected costs of a possible second period treatment, which is not needed. With probability $(1-q)(1-\sigma)$,

[29] We conjecture that equal markups on the expected costs of a treatment strategy provide optimal incentives for costly diagnosis not only in our setting but also in more general environments. The reason is that with such payments the expert will seek to minimise expected treatment costs.

however, the low-cost treatment is incorrectly administered and the expert has to supply the high-cost treatment in period 2. This implies a loss of $q\delta T_H$, as he only receives the expected costs of the second period treatment $(1-q)\delta T_H$. Taking all together, information acquisition is preferred whenever it is cheap enough so that (23) holds. For a given combination of q and c the prices $\hat{p}$ are not necessarily the only ones that implement effort. But they are chosen so that even for the highest cost $c = \hat{c}(q)$ effort is implemented. In other words, they maximise the range of parameter combinations for which effort is induced.

For $\delta = 0$ the payments in (24) become the equal markup payments in (16). But in this special case $\hat{c}(q) = 0$ and hence effort is only implemented when it is costless. This raises the important question whether equal markup payments can implement effort for $\delta > 0$. As we have seen above, the payments in (16) give the consumer no incentive to misreport the outcome of the low–cost treatment. Yet, as the following result shows, they fail to provide incentives for the expert to invest in costly information.

PROPOSITION 4. *Equal markup payments, as defined in (16), implement a treatment with diagnosis effort if and only if information acquisition is costless, i.e.* $c = 0$.

PROOF: Since equal markup prices satisfy the truthful reporting constraint, it remains to check whether they satisfy the expert's effort constraint. Inserting the prices in (16) into (20) and (21) yields $c_A(p,q) = c_B(p,q) = 0$. Therefore, they satisfy (22) if and only if $c = 0$. Q.E.D.

The intuition for why equal markups do not induce information acquisition is closely related to their virtue in the standard model (Dulleck and Kerschbamer, 2006). In that setting the diagnostic effort of the expert is costless and the only issue is to provide him with the appropriate incentives to reveal his information. If markups are unequal and higher, say, for the high-cost treatment, then the expert has an incentive to always recommend this treatment, even if the low-cost treatment would have been sufficient. So the expert has to be indifferent. But if he is indifferent gaining some markup k with each treatment, then, by construction, both treatment choices based on prior information alone yield k and information acquisition does not pay, because with such a strategy he also obtains k but has to pay the cost of information c. The conclusion that equal markups prevent the expert from exerting costly diagnosis effort remains valid also in more general settings than our binary environment with two types of problems and two treatments: the idea is simply that if for

any choice of treatment strategy the expert is reimbursed for the total cost of treatments plus some constant markup, then his net payoff is the same for all treatment strategies. Therefore, it is never optimal for him to spend diagnosis costs.[30]

Under our assumptions we have $\tilde{c}(q) > 0$ for all $q \in (0,1)$. Therefore, for any $q \in (0,1)$ diagnosis effort is implementable if c is sufficiently small. Diagnostic effort is easier to implement (or equivalently $\tilde{c}$ is the higher), the higher the precision of information σ, the more diffuse the prior and the larger the scope for combined treatments as measured by δ. While the first two are roughly in line with the first–best outcome, the latter plays an important role. On one hand, we already mentioned that the extreme case of $\delta = 0$ implies $\hat{c}(q) = 0$ so that effort is only implementable when it is costless. On the other hand, as we will see next, the other extreme of $\delta = 1$ yields an efficiency result.

PROPOSITION 5. *If and only if $\delta = 1$, diagnosis effort can be contractually implemented for all parameter combinations for which it is optimal in the first–best. That is,*

$$\{c, q | c \leq \bar{c}(q)\} \subseteq \{c, q | c \leq \hat{c}(q)\}$$

if and only if $\delta = 1$.

PROOF: From (8), (12) and (23) we obtain that

$$\hat{c}(q^*) - \bar{c}(q^*) = -\frac{(1-\delta)(2\sigma-1)\nu(T_H - T_L)[(1-\delta)(\nu - T_H) + T_L]}{[\nu(1-\delta) + \delta T_H]^2}. \tag{28}$$

Further, by (9,(10), and (23) we have

$$\hat{c}(0) - \bar{c}(0) = \hat{c}(0) - c_I(0) = (1-\sigma)[(1-\delta)(\nu - T_H) + T_L] \geq 0, \tag{29}$$

$$\hat{c}(1) - \bar{c}(1) = \hat{c}(1) - c_{II}(1) = (1-\sigma)(T_H - T_L) \geq 0. \tag{30}$$

Recall that $\bar{c}(\cdot)$ is linearly increasing in q for $q < q^*$ and linearly decreasing for $q > q^*$ and is thus maximised by q^*. The function $\hat{c}(\cdot)$ is strictly concave. For $\delta = 1$, we have $\hat{c}(q^*) = \bar{c}(q^*)$. This together with (29) and (30) implies that $\hat{c}(q) \geq \bar{c}(q)$ for all $q \in [0,1]$. Therefore, for $\delta = 1$ the first–best can be implemented by Proposition 3, whenever diagnosis effort is optimal in the first–best.

