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Price Discrimination in Markets for Experts' Services

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Abstract

This article studies the consequences of price discrimination in a market for experts' services. In the case of experts markets, where the expert observes the intervention that a consumer needs to fix his problem and also provides a treatment, price discrimination proceeds along the dimension of quality of advice offered. High quality advice and appropriate treatment is provided to the most profitable market segment only. Less profitable consumers are induced to demand either unnecessary or insufficient procedures. The welfare consequences of price discrimination are ambiguous: On the one hand, price discrimination increases the number of consumers that get an intervention. On the other hand, some consumers that are efficiently served under non-discrimination get the wrong procedure if the expert can discriminate among customers.

JEL Classifications: L15, D82, D40

Keywords: Price Discrimination, Credence Goods, Experts, Fraud

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1 Introduction

This article studies the consequences of price discrimination in a market for credence goods. Credence goods have the characteristic that, even when consumers can observe the utility they derive from the good *ex post,* they cannot judge whether the quality they received is the *ex ante* needed one. Moreover, depending on the concrete example, consumers may also be unable to observe which quality they actually received. An expert seller, on the other hand, is able to identify the quality that fits customers' needs by performing a diagnosis. He can then recommend and provide the right quality, or he can exploit the information asymmetry by defrauding customers. Darby and Karni (1973) added this type of goods to Nelson's (1970) classification in ordinary, search and experience goods. They mention provision of repair services, execution of taxicab rides and removal of appendices as typical examples.

Dulleck and Kerschbamer (2001) provide a uniforming framework to analyze the behavior of experts in credence goods markets. They show in a survey fashion that the market works efficiently if three conditions hold, namely (i) that either experts are liable to provide sufficient treatment or customers are able to observe the quality of treatment they receive (but not necessarily able to judge whether the quality was really necessary), (ii) that getting a second opinion is sufficiently costly because there exist pronounced economies of scope between diagnosis and treatment and (iii) that consumers are homogeneous. Whereas many contributions focus on the relaxation of conditions (i) and (ii) the present paper studies the effects of heterogeneous consumers in a setting where experts have market power.

With heterogeneous consumers and experts who have market power price discrimination may emerge in equilibrium. We show that a non-discriminating expert serves her customers honestly but prices might be such that some consumers do not consult her even though serving them would be efficient. This is nothing but the familiar monopoly-pricing inefficiency: The expert would like to appropriate as much of the net gain from treatment as possible but, because of heterogeneous consumers he puts up with loosing some customers in order to get a higher price from the remaining ones. Price discrimination alleviates this problem but brings in a new dimension of inefficiency: With price discrimination the expert provides low quality diagnosis to some consumers. As a result those consumers either demand unnecessary or insufficient procedures.

If consumers differ in the probability of needing different interventions then low risk consumers get high quality diagnosis and appropriate treatment while high risk consumers are potentially overtreated; that is, they are induced to demand a high quality intervention without a serious diagnosis. By contrast, under heterogeneity in the valuation of a successful intervention high valuation consumers get efficient diagnosis and treatment, while low valuation ones are potentially undertreated; that is, they are induced to demand a simple procedure independently of the severity of their problem. In both cases the welfare consequences of price discrimination are ambiguous: On the one hand, price discrimination potentially increases the number of consumers that get a treatment. On the other hand, some consumers that are efficiently served in the non-discrimination case get the wrong procedure if the expert can discriminate among customers.

Let us now detail our framework and findings. We build our contribution on existing models of credence goods, primarily that of Dulleck and Kerschbamer (2001) who provide a general framework to study the problems in such markets. To get an adequate framework for our analysis we use in their terminology a setup with heterogeneous consumers, market power, price pre-commitment and verifiability. To get a simple setting with market power we consider a monopolistic expert.[1] Price pre-commitment means that the expert can commit to a menu of tariffs *ex ante*. Each tariff specifies a list of repair prices. Consumers observe the menu and then decide whether to visit the expert. If a consumer decides for a visit, he specifies the tariff under which he wishes to be served. Now the expert performs a diagnosis and then provides a treatment and charges for it.

A consumer never discovers the veracity of the diagnosis and he may also be unable to observe whether the treatment the expert charges for was really provided. This gives the expert several opportunities to defraud customers. Two forms of fraud have been the focus of research on credence goods markets: Recommending and providing an inappropriate treatment and charging for a more expensive treatment than provided. The former kind of fraud

[1] The relevant condition is not that a single expert monopolizes the market, but rather that experts have some degree of market power in providing treatments. In a model in which capacity is required to serve customers (cf. e.g. Emons 1997 and 2001, Richardson 1999) experts have market power (independently of the number of experts who compete for customers) whenever tight capacity constraints hamper competition. Similarly, consumer loyalty, travel costs together with location, search costs, collusion and many, many other factors might give rise to market power.

comes in two varieties called by Dulleck and Kerschbamer (2001) 'undertreatment' (provision of a simple procedure when a high quality intervention is needed to fix the loss) and 'overtreatment' (provision of a high quality repair when a simple one would have been sufficient to solve the problem). The latter kind of fraud is termed by them 'overcharging'. In the present contribution we concentrate on the two varieties of the former kind of problem. Overcharging is ruled out in our model by the verifiability assumption, that is, by the assumption that consumers are able to observe and verify the intervention performed by the expert.

Under verifiability an expert's incentives in performing the diagnosis and providing a treatment depend upon the type of tariff under which a customer is served. If the intervention prices specified by the tariff are such that providing one of the treatments is more profitable than providing any of the others then the expert will recommend and provide the most profitable treatment without a serious diagnosis. Only under equal mark-up tariffs where the differences in the intervention prices reflect the differences in treatment costs will the expert perform a serious diagnosis and recommend the appropriate treatment. Consumers know that; that is, they infer the expert's incentives from the intervention prices.

First we analyze a simple setting in which there are only two types of problem and two types of intervention and in which consumers differ in the expected cost of efficient treatment. We show that without price discrimination the expert may serve less than the efficient number of consumers but whoever is served gets efficient diagnosis and appropriate treatment. If we allow for price discrimination, the number of consumers who get served increases but only a part of the market gets efficient diagnosis and appropriate treatment. The rest of the consumers is potentially overtreated; that is, they are induced to buy a high quality treatment without a serious diagnosis. Regarding welfare, the effect of price discrimination is ambiguous. On the one hand, price discrimination increases the number of consumers that get a treatment. On the other hand, some consumers that are efficiently served in the non-discrimination case get the wrong procedure if the expert can discriminate among customers.

Next we analyze the robustness of our main results. First we extend the analysis to an arbitrary number of problems and an arbitrary number of procedures. It turns out that the result that low cost consumers get honest diagnosis and appropriate treatment while high cost ones are potentially *overtreated* extends in this direction. More interesting is another modification of our basic model. In a setting where consumers differ in their valuation of a successful intervention we show that price discrimination entails that the expert provides a serious diagnosis and appropriate treatment only to high valuation consumers. Low valuation ones are potentially *undertreated*; that is, they are induced to demand a low quality intervention without a serious diagnosis.

The intuition for our over- and undertreatment results is as follows: If perfect price discrimination were possible, the expert would provide high quality diagnosis and appropriate treatment to all consumers. This follows from the observation that consumers infer the expert's behavior from treatment prices. So the expert cannot gain by cheating. Consequently the best he can hope for is to appropriate the entire surplus generated by honest behavior. Perfect discrimination is impossible. With imperfect discrimination the expert sells high quality diagnosis and appropriate treatment at a relative high expected price to the most profitable market segment. For the rest of the market the efficient diagnosis and treatment policy is unattractive since the expected price is larger than the valuation of a successful intervention. Offering efficient diagnosis and treatment at a lower expected price to the residual demand is impossible because this would induce the more profitable market segment to switch to the cheaper policy. So, the expert offers in addition to the expensive efficient diagnosis and treatment policy a cheaper but also less efficient one. This latter policy is designed in such a way that it attracts the less profitable residual demand while being unattractive for the rest of the market.

