

Credence Goods: The Monopoly Case

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Abstract

With a credence good consumers are never sure about the extent of the good they actually need. Therefore, the seller acts as the expert determining the customers' requirements. This information asymmetry between buyers and the seller creates strong incentives for the seller to cheat. We analyze whether the market mechanism may induce non-fraudulent seller behavior. First, we consider observable and verifiable expert services, i.e., buyers observe how much of the good they get, yet they do not know how much they need. There we distinguish two different scenarios. From the observation of a) capacity and prices or b) just prices consumers attempt to infer the quality of the seller's services. We show for both constellations that profit maximizing credence goods monopolists always choose non-fraudulent behavior. Second, we analyze unobservable expert services, i.e., consumers neither know how much they need nor how much they get. If consumers observe a) capacity and prices, they obtain honest service. If, however, consumer observe b) only prices, no trade takes place.

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1. Introduction

This paper is about expert services. Expert services are provided by medical doctors and lawyers as well as by less glorified repair professions like auto mechanics and appliance service-persons. All these professions have in common that typically the seller not only provides the repair services; at the same time, the seller acts as the expert who determines how much treatment is necessary simply because the customer is unfamiliar with the intricacies and peculiarities of the good in question.

Aggravating this special feature is the fact that even ex post consumers can hardly determine the extent of the service that was required ex ante. It is often prohibitively costly to find out whether repairs were really needed or whether necessary treatments were not performed. Brake shoes changed prematurely work in the same way as if the shoes replaced had really been faulty; so does the patient with his appendix removed (un-)necessarily. In contrast, the wisdom tooth may hurt even when it was in perfect condition at the time of the last check-up; toothache need therefore not prove that necessary treatment was not carried out. Since from ex post observations the buyer can never be certain of the quality of the services he has purchased, such services have been termed credence goods (Darby and Karni (1973)).

The information asymmetry between buyer and seller obviously creates strong incentives for opportunistic seller behavior. On the one hand, if there is plenty of money in repair, the seller may recommend treatments that are not necessary. On the other hand, she may not perform an urgently needed repair if other activities are more profitable. The chances of consumers finding out about such fraudulent behavior are typically slim.

To give a few anecdotes where fraud was covered up: In the Swiss Canton of Ticino ‘ordinary patients’ (i.e., the population average) had 33% more of the seven most important operations than medical doctors and their families. Interestingly enough, lawyers and their beloved have about the same operation frequency as the families of medical doctors (Domenighetti et al. (1993)). In Switzerland patients with the minimum level of schooling are twice as likely to have their womb or gall-stones removed than patients with a university degree; for hip-joint operations the probability is even 150% higher. Ordinary children are 80% more likely to have their tonsils out than children of medical doctors (Ktip 05/22/1996). Further empirical evidence from the market for physician services suggests, e.g., that fee-for-service doctors tend to overprescribe while salaried doctors tend to shirk; see Gaynor (1994) for a survey of this literature. In the auto-repair business the most expensive German shops charge up to double of what the cheapest garages charge for bodywork without necessarily being any better (ADAC Motorwelt 11/92). In the US

unnecessary repairs were recommended to car owners by employees of Sears Automotive Centers in 90% of the test cases (Wall Street Journal 6/23/92). Other examples include the life-insurance industry where a New York investigation found the sale of unsuitable policies, high-pressure selling, and unbridled sales expenses (Newsweek 2/7/1994), as well as the market for legal advice where the anecdotal evidence is perhaps best summarized by the joke of the longevity study which found that the average lawyer lives twice as long as the average school teacher: Life span for lawyers was computed using billing hours.

Apparently, there is a need for mechanisms to discipline fraudulent experts. Perhaps the simplest mechanism ensuring honest services is the separation of diagnosis and treatment. Unless there is collusion, the diagnosing expert has no incentive to recommend unnecessary treatments and the repairing expert may only fix what has been diagnosed by her colleague. An example of this simple yet effective mechanism is the often encountered separation of the prescription and the preparation of drugs.

This ‘separation’ mechanism, however, fails to do a good job when it is cheaper to provide diagnosis and repair jointly rather than separately. It is, for example, cheaper to repair any damage while the transmission or belly is open for diagnosis than to put everything back together and repeat the process elsewhere for the actual repair. Apparently, such economies of scope between diagnosis and repair also make the related mechanism of calling upon a second opinion unattractive.

In this paper we want to analyze whether the market may solve the fraudulent expert problem when there are profound economies of scope between diagnosis and treatment. In our set-up repair is possible only after diagnosis. If a customer were to choose the services of a second expert, he would automatically incur the cost of a further diagnosis which makes the ‘separation’ as well as the ‘second opinion’ mechanisms unattractive.

For expositional convenience we consider a credence good monopolist.¹⁾ The analysis of the monopoly case enables us to highlight the incentive issues involved without obscuring the main points by strategic competition considerations. Our credence good monopolist has to invest in capacity before actually performing diagnosis and repair. This implies that the expert may have to ration her clientele due to insufficient capacity or that she may also end up with idle capacity. The cost of capacity is sunk. The expert charges separate prices for diagnosis and repair.

To understand our results it is quite useful to know what is efficient if there were no information asymmetry between buyers and seller. In such a world with symmetric information the sum of the consumers’ and the producer’s surplus is maximized when the seller is honest and sets capacity to the level allowing her to satisfy the entire demand by means of non-fraudulent services.

Next, suppose that in our set-up with asymmetric information consumers infer the seller's behavior from ex ante observations. This, in fact, implies that the seller cannot gain anything by cheating: consumers will detect fraud beforehand and their willingness-to-pay for the services is lower than if the seller were honest. Consequently, the best the seller can hope for is to appropriate the surplus that is generated by honest behavior. To achieve this, she has to persuade consumers of her non-fraudulent services. It remains to be explained how consumers infer the seller's incentives.

We start our analysis with the case where the expert's diagnosis and repair services are observable and verifiable, i.e., buyers observe how much diagnosis and repair they get, yet they have no idea how much of it is actually necessary. First, we consider the situation in which consumers observe the expert's capacity choice. With observability the expert can commit herself to a certain capacity level to convince consumers of her honest repair policy. We analyze how the expert's incentives depend on the interplay of prices, capacity, and the size of her clientele. If, say, the expert does not have enough customers, she may carry out unnecessary repairs to utilize her otherwise idle capacity; with too many customers she may repair inefficiently little if diagnosis is more profitable than treatment.

We show that in equilibrium the expert picks the capacity level allowing her to serve the whole market with honest behavior. Given that she has committed herself to this capacity level, all prices under which diagnosis is at least as profitable as repair induce non-fraudulent behavior. If diagnosis and repair generate the same profit, the expert is indifferent between the two activities and, accordingly, has no incentive to cheat. If diagnosis is more profitable than repair, the expert wishes to increase the number of diagnoses at the expense of repairs. Yet if she diagnoses all products, the only way to use up the capacity she committed herself to is by carrying out non-fraudulent repair. The expert sets the price level so as to appropriate the entire surplus. Consequently, all equilibria of this game share the following features: the expert sets capacity so as to serve the whole market with non-fraudulent behavior. All consumers consult the expert who, in turn, is honest. The equilibria are, therefore, efficient. The expert appropriates the entire surplus.

In a next step we analyze to what extent these nice efficiency properties depend on the fact that the expert can commit herself to a certain capacity level. To do this we consider a second scenario in which capacity is unobservable. With unobservable capacity the expert's incentive structure changes rather drastically. It is no longer the relative profitability of diagnosis to repair which plays the major role in determining behavior; now the price per repair relative to the capacity cost crucially determines the expert's

incentives. If, say, the price per repair exceeds its costs, the expert will ‘fix’ all products she can get hold of. She cannot use the capacity level to commit herself not to do such nasty things.