[30] The argument is the same as in the standard moral hazard model à la Holmström (1979) that the agent will exert no effort if his wage is constant and does not depend on his output.

For $\delta < 1$, by (28) we have $\hat{c}(q^*) < \bar{c}(q^*)$. This implies that $\hat{c}(q) < \bar{c}(q)$ for some values of q sufficiently close to q^* and so diagnosis effort cannot be contractually implemented if $c \in (\hat{c}(q), \bar{c}(q))$, even though it is optimal in the first–best. Q.E.D.

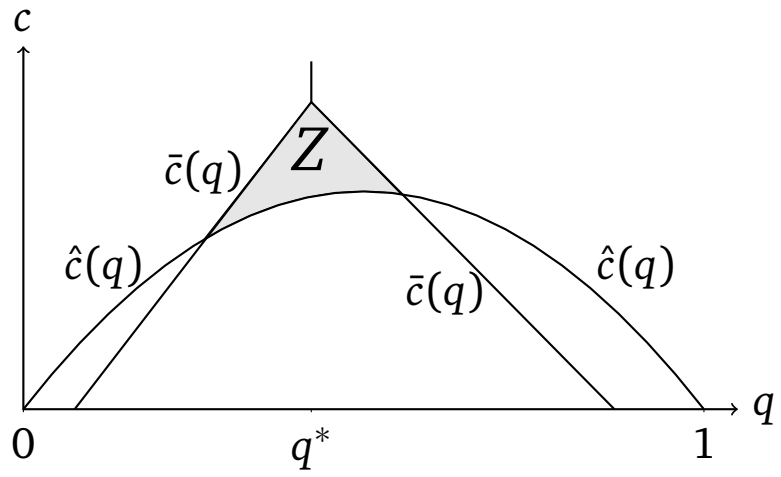


Fig. 2: *Non–implementability of First–best*

The set of parameter combinations for which the first–best requires a treatment based on information acquisition, but this is not implementable by a contract, is equal to

$$Z \equiv \{c, q | \hat{c}(q) < c < \bar{c}(q)\}\,. \tag{31}$$

By Proposition 5, this set is non–empty if and only if $\delta < 1$. In Figure 2 the set Z is depicted for this case by the grey shaded area. For a parameter combination in Z only a second–best solution without diagnosis effort can be obtained by the contracting parties. From our previous analysis it follows that the optimal contract then has the following properties:

PROPOSITION 6. *Let $(c, q) \in Z$. Then contractually implementing the high-cost treatment without diagnosis is optimal if $q \leq q^*$, and implementing the trial-&-error strategy without diagnosis is optimal if $q \geq q^*$.*

In comparison with the first–best, the second–best solution involves a higher likelihood of overtreatment for the high-cost treatment, and of undertreatment for the the trial-&-error strategy. More precisely, the following efficiency losses arise for $q \leq q^*$ and $q > q^*$,

respectively:

$$\begin{aligned} S_I^* - S_H^* &= q\sigma(T_H - T_L) - (1-q)(1-\sigma)[(1-\delta)(v-T_H) + T_L] - c, \qquad (32) \\ S_I^* - S_{T\&E}^* &= (1-q)\sigma[(1-\delta)(v-T_H) + T_L] - q(1-\sigma)(T_H - T_L) - c. \end{aligned}$$

In both expressions, the first term indicates the gain from more precise information, allowing to avoid overtreatment and undertreatment, respectively. The second term arises from the fact that the signal is sometimes incorrect and following it leads to undertreatment and overtreatment, respectively. Lastly, the diagnosis cost has to be taken into account.

