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COMPETITION IN MARKETS FOR CREDENCE GOODS

by

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ABSTRACT

This paper investigates the functioning of markets for credence goods. These are markets in which the information asymmetries are of the form that sellers are also experts who determine customers' needs. It examines the role of customers' search for multiple opinions in disciplining experts. It characterizes the equilibrium amount of fraud in such markets and shows that, despite intense competition, the information asymmetry will be translated into a mark-up over cost embodied in the prices of the less expensive services. It points out that the equilibrium does not maximize the expected customers' surplus, even subject to the informational constraints regarding the experts' superior information.

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1. Introduction

The term credence goods refers to goods and services whose sellers are also the experts who determine the customers' needs. This feature is shared by medical and legal services and a wide variety of repair services. In such markets, even when the success of performing the service is observable, customers often cannot determine the extent of the service that was needed and how much was actually performed. This information asymmetry creates obvious incentives for opportunistic behavior by the sellers. Although evidence on seller honesty is naturally difficult to obtain, regulatory agencies have made some attempts to study this aspect. A field study of the optometry industry conducted by the FTC [1980] documented consistent tendency by optometrists to prescribe unnecessary treatment; a survey of 62 automobile repair shops conducted by DOT found that 53% of the service charges were for needless repairs[1]

The purpose of this paper is to present a simple model and use it to examine how this special information asymmetry[2] affects the functioning of such markets. The model assumes two possible types of problem--a major, high cost, problem (denoted H) and a minor, low cost, one (denoted L). The basic force that mitigates experts' incentives to misrepresent minor treatments as major ones is customers' search for multiple opinions. Customers' search is costly and the tension is between the asymmetry of information and the search-cum-diagnosis cost, which induces customers to economize on the number of opinions. In the main scenario considered here (Section 3) we focus on an interior equilibrium which involves search by the customers (there is also a degenerate equilibrium in which experts recommend the expensive service to all and customers never search). The equilibrium outcome involves a certain amount of "fraud" which exactly balances the incentives to cheat and the incentives to search: the extent of fraud is just sufficient to induce customers to seek second opinions, and this in turn prevents experts from always recommending the expensive service. To achieve this balance, the equilibrium price of the minor service has to embody a sufficient markup over cost. Thus, in this scenario, the asymmetry of information is translated into excessive search and diagnosis effort as well as higher prices. It turns out that, despite the competition, the equilibrium outcome does not maximize the customers' expected surplus, even subject to the informational constraints regarding the experts' superior information. This is because there is additional source of information asymmetry owing to the experts' ignorance concerning customers' search history.

The theoretical literature on markets of this type is not very large. Arrow [1963] provides a broad discussion of the informational aspects of the market for medical services. Darby and Karni [1973] term such goods "credence goods" and discuss how reputation combined with market conditions and technological factors affect the amount of fraud. Plott and Wilde [1980, 1991] characterize customers' optimal search and report laboratory experiments designed to mimic such a market. They do not attempt an equilibrium analysis. Pitchik and Schotter [1987, 1989] are closer to the present paper both in terms of the model and its focus. The major difference is that in their model the prices are exogenously fixed whereas here the focus is on competitive interaction through explicit price competition. Wolinsky [1993] and Glazer and McGuire [1991] show that the information asymmetry under consideration might induce expert specialization (this idea is discussed in Section 4 below).

Emmons [1994] identifies a certain cost structure for experts' services under which price competition results in non-fraudulent behavior.

In a less direct way this paper is also related to the literature on product quality provision under conditions of asymmetric information (see, e.g., Klein and Leffler [1981], Wolinsky [1983]). There too better informed sellers face less informed buyers and some of the main questions concern the manner in which competition and monitoring devices, such as search or reputation, interact to determine the prices and the range of products. Owing to the special nature of the services considered here, there are at least two important features which separate this paper from that literature. First, since after getting the service customers still remain uncertain about its exact nature, the information problem here remains significant even when the result of the service can be contracted upon. Second, the cost side here features a certain type of economies of scope: the search-cum-diagnosis cost makes it more efficient to have one expert provide a range of services as well as diagnosis.

2. The model

There are many (a continuum) customers in this market and each of whom has either a major or a minor problem. A customer knows that he has a problem, but does not know how serious it is. There are N (a large finite number) experts whose task is to diagnose and fix these problems. The cost of fixing the major problem is H (for "high") and the cost of fixing the minor one is L (for "low"), $L<H$. The existence of a problem is both observable and verifiable, but the type of service (H or L) is not observable to customers. This means that payments can be conditioned on the resolution of a problem but not on the type of treatment, and this implies in turn that experts might be

induced to misrepresent a minor service as a major one.