Under heterogeneity in the valuation of a successful intervention the more profitable market segment is the segment of high valuation consumers. So, the expert wants to skim off this segment with the efficient diagnosis and provision policy and his difficulty in designing a second cheaper policy for the rest of the market is to prevent the high valuation segment from choosing this latter policy. The solution is to potentially undertreat the residual demand consisting of low valuation consumers; that is, to sell them a low quality procedure without a serious diagnosis. This undertreatment policy is unattractive for high valuation consumers because they have more to lose if the procedure fails.

In the difference in the expected cost setting the more profitable market segment is the segment of low cost consumers. Thus, this is the segment to which the expert wants to sell efficient diagnosis and treatment at a relative high price and his problem in designing a second cheaper policy for the rest of the market is to prevent the low cost segment from choosing the cheaper policy. The solution is to potentially overtreat the residual demand consisting of high cost consumers; that is, to induce them to demand a high quality intervention (a new engine) without a serious diagnosis. For low risk consumers this policy is unattractive since their problem is most likely to be a minor one, implying that buying the expensive efficient diagnosis and treatment policy still entails a lower expected cost than buying the high quality treatment at a bargain price.

Our undertreatment result stands in sharp contrast to the findings in another credence goods paper that has the verifiability assumption and heterogeneous consumers.[2] In a model with capacity constrained experts who provide procedures to consumers who differ in their valuation of a successful intervention, Richardson (1999) finds that in equilibrium all treated consumers are potentially overtreated; that is, they get a high quality intervention independently of the outcome of the diagnosis. A closer lock at his paper reveals that the driving forces behind the Richardson overtreatment and our undertreatment result differ. Our (over- and undertreatment) results are driven by the expert's desire to induce self selection among consumers. By contrast, Richardson's findings result from a lack of price pre-commitment power. Consider an expert who can *ex ante* pre-commit only to the price for a low quality basic intervention. At the diagnosis stage the expert can tell the consumer that the basic intervention is insufficient to cure his problem and inform him about the additional amount he would have to pay if he accepts an upgrade to a more advanced procedure. The customer knows that he might have a serious problem and that the basic intervention fails in this case. He is therefore prepared to pay some additional amount for a stronger treatment. If this amount exceeds the difference in treatment costs (as it is the case under Richardson's assumptions) then the expert has an incentive to always recommend a stronger treatment even if the basic procedure would have been sufficient to cure the problem.[3]

Other papers analyze substantially different settings. Emons (1987 and 1993) assumes that the type of intervention is verifiable and studies the incen-

[2] To the best of our knowledge there are only two further contributions with heterogeneous consumers, one of them is the more verbal paper by Darby and Karni (1973), the other the 1993 article by Pitchik and Schotter. In both papers heterogeneity is only used to purify a mixed strategy equilibrium.

[3] Here, remember that equal mark-ups are necessary to induce an expert to perform a serious diagnosis and to provide the appropriate treatment.

tives of experts to under- or overtreat homogeneous consumers. He finds that whether the market mechanism induces non-fraudulent behavior depends on the amount of information consumers have at hand to infer the experts' incentives to be honest. Alger and Salanié (2002) study a homogeneous-consumer model in which the degree of verifiability is a continuous variable. They identify an equilibrium in which experts defraud consumers in order to keep them uninformed, as this deters them from seeking a better price elsewhere. Pitchik and Schotter (1987 and 1993), Wolinsky (1993 and 1995) and Taylor (1995) assume that the type of intervention is not verifiable and analyze expert's temptation to overcharge homogeneous customers. Pesendorfer and Wolinsky (1999) investigate a model where effort is needed to diagnose a consumer and where an expert's effort investment is unobservable. Their contribution focuses on the effect an additional diagnosis (by a different expert) has on the consumer's evaluation of a given expert's effort.

The next section introduces our basic model in which there are only two types of problem and two types of procedures and in which consumers differ in the expected cost of efficient treatment. In Section 3 we explore the effects of price discrimination in the basic model. Section 4 discusses several extensions/modifications. First, we extend the basic model to allow for an arbitrary number of problems and arbitrary number of interventions, then we modify our basic model to a setting where consumers differ not in the expected cost of efficient treatment but rather in their valuation of a successful intervention, and finally we look at a setting in which consumers differ in both dimensions, in their expected cost of efficient treatment and in their valuation of a successful intervention. Section 5 concludes. Some of the proofs are in the Appendix.

2 A Basic Model of Credence Goods

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

With credence goods, even when consumers can observe the utility they derive from the goods *ex post,* they cannot tell whether the quality of the good or service they received is the *ex ante* needed one. Furthermore, depending on the concrete framework, consumers may also be unable to observe which quality they actually received. Thus, with credence goods consumers need to trust expert sellers. To refer to examples, consider personal computers. An expert seller can help to find the right quality that fits customers' needs. A consumer will not be able to tell whenever he has received a quality that is too high. Only an inappropriate low quality is detected. Similarly, a car with a new muffler will work as well as with the repair of the old muffler when a repair would have been sufficient. The customer cannot tell whether the new part was really needed. The same problem arises when seeing a doctor: as long as the patient feels as healthy as he thinks it was possible, he cannot tell whether he was treated correctly or was overtreated. As in the other examples, customers are only able to detect too little treatment.

To model this situation, we assume that each consumer (he) has a problem that needs to be treated. The consumer knows that he has a problem, but does not know how severe it is. He only knows that he has an *ex ante* probability of g_k to have a problem of degree k. An expert (she), on the other hand, is able to detect the severity of the problem by performing a diagnosis. She can then provide the appropriate treatment and charge for it, or she can exploit the information asymmetry by defrauding the customer. In the basic model of Section 3 we assume that there are only two degrees of problem, a minor ($k = 1$) and a major ($k = 2$) one. Each of them can be treated efficiently by exactly one treatment. We denote the type of treatment that efficiently fixes a problem of degree k by c_k. The less severe problem is less costly to be treated. That is, if we denote the cost of the treatment that efficiently fixes a problem of degree k by c_k then $c_1 < c_2$.[4] The more expensive treatment fixes either problem, while the cheap one is only good for the minor problem.[5]

Table 1 represents the gross utility of a consumer given the type of treatment he needs and the type he gets. If the type of treatment is sufficient, a consumer gets utility v. Otherwise he gets 0. To motivate this payoff structure consider a car with either a minor problem (car needs oil in the engine) or a major problem (car needs new engine), with the outcomes being 'car works' (if appropriately treated or overtreated) and 'car does not work' (if undertreated).[6] The credence goods characteristic stems from the fact that

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

[5] In Section 4 we extend the basic model to allow for $n > 2$ degrees of problem ($k \in \{1, .., n\}$). There we assume without loss of generality that, for any $k < l$, problem k is less severe than problem l so that $c_k < c_l$. A more expensive treatment fixes all problems cheaper treatments fix, while the cheapest one is only good for the least severe problem.

[6] Of course, not all credence goods have such a simple payoff structure. For instance,

Customer's utility		Customer needs c_1	c_2
Customer gets	c_1	v	0
	c_2	v	v

Table 1: Utility from a Credence Good

the customer is satisfied in all cases in the lower triangle. In general, he is satisfied whenever he gets a treatment quality at least as good as the needed one. In the upper triangle (consisting of a single cell in the basic model with two degrees of problem and two treatment qualities) he has a more severe problem than the treatment he gets is able to cure. In this case he will discover *ex post* that the treatment he got was not sufficient to fix his problem.