4 Separation of Diagnosis and Treatment

Our analysis in the previous sections implicitly assumes that a single expert is responsible for both diagnosis and treatment. We now show that the first–best outcome can be obtained if separating diagnosis and treatment is feasible. As we indicate in the Introduction, this is possible in situations where diagnosis and treatment are essentially independent procedures with small economies of scope. To simplify our analysis, in this section we completely abstract from any kind of interdependencies or economies of scope.[31]

Suppose the consumer contracts with two different experts, a and b, for diagnosis and treatment. Expert a is an expert for diagnosis and can acquire information about the consumer's problem by investing the effort cost c; expert b incurs the cost T for providing treatment T. After a diagnosis, expert a prescribes a treatment which is then executed by expert b. Otherwise, the sequence of events and the assumptions on observability are the same as explained in Section 1. A contract specifies the payments

$$p^a \equiv (p_H^a, p_{LS}^a, p_{LF}^a), \quad p^b \equiv (p_H^b, p_{LS}^b, p_{LF}^b) \qquad (33)$$

each expert receives, contingent on the first period treatment and the consumer's report about the outcome in case of treatment T_L. As before, when the consumer reports failure of treatment T_L, the payment p_{LF}^b includes expert b's compensation for the additional treatment T_H in the second period. In total the consumer now has to pay

$$p_H \equiv p_H^a + p_H^b, \quad p_{LS} \equiv p_{LS}^a + p_{LS}^b, \quad p_{LF} \equiv p_{LF}^a + p_{LF}^b. \qquad (34)$$

[31] We also assume that the two experts are prevented from colluding on information revelation and treatment choice by exchanging side payments. Indeed, if side contracting cannot be detected, the experts can evade separation and will act as under joint provision.

To ensure that he reports success and failure of the low–cost treatment truthfully, his total payments have to satisfy condition (14).

After investing the diagnosis cost c and observing a signal $s \in \{s_L, s_H\}$, expert a's posterior belief that the consumer has the minor problem θ_L is equal to

$$\begin{aligned} \pi_L &\equiv \text{Prob}(\theta_L|s_L) = 1 - \text{Prob}(\theta_H|s_L) = \frac{\sigma q}{\sigma q + (1-\sigma)(1-q)}, \\ \pi_H &\equiv \text{Prob}(\theta_L|s_H) = 1 - \text{Prob}(\theta_H|s_H) = \frac{(1-\sigma)q}{(1-\sigma)q + \sigma(1-q)}, \end{aligned} \tag{35}$$

for signal s_L and s_H, respectively. Note that $\pi_L > \pi_H$ as $\sigma > 1/2$. A contract optimally delegates the choice of treatment to the diagnosis expert a. Thus, after the diagnosis expert a informs expert b about the appropriate treatment.

Since the information obtained by diagnosis effort is not publicly observable, under an optimal contract expert a should truthfully reveal the appropriate treatment that expert b has to execute. The following lemma characterises the payments p^a that make prescribing the appropriate treatment incentive compatible for expert a:

LEMMA 2. *Let (14) hold so that the consumer reports success and failure truthfully after treatment T_L. Then expert a prescribes T_H after observing signal s_H, and T_L after signal s_L, if and only if*

$$\pi_H p^a_{LS} + (1-\pi_H)\, p^a_{LF} \leq p^a_H \leq \pi_L p^a_{LS} + (1-\pi_L)\, p^a_{LF}. \tag{36}$$

PROOF: If expert a selects treatment T_H after observing signal s, his payoff is simply p^a_H because this treatment always succeeds. If instead he chooses T_L, his expected payoff after observing signal s_i is $\pi_i p^a_{LS} + (1-\pi_i)\, p^a_{LF}$, because the posterior probability of failure is $1-\pi_i$. Therefore, the first inequality in (36) ensures that choosing T_H after s_H is optimal, and the second inequality that T_L is optimal after s_L. Q.E.D.

Intuitively, the expected payments from prescribing the low-cost treatment must be lower than the payments for the high-cost treatment when expert a believes that the latter is appropriate, and higher when he thinks the low-cost treatment is correct.

Finally, since expert a is employed as diagnosis expert, the contract has to ensure that he invests the information cost c. By doing so he receives the ex ante expected payoff

$$V^a_I(p^a) \equiv q\left[\sigma p^a_{LS} + (1-\sigma)p^a_H\right] + (1-q)\left[\sigma p^a_H + (1-\sigma)p^a_{LF}\right] - c. \tag{37}$$

Note that the difference with $V_I(\cdot)$ in (18) is that expert a does not incur any treatment costs, because now expert b performs the treatment. When not investing in diagnosis, expert a can either get the payoff $V_H^a(p^a)$ by prescribing T_H or $V_{T\&E}^a(p^a)$ by the trial-&-error strategy, where

$$V_H^a(p^a) \equiv p_H^a, \quad V_{T\&E}^a(p^a) \equiv qp_{LS}^a + (1-q)p_{LF}^a. \tag{38}$$

Thus, the effort incentive constraint

$$V_I^a(p^a) \geq V_H^a(p^a), \quad V_I^a(p^a) \geq V_{T\&E}^a(p^a) \tag{39}$$

implements diagnosis effort by expert a.