The interaction is modelled as follows. Time is divided into discrete periods and has no beginning or end (i.e., time goes from $-\infty$ to ∞). At the beginning of each period a new batch of customers enters the market. Their measure is M and fractions w and (1-w) have the H and L problems respectively. They join the pool of customers who were left from previous periods. Then each customer chooses an expert and offers a price p. The expert diagnoses the problem and decides whether to serve this customer at p. If the expert rejects this offer, the customer has an opportunity to offer immediately another price $p \geq H$. If the expert agrees to either of these price offers, he will serve the customer who will then leave the market. If the customer decides not to offer a second price or if this offer is rejected, he will either leave the market or proceed to the next period.

The first price p that a customer offers to an expert will typically satisfy $L \leq p < H$ and will be interpreted as the price this customer will pay if the expert diagnoses him as L. Rejection of this offer is interpreted as an H diagnosis, after which either the customer will offer the price H to which the expert will agree or he will go on[3].

A customer incurs a cost k(n) which increases in the number n of experts that he samples. This cost accounts for the time and effort spent on search as well as for any diagnosis costs which are passed on to customers in the form of diagnosis fees[4]. We shall focus on the case where customers sample at most two experts. That is, $k(n)=nk>0$ for $n=1,2$ and $K(n)$ is prohibitively large for $k \geq 3$. We shall also consider briefly the case $k(n)=nk$ for all n.

The utility to a customer who visited n experts will be $B-P-k(n)$ if he ends up being served for the price P, and it will be $-k(n)$ if he is not served. Customers are maximizers of expected utility. The reservation value B is assumed large enough so as to assure that participation is always desirable for customers. The profit that an expert derives from a customer is simply the price minus the cost if the service is administered and it is 0 otherwise. Since in the main version of the model experts cannot affect the number or type of their potential customers, their objective is simply to maximize the per customer profit.

A more formal description of the behavior which sums up the above is as follows. A strategy for an expert is a function x(p) capturing the probability with which this expert will reject a price offer p, conditional on diagnosing the customer as L. Given the particular search technology assumed here, a customer's strategy is a triple $(p^1, p^2(p), y(p))$, where p^1 is the price offered by the customer in the first visit, $p^2(p)$ is the price offered in the second visit after offering p in the first, and y(p) is the probability with which a customer on his first visit accepts the H recommendation when it follows a price offer p. An expert's belief, b(p), is the probability that he assigns to the event that a type L customer who offered p is on his first visit.

Note that the formal statement of the strategies includes neither specification of the price offered by a buyer who decides to stay with an expert who rejected his initial offer, nor specification of the acceptance policy of the seller in such an event. Instead, it is assumed that in such a case the buyer will offer H and the seller will accept. We do not include these parts of the behavior in the specification of the strategies, since in any equilibrium the behavior will be anyway as assumed and the expanded description might just needlessly clutter the presentation.

Let $\pi[p', x(p), y(p), b(p)]$ denote the profit that an expert with beliefs b(p) and strategy x(p) expects to get from an L customer who has offered p' and whose search strategy is given by y(p),

$$(1)\quad \pi[p',x(p),y(p),b(p)] = [1-x(p')](p'-L) + x(p')[b(p')y(p')+(1-b(p'))](H-L).$$

The term p'-L is the expert's profit if he accepts the offer p'; $[b(p')y(p')+(1-b(p'))](H-L)$ is the expected profit upon rejection. The latter term accounts for the probability that the customer is on his second visit, 1-b(p'), and the probability that the customer is on his first visit but will stay b(p')y(p').

Let $c[p^1,p^2,y,x(p)]$ denote the expected cost for a customer who starts by offering p^1, continues after rejection with probability y and offers p^2 in his second visit where experts employ x(p),

$$(2)\quad c[p^1,p^2,y,x(p)] = k + (1-w)(1-x(p^1))p^1 + [w+(1-w)x(p^1)]yH +$$

$$+ [w+(1-w)x(p^1)](1-y)\left[k + \frac{(1-w)x(p^1)(1-x(p^2))p^2 + [w+(1-w)x(p^1)x(p^2)]H}{w+(1-w)x(p^1)}\right]$$

The term $(1-w)(1-x(p^1))$ is the probability that p^1 will be accepted by the first expert; $[w+(1-w)x(p^1)]y$ is the probability that the first expert will reject p^1, but the customer will stay and pay H; the last term accounts for the event that p^1 is rejected and the customer goes to another expert. In the latter case the cost k is incurred again and the expected price (captured by the large fraction) is evaluated using the updated probability $(1-w)x(p^1)/[w+(1-w)x(p^1)]$ that this customer is of the L type.