As mentioned before, the focus of the credence goods literature has been twofold: inefficient treatment, either under- or overtreatment, and overcharging. The inefficiency of treatment can be described by referring to Table 1. The case of undertreatment is the upper right triangle of the table, the case of overtreatment is the lower left triangle. Note that overtreatment is not detected by the customer ($v = v$) and hence cannot be ruled out by institutional arrangements. This is not the case with undertreatment; it is detected by the customer ($0 < v$) and might even be verifiable. If this is the case, and if a legal rule is in effect that makes an expert liable for the provision of inappropriate low quality Dulleck and Kerschbamer (2002) say that the liability assumption holds. We do not consider this case here, see their article for an extended discussion of liability.

Referring again to Table 1, the second potential problem is that the customer might never receive a signal that discriminates between the cells in the lower left triangle of the table (the "v cells"). If this is the case, an expert who discovers that the customer has the minor problem can charge for the expensive treatment although she provides only the cheap one. This overcharging is ruled out if consumers are able to observe and verify the delivered

in the medical example the payoff for an appropriately treated major disease might differ from that of an appropriately treated minor disease. Similarly, the payoff for a correctly treated minor disease might differ from that of an overtreated minor disease. Introducing such differences would burden the analysis with additional notation, without changing any of the results, however.

quality (they know and can prove in which row of the table they are). In this contribution we assume that consumers have this ability. More precisely, we impose Dulleck and Kerschbamer (2002)'s shortcut assumption (see Figure 1):[7]

Assumption V (Verifiability) *An expert cannot charge for a more expensive treatment if she has provided a cheaper one.*

Regarding the magnitude of economies of scope between diagnosis and treatment there are two different scenarios to consider. If these economies are small, consulting the expert for a diagnosis only may become attractive. With profound economies of scope, on the other hand, expert and customer are in effect tied together once the diagnosis is made. In this contribution we assume large economies of scope. Again, we work with Dulleck and Kerschbamer's shortcut assumption:

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

Let us now describe the market environment. There is a single risk neutral expert in the credence goods market. The expert posts take-it-or-leave-it tariffs. Each tariff specifies the prices for the different interventions. Let p_k denote the price posted by the expert for the treatment c_k. The expert's profit is the sum of revenues minus costs over the customers she treated. By assumption, the expert provides the appropriate treatment if she is indifferent between providing the appropriate and providing the wrong treatment and this fact is common knowledge among all players.[8]

There is a continuum with mass one of risk-neutral consumers in the market. Each consumer incurs a diagnosis cost d if he visits the expert.[9]

[7]The verifiability assumption is more plausible in environments where the customer is physically and mentally present during the treatment than for the alternative case where he is not. For example, for dental services and minor car- or appliance-repairs this assumption is likely to be appropriate, whereas for more sophisticated repairs (where the customer is unlikely to wait for the repair to be performed in his sight) and surgery (where the patient is often under anaesthetic during the treatment) it is not.

[8]Introducing some guilt disutility associated with providing the wrong treatment would yield the same qualitative results as this common knowledge assumption provided the effect is small enough to not outweigh the pecuniary incentives.

[9]Provision of treatment without diagnosis is assumed to be impossible. The diagnosis cost d is assumed to include the time and effort cost incurred by the consumer in visiting a doctor, taking the car to a mechanic, etc. It is also assumed to include a fair diagnosis fee paid to the expert to cover her opportunity cost.

The net payoff of a consumer who has been treated is his gross valuation as depicted in Table 1 minus the price paid for the treatment minus diagnosis cost. The payoff of a consumer who has not been treated is his reservation payoff, which we normalize to equal zero.[10] By assumption, it is always (i.e., even *ex post*) efficient that a consumer is treated when he has a problem. That is, $v - c_2 - d > 0$. Also, by assumption, if a consumer is indifferent between visiting the expert and not visiting the expert, he decides for a visit.

To analyze the effects of price discrimination we need heterogeneous consumers. Consumers might differ in several dimensions, for instance in their "risk" of having different degrees of problem and/or in their valuation of a successful intervention v. In the basic model of Section 3 we assume that consumers differ only in their probabilities of needing different treatments. More precisely, we assume that each consumer is characterized by his type t and that a consumer of type t has the major problem with probability $g_2^t = t$ and the minor one with probability $g_1^t = 1 - t$. Consumers' types are drawn independently from the same concave distribution $F(\cdot)$, with differentiable strictly positive density $f(\cdot)$ on $[0, 1]$. $F(\cdot)$ is common knowledge, but a consumer's type is the consumer's private information.[11] For further use, we define C^t as type t's expected cost of efficient treatment net of diagnosis cost, i.e., $C^t = \sum_{k=1}^{2} g_k^t c_k + d = c_1 + t(c_2 - c_1) + d$.

For the considered time and information structure we refer to Figure 1. This figure shows the game tree for the special case where the monopolistic expert courts a single consumer whose type is known with certainty. The variables v, g_1, g_2, c_1 and c_2 are assumed to be common knowledge. At the outset the expert posts tariffs specifying treatment prices p_1 and p_2 for c_1 and c_2, respectively. In the special case covered by the figure the expert posts a single tariff only. With heterogeneous consumers the expert might want to post a menu of tariffs. The consumer observes the tariffs and then decides whether to visit the expert or not. If he decides against the visit, he

[10] Here, the implicit assumption is that the outside option is not to be treated at all. Again, the car example provides a good illustration. A car may be inoperable for a minor or a major reason, with the lack of treatment giving the same outcome ('car does not work') as undertreatment. The medical example behaves differently. For instance, letting a cancerous growth go untreated is much different than letting a benign growth go untreated. See Footnote 6 above, however.

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

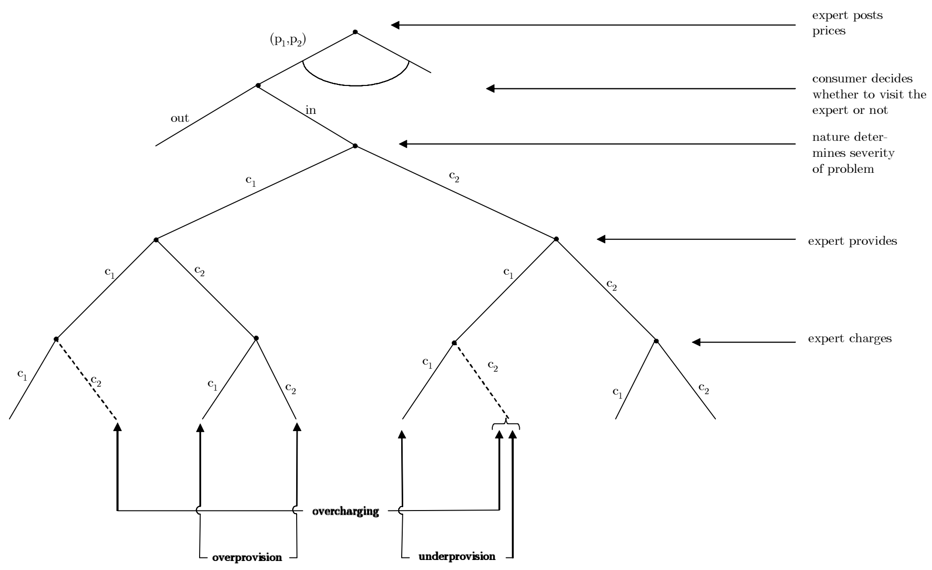

Figure 1: Game Tree for the Basic Model ($t = \bar{t}$ for all consumers, say)

remains untreated yielding a payoff of zero for both players. If he decides for a visit, he specifies the tariff under which he wants to be treated.[12] Then a random move of nature determines the severity of his problem.[13] Now the expert diagnoses the consumer. In the course of her diagnosis she learns the customer's problem, then she provides a treatment and charges for it. The game ends with payoffs determined in the obvious way. The extensive form for our model with a continuum of heterogeneous consumers and with a menu of tariffs can be constructed from this game tree in the usual way.