It turns out that our game with unobservable capacity has a unique equilibrium. Per repair the expert charges a price that equals its cost. With this price the expert is indifferent between fixing and not fixing a product and, therefore, has proper incentives concerning repair. Per diagnosis she charges a price enabling her to appropriate the entire surplus. With these two prices the expert wishes to diagnose all products and to repair only the defective ones. Accordingly, she picks the capacity level allowing her to serve the entire market with non-fraudulent behavior. All consumers consult the expert who, in turn, is honest. Consequently, the equilibrium of the game with unobservable capacity has the same welfare properties as the equilibria of the game with observable capacity. Loosely speaking, by dropping the assumption of observability of the capacity, we reduce the set of equilibria.

Then we turn to the case in which the expert’s diagnosis and repair services are unobservable, i.e., consumers neither know how much service they need nor how much service they actually get. With unobservable services the expert has yet another possibility to defraud her customers: She can charge for diagnoses and repairs that she never performed. Here we also start with the case where consumers observe the expert’s capacity choice. Since consumers cannot observe the expert’s services, her billing policy is in fact independent of her service policy. This also implies that the expert’s incentives to provide services do not depend on prices. In equilibrium she charges each customer for a diagnosis and a repair.

If the expert has chosen the capacity level allowing her to efficiently serve the market, there is nothing she can do with this capacity but to provide honest services. In equilibrium the expert commits herself to this capacity level and consumers know that they get honest diagnosis and treatment. Accordingly, in equilibrium the expert overcharges but provides efficient service.

Finally, we consider the case where services and capacity are unobservable. Here the market mechanism no longer solves the fraudulent expert problem. The expert charges each customer and at the same time provides no service. If she has customers, reducing the service rate to zero increases profits. Consumers anticipate this dominant strategy and, in turn, do not consult the expert in the first place. Accordingly, no trade takes place.

The extent of the theoretical literature on fraudulent experts is fairly small. In a classic article Darby and Karni (1973) discuss how reputation, market conditions, and

technological factors affect the amount of fraud. Their paper relies heavily on verbal arguments and anecdotes. Yet it contains some of the ideas we formalize in the paper at hand. Demski and Sappington (1987) focus on the problem of inducing an expert to acquire a costly expertise. While in our model diagnosis is necessary prior to repair, ‘blind treatment’ is possible in Demski and Sappington; repair is assumed to be costless. In this set-up they study optimal contracts between a principal and an expert (agent).

Pitchik and Schotter (1987) describe a mixed-strategy equilibrium in an expert-customer game. The expert randomizes between either reporting truthfully or not; the customer randomizes between acceptance and rejection of a treatment recommendation. Wolinsky (1993) examines customer search for multiple opinions and reputation considerations. In his specialization equilibrium some experts exclusively provide diagnosis while the other experts engage in either activity. Consumers first visit a ‘diagnosis-only’ expert. If she recommends treatment, consumers visit a ‘two-activity’ expert for a second diagnosis and the actual repair. Taylor (1995) considers experts who may recommend unnecessary treatments. His experts never diagnose a product as healthy; moreover, ex post contracting, free diagnostic checks, consumer procrastination in obtaining checkups, and long-term maintenance agreements may occur in Taylor’s equilibria.

The major difference between the paper at hand and Pitchik and Schotter (1987), Wolinsky (1993), and Taylor (1995) is that they all (implicitly) assume unnecessary repairs to be costless whereas our expert needs resources for unnecessary treatments. This implies that overtreatment is always profitable in their set-up. In contrast, the profitability of overtreatment in our model depends on demand conditions and is determined endogenously. Moreover, they assume the problem of undertreatment away while we solve both, the problems of over- and undertreatment simultaneously.

In Emons (1997) we consider experts engaging in Bertrand-Edgeworth competition. We show that a market equilibrium exists in which experts are honest and all the surplus goes to consumers. This paper differs from Emons (1997) in the following important respects. While the first paper deals only with the case of observable services together with observable capacity, here we also allow for unobservable services and/or unobservable capacity. Moreover, here we analyze credence goods monopolists whereas the other paper is about competitive experts. Nevertheless, the two papers are related in their basic result: if consumers rationally process ex ante information, the market mechanism can solve the fraudulent expert problem.²⁾ The paper at hand is an extended version of Emons (2001).

The remainder of the paper is organized as follows. In section 2. we analyze observable services. In section 2.1. we describe the basic model. Section 2.2. deals with the case of observable capacity while in section 2.3. we analyze the scenario with unobserv-

able capacity. Section 3. is about unobservable services. After describing the model, in section 3.2. we analyze observable and in section 3.3. unobservable capacity. Section 4. concludes the paper. Proofs are relegated to the Appendix.

2. Observable Expert Services

2.1. The Model

We consider a durable good endowed with a stock of services. When a certain amount of services is left over, the product is up for diagnosis and potential repair. We normalize this remaining capacity to 1 monetary unit. During its remaining life, our durable is of the ‘one-hoss shay’ type, i.e., either it makes available total remaining services 1 or it delivers services 0.

When the product is up for diagnosis, it can be either in good or in bad shape. If the product is in good shape, it makes available services 1 with probability $q_h \in (0, 1)$; when the product is in bad shape, the corresponding probability is q_ℓ with $0 < q_\ell < q_h$. Accordingly, in either condition the product may work or fail. Yet when it is in good shape, the probability of making available total capacity is higher. Let p denote the probability that the product is in bad and $(1 - p)$ the probability of the product being in good shape. The consumer does not know in which of the two conditions his product is.

The expert, however, is able to detect the product’s condition. By diagnosing the product, the expert finds out whether it is in good or in bad shape. When the product is in bad shape the expert can fix it so that it is in good shape afterwards. Let $d > 0$ be the total resource cost of diagnosing a product; the total resource cost of a repair is $r > 0$.

The timing of the production decisions, however, is such that these costs are not experienced as genuine marginal costs. The expert makes a prior capacity choice. More specifically, the expert chooses $L \geq 0$ units capacity, say hours of time. If she does not invest this time in the expertise business, she can work the L hours in an alternative job. If she does enter the expert business with capacity L , she allocates the L units of time to diagnosis and repair; d is the time an expert needs per diagnosis and r the time per repair. An expert’s capacity cost, however, is sunk. Once she has picked capacity L for the expertise business, she can only use these hours for diagnosis and repair; this time is no longer available for the alternative job.

The expert’s reservation wage is normalized to 1. Accordingly, L is the sunk cost of the capacity choice; d and r measure the minimum average costs of diagnosis and repair if, say, the expert performs either activity exclusively. Note that marginal costs are different from average costs. The expert has fixed capacity the cost of which is sunk. Therefore,

her marginal costs are 0 except for the capacity margin where marginal costs are “ $+\infty$ ”. When we talk about minimum average costs in the following, we mean d and r .

There is a continuum of identical consumers with total measure 1.³⁾ Consumers are risk neutral and care only about monetary flows. Accordingly, given that we have normalized the product’s remaining capacity to 1 monetary unit, without diagnosis and repair a consumer’s expected utility is $\bar{U} = (1 - p)q_h + pq_\ell$. With (honest) diagnosis and repair priced at minimum average costs the consumer’s expected utility amounts to $q_h - d - pr$. The consumer incurs the cost of diagnosis in any case. With probability p the product is in bad shape and needs treatment. In return the consumer has a product that is in good shape for sure.

It is efficient to check the product and fix it if necessary, meaning $q_h - d - pr > \bar{U}$ or $p(q_h - q_\ell) > d + pr$. Fixing a bad product increases the consumer’s utility by $(q_h - q_\ell)$. With probability p the product is in bad shape. Accordingly, the expected benefit from diagnosing and repairing the product is $p(q_h - q_\ell)$. The surplus the expert’s services may generate, therefore, is $W := p(q_h - q_\ell) - (d + pr)$. For notational purposes we also define the ratio of benefit to costs $w := p(q_h - q_\ell)/(d + pr)$.

We assume that repair is possible only after diagnosis.⁴⁾ Given non-fraudulent behavior, the expert’s capacity L in units of time thus translates into the capacity $L/(d + pr)$ in terms of customers.