As the choice of treatment is verifiable, expert b can be contractually obliged to provide the treatment prescribed by expert a. Therefore, there are no further incentive problems and a treatment based on diagnosis effort is implemented by the payments (p^a, p^b) whenever the constraints (14), (36), and (39) are satisfied. Actually, in what follows we can ignore constraint (36) because the following lemma shows that it is redundant.

LEMMA 3. *Let the effort incentive constraint (39) hold. Then also the treatment incentive constraint (36) is satisfied.*

PROOF: Solving the inequality $V_I^a(p^a) \geq V_H^a(p^a)$ for p_H^a yields

$$p_H^a \leq \pi_L p_{LS}^a + (1-\pi_L)p_{LF}^a - \pi_L \frac{c}{\sigma q}. \tag{40}$$

Since $c \geq 0$, this implies that the second inequality in (36) holds. Solving the inequality $V_I^a(p^a) \geq V_{T\&E}^a(p^a)$ for p_H^a yields

$$p_H^a \geq \pi_H p_{LS}^a + (1-\pi_H)p_{LF}^a + \pi_H \frac{c}{(1-\sigma)q}. \tag{41}$$

Since $c \geq 0$, this implies that the first inequality in (36) holds. This proves that (39) implies (36). Q.E.D.

The first inequality in (39) keeps expert a from prescribing treatment T_H without prior diagnosis. This immediately implies that expert a will prescribe T_L after his diagnosis reveals signal s_L, because investing in costly diagnosis and then prescribing T_H independently of the signal cannot be optimal. Similarly, the second inequality in (39) ensures that expert a prescribes T_H only after observing signal s_H. Thus, in our binary setting with two

treatments and two signals the expert's effort constraint (39) keeps him from making fraudulent prescriptions. This simplifies our analysis because we can ignore the truth-telling constraints (36). In a more general framework with more than two signals and treatments this simplification may not apply because the expert may want to invest in costly diagnosis but make honest prescriptions for some signals and lie for others. In such a framework the truth-telling constraints would impose additional restrictions on payments and cannot be ignored.[32]

By Lemma 3, finding payments so that (14) and (39) hold is sufficient to prove that a treatment based on information acquisition can be implemented. The following proposition shows that this is possible whenever this treatment strategy is first–best.

PROPOSITION 7. *Suppose a treatment based on information acquisition is optimal in the first–best, i.e.* $c \leq \bar{c}(q)$. *Then the first–best outcome can be contractually implemented by separating diagnosis and treatment with the payments for diagnosis*

$$p^a_H = v - T_H + k^a, \quad p^a_{LS} = v - T_L + k^a, \quad p^a_{LF} = \delta(v - T_H) - T_L + k^a, \tag{42}$$

to expert a, and for treatment

$$p^b_H = T_H + k^b, \quad p^b_{LS} = T_L + k^b, \quad p^b_{LF} = T_L + \delta T_H + (1-\delta)v + k^b \tag{43}$$

to expert b, where k^a *and* k^b *are some constants.*

PROOF: From the definition of the first–best surplus of the different treatment strategies in (5), (6), and (7) it immediately follows that expert a's payoff in (37) and (38) satisfies

$$V^a_H(p^a) = S^*_H + k^a, \quad V^a_{T\&E}(p^a) = S^*_{T\&E} + k^a, \quad V^a_I(p^a) = S^*_I + k^a. \tag{44}$$

under the payments in (42). Therefore, whenever exerting diagnosis effort is optimal in the first–best because $S^*_I \geq \max[S^*_H, S^*_{T\&E}]$, then also expert a's effort incentive constraint (39) is fulfilled.

[32]Indeed, consider a setting with n treatments T_i and n signals s_i such that after signal s_i the expert should prescribe treatment T_i. Then the effort incentive constraints for diagnosis would consist of n inequalities to keep the expert from prescribing one of the n treatments without prior diagnosis. At the same time, there would be $n(n-1)$ truth-telling constraints to induce the expert after each signal s_i to prescribe treatment T_i rather than one of the other $n-1$ treatments. Thus for $n > 2$ there would be more truth-telling constraints than effort incentive constraints. This means that for $n > 2$ one cannot expect that effort incentives are sufficient to induce truth-telling.