This is the basic setup of our credence goods game. In Section 3 we analyze monopolistic price discrimination in this basic model. In Section 4 we extend the model to allow for an arbitrary number of problems and an arbitrary number of treatments. There we also analyze the setting where consumers differ in their valuation for a successful intervention.

Throughout the paper we use the following notation: A tariff (p_1, p_2) implies incentives it provides for the expert to perform diagnosis and to

[12] This move is absent in the figure where the expert posts a single tariff only.

[13] Here note that, from a game-theoretic point of view, there is no difference between a model in which nature determines the severity of the problem at the outset and our model where this move occurs after the consumer has consulted an expert (but before the expert has performed the diagnosis).

provide treatment. Three classes of tariffs are to be distinguished, tariffs that contain a higher mark-up for the expensive treatment ($p_2 - c_2 > p_1 - c_1$), tariffs that have a higher mark-up for the cheap treatment ($p_2 - c_2 < p_1 - c_1$), and tariffs with equal mark-ups ($p_2 - c_2 = p_1 - c_1$). We denote tariffs in the first class by Δ_{02}, tariffs in the second by Δ_{10}, and tariffs in the third by Δ_{12}. As will become clear below, only under tariffs where the differences in the intervention prices reflect the differences in treatment costs (equal mark-up tariffs) will the expert perform a serious diagnosis and recommend the appropriate treatment. Under tariffs where the intervention prices depart from the equal mark-up rule the expert will recommend and provide the most profitable treatment without a serious diagnosis. That is, the expert will perform a honest diagnosis and provide the appropriate treatment under a Δ_{02} tariff, she will always recommend and provide the cheap treatment independently of the outcome of the diagnosis under a Δ_{10} contract and she will always recommend and provide the expensive treatment independently of the outcome of the diagnosis under a Δ_{20} contract.[14] For convenience we will often denote not only a specific tariff but also the implied mark-up by Δ_{ij}. That is, the term Δ_{ij} will then stand for the mark-up on the treatment that is provided under the respective contract ($\Delta_{ij} = \max\{p_1 - c_1, p_2 - c_2\}$).

3 Price Discrimination in the Basic Model: Overtreatment

In this section we analyze the effects of price discrimination in our basic model. Before beginning we present a benchmark result for a setting in which the expert cannot price discriminate among consumers. Without price discrimination the expert chooses equal mark-up prices and serves her customers honestly. If the difference in the expected cost between the best and the worst type is small relative to the efficiency gain of treating the worst type then the expert serves all consumers. Otherwise prices are such that some consumers do not consult her even though serving them would be efficient. This is nothing but the familiar monopoly-pricing inefficiency: The monopolistic expert would like to appropriate as much of the net gain from treatment as possible but, because of heterogeneous consumers, she puts up with the risk of losing some consumers in order to get a higher price from

[14] We use the terms tariff, price-vector and contract interchangeably.

the remaining ones. We record the monopoly pricing result in Proposition 1.

Proposition 1 *Consider the basic model with two degrees of problem and consumers who differ in their probabilities of needing different treatments only. Suppose the monopolistic expert cannot price-discriminate among customers. Then, in the unique subgame-perfect equilibrium, the expert posts and charges equal mark-up prices* ($p_k - c_k = \Delta$ *for* $k = 1, 2$)*. If the difference in expected cost between the best and the worst type is large relative to the efficiency gain of treating the worst type* ($c_2 - c_1 > v - d - c_2$) *then prices are such that high cost consumers decide to remain untreated* ($\Delta > v - C^t$ *for* t *strictly higher than some* $\bar{t} \in (0, 1)$)*, while all other types visit the expert* ($\Delta \leq v - C^t$ *for* $t \leq \bar{t}$) *and get serious diagnosis and appropriate treatment. Otherwise all consumers are efficiently served under equal mark-up prices* ($\Delta \leq v - C^t$ *for all* t)

Proof. First note that with verifiability the expert will always charge for the treatment she provided. The treatment quality provided depends upon the type of tariff under which the customer is served. A customer under a Δ_{02} contract will always get the expensive, a customer under Δ_{10} always the cheap treatment. Only under Δ_{12} the expert is indifferent between the two types of treatment and, therefore, behaves honestly.[15]

Consumers infer the expert's incentives from treatment prices. The maximal profit the monopolist can realize form serving a type t consumer with equal mark-up prices is therefore $v - C^t$. The maximal obtainable profit with Δ_{02} tariffs is $v - C^t \ -g_1^t(c_2 - c_1)$, and the maximal profit with Δ_{10} tariffs is $v - C^t \ -g_2^t(v - c_2 + c_1)$. Thus, since $v > c_2 - c_1$, the expert will post an equal mark-up tariff and she will provide the appropriate treatment to all of her customers. With equal mark-ups the monopolistic expert is interested in two variables only, in the magnitude of the mark-up $\Delta = \Delta_{12}$ and in the number of visiting consumers. The result then follows

[15] The assumption that it is common knowledge among players that the expert provides the appropriate treatment whenever she is indifferent plays an important role in Proposition 1 in generating a unique subgame-perfect equilibrium. Without this assumption there exist other subgame-perfect equilibria which are supported by the belief that the expert deliberately mistreats her customers under each equal mark-up vector - or, that the expert deliberately mistreats her customers under equal mark-up prices that are too high. We regard such equilibria as implausible (see Footnote 8 above) and have therefore introduced the common knowledge assumption which acts as a restriction on consumers' beliefs.

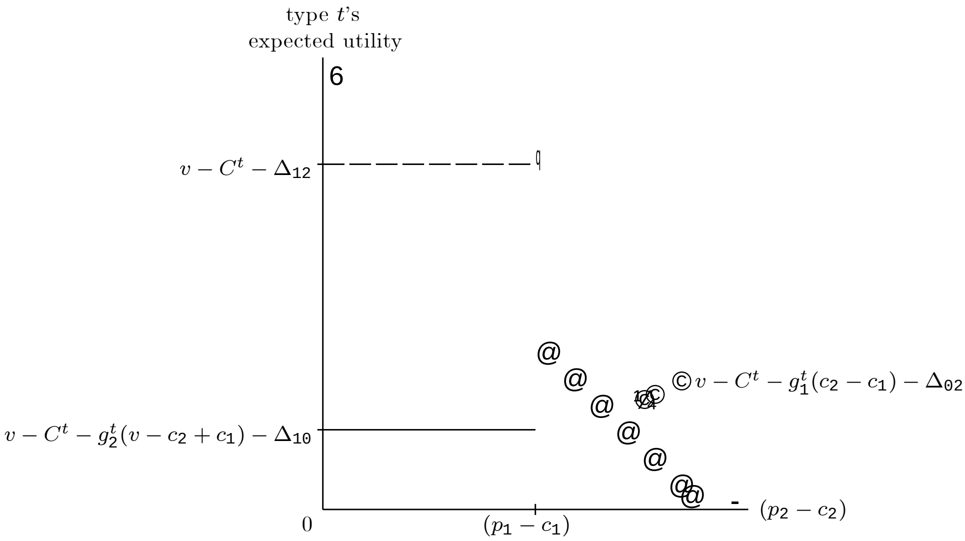

Figure 2: Type t's Expected Utility under Different Price Vectors

from the observation that the expert's problem is nothing but the familiar monopoly pricing problem for revenue per customer Δ and demand curve $D(\Delta) = F[(v - d - c_1 - \Delta)/(c_2 - c_1)]$.[16] ■