Let us now describe how the expert may defraud consumers. The consumer does not know in which condition the product is. Later when consuming the remaining services he learns whether his product will work or fail. Yet, a good product may break down and a bad product may work satisfactorily. Accordingly, the consumer cannot use the information about his product’s future performance to infer its condition at the time when it was up for diagnosis and repair.

After diagnosis the expert knows in which condition the product is. When the product is in bad shape, she can repair it, i.e., turn it into good shape. Yet she can also ‘repair’ a good product; in this case the expert unnecessarily works r units of time on the product — leaving it at least in good shape. Alternatively, when the product is in good condition, the expert can recommend not to fix it. Nevertheless, she can make the same recommendation when the product is in bad shape. Ex post the consumer has no way of finding out whether his product was repaired unnecessarily or whether it needed treatment that was not provided. The expert’s services thus constitute ‘credence’ goods as distinct from search and experience goods — from ex post observations the consumer can never be certain of the quality of the services he has purchased. The only possibility for the consumer not to be defrauded is to infer the expert’s incentives to be honest from

ex ante observable variables such as the quoted prices and size of the clientele.⁵⁾

The expert picks prices D and R that she charges for diagnosis and repair. Moreover, she chooses a repair policy conditional on the product's condition. We identify this policy by the probability of repair. Let α denote the probability of repair given that the product is in good shape and β the probability of treatment if the product is in bad shape. These two conditional probabilities determine the unconditional ex ante probability of repair $\gamma = (1 - p)\alpha + p\beta$ which is quite useful for later purposes.

With this notation we may distinguish three scenarios. If $\alpha = 0$, $\beta = 1$, and thus $\gamma = p$ we talk of *efficient repair*. The expert fixes all bad and no good products; thereafter a product is certainly in good shape. A consumer's expected utility with this honest repair policy is $q_h - D - pR$.

If $\alpha > 0$, $\beta = 1$, and thus $\gamma = (1 - p)\alpha + p$ we talk of *too much repair*. The expert not only fixes all bad but also good products. With this fraudulent repair policy a consumer's expected utility amounts to $q_h - D - \gamma R$. Obviously, at the same prices the consumer prefers efficient repair to too much repair.

Finally, if $\alpha = 0$, $\beta < 1$, and thus $\gamma = \beta p$ we will talk of *too little repair*. The expert fixes no good and not all bad products. With this deceitful repair policy a product may be in bad shape and the consumer's expected utility is $(1 - p + \gamma)q_h + (p - \gamma)q_\ell - D - \gamma R$. The consumer prefers efficient to too little repair if $(q_h - q_\ell) \geq R$ which must be satisfied since $(q_h - q_\ell)$ is the consumer's reservation utility for repair if the product is in bad shape. If the expert is indifferent between honest and fraudulent behavior, she behaves honestly. Note that the expert's repair policy defines her capacity in terms of customers $L/(d + \gamma r)$.

Let $\eta \in \{0, 1\}$ denote the probability that a consumer goes to the expert.⁶⁾ If the expert has no capacity, a consumer picks $\eta = 0$. If she has positive capacity and the consumer is indifferent between consulting and not consulting the expert, he opts for $\eta = 1$. If a consumer is rationed by the expert, he pays nothing yet obtains no services so that he ends up with his reservation utility \bar{U} .

Consumers have total mass 1. Accordingly, η also measures the expert's clientele. If $\eta \leq L/(d + \gamma r)$, the expert has enough capacity to treat her entire clientele. If $\eta > L/(d + \gamma r)$, the expert has more customers than she can handle with her repair policy. In this case she has to ration her customers. The number of customers treated by the expert is thus $\min\{\eta; L/(d + \gamma r)\}$; her expected profit amounts to $\min\{\eta; L/(d + \gamma r)\}(D + \gamma R) - L$.

The specification of the game depends on whether or not consumers observe the expert's capacity choice. We will present the two different formulations, the solution concept, and the analyses in the following two subsections.

2.2. Observable Capacity

Let us start the analysis with the case in which consumers observe the expert's capacity choice. If this choice is observable, the expert can commit herself to a certain capacity level. This in turn may induce a repair policy that the expert would not have chosen had the capacity level been different. Accordingly, observable capacity is a tool that may help to convince consumers of the expert's good intentions.

We formulate these ideas by a three stage game of perfect information.⁷⁾ In the first stage of the game the expert picks (D, R, L) . In the second stage consumers observe the quoted prices (D, R) as well as the expert's capacity L . Then each consumer chooses whether or not to go to the expert, i.e., each consumer picks $\eta \in \{0, 1\}$. In the third stage the expert observes the consumers' decisions and picks her repair policy α and β .

In stage two consumers have beliefs about the expert's stage three repair policy. Consumers evaluate the expected utility of consulting the expert according to these beliefs. Each consumer chooses η so as to maximize his expected utility. We confine our attention to symmetric consumer strategies. The credence goods monopolist chooses prices, capacity, and her repair policy so as to maximize her expected profits.

We focus on subgame perfect equilibria. This means, in particular, that each decision maker acts in a sequentially rational fashion, following a strategy from each point forward that maximizes the expected payoff given the current information and beliefs. In our set-up this implies that the expert's repair policy is indeed optimal once consumers arrive. In equilibrium the consumers' beliefs are borne out: what consumers expect is what experts actually choose to do.

It turns out that the equilibria of our game have a neat structure: The equilibrium capacity is tied down uniquely at the level where the expert can just serve the whole market non-fraudulently. She repairs honestly. All consumers consult the expert and pay prices which enable the expert to appropriate the entire surplus W . Formally, the set of equilibria is given by the following Proposition.

Proposition 1: *In a subgame perfect equilibrium in stage one the expert sets $L = (d+pr)$. Furthermore, she charges prices $D \in [dw; p(q_h - q_\ell)]$ and $R = q_h - q_\ell - D/p$. In stage two consumers believe that $\alpha = 0$, $\beta = 1$, and choose $\eta = 1$. In stage three the expert picks $\alpha = 0$ and $\beta = 1$.*

This result may be explained as follows: Suppose, for the moment, a consumer can deduce the expert's repair policy from the observation of capacity and prices. A consumer is happiest about the expert's services when he is certain to get a product in good shape;

the consumer then has the maximum willingness-to-pay of $p(q_h - q_\ell)$ for the expert's services. The consumer certainly has a good product if the expert repairs efficiently or if she repairs too much. The consumer's overall willingness-to-pay does not increase if the expert raises repair above the efficient level. Yet, if the expert repairs too much, she employs more of her costly time than with efficient repair, without making more money. Accordingly, the expert maximizes her profits by non-fraudulent repair. The maximum prices the consumer is willing to pay for non-fraudulent repair, i.e., the prices generating utility \bar{U} , are given by the indifference curve $R = q_h - q_\ell - D/p$; see Figure 1. With these prices and honest repair the consumer sets $\eta = 1$.

< insert Figure 1 about here >

Let us now analyze how the consumer finds out about the expert's repair policy in stage three. Recall that at this stage the expert has capacity L , the cost of which is sunk. In terms of customers the expert has capacity $L/(d + pr)$ given honest behavior. Apparently, the expert's behavior depends on the size of her clientele η relative to her capacity $L/(d + pr)$. If, say, $\eta < L/(d + pr)$, the expert may start 'repairing' good products to utilize her otherwise idle capacities. Conversely, if $\eta > L/(d + pr)$, she may, e.g., be tempted not to fix all bad products given that diagnosis is more profitable than repair.

The last example indicates that the expert's incentives also depend on the relative profitability of diagnosis to repair which in turn is determined by her prices D and R . If the expert has too many customers, the only constraint she faces (at the margin) is her precious time. To maximize profits, she compares the profit per hour repair $(R - r)/r$ with the profit per hour diagnosis $(D - d)/d$. If the former exceeds the latter, she will repair too much and vice versa if diagnosis is more profitable than treatment.