In a symmetric <u>equilibrium</u> all customers use the same strategy $(p^1,p^2(p),y(p))$, all experts have the same beliefs b(p) and use the same strategy x(p) and these satisfy:

(I) For all p, $x(p)$ maximizes $\pi[x(p),p,y(p),b(p)]$

(II) p^1 minimizes $c[p^1,p^2(p^1),y(p^1),x(p)]$ and,

for any p, $p^2=p^2(p)$ and $y=y(p)$ minimize $c[p,p^2,y,x(p)]$.

(III) The beliefs $b(p^i)$, $i=1,2$, are confirmed in equilibrium.

These equilibrium conditions are standard requirements in the spirit of sequential (or perfect bayesian) equilibrium and hence do not require further explanation.

Finally, let us point out that the role of the time dimension is rather limited. Its only purpose is to achieve the effect that the population's mix of customers who seek first and second opinions remains constant throughout the operation of this market, so that experts cannot infer customers' "market age" from the timing of their visit. Alternatively, we can model the interaction as timeless with the understanding that such inferences are not possible.

3. Equilibrium Analysis

We shall refer to an equilibrium as _interior_, if for some $p<H$, $x(p)<1$ (i.e., some L customers are served for a price below H).

Claim 1: In an interior equilibrium: (i) $x(p^1)<1$; (ii) $p^1=p^2(p^1)$; (iii) For all $p<H$, $x(p)>0$; (iv) For all $p<H$, $y(p)<1$.

Proof: (i) It may not be that $x(p^1)=1$, since by virtue of this being an interior equilibrium there is $p<H$ such that $x(p)<1$ to which customers can deviate profitably.

(ii) First, note that $y(p^1)<1$, since it follows from (1) that $y(p^1)=1$ implies $x(p^1)=1$, contrary to (i). This means that $p^2(p^1)$ is offered at equilibrium. Therefore, $p^1\neq p^2(p^1)$ implies $b[p^2(p^1)]=0$ and hence $x(p^2(p^1))=1$. But this means that a second visit customer will profit from deviating to p^1.

(iii) It follows from (2) and equilibrium condition (II) that $x(p)=0$ implies $y(p)=1$ which in turn implies $x(p)=1$.

(iv) Note that $x(p')<1$ implies $y(p')<1$ since, as noted above, $y(p')=1$ implies $x(p)=1$. Now, from $x(p^1)<1$ and $y(p^1)<1$ it follows that, $x(p)=1$ implies $y(p)=0$. This can be observed by minimizing (2) but is also intuitively clear: after offering p the customer's updated probability that he is of type L is higher than after offering p^1 (since $x(p^1)<1$ while $x(p)=1$) and hence continued search is more attractive. QED

Therefore, an interior equilibrium outcome is characterized by a price $p^*=p^1=p^2(p^1)$, and two probabilities $x^*=x(p^*)$ and $y^*=y(p^*)$ such that $0<x^*<1$ and $y^*<1$. It works as follows. A customer goes to an expert and offers the price p^*. If the problem is H the expert declines and if it is L he accepts with probability $(1-x^*)$. Following a rejection, a second time customer agrees to be treated at the price H, while a first time customer agrees with a probability y^*.

From Claim 1 and expressions (1) and (2) we have that the equilibrium strategies satisfy for all $p<H$

$$(3) \qquad (p-L) \leq (H-L)[y(p)+x^*(1-y^*)]/[1+x^*(1-y^*)]$$

$$(4) \qquad H \geq k + \frac{(1-w)x(p)[1-x(p^2(p))]p^2(p) + [w+(1-w)x(p)x(p^2(p)]H}{w+(1-w)x(p)}$$

A strict inequality in (3) implies $x(p)=1$ and a strict inequality in (4) implies $y(p)=o$. Notice that the reversed inequalities are ruled out by parts (iii) and (iv) of Claim 1 respectively. Part (i) of that claim implies that for $p=p*$, (3) holds with equality. This means that an expert who faces a type L customer weakly prefers serving him at p^* and earning p^*-L to recommending H and earning H-L with probability $[y^*+x^*(1-y^*)]/[1+x^*(1-y^*)]$. This probability takes into account that a fraction $1/[1+x^*(1-y^*)]$ of the L customers are visiting for the first time and hence will accept an H-recommendation with probability y^*, while the remaining fraction $x^*(1-y^*)/[1+x^*(1-y^*)]$ have visited already another expert before and will accept such recommendation with certainty. Inequality (4) assures that a customer who has offered p and received an H-recommendation in his first visit weakly prefers to continue searching. The RHS captures the expected value of continuing the search: the conditional probability that this customer has the L-problem is $(1-w)x(p)/[w+(1-w)x(p)]$ which multiplied by $[1-x(p^2(p))]$ gives the probability that the next expert will offer him the L-service; the complementary probability, that the next expert will offer him the H-service, is then $\{w+(1-w)x(p)x[p^2(p)]\}/[w+(1-w)x(p)]$.