The equal mark-up result is readily illustrated graphically. First notice that under verifiability the expert's incentives in performing the diagnosis and in providing a treatment depend upon the type of tariff under which a customer is served. If the intervention prices specified by the tariff are such that providing one of the treatments is more profitable than providing the other then the expert will recommend and provide the more profitable treatment without a serious diagnosis. So, if we fix the mark-up for the cheaper intervention at $p_1 - c_1$ and increase the mark-up for the expensive intervention from 0 (as it is done in Figure 2) then the expert's incentives remain unchanged over the interval $(0, p_1 - c_1)$: she will always recommend and provide the cheap treatment at the price $p_1 = c_1 + \Delta_{10}$. Consequently, the expected utility of a consumer of type t is constant in this interval at $v - C^t - t(v - c_2 + c_1) - \Delta_{10}$, where the term $t(v - c_2 + c_1)$ reflects the efficiency loss from undertreatment. Similarly, if we start at $p_1 - c_1$ and increase $p_2 - c_2$

[16]That the condition $(c_2 - c_1) > v - d - c_2$ is sufficient for an interior solution is easily verified by first solving the linear case (where $F(.)$ is the uniform distribution) and then noting that the mark-up cannot be lower if $F(.)$ is strictly concave rather than linear.

then the expert will always recommend and provide the expensive treatment at the price $p_2 = c_2 + \Delta_{02}$. So, the consumer's utility in this segment is $v - C^t - (1-t)(c_2 - c_1) - \Delta_{02}$, where the term $(1-t)(c_2 - c_1)$ reflects the efficiency loss from overtreatment. Only at the single point $p_2 - c_2 = p_1 - c_1 = \Delta_{12}$ where the difference in the intervention prices reflects the difference in treatment costs will the expert perform a serious diagnosis and recommend the appropriate treatment. So, at this point there is no efficiency loss and type t's expected utility jumps discontinuously upward to $v - C^t - \Delta_{12}$. Consumers infer the expert's incentives from the intervention prices. So the expert cannot gain by cheating. Consequently, the best she can do is to post an equal mark-up tariff and to behave honestly.

Equal mark-up prices are common in important credence goods markets, including dental services, automobile and equipment repair and pest control. Equal mark-up prices are also often seen in case of expert sellers. Computer stores are an obvious example. Customers can control which quality they receive. Other examples are pricing schemes of insurance brokers and travel agents. The mark-up insurance brokers and travels agents charge (the margin plus any bonuses offered by the provider) is similar for all products.

For our next result we allow the expert to (second degree) price discriminate among consumers. That is, we let the monopolistic expert post a menu of tariffs; consumers observe the menu and then decide under which contract, if any, they wish to be served.

Under standard conditions, second degree discriminatory pricing reduces the monopoly-pricing inefficiency. As the following result shows, a new inefficiency appears in the present model with credence goods.

Proposition 2 *Consider the basic model with two degrees of problem and consumers who differ in their probabilities of needing different treatment only. Suppose that the expert can price discriminate among consumers (rather than being restricted to post a single tariff only). Then, in any subgame-perfect equilibrium, the expert posts two tariffs, one with equal mark-ups, and one with a higher mark-up for the expensive treatment.*[17] *Both tariffs attract customers and in total all consumers are served. Low cost consumers are served under the former tariff and always get honest diagnosis and appropriate treatment; high cost consumers are served under the latter and always get the expensive treatment, sometimes inefficiently.*

[17] The menu may contain some redundant tariffs too, i.e., some tariffs that attract no consumers.

Proof. The proof proceeds in four steps. In *Step 1* we first show that any arbitrary menu of tariffs partitions the type-set into (at most) three subintervals delimited by cut-off values t_{10}, t_{12} and t_{02} with $0 \leq t_{10} \leq t_{12} \leq t_{02} \leq 1$ and either $t_{12} = t_{02}$ or $t_{02} = 1$ (or both) such that (i) the optimal strategy of types in $[0, t_{10})$ is to choose a Δ_{10} tariff, (ii) the optimal strategy of types in $[t_{10}, t_{12}]$ is to decide for a Δ_{12} tariff, and (iii) the optimal strategy of types in $(t_{12}, 1]$ is either to choose a Δ_{02} tariff ($t_{02} = 1$), or to remain untreated ($t_{12} = t_{02}$).[18] Our strategy is then to show in *Step 2* that an optimal price-discriminating menu cannot have $t_{10} = t_{12}$ (that is, there must be an equal mark-up tariff which attracts a strictly positive measure of types), to show next (in *Step 3*) that $t_{10} = 0$ whenever $t_{10} < t_{12}$ (that is, the expert has never an incentive to post a menu where both an equal mark-up tariff and a tariff with a higher mark-up for the cheap treatment attract types), and to show in the end (*Step 4*) that the expert has indeed always a strict incentive to cover a strictly positive interval by a tariff with a higher mark-up for the expensive treatment ($t_{12} < t_{02} = 1$).

Step 1 First note that any arbitrary menu of tariffs can be represented by (at most) three variables, by the lowest $\Delta_{02} = p_2 - c_2$ from the class of Δ_{02} tariffs (we denote the lowest Δ_{02} in this class by Δ_{02}^l), by the lowest $\Delta_{10} = p_1 - c_1$ from the class of Δ_{10} tariffs (we denote the lowest Δ_{10} in this class by Δ_{10}^l), and by the lowest equal mark-up Δ_{12} from the class of all equal mark-up tariffs in the menu (denoted by Δ_{12}^l).[19] To see this, note that with $n = 2$ each possible price vector is member of exactly one of these three classes, and that a customer who decides for a vector in a given class will always decide for the one with the lowest Δ.[20] An immediate implication is that each menu of tariffs partitions the type-set into the above mentioned

[18] The borderline types t_{10} and t_{12} are indifferent between the strategies of the types in the adjacent intervals (whenever such intervals exist). Here note that we allow for $t_{12} = 1$ (all consumers are served and no consumer chooses a Δ_{02} tariff), for $t_{10} = t_{12}$ (no consumer is attracted by a Δ_{12} tariff), and for $t_{10} = 0$ (no consumer is attracted by a Δ_{10} tariff). Price discrimination requires, however, that at least two of the three relations hold as strict inequalities.

[19] An immediate implication of this observation is that successful price discrimination requires that some types are mistreated with strictly positive probability. Why? Since at least two tariffs must attract a positive measure of consumers and since only one of them can be an equal mark-up tariff.

[20] Under a Δ_{02} tariff neither the consumer nor the expert cares about the associated p_1. All tariffs in the group that have the same Δ_{02} can therefore be thought off as being a single tariff without any loss in generality. The argument for Δ_{10} tariffs is symmetric.

three subintervals. This follows from the fact that the expected utility under Δ_{02}^l is type-independent (implying that either $t_{12} = t_{02}$ or $t_{02} = 1$ or both), while the expected utility under both the Δ_{12}^l tariff and the Δ_{10}^l tariff is strictly decreasing in t, and from $v > c_2 - c_1$ (implying that the Δ_{10}^l-function is steeper than the Δ_{12}^l-function).

Step 2 To see that $t_{10} < t_{12}$, suppose to the contrary that $t_{10} = t_{12}$. Then $t_{10} > 0$, since $t_{10} = t_{12} = 0$ is incompatible with price-discrimination (and since - by Proposition 1 - a non-price-discriminating expert will always decide for a Δ_{12} vector). But such a menu is strictly dominated, since the Δ_{10}^l vector can always be replaced by a vector with equal mark-ups of $\Delta_{12} = \Delta_{10}^l + g_2^{t_{10}}(v - c_2 + c_1)$; the latter attracts exactly the same types as the replaced one and yields a strictly higher profit.