To be more specific, consider Figure 1. Along the line $R = rD/d$ we have $(R - r)/r = (D - d)/d$. Accordingly, on this line the expert is indifferent between diagnosis and treatment so that with $\eta \geq L/(d + pr)$ customers she opts for efficient repair.⁸⁾ In region (I) where $R > rD/d$ the expert prefers repair to diagnosis. Whatever the number of customers, she will 'fix' anything she diagnoses, i.e., repair too much. In region (II) in which $R < rD/d$ the expert prefers diagnosis to repair so that she wishes to increase the number of diagnoses at the expense of repairs. With $\eta = L/(d + pr)$ customers, however, if she diagnoses all products, she uses up her otherwise idle capacity by efficient repair. If $\eta < L/(d + pr)$, the expert has proper incentives if and only if $R = 0$. She does not repair too much to utilize her idle capacity because there is no money in treatment.⁹⁾

Subgame perfection implies that the consumers' beliefs reflect the expert's incentive

structure we have just derived. Note that it is possible to pin down the expert's incentives even further once we incorporate the exact specifications of L and η . We do this in the proof. The most important aspects of the expert's incentives, however, are summarized by the previous discussion.

Finally, note that prices on the lower (heavy) part of the indifference curve $R = q_h - q_\ell - D/p$, together with the capacity inducing honest repair, give rise to positive profits per customer. Accordingly, to maximize profits the expert chooses $L = d + pr$ so that she serves the entire market with honest behavior. Given this capacity level, all prices on the indifference curve $R = q_h - q_\ell - D/p$ with $D \in [dw; p(q_h - q_\ell)]$ support non-fraudulent repair.

2.3. Unobservable Capacity

Let us now turn to the case in which the expert's capacity choice is unobservable. With unobservable capacity the expert cannot commit herself to a certain capacity level to persuade consumers of her honest repair policy. Certain prices that support honesty in the previous set-up will no longer induce non-fraudulent repair if the expert can secretly increase her capacity. As will become clear in the following discussion, observable capacity is like Cortés burning his ships upon arrival in Mexico as a commitment not to retreat or like Odysseus having himself lashed to the mast and ordering his sailors to plug their ears with wax as a commitment not to go to the Siren's island.

To be more specific, consider, e.g., the prices $D = dw$ and $R = rw$; see Figure 1. These prices, together with the commitment to the capacity $L = d + pr$, induce non-fraudulent repair in the preceding set-up. Note, however, that repair is more profitable than the alternative job, i.e., $R = rw > r$. If the expert can increase the number of repairs at the expense of the time she devotes to the alternative job, clearly she will do it. Accordingly, with the above prices and unobservable capacity consumers should expect the expert to repair all products and to have capacity $L = d + r$.

Let us now tackle the task of modeling unobservable capacity. We want to capture the fact that consumers have not yet seen the expert's capacity choice when they pick η . There are potentially two ways of achieving this: Either we stick to the previous formulation in which the expert picks capacity in stage one and assume that consumers do not observe this choice; or, alternatively, the expert chooses her capacity only in stage three together with the repair policy. Under both formulations consumers do not observe the expert's capacity when they pick η .

While the first formulation may appear more natural, there is a snag to it. When

consumers decide, they have beliefs about the expert's capacity choice which has already taken place. Technically, this formulation gives rise to a game of imperfect information. To solve it we need sophisticated solution concepts such as perfect Bayesian or sequential equilibria.

If we choose the second formulation, we have once again a game of perfect information. We can solve it using subgame perfect equilibria which, in turn, can be found by simple backwards induction. For this technical reason we opt for the second formulation. Nevertheless, the equilibrium we derive is also an equilibrium for the first formulation with the strategies and beliefs adjusted accordingly.

More specifically, in stage one the expert chooses D and R . In stage two consumers observe these prices and have beliefs about the repair policy *and* the capacity. According to these beliefs consumers evaluate the expected utility with the expert and pick η . In stage three the expert chooses (α, β, L) .

It turns out that this game has a unique equilibrium: The expert sets her capacity to the level allowing her to serve the whole market with non-fraudulent behavior. She repairs honestly. All consumers consult the expert. With the price for repair the expert persuades consumers of her honesty; with the price for diagnosis she appropriates the entire surplus W . Formally, the equilibrium is given by the following Proposition.

Proposition 2: *In the unique subgame perfect equilibrium in stage one the expert charges $D = p(q_h - q_\ell) - pr$ and $R = r$. In stage two consumers believe that $\alpha = 0$, $\beta = 1$, $L = d + pr$, and choose $\eta = 1$. In stage three the expert picks $\alpha = 0$, $\beta = 1$, and $L = d + pr$.*

This result is driven by the following ideas. Since the expert simultaneously picks her capacity and her repair policy, she will co-ordinate these choices. This means that if she opts for positive capacity, she will exhaust it with her repair policy; she will have neither insufficient nor excess capacity. Put differently, once we know her capacity, we know her repair policy, and vice versa.

Let us first look at the capacity choice. Given an ex ante probability of repair γ , the expert earns $(D + \gamma R)$ per customer at a cost of $(d + \gamma r)$. If the latter exceeds the former, she makes a loss per customer and, accordingly, sets $L = 0$. If the former exceeds the latter, the expertise business is more profitable than the alternative job. The expert sets capacity so as to satisfy the entire demand with her repair policy. Consequently, $L = 0$ for prices below the (heavy) line $D = d + \gamma(r - R)$ whereas for prices above this kinked line $L = \eta[d + \gamma r]$. See Figure 2.

< insert Figure 2 about here >

Let us now determine the expert's optimal repair policy. If $R < r$, repair is less attractive than the outside job and, therefore, the expert does not repair at all so that $\gamma = 0$. If $R = r$, the price of a repair equals its minimum average costs. The expert is indifferent and thus repairs efficiently, implying $\gamma = p$. Finally, if $R > r$ the expert repairs anything she can get hold of because repair is more profitable than the alternative job, i.e., $\gamma = 1$. See Figure 2.

If the expert repairs efficiently or too much, the consumers' willingness-to-pay for the expert's services equals $p(q_h - q_\ell)$. Efficient repair generates this revenue at a lower cost than too much repair. Consequently, the expert maximizes profits by non-fraudulent repair and she persuades consumers of her honesty by charging $R = r$. She sets $D = p(q_h - q_\ell) - pr$ so as to appropriate the surplus W .

3. Unobservable Expert Services

So far we have assumed that diagnosis and repair are observable and also verifiable. This assumption is appropriate for, say, dentists whose customers, willy-nilly, suffer any (un-) necessary drilling. It is however inappropriate for, e.g., a customer taking his car to the shop in the morning and picking it up in the evening without being able to tell whether the mechanic has worked on the vehicle. With unobservable services the expert has yet another possibility to defraud her customers: She can claim to have checked and fixed the car without even having looked at it, thus collecting diagnosis and repair fees from an unlimited number of customers.¹⁰⁾

3.1 The Model

Our previous model is easily extended to be able to cope with unobservable services. First, we have to introduce a diagnosis policy which we capture by the probability of diagnosis $\delta \in [0, 1]$. Since a repair is possible only after a diagnosis, the ex ante probability of repair has to be modified to $\delta\gamma$. If the expert is indifferent between working and not working, she works; if she is indifferent between underdiagnosis and underrepair she diagnoses too little but efficiently repairs all products she has a look at.

Next we have to introduce the expert's billing policy. By $\Delta, \Gamma \in [0, 1]$ we denote the probabilities that she charges for a diagnosis or a repair, resp. Since consumers cannot observe the expert's services, her billing policy is independent of her actual diagnosis

and repair policies. Nevertheless, since consumers know that repair is possible only after diagnosis, $\Delta \geq \Gamma$.

3.2. Observable Capacity

We start the analysis of unobservable services with the case where consumers observe the expert's capacity choice. It turns out that observable capacity is such a strong commitment device that in equilibrium the expert provides efficient diagnosis and repair; yet, unless the repair fee is zero, she overcharges.