Now, if p^* were exogenously fixed, and x^* and y^* satisfied (3) and (4), with (3) holding as equality, this configuration would be an equilibrium. This is in the sense that the expert's strategy, which reduces to the choice of x, and the customer's strategy which reduces to the choice of y are mutual best responses. The incentives to cheat and the incentives to search are exactly balanced: there is sufficient amount of fraud to induce some customers to seek second opinions, and customers seek second opinions sufficiently vigorously to prevent experts from always rejecting offers below H.

For a triple p^*, x^* and y^* satisfying (3)-(4) to constitute an equilibrium outcome it has to be that customers do not wish to deviate to any other p. It is easy to see that, if we allow optimistic beliefs whereby after $p \neq p^*$ the expert believes that he is facing a second time customer, then any such triple can be supported as an equilibrium outcome by $x(p)=1$ for all $p \neq p^*$.

Such beliefs, however, artificially arrest the competitive pressures. We would therefore analyze the equilibria under the restriction that out-of-equilibrium beliefs coincide with the population distribution. That is,

(5) $$b(p)=1/[1+x^*(1-y^*)].$$

Under this restriction we get the following characterization.

<u>Proposition</u>: Let b(p) be given by (5).

(i) If $k>(1-w)(H-L)/(1+SQRT(2w))$, the unique symmetric equilibrium is degenerate in the sense that $x(p)=1$ and $y(p)=1$, for all $p<H$. That is, all customers are served at the price H by the first expert they sample.

(ii) If $k<(1-w)(H-L)/(1+SQRT(2w))$, there are three equilibria. One equilibrium is the degenerate one described in (i). The other two are interior equilibria in which $p^*<H$, $0<x^*<1$, $y^*=0$ and (3)-(4) hold with equalities.

<u>Proof</u>: First note that $p^*=H$, $y(p)=1$ and $x(p)=1$ for all p is always an equilibrium. Next consider the system

(6) $$(p^*-L) = (H-L)x^*/(1+x^*)$$

(7) $$H = k + \frac{(1-w)x^*(1-x^*)p^* + [w+(1-w)(x^*)^2]H}{w+(1-w)x^*}$$

which is system (3)-(4) with $y^*=0$.

<u>Claim 2</u>: System (6)-(7) has a positive solution x^* iff $k\leq(1-w)(H-L)/(1+SQRT(2w))$. If the inequality is strict, there are two solutions and both are between 0 and 1.

<u>Proof</u>: Substitution from (6) into (7) and rearrangement yield that an x^* solution is a solution to the following quadratic equation.

(8) $$(1-w)(H-L+k)x^2 + [k-(1-w)(H-L)]x + kw = 0$$

Now (8) has a solution if

$$[(1-w)(H-L)-k]^2 - 4(1-w)(H-L+k)wk \geq 0,$$

i.e., if $k \leq (1-w)(H-L)/(1+\text{SQRT}(2w))$ or $k \geq (1-w)(H-L)/(1-\text{SQRT}(2w))$. But only the first range is relevant, since for k in the second range the x solutions of (8) are negative. For k in the first range, the x solutions of (8) is between 0 and 1. To see this, note that the LHS of (8) is positive at $x=0$ and $x=1$ and, for $k<(1-w)(H-L)$, its minimum point $x=[(1-w)(H-L)-k]/2(H-L+k)$ is between 0 and 1. Finally, if $k<(1-w)(H-L)/(1+\text{SQRT}(2w))$ there are two solutions. □

Now, for $k<(1-w)(H-L)/(1+\text{SQRT}(2w))$, let p^* and x^* solve system (6)-(7) and consider the following strategies.

(9) For the customers

$$p^1 = p^*; \quad p^2(p) = p^* \text{ for all } p; \quad y(p) = \begin{cases} 0 & \text{for } p \leq p^* \\ (p-L)(1+x^*)/(H-L) - x^* & \text{for } p>p^* \end{cases}$$

and for the experts

$$x(p) = \begin{cases} 1 & \text{for } p<p^* \\ x(p)=x^* & \text{for } p \geq p^*. \end{cases}$$

Claim 3: The above strategies constitute an equilibrium.