Step 3 To see that $t_{10} = 0$ whenever $t_{10} < t_{12}$, suppose to the contrary that $0 < t_{10} < t_{12}$. Then the expert's profit is strictly increased by removing all Δ_{10} vectors from the menu. This follows from the observation that (by the monotonicity of the expected utility $-$ in t $-$ under Δ_{12}) all types in $[0, t_{10})$ switch to Δ_{12}^l when all Δ_{10} vectors are removed from the menu, and from the fact that the expected profit per customer is strictly higher under Δ_{12}^l than under Δ_{10}^l whenever $0 < t_{10} < t_{12}$, since $\Delta_{12}^l \leq \Delta_{10}^l$ is incompatible with the shape of expected utilities ($\Delta_{12}^l \leq \Delta_{10}^l$ implies that $v - C^t - \Delta_{12}^l > v - C^t - \Delta_{10}^l - g_2^t(v - c_2 + c_1)$ for all $t > 0$ contradicting $t_{10} > 0$).Thus, $t_{10} = 0 < t_{12} \leq t_{02} \leq 1$. So, if price discrimination is observed in equilibrium it is performed via a menu that contains two tariffs, one with equal mark-ups, and one with a higher mark-up for the more expensive treatment.[21]

Step 4 We now show that the expert has always a strict incentive to post such a menu. Consider the equal mark-up vector posted by the expert under the conditions of Proposition 1. The mark-up in this vector is at least $\Delta_{12} = v - d - c_2$, in an interior solution even higher. First suppose that the monopolist's maximization problem under the conditions of Proposition 1 yields an interior solution (i.e., $\Delta_{12} > v - d - c_2$). Then the expert can increase her profit by posting a menu consisting of two vectors, the one chosen under the conditions of Proposition 1 and a Δ_{02} vector with $p_2 = v - d$. The latter vector guarantees each type an expected utility equal to the reservation utility of 0. Thus, all types that remain untreated under the conditions of Proposition 1 will opt for it since they are indifferent. Also,

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

all types served under the conditions of Proposition 1 still choose the equal mark-up vector since $v - C^t$ is strictly decreasing in t. Hence, since $v - d > c_2$, and since all types in $[0, 1]$ have strictly positive probability, the expert's expected profit is increased.[22] Now suppose that the monopolist's maximization problem under the conditions of Proposition 1 yields the corner solution $\Delta_{12} = v - d - c_2$. Then again the monopolist can increase her profit by posting a menu consisting of two tariffs, a Δ_{02} contract with $p_2 = v - d$, and a Δ_{12} contract that maximizes $\pi(\Delta_{12}) = \Delta_{12}F[(v - d - c_1 - \Delta_{12})/(c_2 - c_1)] + (v - d - c_2)(1 - F[(v - d - c_1 - \Delta_{12})/(c_2 - c_1)])$. Since $\pi(\Delta_{12})$ is strictly increasing in Δ_{12} at $\Delta_{12} = v - d - c_2$ an interior solution is guaranteed. ■

Under the conditions of Proposition 2 the expert posts two tariffs, one with equal mark-ups to skim-off low cost consumers and a less profitable tariff with a higher mark-up for the more expensive treatment to serve the rest. Consumers served under the former tariff get honest diagnosis and appropriate treatment, consumers served under the latter always get the expensive treatment, sometimes inefficiently.

Figure 3 illustrates the result. This figure shows how consumers' expected utility under different tariffs varies in the type. First notice that consumers' expected utility under Δ_{02} (where the expert always provides the expensive intervention) is type-independent, while the expected utility under both the Δ_{12} tariff (where the expert behaves honestly) and the Δ_{10} tariff (where the expert undertreats the customer) is strictly decreasing in t. Next notice that the Δ_{10}-function is strictly steeper than the Δ_{21}-function. This follows from the observation that under Δ_{10} higher types have a higher probability that the intervention fails (leading to a loss of v) while under Δ_{21} they have only a higher probability to get charged for the more expensive treatment (leading to an additional cost of $c_2 - c_1 < v$). Finally remember from the discussion of Figure 2 that if a Δ_{10} tariff, a Δ_{12} tariff and a Δ_{02} tariff simultaneously attract customers (as it is the case in the situation depicted in Figure 3) then the inefficient tariffs Δ_{10} and Δ_{02} must have lower mark-ups than the efficient one. Consequently, a situation as depicted in Figure 3 can never arise

[22] Here note that the expert can do even better by increasing Δ_{12}^l. This follows from the observation that the expert's trade-off under the conditions of Proposition 1 is between increasing the mark-up charged from the types in the segment of served customers and losing some types to the unprofitable segment of not served consumers, while the trade-off here is between increasing the mark-up charged from the types in the segment of customers served under the more profitable equal mark-up vector and losing some types to the segment of customers served under the less profitable $\Delta_{0,2}^l$ vector.

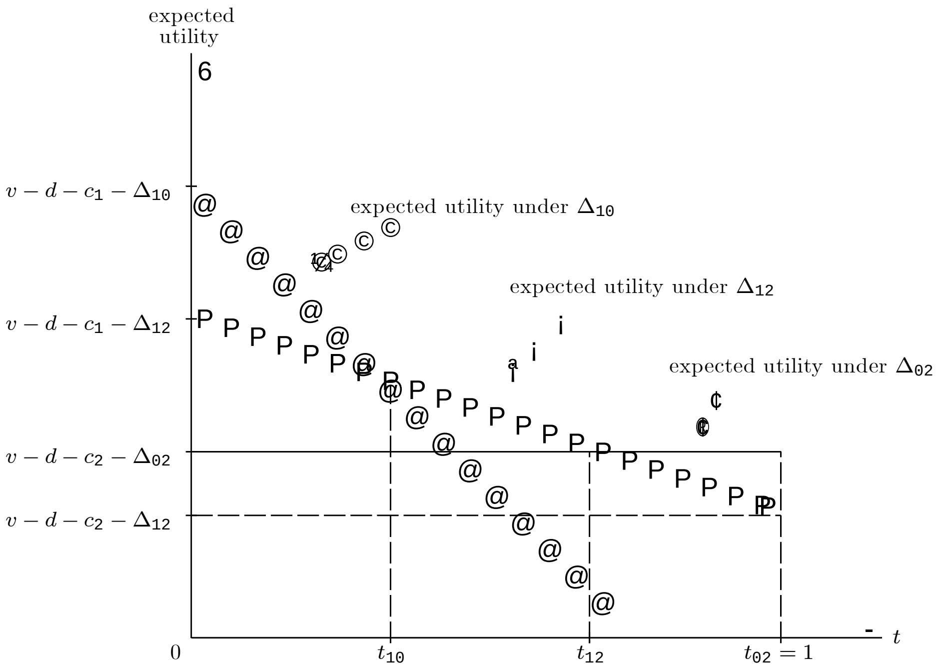

Figure 3: Type Dependent Expected Utilities with $C^t = c_1 + t(c_2 - c_1) + d$

in equilibrium: the expert could always remove the Δ_{10} tariff from the menu; then all types in $[0, t_{10})$ would switch to Δ_{12} and the expert's profit would be increased. Also, a menu where only a Δ_{10} tariff and Δ_{02} tariff attract types can never be an equilibrium menu: the expert could always replace the Δ_{10} tariff by an efficient tariff such that the highest type attracted by Δ_{10} is exactly indifferent between Δ_{10} and Δ_{10}; the Δ_{12} tariff would attract exactly the same types as the replaced Δ_{10} contract and yield a strictly higher profit. So, if price discrimination is observed in equilibrium it is performed via a menu that contains two tariffs, one with equal mark-ups, and one with a higher mark-up for the more expensive treatment.