The consumer's payments in (42) and (43) to both experts sum up to

$$p_H = p_{LS} = p_{LF} = v + k^a + k^b. \tag{45}$$

Therefore, (14) is satisfied. Q.E.D.

With the payments specified in Proposition 7 the three parties together obtain the joint surplus S_I^*, as in the first–best. At the contracting stage this surplus can be split in an arbitrary way by adjusting the constants k^a and k^b according to market conditions or the parties' bargaining power.

The intuition for the efficiency result is that there are no incentive problems on the part of expert b, because he is contractually obliged to provide the required treatment. On the one hand, this allows adjusting the consumer's total payments to both experts so that he reports success and failure honestly. On the other hand, expert a can now be made the residual claimant by payments that align his payoffs with the first–best surplus. Since this expert seeks to maximise the first–best surplus, he has the correct incentives for diagnosis and truthful reporting. This insight should extend beyond our binary framework with two signals and treatments: The basic idea is that by separation the problem of subjective evaluation can be circumvented. Therefore, payments become flexible to make the diagnosis expert the residual claimant, whose diagnosis and reporting behaviour implements the first–best.

Is separation of diagnosis and treatment required for this construction? To answer this question consider the framework of Section 3 with a single expert and suppose that the expert is paid following (45), that is $p_H = p_{LS} = p_{LF}$. Clearly, the consumer has no incentive to misreport, as (14) is satisfied. Further, the critical cost levels in (20) and (21) can be rewritten as

$$c_A(p,q) = c_I(q) + (1-\sigma)(1-q)(1-\delta)v \tag{46}$$

and

$$c_B(p,q) = c_{II}(q) - \sigma(1-q)(1-\delta)v. \tag{47}$$

It is easy to see that if $\delta = 1$, these payments establish the correct effort incentives for implementing diagnosis.[33] When $\delta < 1$, however, it is no longer true that $c_A(p,q) = c_I(q)$ and $c_B(p,q) = c_{II}(q)$, implying that the effort incentive constraint is distorted. In contrast, separation allows to preserve the correct incentives for expert a *and* the consumer by payments

[33]Note that, as stated above, the payments in Proposition 5 are not unique.

that increase expert b's net payoff by an amount of $(1-\delta)v$ whenever the consumer reports failure.

Indeed, the payments to expert b serve to provide the correct incentives for the consumer and expert a, rather than establishing incentives for expert b. This resembles results in the literature on subjective evaluation: As MacLeod (2003) shows in a setting with a principal and a single agent, wasteful payments to a third party are required to provide incentives for the agent to exert effort *and* for the principal to truthfully reveal his subjective evaluation. Such payments allow punishing the agent for poor performance without giving the principal incentives for unjustified punishments. In our setting with two experts, expert b effectively plays the role of a third party, which acts as a budget breaker. But, the payments to him are not wasteful because they remain part of the overall surplus. This feature is similar to the use of 'bonus pools' in Rajan and Reichelstein (2006): In a principal–agent relation with multiple agents, an outside budget breaker is not needed because one can penalise one agent by redistributing payments to other agents.

5 Concluding Remarks

We have studied a credence good problem in which a consumer relies on the advice of an expert in order to choose one of two services. In our model payments must be designed in order to solve a two-sided incentive problem. On one hand, costly diagnostic effort and the diagnosis outcome are not observable. This creates incentive problems both for the expert's choice of diagnostic effort and for his treatment recommendation. On the other hand, treatment success is not publicly observable and payments must depend on the subjective evaluation of the consumer. We find that payments with equal markups on the expected treatment costs before receiving information can implement the first–best for some range of parameter combinations. This range increases when the discount factor increases and includes all parameter combinations when the discount factor is one.

Our model assumes that treatments are vertically differentiated, because the high-cost treatment is equally effective as the low-cost treatment when the consumer's problem is minor but more effective when the problem is major. The main conclusions of our analysis, however, remain valid also for horizontally differentiated treatments. In particular, it can be shown that the first–best solution can always be contractually implemented if and only if

the parties' common discount factor is one. Moreover, payments with equal markups on the expected treatment costs before receiving information are optimal in order to implement diagnosis effort.[34]

We also show that the first–best is always attainable under the assumption that diagnosis and treatment can be separated at no additional cost. Of course, separation may be inefficient and more costly than joint provision. There could be economies of scope in provision of diagnosis and treatment or there could be costs reflecting the consumer's time lost by consulting several experts.[35] In such a situation our analysis indicates that, if the discount factor is less than one, there a is a trade-off between diagnosis effort incentives and the additional cost of separation. As the discount factor decreases, separation becomes more attractive, because the set of parameter combinations for which under combined provision the first–best can be reached shrinks.