Proof: First, since p^* and x^* satisfy (6), experts are just indifferent between agreeing to a p^* offer from an L type or rejecting it and hence x^* is a best response. Second, since (7) is satisfied, first time customers are just indifferent between stopping and continuing to search so that $y(p^*)=0$ is best response. Third, after $p<p^*$, the continuations $x(p)=1$ and $(p^2(p),y(p))=(p^*,0)$ are mutual best responses: $x(p)=1$ is a best response since

$$(p-L) < (H-L)x^*/(1+x^*);$$

$p^2(p)=p^*$ is obviously a best response to the equilibrium $x(.)$; $y(p)=$ is a best response since

$$H > k + \frac{(1-w)x(p)(1-x^*)p^* + [w+(1-w)x(p)x^*]H}{w+(1-w)x(p)}$$

Finally, after $p>p^*$, the continuations $x(p)=x^*$ and $(p^2(p),y(p))=(p^*,[(p-L)(1+x^*)-(H-L)x^*]/(H-L))$ are mutual best responses: as before $p^2(p)=p^*$ is obviously optimal; $x(p)=x^*$ is a best response since $y(p)$ is so chosen that the appropriate version of (3) holds with equality

$$(p-L) = (H-L)[y(p)+x^*]/(1+x^*);$$

$y(p)$ is a best response since due to $x(p)=x^*$ the value of continued search is given by the RHS of (7) which means that all y's are best responses. Thus, the strategies described in (9) constitute an equilibrium. □

Since for $k<(1-w)(H-L)/(1+SQRT(2w))$ system (6)-(7) has two solutions and in both x^* is between 0 and 1, there are precisely two equilibria of this type. It remains to show that these are the only interior equilibria. Let $p^*,p^2(p),y(p),x(p)$ be an interior equilibrium different from the above. Since by claim 1, $x(p)>0$ and $y(p)<1$ for any $p<H$, there are only two cases to consider. Either $0<x^*<1$ and $0<y^*<1$, or $0<x^*<1$ and $y^*=0$. In the first case (3) and (4) hold as equalities for $p=p^*$, while in the second case (3) holds as an equality and (4) as a strict inequality (if (4) held as equality this would be one of the equilibria described in (9)).

<u>Claim 4</u>: There is no interior equilibrium with $0<x^*<1$ and $0<y^*<1$.

<u>Proof</u>: Suppose there is. Since for $p=p^*$ (3) holds with equality, there is a close enough $p<p^*$ such that

(10) $$(p-L) > (H-L)x^*(1-y^*)/[1 + x^*(1-y^*)].$$

It follows that $y(p)>0$ since, by (10), $y(p)=0$ would imply $x(p)=0$ contrary to Claim 1. But $0<y(p)<1$ requires that (4) holds with equality for this p. Since $0<y^*<1$, (4) holds with equality for $p=p^*$ as well (i.e., (7) holds). This means that the RHS of (4) is the same for p^* and some $p<p^*$. But this is impossible. To see this, notice first that the RHS of (4) weakly increases if we replace $p^2(p)$ by p^* since $p^2(p)$ optimizes the customer's second price offer. Second, since $p<p^*$, it has to be that $x(p)>x^*$, for otherwise p would be a profitable deviation. But since the RHS of (4) is decreasing in $x(p)$ it follows that RHS of (4) is larger with $p=p^*$ than with $p<p^*$. Therefore, there is no interior equilibrium with these properties. □

Claim 5: There is no interior equilibrium with $0<x^*<1$, $y^*=0$ and with (4) holding as strict inequality for $p=p^*$.

Proof: Suppose there is. If for some $p>p^*$, $x(p)=1$ then (4) holds with strict inequality for this p. This implies $y(p)=0$ which together with $p>p^*$ and the fact that (3) holds as equality for $p=p^*$, yield the strict inequality (10). Hence $x(p)=0$ contradicting $x(p)=1$. Therefore, $x(p)<1$ which means that (3) holds with equality for any $p>p^*$. Now, $p>p^*$, the fact that (3) holds with equality for $p=p^*$ and $y(p^*)=y^*=0$ imply that $y(p)>0$. This requires that (4) holds with equality for p. But since (4) holds with strict inequality for $p=p^*$ and since the RHS of (4) is a continuous function of $x(p)$, there must be $\varepsilon>0$ such that $x(p)<x^*-\varepsilon$ for all $p>p^*$. Hence, the deviation to a $p>p^*$ sufficiently close to p^* is profitable, contrary to the assumption that this is an equilibrium. Therefore, there is no interior equilibrium with these properties. □

Thus, Claims 4 and 5 rule out all the remaining candidates for interior equilibria, so that the equilibria described in part (ii) of the proposition and more precisely in (9) are the only interior equilibria with the postulated out-of-equilibrium beliefs. QED

These interior equilibria feature the maximum amount of search -- $y^*=0$ means that all those who are recommended the expensive service solicit a second opinion. But despite this, the equilibrium still features a certain amount of "fraud" as captured by $x^*>0$.