We consider the following three stage game. In stage one the expert chooses (D, R, L) . In stage two consumers observe these choices. They have beliefs about the diagnosis, repair, and billing policies. According to these beliefs consumers evaluate the expected utility with the expert and pick η . In stage three the expert chooses $(\delta, \alpha, \beta, \Delta, \Gamma)$.

Proposition 3: *In a subgame perfect equilibrium in stage one the expert sets $L = (d + pr)$. Furthermore, she charges $D \in [0, p(q_h - q_\ell)]$ and $R = p(q_h - q_\ell) - D$. In stage two consumers believe that $\delta = 1$, $\alpha = 0$, $\beta = 1$, $\Delta = 1$, $\Gamma = 1$, and choose $\eta = 1$. In stage three the expert picks $\delta = 1$, $\alpha = 0$, $\beta = 1$, $\Delta = 1$, and $\Gamma = 1$.*

This result rests on the following reasoning. Since consumers cannot observe the expert's services, her billing policy is independent of her actual diagnosis and repair policy. It is, therefore, a (weakly) dominant strategy to charge each customer for a diagnosis and repair.

Let us now determine her diagnosis and repair policy. First, note that if the expert has positive capacity, there is nothing she can do with it but to diagnose and repair. Thus, if with honest services the number of customers does not exceed her capacity, the expert diagnoses and repairs efficiently. If, on the other hand, she has more customers than she can handle with honest services, only a fraction of her clientele gets treatment.

With honest services the consumers' willingness-to-pay is $p(q_h - q_\ell)$. Accordingly, if the expert has capacity $L \geq (d + pr)$ and charges prices such that $D + R \leq p(q_h - q_\ell)$, consumers are happy and consult the expert. The consumers' willingness-to-pay is lower if $L < (d + pr)$ because in this case they do not get treatment for sure. Finally, note that if the expert sets $L = (d + pr)$ and charges prices such that $D + R = p(q_h - q_\ell)$, she appropriates the entire surplus W .¹¹⁾

It is perhaps surprising that the commitment device capacity alone is sufficient to guarantee honest services. If the expert has the efficient capacity level, there is nothing she can do with it but to diagnose and repair efficiently. Since she can charge independently

of the services she performs, her incentives do not depend on prices. This observation also explains why it is ‘easier’ to establish Proposition 3 than Proposition 1 where the expert’s incentives depend on capacity and prices.

3.3. Unobservable Capacity

Let us now briefly consider the case of unobservable capacity. To do so we change the game of section 3.2. as follows: The expert chooses capacity in stage 3 instead of stage 1; in stage 2 consumers have beliefs about this capacity choice. It is straightforward to see that in any equilibrium of this game the expert has no capacity and, accordingly, provides no services. Whatever the prices and the number of customers, in stage 3 it is a dominant strategy for the expert to charge each customer for a diagnosis and a repair, ii) to set capacity to zero, and iii) to diagnose and repair nothing. A positive capacity level would increase costs without generating additional revenue.

With unobservable capacity the expert will thus always pick $L = 0$. Since consumers anticipate this behavior, they will not consult the expert in the first place so that we have no trade. Thus, if the expert cannot commit herself to a capacity level, with unobservable services she makes no profit. Consequently, if services and capacity are unobservable, the market mechanism cannot solve the fraudulent expert problem. This last result should help to clarify the central role capacity plays as commitment device in the previous section.

4. Discussion and Conclusions

We have analyzed a credence good which is provided by an expert. Since consumers can never be certain of the quality of the seller’s services, the expert has strong incentives to cheat. We have shown that if consumers rationally process all the information about market conditions, they can infer the seller’s incentives: In three out of four constellations the market does indeed solve the fraudulent expert problem. Only when services and capacity are unobservable do we end up with a no-trade equilibrium.

These findings corroborate our earlier results (Emons (1997)). There we show for a competitive framework that a market equilibrium exists in which experts are honest and all the surplus goes to consumers. Accordingly, the message of the two papers is in the same spirit: If consumers rationally process ex ante information about market conditions, the market mechanism can solve the fraudulent expert problem. Experts are honest in order to maximize the consumers’ surplus. In the competitive set-up honesty is necessary in order to survive; in the monopoly case non-fraudulent service generates the highest profit for the credence goods monopolist.

A few more remarks seem to be in order. First note that the possibility of charging separate prices for diagnosis and repair is crucial for our results on honest expert services. If we restrict the price of diagnosis to be zero and allow only the repair fee to be positive, as seems to be common practice at full-repair shops in the US, our model makes the following predictions: With observable services and capacity there is always overtreatment because repair is (infinitely) more profitable than diagnosis. With observable services and unobservable capacity the price of a repair must exceed its average cost to cover the free diagnosis; but then repair is also more profitable than the outside job and the expert will ‘repair’ anything she can get hold of. Only when services are unobservable and capacity is observable there exists an equilibrium with free diagnosis and non-fraudulent services. In this scenario capacity alone serves as an incentive device and efficient services go along with a whole range of prices, including the pricing policy of American full-repair shops.

Second, a comparison between Propositions 1 and 3 sheds some more light on the role of observability of services. With unobservable services the capacity commitment, in and of itself, is sufficient to sustain the efficient outcome. Since the expert charges all customers a repair anyway, her repair policy is completely independent of her pricing policy. Therefore, the relative price of repair and diagnosis doesn’t matter at all and the whole range of relative prices from zero to infinity is consistent with honest services. Things are different with observable services. Here the repair and pricing policies are not independent: the expert may only charge for those repairs she actually performed. If repair is more profitable than diagnosis, the expert repairs too much. Accordingly, with observable services the range of prices consistent with non-fraudulent services is ‘smaller’ than with unobservable services.

Third, note that the positive result of Proposition 3 depends crucially on our assumption of zero variable costs up to capacity: once capacity is installed, there is nothing the expert can do with it but work honestly. In contrast, if there were, say, positive variable costs of repair, the expert might try to slash these costs by undertreatment. What are then examples for this cost-structure that is the driving force for our positive result? The most obvious example is the small, owner-operated firm. Our model may thus help to explain why many credence goods are provided by owner-operated firms. If the firm grows and services are provided by employees instead of the owner herself, the prediction depends on whether wages constitute a variable cost or not. If wages are a fixed cost in the short run, as is typically the case in Europe, our cost structure is a reasonable approximation of a firm with employees; if, however, hire and fire policies are the rule, wages are a variable cost and capacity alone can no longer commit the seller to provide efficient services. In such a situation partnerships might be an attempt to mimic the cost

structure that is necessary for capacity to work as a commitment device.

Our next remarks concern the interpretation of capacity. A legal practice of two lawyers has (approximately) double the capacity of a one-woman-firm. A plumber with 20 employees has a much higher capacity than her colleague working with an apprentice only. If capacity is, say, an X-ray machine (the opportunity cost of which is its price), even an ordinary patient has an idea whether this machine can handle 5 or 50 patients a day. The important ratio clientele/capacity may be proxied simply by how crowded the shop typically is.

Next, a few remarks for the empirically-inclined reader. Empirical tests of the theoretical results are extremely difficult due to the very nature of the problem: it is fraud that we are looking for. Nevertheless, Marty (1998) shows using 8000 bills of Swiss general practitioners that busy doctors charge significantly less per patient than doctors with insufficient demand, indicating that there is indeed demand inducement. Keeler and Fok (1996) study the impact of an insurance reform in California that, after higher reimbursements for cesarean deliveries, equalized fees for vaginal and cesarean delivery, a relative price shift of 21%. They found a 0.7% nonsignificant drop of cesarean rates. This result, which doesn't appear consistent with the result of Proposition 1, may perhaps be explained by other high powered incentive devices such as medical malpractice suits that certainly discipline medical doctors in California. Interestingly enough, despite their result Keeler and Fok (1996) recommend the equalization of fees because it need not hurt providers and may improve patient trust.