Our model generalises the information technology of the expert that the literature on credence goods usually considers. Further generalizations of that technology are likely to make it more difficult to implement the first–best when the expert provides both diagnosis and treatment. However, our efficiency result when separation of both activities is possible is likely to persist. The basic forces in our model are hence likely to be robust. Consider for instance a setting in which the expert chooses the precision of the signal and the cost of the signal is an increasing and convex function of its quality. The first–best requires that the marginal benefit of higher precision equals marginal cost and adds an additional constraint that optimal contracts must fulfill. This may make it more difficult to obtain the first–best under joint provision of diagnosis and treatment. When separation is possible, however, the expert's payments under the optimal contract differ from the first–best surplus by an additive constant, and set therefore the right incentives.

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[34]This is shown in a note which is available from the authors upon request.
[35]Darby and Karni (1973, footnote 5) and Emons (1997, 2001).

References

Alger, I. and Salanié, F. (2006). 'A theory of fraud and overtreatment in experts markets', *Journal of Economics and Management*, vol. 15(4), pp. 853–881.

Alonso, R. and Matouscheck, N. (2008). 'Optimal delegation', *Review of Economic Studies*, vol. 75(1), pp. 259–293.

Baker, G. P., Gibbons, R. and Murphy, K. J. (1994). 'Subjective performance measures in optimal incentive contracts', *Quarterly Journal of Economics*, vol. 109(4), pp. 1125-1156.

Berenson, R. A., Paulus, R. A. and Kalman, N. S. (2012). 'Perspective: medicare's readmissions-reduction program – a positive alternative', *New England Journal of Medicine*, vol. 366(15), pp. 1364–1366.

Bergemann, D. and Hege, U. (2005). 'The financing of innovation: learning and stopping', *RAND Journal of Economics*, vol. 36(4), pp. 719–752.

Berwick, D. M. and Hackbarth, A. D. (2009). 'Eliminating waste in US health care', *JAMA*, vol. 307(14), pp. 1513–1516.

Bonroy, O., Lemarié, S. and Tropéano, J.-P. (2013). 'Credence goods, experts and risk aversion', *Economics Letters*, vol. 120(3), pp. 464–467.

Brown, J. and Minor, D. (2012). 'Misconduct in credence good markets', Working Paper, Northwestern University.

Causholli, M., Knechel, W. R., Lin, H. and Sappington, D. E. M. (2013). 'Competitive procurement of auditing services with limited information', *European Accounting Review*, vol. 22(3), pp. 573–605.

Clemens, J. and Gottlieb, J. D. (2014). 'Do physicians' financial incentives affect treatment patterns and patient health?', *American Economic Review*, vol. 104(4), pp. 1320–1349.

Darby, M. R. and Karni, E. (1973). 'Free competition and the optimal amount of fraud', *Journal of Law and Economics*, vol. 16(1), pp. 67–88.

De Jaegher, K. and Jegers, M. (2001). 'The physician–patient relationship as a game of strategic information transmission', *Health Economics*, vol. 10(7), pp. 651–668.

Demski, J. and Sappington, D. (1987). 'Delegated expertise', *Journal of Accounting Research*, vol. 25(1), pp. 68–89.

Donaldson, C. and Gerard, K. (1989). 'Paying general practitioners: shedding light on the review of health services', *Journal of the Royal College of General Practitioners*, vol. 39(320), pp. 114–117.

Dulleck, U. and Wigger, B.U. (2015). 'Politicians as experts, electoral control, and fiscal restraints', *Journal of Public Economics*, vol. 121, pp. 106–116.

Dulleck, U. and Kerschbamer, R. (2006). 'On doctors, mechanics, and computer specialists: the economics of credence goods', *Journal of Economic Literature*, vol. 44(1), pp. 5–42.

Dulleck, U. and Kerschbamer, R. (2009). 'Experts vs. discounters: consumer free-riding and experts withholding advice in markets for credence goods', *International Journal of Industrial Organization*, vol. 27(1), pp. 15–23.

Dulleck, U., Gong, J. and Li, J. (2015). 'Contracting for infrastructure projects as credence goods', *Journal of Public Economic Theory*, vol. 17(3), pp. 328–345.