Notice that the two interior equilibria can be distinguished in terms of their <u>pseudo-stability</u> in the following sense. Think of x and y as the appropriate <u>fractions</u> of the expert and customer populations. Now dislocate the equilibrium x^*, adjust p^* so that (3) holds and let the system follow the direction of the best responses. Consider the equilibrium with the lower x^*. If x is lowered in this manner, (4) will hold with "$<$". Consequently, y will adjust upwards turning (3) into a "$<$" and hence driving x upwards. If x is increased relative to the equilibrium, (4) holds with "$>$" and customers' best response is to offer a slightly higher p. This increases the LHS of (3) and drives x downwards. Thus, the forces generated by the dislocation drive x back to its original equilibrium level. The reverse is true for the equilibrium with the higher x^*. There an increase in x causes (4) to hold with "$>$" thereby driving y upwards and hence x further upwards and away from the original equilibrium level. Thus, only the equilibrium with the lower x^* is pseudo-stable in the above sense.

Consider the comparative statics exercise of raising the search cum diagnosis cost k. Observe from (8) that this will raise the lower equilibrium x^* and will lower the higher one. Thus, in the stable equilibrium a higher k is translated into a higher level of "fraud" and a higher price, which is the natural response to be expected. In the unstable equilibrium, this comparative statics exercise will lead to the counter-intuitive reversed results.

4. Discussion

Welfare

Since in this model the demands are inelastic and all customers are served, maximization of the total surplus (the sum of customers' surplus and experts' profits) is equivalent to minimization of the aggregate search-cum-diagnosis costs. Since multiple visits involve duplication of the diagnosis costs, total costs are minimized when each customer visits only one expert, in which case the cost is k per customer. In contrast, in the interior equilibria characterized above this cost is $[1+w+(1-w)x^*]k$ per customer, because all customers who are recommended the H service seek a second opinion, and this includes the fraction w of all customers who truly need the major service and the fraction $(1-w)x^*$ who were "deceived" by the first expert.

The information asymmetry regarding the severity of the problem alone does not necessarily cause inefficiency in this environment. After all, the no-search equilibrium, where each customer is served by the first expert he visits at the price H, minimizes the search costs and hence is efficient. Furthermore, even if some customers had reservation values between L and H, so that a uniform price of H involves inefficiency, or if the welfare measure puts more weight on the customers' surplus, it is still possible to design centralized mechanisms that achieve a welfare level arbitrarily close to the maximum. This can be accomplished through a mechanism that, with small probability, resorts to a second opinion after an H diagnosis and levies a heavy fine on an expert whose H diagnosis is being contradicted. However, the competition considered here does not admit contracts which condition on multiple opinions and levy fines.

Even when we impose the constraints that experts cannot be forced below their cost, and that payments to an expert can be conditioned only on the diagnosis he made and the service he provided, the interior equilibrium does not maximize customers' surplus. To see this, note that a mechanism which satisfies these constraints has to be of the following form: if the expert diagnoses the problem as L, he gets to fix it at some price P_L; if he diagnoses it as H, he gets to fix it for some price P_H with probability y and with the complementary probability of 1-y it is taken to another expert who fixes it for H. The problem of maximizing customers' surplus subject to these constraints is then to choose P_L, P_H and y to minimize

$$(11) \qquad (1-w)P_L + w[yP_H + (1-y)(k+H)]$$

$$\text{subject to} \quad P_L - L \geq y(P_H - L)$$

$$P_L \geq L; \; P_H \geq H.$$

The first constraint is the incentive compatibility constraint which assures that the expert has no incentive to misrepresent the L service as an H service. Substituting the constraints into the minimand, the problem becomes one of choosing $y \in [0,1]$ to minimize

$$(1-w)[L + y(H-L)] + w[H + (1-y)k].$$

The solution is y=1 or 0 according to whether k is greater or smaller than $(1-w)(H-L)/w$. Thus, under this mechanism, for small k, the expected payment per customer is $wH+(1-w)L$ while the expected search cost is $[1+w]k$. In contrast, at the interior equilibrium, both of these magnitudes are higher: the expected payment is $[w+(1-w)(x^*)^2]H+(1-w)[1-(x^*)^2]p^*$ while the expected search cost is $[1+w+(1-w)x^*]k$.