In a simple framework we were able to work out conditions under which the market mechanism can solve the fraudulent expert problem. For a lot of skilled trades offering services of credence quality the market mechanism actually seems to do a fairly good job just as our model predicts; at least we couldn't find any anecdotes of, say, cheating plumbers, electricians, or cobblers.¹²⁾ In other professions, as the examples in the Introduction suggest, there is, however, fraud. The majority of these examples is from the medical profession where the market certainly does not operate in such an unhampered way as is assumed in our model; prices are often set by a regulator rather than the seller, insurers pay for the services, distorting consumers' incentives to gather and process the necessary information, etc. Accordingly, these examples of fraud do not contradict our analysis. Perhaps our results may help to find out what goes wrong in these professions so that better mechanism can be designed to induce honest services. Since expert services are often subject to licensing and regulation, a more thorough understanding of these markets will be helpful for public policy purposes. For credence goods sellers the following strategy recommendations follow from our analysis: With the cost structure given in

the paper it is possible to convince rational consumers of the quality of your services and to make a lot of money. Therefore, try to mimic this cost structure by setting up, e.g., a partnership; moreover, try to commit to a sunk capacity, in particular if your services are unobservable

Endnotes

1) We do not need a monopolist in the market structure sense. High information and search costs to consumers, which do definitely exist with credence goods, often provide a source of imperfect competition. A nice example is Chadwick's analysis of funeral provisions in England in the 19th century, when there were about 600-700 undertakers in London to provide 120 funerals per day. Chadwick argues that supply-side competitiveness was thwarted by demand-side characteristics such as high search costs and led to monopoly-like conditions over each funeral service; see, e.g., Ekelund and Price (1979). Moreover, note that since we deal with a credence goods monopolist, the 'separation' and the 'second opinion' mechanisms described in the preceding paragraph cannot work simply for lack of a second expert.

2) Other related theoretical papers include Milgrom and Roberts (1986), Glazer and McGuire (1991), Pitchik and Schotter (1993), Dana and Spier (1993), Wolinsky (1995), Dulleck (1998), Alger and Salanié (2001), Emons (2001), Liebi (2002a and 2002b), and Pesendorfer and Wolinsky (2003). For an experimental study mimicking a market for expertise, see Plott and Wilde (1991). There is also a small empirical literature on credence goods. Ekelund et al. (1995) and Mixon (1995) extend an approach of Laband (1986) to classify search and experience goods to include credence goods. They show that sellers of credence goods provide more informational cues such as certification and licensing in the *Yellow Pages* than do sellers of search goods. Laband (1991) argues that price may work to proxy experience and credence goods.

3) We make the continuum assumption not only for notational convenience. With a finite number of consumers we run into the following problem. Suppose the expert expects a clientele with $(1 - p)$ good and p bad products. With a finite number of customers, however, the actual realization of her clientele will be different from the expected one. Accordingly, at the end of the day she will realize that she has either too little or excess capacity and she will start behaving fraudulently (suggesting that it is better to see an expert in the morning rather than late afternoon). With a continuum of customers we do not encounter this difficulty which would complicate the analysis substantially. Yet in such a more general set-up, if appropriately modelled our qualitative results should still hold in expectation.

4) This is the standard assumption made in literature; see, e.g., Nitzan and Tzur (1991), Wolinsky (1993), or Taylor (1995). It captures in a straightforward manner the idea that it is cheaper to provide diagnosis and repair jointly rather than separately. An exception is the paper by Demski and Sappington (1987).

5) The fraudulent expert problem may disappear if consumers were to purchase long term insurance contracts that fully cover all repairs *and* forgone services during the entire product life; such covenants are commonly known as service or health maintenance plans. With these

contracts experts have correct incentives since they bear all marginal costs; they are the residual claimants. Yet such long term insurance contracts are particularly prone to consumer moral hazard so that in equilibrium consumers may purchase no service maintenance plans. The problem of too little repair may be solved by a short term warranty for lost services: if the product fails, the expert pays the consumer a sufficiently large amount of money. An honest expert may offer such a warranty at a lower cost than an expert who, say, doesn't repair at all. Such warranties provide experts with an incentive not to cheat. Yet, they may easily fail to do the job when there is consumer moral hazard in the last stage of product life. See Emons (1988, 1989). There are still a few other mechanisms dealing with the fraudulent expert problem: reputation for honest services, watchdog agencies verifying service quality etc. These mechanisms work only if there is the possibility of heavily punishing the expert if fraud is detected (they need some kind of repeated interaction) and thus lie outside the scope of our set-up.

6) Extending η to a strictly mixed strategy adds nothing to the analysis due to the assumed tie-breaking rules.

7) Since consumers choose simultaneously in stage two, we have, in fact, a game of 'almost perfect' instead of 'perfect' information. See, e.g., Tirole (1988), 431-432. After stage three payoffs are determined as follows. First, nature chooses whether the product is in good or bad shape. Then players follow their plans of stages one to three. Finally, nature decides whether the product works or fails and the actual payoffs are realized.

8) In the principal-agent literature a related result is known as the equal compensation principle. See, e.g., Milgrom and Roberts (1992), 228-232.

9) Darby and Karni (1973) also point out that the sellers' incentives depend on the state of demand. When there is 'no customer waiting for service', sellers have an incentive to oversell their services to utilize idle resources; this incentive to oversell disappears when 'the length of the queue of customers waiting for service is positive'. Darby and Karni do not discuss that the sellers' incentives also depend on prices.

10) Note that in Wolinsky's (1993) model diagnosis is verifiable and repair is unverifiable.

11) It is worth mentioning that if $D = p(q_h - q_\ell)$ and $R = 0$, trivially any $\Gamma \in [0, 1]$ is optimal for the expert. She may thus set $\Gamma = p$ so that in this particular equilibrium she does not overcharge.

12) See also Plott and Wilde (1982, p. 99) who were 'amazed' by how well the market did in their experiments. They conclude that markets as social control devices cannot be dismissed a priori.

Appendix

Proof of Proposition 1: We solve the game by backwards induction.

a) If $1 > L/(d + pr)$, the expert has more customers than she can handle with honest behavior. Given her time constraint, she is only interested in the profit per hour repair $(R - r)/r$ compared to the profit per hour diagnosis $(D - d)/d$.

If $R = rD/d$ which implies $(R - r)/r = (D - d)/d$, the expert is indifferent between diagnosis and repair and, therefore, repairs honestly. Accordingly, she sets $\alpha = 0$, $\beta = 1$ so that $\gamma = p$. A consumer who is served has utility $q_h - D - pR$. The consumer buys, i.e., sets $\eta = 1$, if prices do not exceed $D = dw$ and $R = rw$. With these maximum prices that consumers still accept the expert makes profits $(L/(d + pr)) [D + pR] - L = (L/(d + pr)) [p(q_h - q_\ell) - (d + pr)] < W$ because $L/(d + pr) < 1$.

If $R > rD/d$, the expert prefers repair to diagnosis. She sets $\alpha = \beta = \gamma = 1$ and thus treats $L/(d + r)$ customers. A consumer who is served has utility $q_h - D - R$. The maximum prices the consumer is willing to pay are $D \in [0; dw]$ and $R = p(q_h - q_\ell) - D$. With these prices the expert makes profits $(L/(d + r)) [D + R] - L = (L/(d + r)) [p(q_h - q_\ell) - (d + r)] < W$ because $L/(d + r) < 1$ and $(d + r) > (d + pr)$.