Emons, W. (1997). 'Credence goods and fraudulent experts', *RAND Journal of Economics*, vol. 28(1), pp. 107–119.

Emons, W. (2001). 'Credence goods monopolists', *International Journal of Industrial Organization*, vol. 19(3-4), pp. 375–389.

Fong, Y.-F. (2005). 'When do experts cheat and whom do they target?', *RAND Journal of Economics*, vol. 36(1), pp. 113–130.

Fong, Y.-F., Ting, L. and Wright, D.J. (2014). 'On the role of verifiability and commitment in credence goods markets', *International Journal of Industrial Organization*, vol. 37, pp. 118–129.

Frankel, A. and Schwarz, M. (2014). 'Experts and their records', *Economic Inquiry*, vol. 52(1), pp. 56–71.

Fuchs, V. R. (2009). 'Eliminating 'waste' in health care', *JAMA*, vol. 302(22), pp. 2481–2482.

Fuchs, W. (2007). 'Contracting with repeated moral hazard and private evaluations', *American Economic Review*, vol. 97(4), pp. 1432-1448.

Gabszewicz, J. J. and Resende, J. (2012). 'Differentiated credence goods and price competition', *Information Economics and Policy*, vol. 24(3-4), pp. 277–287.

Henning-Schmidt, H., Selten, R. and Wiesen, D. (2011). 'How payment systems affect physicians' provision behaviour – an experimental investigation', *Journal of Health Economics*, vol. 30(4), pp. 637–646.

Hilger, N. (2016). 'Why don't people trust experts', *Journal of Law and Economics*, vol. 59(2), pp. 293–311.

Hörner, J. and Samuelson, L. (2013). 'Incentives for experimenting agents', *RAND Journal of Economics*, vol. 44(4), pp. 632–663.

Holmström, B. (1979). 'Moral hazard and observability', *Bell Journal of Economics*, vol. 10(1), pp. 74–91.

Holmström, B. (1984). 'On the theory of delegation', in (M. Boyer, and R. Kihlstrom, eds.) *Bayesian Models in Economic Theory*, pp. 115–141, Amsterdam: North-Holland.

Hyndman, K. and Ozerturk, S. (2011). 'Consumer information in a market for expert services', *Journal of Economic Behavior and Organization*, vol. 80(3), pp. 628–640.

Jegers, M., Kesteloot, K., De Graeve, D. and Gilles, W. (2002). 'A typology for provider payment systems in health care', *Health Policy*, vol. 60 (3), pp. 255–273.

Kale, M. S., Bishop, T. F., Federman, A. D. and Keyhani, S. (2011). "Top 5' lists top $5 billion', *Archives of Internal Medicine,* vol. 171(20), pp. 1856–1858.

Knechel, W. R. (2013). 'Do auditing standards matter?', *Current Issues in Auditing*, vol. 7(2), pp. A1–A16.

Levin, J. (2003). 'Relational incentive contracts', *American Economic Review*, vol. 93(3), pp. 835-857.

Liu, T. (2011). 'Credence goods markets with conscientious and selfish experts', *International Economic Review*, vol. 52(1), pp. 227–244.

Liu, T. and Ma, C. (2013). 'Health insurance, treatment plan, and delegation to altruistic physician', *Journal of Economic Behavior & Organization*, vol. 85, pp. 79–96.

MacLeod, B. (2003). 'Optimal contracting with subjective evaluation', *American Economic Review*, vol. 93(1), pp. 216-240.

Malcomson, J.M. (2004). 'Health service gatekeepers', *RAND Journal of Economics*, vol. 35(2), pp. 401–421.

Mullainathan, S., Noeth, M. and Schoar, A. (2012). 'The market for financial advice: an audit study', NBER Working Paper No. 17929.

Myerson, R. (1979). 'Incentive compatibility and the bargaining problem', *Econometrica*, vol. 47(1), pp. 61–73.

Myerson, R. (1986). 'Multistage games with communication', *Econometrica*, vol. 54(2), pp. 323–58.

Pesendorfer, W. and Wolinsky, A. (2003). 'Second opinions and price competition: inefficiency in the market for expert advice', *Review of Economic Studies*, vol. 70(2), pp. 417–437.

Pearce, D. G. and Stacchetti, E. (1998). 'The interaction of implicit and explicit contracts in repeated agency', *Games and Economic Behavior*, vol. 23(1), pp. 75-96.

Pitchik, C. and Schotter, A. (1987). 'Honesty in a model of strategic information', *American Economic Review*, vol. 77(5), pp. 1032–1036.