Note that such mechanism can outperform the equilibrium because of two built-in advantages that it has. First, it eliminates the expert's uncertainty on whether a buyer is in his first or second visit to an expert. It also can commit to continue the search with a positive probability although this is not profitable ex-post and hence will not be sustainable in equilibrium.

Diagnosis costs

The cost k represents both the customer's search cost and the cost of diagnosis. A more complete model would distinguish between a diagnosis cost d, a diagnosis fee, f, charged by the expert for a visit, and a search cost s borne by the customer. The sum s+f corresponds to the cost k in the above model. We may now assume that the experts engage in a Bertrand style competition over their diagnosis fees, f, which they announce simultaneously. In this case, the model can be closed by the additional equilibrium condition

$$(p^*-L)(1-w)(1+x^*)/[1+w+(1-w)x^*] + f = d$$

The LHS captures the expected revenue net of service cost per customer, which in Bertrand competition will be driven to equality the diagnosis cost. Note that if such equality is achieved with a negative f, it might be interpreted as advertising, office decoration or other rent dissipating expenditures aimed at attracting customers.

Sequential search

Suppose that customers can take unlimited number of observations sequentially at cost k per observation. A strategy for a customer is then characterized by an integer n which stands for the number of experts he will visit before agreeing to an H recommendation by the (n+1)st. An interior equilibrium outcome has to satisfy the counterpart of conditions (6) and (7) which here take the following form.

$$(p^*-L) = (H-L)(x^*)^n/[1+x^*+...+(x^*)^n] \tag{12}$$

$$(13) \qquad H = k + \frac{(1-w)(x^*)^n(1-x^*)p^* + [w+(1-w)(x^*)^{n+1}]H}{w+(1-w)(x^*)^n}$$

The equality in (13) means that customers who are recommended H in their n-th visit will continue to the (n+1)-st although they are indifferent to doing so. This follows from the same arguments that implied $y^*=0$ in the interior equilibria analyzed above.

Experts set prices

The particular manner in which price determination was modelled above involves of course substantial abstraction. An important reason for modeling it in this manner is the relative simplicity of the analysis that it affords. The assumption that prices are determined privately in each expert-customer meeting is not obviously less realistic then the alternative, but it was adopted here because it also allows to avoid further complications that would arise when prices are observable. For example, if prices were set publicly by experts, an observable price deviation which attracts customers might complicate matters by changing the "market-age" distribution of customers frequenting other experts and hence affect their recommendations. Once we take the approach that prices are determined in private, we must assume that customers have sufficient bargaining power or else the only equilibrium will involve no search for reasons familiar from the search literature (see Diamond [1971]). The assumption that customers alone offer prices carries this to an extreme for the sake of analytical simplicity.

An alternative approach would be to think of the experts as the price setters. Here the experts quote simultaneously a menu of prices (P_L, P_H) which customers observe prior to their search for service recommendations. The observability of the menu prior to the search is necessary for the viability of an interior equilibrium for the same search theoretic reasons mentioned above. An expert's strategy is now $[(P^i_L, P^i_H), x^i]$ where x^i captures the recommendation policy. As before, x^i is the probability of recommending H to an L customer, but here it is a function of the entire price distribution. That is $x^i = x^i(\underline{\mathbf{P}})$ where $\underline{\mathbf{P}} = ((P^i_L, P^i_H), x^i)_{i=1,...N}$. Similarly, let $\underline{\mathbf{X}} = (x^1, \ldots, x^N)$. A customer's strategy is a search plan (i,y,j) with the meaning: start by visiting i, after an H diagnosis seek a second opinion with probability y, from expert j. These components are all functions of the entire price distribution, $\underline{\mathbf{P}}$, as well. We also assume that when a customer is indifferent among a number of experts the choice is random with equal probability. Experts' belief regarding a customer's market age, $b(\underline{\mathbf{P}})$ is also of course a function of $\underline{\mathbf{P}}$.

The equilibrium consists of experts' strategies $(\underline{\mathbf{P}}, \underline{\mathbf{X}})$ and beliefs $b(\underline{\mathbf{P}})$, and customers' strategies which satisfy:

(i) For each i, $[(P^i_L, P^i_H), x^i(\underline{\mathbf{P}})]$ maximizes expert i's one period's profit, given $(\underline{\mathbf{P}}_{-i}, \underline{\mathbf{X}}_{-i})$, $b(\underline{\mathbf{P}})$, and customers' strategies.
Also, for any distribution $\underline{\mathbf{P}}'$, $x^i(\underline{\mathbf{P}}')$ is optimal given $b(\underline{\mathbf{P}}')$ and the customers' strategies.