If $R < rD/d$, the expert prefers diagnosis to repair. She diagnoses all products and repairs only to use her otherwise idle capacity. Accordingly, she sets

$$\gamma = \begin{cases} (L - \eta d)/\eta r, & \text{if } L/(d + pr) < \eta < L/d; \\ 0, & \text{otherwise.} \end{cases}$$

A consumer who is served has utility $q_h - (p - \gamma)(q_h - q_\ell) - D - \gamma R$. The maximum prices the consumer is willing to pay are $D \in [(q_h - q_\ell)/(r/d + 1/\gamma); \gamma(q_h - q_\ell)]$ and $R = (q_h - q_\ell) - D/\gamma$. With these prices the expert makes profits $(L/(d + \gamma r)) [D + \gamma R] - L = (L/(d + \gamma r)) [\gamma(q_h - q_\ell) - (d + \gamma r)] < W$ because $r < (q_h - q_\ell)$ and $L/(d + \gamma r) < 1$.

b) If $1 = L/(d + pr)$, the expert fully uses her capacity with non-fraudulent behavior. If $R < rD/d$, she strictly prefers diagnosis to repair. If she carries out diagnoses for her entire clientele, she has $(L - \eta d)$ units of time left; honestly repairing the bad products just exhausts her capacity. If $R = rD/d$, the expert is honest, the argument being along similar lines as in a). Thus if $R \leq rD/d$, we have $\gamma = p$. A consumer has utility $q_h - D - pR$. The maximum prices a consumer is willing to pay are $D \in [dw; p(q_h - q_\ell)]$ and $R = q_h - q_\ell - D/p$. With these prices the expert makes profits $(L/(d + pr)) [D + pR] - L = (L/(d + pr)) [p(q_h - q_\ell) - (d + pr)] = W$ because $L/(d + pr) = 1$.

If $R > rD/d$, the expert prefers repair to diagnosis. She sets $\gamma = 1$ and treats only $L/(d + r)$ customers. A consumer who is served has utility $q_h - D - R$. The maximum prices he is willing to pay are $D \in [0, dw]$ and $R = p(q_h - q_\ell) - D$. With these prices the expert makes

profits $(L/(d+r))[D+R]-L = (L/(d+r))[p(q_h - q_\ell) - (d+r)] < W$ because $L/(d+r) < 1$ and $(d+r) > (d+pr)$.

c) If $1 < L/(d+pr)$, the expert has unused capacity with non-fraudulent behavior. If $R > rD/d$, she repairs anything. Accordingly, she sets $\gamma = 1$ and treats $\min[L/(d+r); 1]$ customers. A consumer who is served has utility $q_h - D - R$. The maximum prices he is willing to pay are $D \in [0, dw)$ and $R = p(q_h - q_\ell) - D$. With these prices the expert makes profits $\min[L/(d+r); 1][D+R]-L \leq (L/(d+r))[D+R]-L = (L/(d+r))[p(q_h - q_\ell) - (d+r)] < W$ because $L/(d+r) \leq 1$ and $(d+r) > (d+pr)$.

If $0 < R \leq rD/d$, the expert prefers diagnosis to repair. She diagnoses all products and uses repairs to exhaust her remaining capacity. Accordingly, she sets

$$\gamma = \begin{cases} 1, & \text{if } 1 \leq L/(d+r); \\ (L - \eta d)/\eta r & \text{if } L/(d+r) < 1 < L/d. \end{cases}$$

A consumer has utility $q_h - D - \gamma R$. The maximum prices he is willing to pay are $D \in [p(q_h - q_\ell)/(1 + \gamma r/d); p(q_h - q_\ell)]$ and $R = [p(q_h - q_\ell) - D]/\gamma$. With these prices the expert makes profits $\min[L/(d+\gamma r); 1][D+\gamma R]-L \leq (L/(d+\gamma r))[p(q_h - q_\ell) - (d+\gamma r)] < W$ because $(d+\gamma r) > (d+pr)$ and $L/(d+\gamma r) \leq 1$.

If $R = 0$, the expert sets $\gamma = p$ because there is no money in repair. With this repair policy a consumer has utility $q_h - D$. The maximum prices he is willing to pay are $D = p(q_h - q_\ell)$ and $R = 0$. With these prices the expert makes profits $D - L < W$ because $1 < L/(d+pr)$.

d) For all other prices the consumers' utility is less than their reservation utility and, accordingly, $\eta = 0$. The expert makes a loss L .

e) If the expert chooses $L = d+pr$, $D \in [dw; p(q_h - q_\ell)]$ and $R = q_h - q_\ell - D/p$ she makes the maximum profit W .

Q.E.D.

Proof of Proposition 2: We solve the game by backwards induction.

Stage 3) Given D, R, η , the triple (L, α, β) generates profits $\min\{L/(d+\gamma r); \eta\}[D+\gamma R]-L$. If $(D+\gamma R)/(d+\gamma r) < 1$, the alternative job is more attractive and the expert sets $L = 0$; if the inequality is reversed, the expertise business is more attractive and the expert sets $L = \eta[d+\gamma r]$ so as to satisfy the entire demand. A capacity in excess of demand is a waste of money.

Next we determine the expert's optimal repair policy. If $R < r$, repair does not cover minimum average cost and the expert sets $\alpha = \beta = \gamma = 0$. If $R = r$, price equals minimum average costs. The expert is indifferent and sets $\alpha = 0$, $\beta = 1$, and thus $\gamma = p$ so that she repairs efficiently. If $R > r$, the expert sets $\alpha = \beta = \gamma = 1$ because repair is more profitable than the outside job.

Stage 2) If the prices are such that $L = 0$, consumers set $\eta = 0$. Now consider those prices with $L = \eta[d+\gamma r]$ so that the entire demand is satisfied. If $R \geq r$, which implies $\gamma \in \{p, 1\}$,

the consumer's expected utility amounts to $q_h - D - \gamma R$. The consumer buys, i.e., sets $\eta = 1$, if prices do not exceed $R = [p(q_h - q_\ell) - D]/\gamma$. For $R < r$ and thus $\gamma = 0$ the consumer's utility is $\bar{U} - D$. He purchases if and only if $D = 0$.

Stage 1) Prices with $R < r$ give rise to zero profits. If for $R \geq r$ the expert charges the maximum prices $R = [p(q_h - q_\ell) - D]/\gamma$, she makes revenue $p(q_h - q_\ell)$. For $R = r$ the expert generates this revenue with capacity $L = d + pr$ while for $R > r$ she needs capacity $L = d + r$. Consequently, the expert maximizes her profits by charging $D = p(q_h - q_\ell) - pr$ and $R = r$.
Q.E.D.

Proof of Proposition 3: We solve the game by backwards induction.

Stage 3) Given (D, R, L, η) , the policies $(\delta, \alpha, \beta, \Delta, \Gamma)$ generate profits $\min\{L/\delta(d + \gamma r); \eta\} \cdot [\Delta D + \Gamma R] - L$. Independently of (δ, α, β) , the billing policy $\Delta = \Gamma = 1$ maximizes profits. These choices are unique unless L, η, D , and/or R is zero. Then any Δ and/or $\Gamma \in [0, 1]$ is optimal.

Let us now determine the optimal diagnosis and repair policy. If $\eta > L/(d + pr)$, the expert has more customers than she can handle with honest services. She sets $\delta = L/\eta(d + pr) < 1$ and $\alpha = 0$ and $\beta = 1$.

If $\eta \leq L/(d + pr)$, with honest services the expert has at least as much capacity as customers. She sets $\delta = 1, \alpha = 0, \beta = 1$; overcapacity idles.

Stage 2) If $1 \leq L/(d + pr)$, a customer gets honest services but is overcharged. His utility is thus $q_h - D - R$. The consumer buys, i.e., sets $\eta = 1$, if $D + R \leq p(q_h - q_\ell)$.

If $1 > L/(d + pr)$, the expert undertreats and overcharges. A consumer's utility is $q_h - (1 - \delta)p(q_h - q_\ell) - D - R$. The consumer buys if $\delta p(q_h - q_\ell) \geq D + R$.

Stage 1) If the expert sets $L \geq (d + pr)$ and charges reservation prices $D + R = p(q_h - q_\ell)$, $\eta = 1$ and the expert's profit is $p(q_h - q_\ell) - L$. By setting $L = (d + pr)$ the expert maximizes this profit and appropriates the entire surplus W .

If she picks $L < (d + pr)$ and charges the corresponding reservation prices $D + R = \delta p(q_h - q_\ell)$, $\eta = 1$ and her profit amounts to $\delta p(q_h - q_\ell) - L = \delta[p(q_h - q_\ell) - (d + pr)] < W$.
Q.E.D.