Pitchik, C. and Schotter, A. (1993). 'Information transmission in regulated markets', *Canadian Journal of Economics*, vol. 26(4), pp. 815–829.

Rajan, M. V. and Reichelstein, S. (2006). 'Subjective performance indicators and discretionary bonus pools', *Journal of Accounting Research*, vol. 44(3), pp. 585-618.

Salisbury, C. (2009). 'Editorial: Using patient experience within pay for performance programmes', *BMJ*, vol. 339, b4224.

Sülzle, K. and Wambach, A. (2005). 'Insurance in a market for credence goods', *The Journal of Risk and Insurance*, vol. 72(1), pp. 159–176.

Taylor, C.R. (1995). 'The economics of breakdowns, checkups, and cures', *Journal of Political Economy*, vol. 103(1), pp. 53–74.

Wolinsky, A. (1993). 'Competition in a market for informed experts' services', *RAND Journal of Economics*, vol. 24(3), pp. 380–398.

Wolinsky, A. (1995). 'Competition in markets for credence goods', *Journal of Institutional and Theoretical Economics (JITE) / Zeitschrift für die gesamte Staatswissenschaft*, vol. 151(1), pp. 117–131.

	θ_L	θ_H
T_L	$v - T_L$	$-T_L + \delta(v - T_H)$
T_H	$v - T_H$	$v - T_H$

Table 1. *Surplus Net of Treatment Cost*

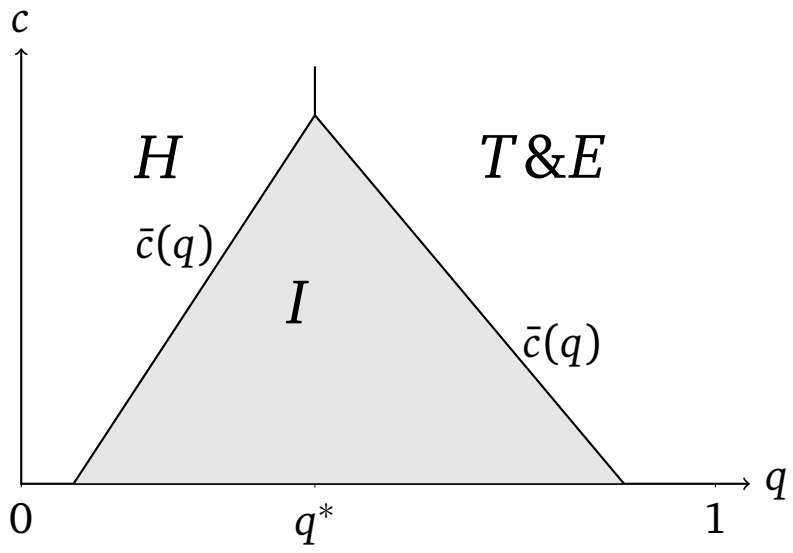


Fig. 1. *First–best Treatment Strategies*

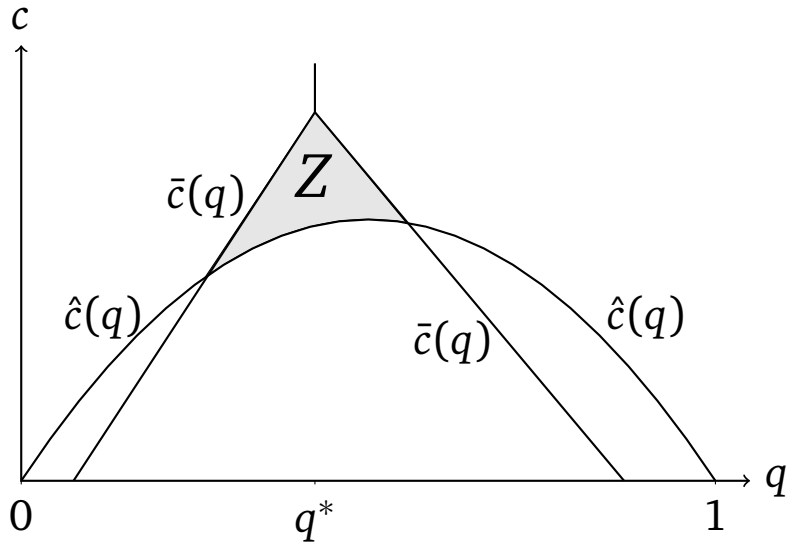


Fig. 2. *Non–implementability of First–best*