(ii) Each customer's strategy is sequentially optimal given $(\underline{\mathbf{P}}, \underline{\mathbf{X}})$.

(iii) Experts' beliefs are confirmed on the path.

It turns out that the results may depend importantly on additional assumptions on the nature of the commitment to prices. In one scenario, it is assumed that all experts provide both services and $P_H = H$. One possible story is that, when a customer decides to agree to the H service, he can costlessly solicit bids for it, so that the price will have to be H. This scenario has the same equilibria as the above model in which customers offer prices. That is, one equilibrium it will have is the no-search equilibrium where $P_L=P_H=H$, and for sufficiently small k it will have the two interior equilibria where $P_L=p^*$, and where experts' recommendation policy and customers' search strategy are given by the x^* and y^* described by proposition 1.

In an alternative scenario a high P_H is taken as a firm commitment by this expert not to provide the H service below that price. So, in effect, this introduces the possibility that an expert specializes in the L service and makes this known. This scenario, which is discussed in detail in Wolinsky [1993], yields a radically different result where each expert specializes in only one of the two types of treatment. More precisely, let $(P_L,P_H)=(P_L,\infty)$ stand for an offer with a prohibitively high P_H which announces that this expert sells only the L service. If $k\leq(1-w)(H-L)/w$, there exists a specialization equilibrium in which some experts (at least two) employ the strategy $((L,\infty),0)$, while others (at least two) employ the strategy $((H,H),x)$. Customers sample first an expert who offers (L,∞) and, if diagnosed as H, go to an expert who offers (H,H). Furthermore, when the number of experts is large, this equilibrium outcome is almost unique in the sense that, to the extent that there are other equilibrium outcomes, the prices at which transactions take place and the recommendation policies that they feature are close[5] to those described here.

Thus, in this scenario, when the search-cum-diagnosis cost is not too high, some experts provide only the minor service and others provide only the major service. The competition drives the prices of both services to their respective costs; customers start by sampling a minor service expert and, if rejected, continue to a major service expert. The experts' incentives to misrepresent the results of their diagnosis are removed because experts who specialize in the minor service lose the business of the customers they diagnose as requiring the major service.

One way to alleviate the information problem in markets for credence goods is by separation of the diagnosis and service. In an environment in which such separation is impossible, vertical specialization may have similar effects. In the case of only two severity levels analyzed above, the vertical specialization amounts to such separation: a visit to an L-expert provides the customer with full diagnosis. In the case of multiple severity levels, vertical specialization might have only a more limited effect, since a single visit to an expert who specializes in a partial range of the services would not necessarily bring out all the relevant information.

5. Concluding Remarks

Markets for credence goods are not discussed extensively in the theoretical literature although their special features sufficiently distinguish them and merit some special attention. Such markets are also sometimes subject to some forms of licensing and regulation, so a closer understanding is immediately useful for purposes of public policy.

The main insights of this analysis are that (i) despite the intense competition, such markets may feature some degree of fraud, that (ii) prices embody mark-ups over costs and that (iii) the equilibrium doe not maximize expected customers' surplus, even subject to the informational constraints regarding experts' superior information.

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Footnotes

1. See "Faulty Car Repairs Found Widespread," New York Times, May 8, 1979.

2. Markets of this type involve of course a number of other important information asymmetries, such as those concerning experts' ability and effort. We shall focus here only on the information asymmetry mentioned above, which seems most special to such markets.

3. This stylized bargaining process can be replaced by a more involved process in which the customer can make a finite or infinite sequence of offers. This will require some extra modeling effort, such as specification of the bargaining time periods and their cost, which we would not like to undertake here. But the behavior in at least one of the equilibria of this process (and perhaps in all) will coincide with one assumed here.

4. The size of the diagnosis fees is thus assumed for now to be exogenous, although presumably such fees are likely to be determined in competition. We shall return to this point in Section 4 where we discuss how to endogenize this aspect.

5. This is in the following sense. For any $\varepsilon>0$, there exists an $N(\varepsilon)$ such that if $N>N(\varepsilon)$ then any equilibrium is ε close to the above equilibrium in the following sense. For $k<(1-w)(H-L)/w - \varepsilon$, in any equilibrium all customers go first to experts with $P_L \leq L+\varepsilon$. The L customers are diagnosed as L with probability higher than $1-\varepsilon$. Those who are diagnosed as H continue with probability higher than $1-\varepsilon$ to another expert who gets only second visit customers and charges $P_H \leq H+\varepsilon$ to all.