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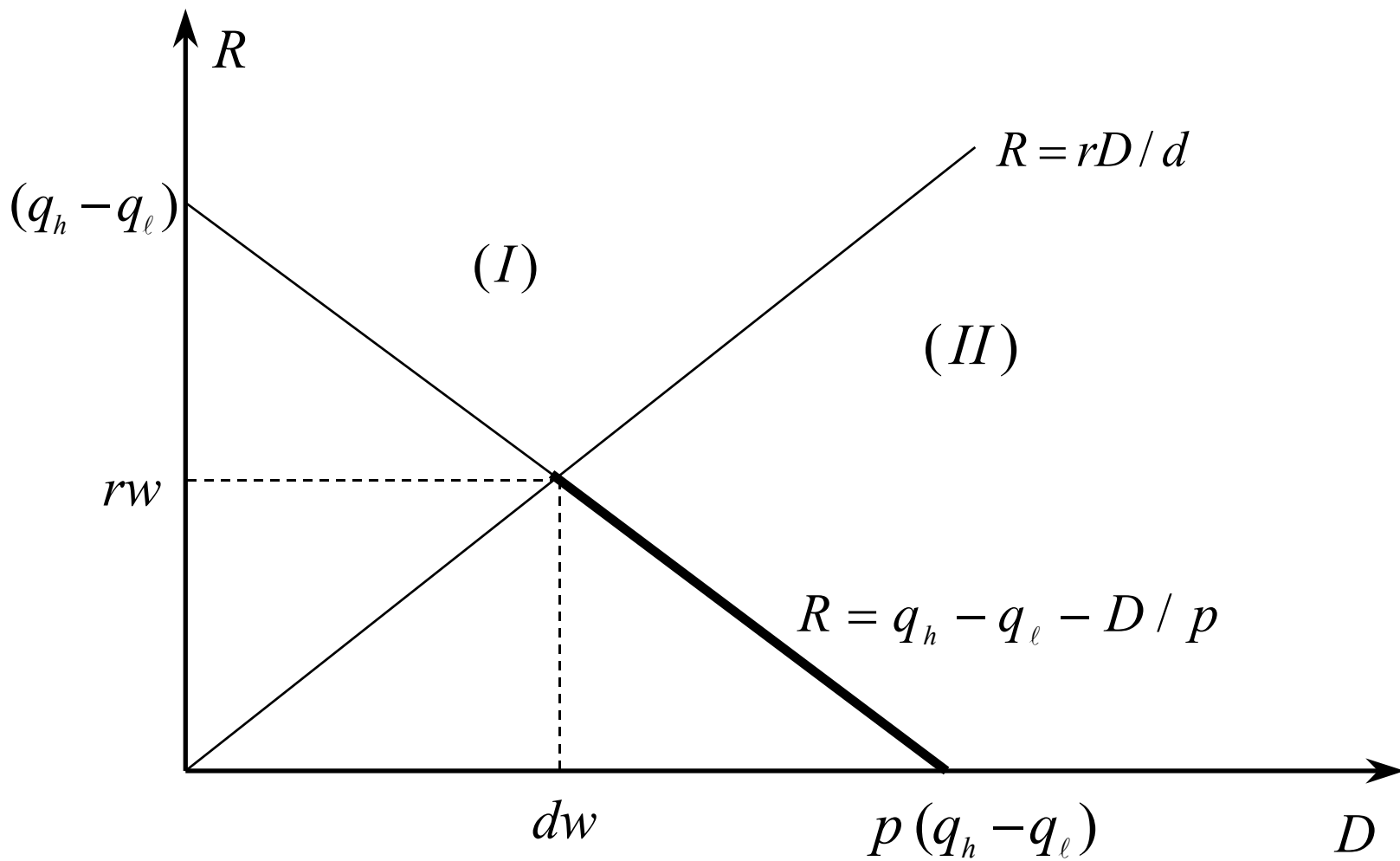


Figure 1: Experts' incentives with observable capacity

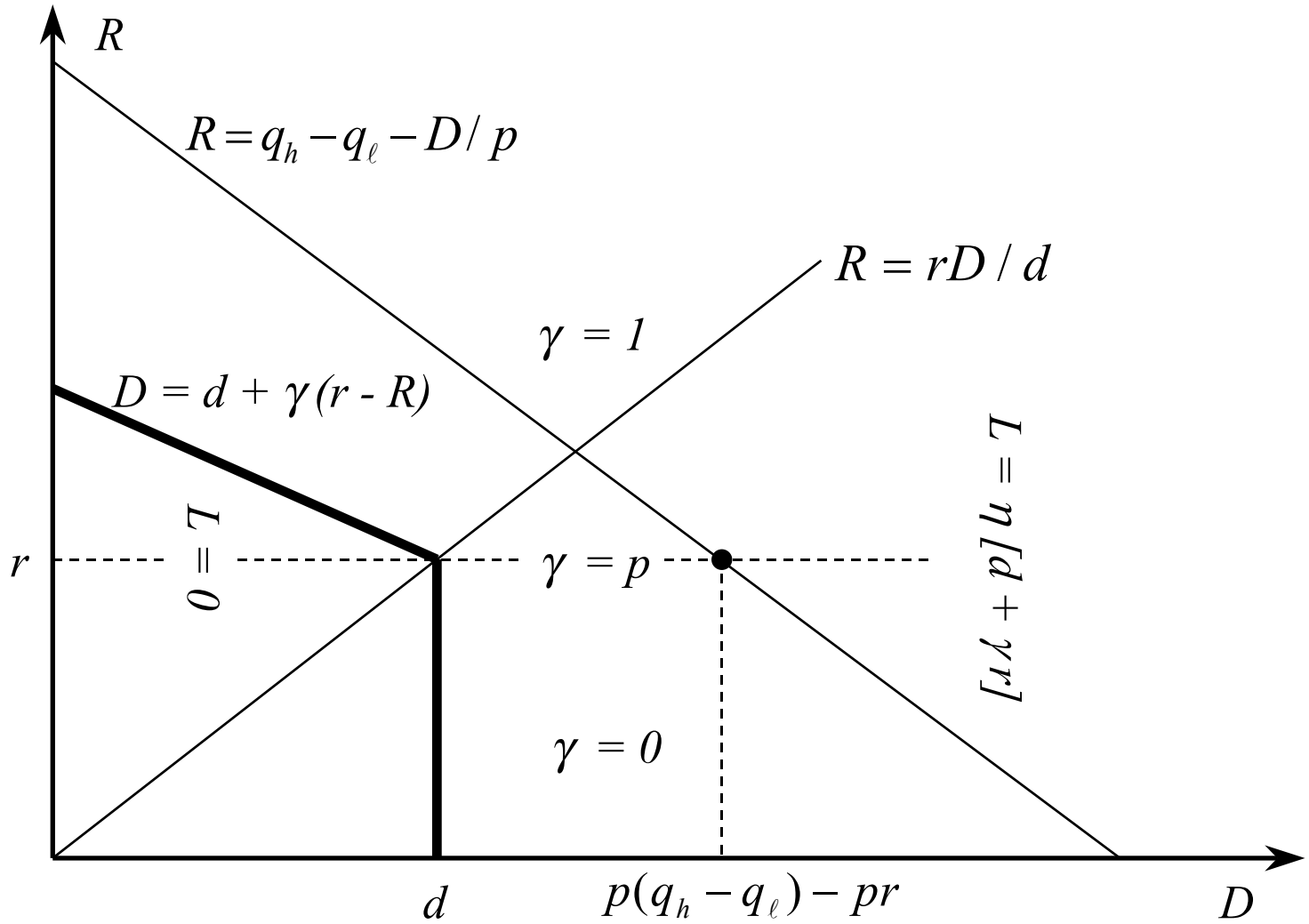


Figure 2: Expert's incentives with unobservable capacity