That the expert has indeed always an incentive to post such a menu is easily seen. First suppose that some consumers are remain unserved under the conditions of Proposition 1. Then the expert can increase her profit by posting a menu consisting of two vectors, the one chosen under the conditions of Proposition 1 and a Δ_{02} tariff that leaves zero rents to consumers ($p_2 = v - d$). Since $v - d > c_2$, and since all types in $[0, 1]$ have strictly positive probability, the expert's expected profit is increased. Next suppose that the expert's maximization problem under the conditions of Proposition 1 yields the corner solution $\Delta_{12} = v - d - c_2$. Then again she can increase her profit by posting a menu consisting of two tariffs, a Δ_{02} contract with $\Delta_{02} = v - d - c_2$, and an efficient tariff with $\Delta_{12} = v - d - c_2 + \varepsilon$. Still all consumers are served. Those served under Δ_{02} leave the expert with exactly the same profit as before, those served under Δ_{12} are served more profitable. Hence, the expert's profit is again increased.

Producers selling their goods through different distribution channels are examples for second degree discriminatory simultaneously attract customers pricing. For instance, many PC manufacturers distribute their computers through IT warehouses that offer only one quality of equipment at a relatively low price, and through specialized dealers that offer the entire assortment as well as advice on choosing the right quality.

The equal mark-up in the tariff posted under the conditions of Proposition 2 is strictly higher than that in the tariff of Proposition 1. This follows from the observation that the expert's trade-off is between increasing the mark-up charged from the types in the segment of served customers and losing some types to the unprofitable segment of not served consumers in the latter case, while the trade-off here is between increasing the mark-up charged from the types served under the more profitable equal mark-up vector and losing some types to the segment of customers served under the less profitable second vector. So, some consumers who always get honest diagnosis and appropriate treatment under the conditions of Proposition 1, get (with strictly positive probability) the wrong treatment when the expert can price discriminate among consumers. So, if the difference in expected cost between the best and the worst type is fairly small (so that the monopolist serves all consumers if she is not allowed to price discriminate) then allowing discrimination unambiguously reduces efficiency. On the other hand, when some consumers are excluded under the conditions of Proposition 1, then there is a trade-off between increasing the number of treated consumers and serving the treated customers efficiently. Overall efficiency might increase or decrease with price discrimination depending on the shape of the distribution function $F(\cdot)$, the valuation v (net of diagnosis costs d, of course) and the cost differential $c_2 - c_1$. As our next result shows, the mass of consumers that are efficiently served under non-discrimination and inefficiently under discrimination increases in the net valuation $v - d$ and decreases in the cost differential $c_2 - c_1$. At the same time, the mass of consumers that are not served under non-discrimination and served under discrimination decreases in the net valuation and increases in the cost differential. So, price discrimination is *ceteris paribus* more likely to be efficiency enhancing if consumers' valuation of an efficient treatment is small and if the cost differential is large.

Proposition 3 *Consider the basic model with two degrees of problem and with consumers who differ in their probabilities of needing different interventions only. Let* $1 - F(t_{12}^a)$ *stand for the mass of consumers that are not served under non-discrimination and served under discrimination. Similarly, let* $F(t_{12}^a)-\ F(t_{12}^b)$ *stand for the mass of consumers that are efficiently served under non-discrimination and inefficiently under discrimination. Then* $1 - F(t_{12}^a)$ *is increasing in* $(c_2 - c_1)$ *and decreasing in* $v - d$ *while* $F(t_{12}^a)-\ F(t_{12}^b)$ *is decreasing in* $(c_2 - c_1)$ *and increasing in* $v - d$ *.*

Proof. Under the conditions of Proposition 1 the monopolist maximizes $\pi(\Delta_{12}) = \Delta_{12}F[(v - d - c_1 - \Delta_{12})/(c_2 - c_1)]$. If this problem has an interior solution Δ_{12}^a then it satisfies $\Delta_{12}^a/(c_2 - c_1) = F[(v - d - c_1 - \Delta_{12}^a)/(c_2 - c_1)] /f[(v - d - c_1 - \Delta_{12}^a)/(c_2 - c_1)]$, where $f(.)$ stands for the density function associated with $F(.)$. Furthermore, if there is an interior solution, then there exists a critical type $t_{12}^a \in (0, 1)$ such that consumers decide to remain untreated for t strictly higher than t_{12}^a and visit the expert for t lower than t_{12}^a. This critical type is given by $t_{12}^a = (v - d - c_1 - \Delta_{12}^a)/(c_2 - c_1)$. What we need to show in a first step is that (a) $1 - F(t_{12}^a)$ is decreasing in $v - d$ and increasing in $(c_2 - c_1)$.

Under the conditions of Proposition 2 the monopolist maximizes $\pi(\Delta_{12}) = \Delta_{12}F[(v-d-c_1-\Delta_{12})/(c_2-c_1)] + (v-d-c_2)(1-F[(v-d-c_1-\Delta_{12})/(c_2-c_1)])$. The solution of this problem satisfies $\Delta_{12}^b/(c_2-c_1) = F[(v-d-c_1-\Delta_{12}^b)/(c_2-c_1)]/f[(v - d - c_1 - \Delta_{12}^b)/(c_2 - c_1)] +(v - d - c_2)/(c_2 - c_1)$. Under the two contract menu $(\Delta_{12}^b, \Delta_{02}^b)$, with $\Delta_{02}^b = v - c_2 - d$, consumers choose Δ_{12}^b for t lower than $t_{12}^b = (v - d - c_1 - \Delta_{12}^b)/(c_2 - c_1)$ and Δ_{02}^b for t higher than t_{12}^b. What we need to show next is that (b) $F(t_{12}^a)-\ F(t_{12}^b)$ is increasing in $v - d$ and decreasing in $(c_2 - c_1)$.

To show (a) and (b) we simplify the notation as follows: We use the variable c for the difference $c_2 - c_1$, the variable $\mathbf{e}$ for the difference $v - d - c_1$ and the function $H(.)$ for the quotient $F(.)/f(.)$. With this notation the implicit formula which determines t_{12}^a and t_{12}^b is given by $G(\mathbf{e}, c, k) = 1 - H(t_{12}(\mathbf{e}, c, k)) + k(\mathbf{e}/c - 1) - t_{12}(\mathbf{e}, c, k) = 0$, where $k = 1$ for t_{12}^a ($t_{12}^a = t_{12}(\mathbf{e}, c, 1)$) and $k = 0$ for t_{12}^b ($t_{12}^b = t_{12}(\mathbf{e}, c, 0)$). Given the definition of $H(.)$ and the assumption that $F(.)$ is concave it follows that $H(.) > 0$ and $H'(.) > 0$. Using this and applying the implicit function theorem, we find that $\partial t_{12}^a/\partial(v-d) = \partial t_{12}(\mathbf{e}, c, 1)/\partial \mathbf{e} = 1/c(1+H'(.)) > 0$, $\partial t_{12}^b/\partial(v-d) = \partial t_{12}(\mathbf{e}, c, 0)/\partial \mathbf{e} = 0$, $\partial t_{12}^a/\partial(c_2-c_1) = \partial t_{12}(\mathbf{e}, c, 1)/\partial c = -\mathbf{e}/c^2(1+H'(.)) < 0$ and $\partial t_{12}^b/\partial(c_2-c_1) = \partial t_{12}(\mathbf{e}, c, 0)/\partial c = 0$. Thus, since $F'(.) > 0$ the result follows. ■

The following examples illustrates the result:

Example: Suppose the distribution function $F(.)$ is given by $F(x) = x^{1/y}$ for $y = 1, 2, ...$ Then $\Delta_{12}^a = y(v-d-c_1)/(y+1)$, $\Delta_{12}^b = [y(v-d-c_1)+(v-d-c_2)]/(y+1)$, $t_{12}^a = (v-d-c_1)/[(y+1)(c_2-c_1)]$, $t_{12}^b = 1/(y+1)$, and $t_{12}^a - t_{12}^b = (v-d-c_2)/[(y+1)(c_2-c_1)]$. So, if $v = 10$, $c_2 = 5$, $c_1 = 2$, $d = 2$, and $y = 1$ (implying that $F(.)$ is the uniform distribution) then the non-price-discriminating expert will serve all consumers efficiently under the equal mark-up tariff $\Delta_{1,2}^a = 3$ ($t_{12}^a = 1$). If she is allowed to price-discriminate then she serves half of the population under the equal mark-up vector $\Delta_{1,2}^b = 4.5$ ($t_{12}^b = 0.5$), and the rest under the 'overtreatment tariff' $\Delta_{0,2}^b = 3$.[23] So, with this parameter constellation welfare is definitely decreasing when moving from non-discrimination to discrimination because under nondiscrimination all consumers are treated efficiently ($W^a = 4.5$) whereas with discrimination customers in the interval $t \in (0.5, 1]$ are potentially overtreated, i.e., they receive with probability $(1-t)$ an unnecessary expensive treatment ($W^b = 4.125$). If c_2 increases from 5 to 7 then the non-price-discriminating expert serves 60% of the consumers efficiently ($t_{12}^a = 6/10$) and the rest remains unserved. With this constellation welfare is higher under discrimination ($W^b = 2.875$) than under non-discrimination ($W^a = 2.7$) because the gain of customers not treated under non-discrimination (those in the interval $(0.6, 1]$) outweights the loss of consumers that are efficiently served under non-discrimination and inefficiently under discrimination (those in the interval $(0.5, 0.6]$).[24] Similarly, if we start from the same starting point and reduce $v-d$ from 8 to 6 then the non-price-discriminating expert serves 66% of the consumers efficiently ($t_{12}^a = 2/3$) and the rest remains unserved. Again, welfare is higher under discrimination ($W^b = 2.125$) than under non-

[23] Note that $\Delta_{12}^a = \Delta_{02}^b$ is due to the fact hat g_2^t has full support on $[0, 1]$ and that parameters are such that all consumers are treated under non-discrimination. Whenever some customers remain untreated under non-discrimination, mark-ups differ. Also, if $g_2^t < 1$ for all t then $\Delta_{12}^a \neq \Delta_{02}^b$.

[24] Here note that the efficiency gain of treating a type t consumer under Δ_{12} is $v - C^t$, while the efficiency gain of (over-)treating a type t customer under Δ_{02} is $v - C^t - (1-t)(c_2 - c_1)$.

discrimination ($W^a = 2$).

4 Extensions/Modifications

In this section we discuss several extensions/modifications. First, we extend the basic model to allow for an arbitrary number of problems and an arbitrary number of interventions. It turns out that our main result that price discrimination entails potential overtreatment of high cost consumers extends in this direction. Next we modify our basic model to a setting where consumers differ not in the expected cost of efficient treatment but rather in their valuation for a successful intervention. We show that in this setting the expert provides serious diagnosis and appropriate treatment only to high valuation consumers while low valuation ones are potentially undertreated; that is, they are induced to demand a simple procedure without a serious diagnosis. Finally we look at a setting in which consumers differ in both dimensions, in their expected cost of efficient treatment and in their valuation of a successful intervention. It turns out that the expert will always serve at least some consumers efficiently. The rest may get unnecessary or insufficient procedures or no treatment at all.

4.1 More than Two Degrees of Problem: Different Degrees of Overtreatment

In this subsection we extend our analysis to $n > 2$ degrees of problem ($k \in \{1, .., n\}$). We denote the type of procedure that efficiently fixes a problem of degree k by c_k. Without loss of generality we assume that if $k < l$ then problem k is less severe than problem l. Again we assume that a less severe problem is less costly to be treated ($c_k < c_l$ for $k < l$) and that a more expensive treatment fixes all problems cheaper treatments fix, while the cheapest one is only good for the least severe problem. As in the basic model each consumer is characterized by his type t and a type t consumer has probability $g_k^t = g^t(c_k) \geq 0$ of needing treatment c_k, with $\sum_{k=1}^{n} g_k^t = 1$. Let $G^t(.)$ be the associated cumulative distribution function, i.e., $G^t(c_l) = \sum_{k=1}^{l} g^t(c_k)$. Also, let C^t denote the associated expected cost of efficient treatment net of diagnosis cost, i.e., $C^t = \sum_{k=1}^{n} g_k^t c_k + d$. For the formal analysis we need some structure on the type set. What we want to have is (i) a continuum of types, (ii) for each type t a strictly positive probability of having a problem of degree k $(= 1, ..., n)$, and (iii) an ordering on the type set such that for any two types s and t with $s \leq t$ the probability of having a problem of at least degree k is higher under $G^t(.)$ than under $G^s(.)$ for every degree of problem. A simple way to get such a structure is to take two distributions $G^1(.)$ and $G^0(.)$ with (densities $g^1(.)$ and $g^0(.)$ that have) full support on $\{c_1, ..., c_n\}$ such that the former first-order stochastically dominates the latter (i.e., $1 - G^1(.) > 1 - G^0(.)$ for all c_k, or equivalently $G^1(.) < G^0(.)$ for all c_k), and to let the cumulative distribution of problem degrees for a type t consumer be given by $G^t(.) = (1-t)G^0(.) + tG^1(.)$. In the sequel we follow this way and assume that consumers' types are drawn independently from the same distribution $F(\cdot)$, with differentiable strictly positive density $f(\cdot)$ on $[0, 1]$. Again, $F(\cdot)$ is assumed to be common knowledge, but a consumer's type is the consumer's private information.

In an $n \geq 2$ framework there are $2^n - 1$ classes of tariffs to consider, the class of equal mark-up tariffs (denoted by $\Delta_{1,2,...,n-1,n}$) and $2^n - 2$ classes of tariffs that have a lower mark-up for at least one and at most $n - 1$ treatments. We denote tariffs that have a lower mark-up for treatment k by $\Delta_{1,..,k-1,0,k+1,...,n}$.[25] For instance, for $n = 3$, a Δ_{103} vector has $p_1 - c_1 = p_3 - c_3 > p_2 - c_2$. Similarly, for $n = 4$, a Δ_{0004} tariff has $p_4 - c_4 > p_k - c_k$ for $k = 1, 2, 3$. The expert's behavior under the n classes of $\Delta_{0,..,0,k,0,..,0}$ tariffs and under $\Delta_{1,2,...,n-1,n}$ is obvious. She will always provide treatment k under tariffs in the former classes, and she will always provide the appropriate treatment under tariffs in the latter class. What about the rest? Our assumption that the expert acts in her customers' interest whenever she is indifferent implies that she uses the cheapest highest mark-up treatment that fixes the problem whenever such a treatment exists. If none of the highest mark-up treatments fixes the problem, then the expert provides the cheapest highest mark-up treatment. For instance, under $\Delta_{0,..,0,k,0,..,0,l,0,..0}$ the expert will provide procedure c_k for problem degrees $h \leq k$, procedure c_l for problem degrees $h \in \{k + 1, .., l\}$, and again procedure k for problem degrees $h > l$.

Given these specifications the net utilities of consumers under all possible tariffs are well defined and we can try to extend the arguments for the $n = 2$ to the $n > 2$ case. As is easily verified, Proposition 1 continues to hold if we replace the condition $c_2 - c_1 > v - d - c_2$ by $C^1 - C^0 > v - C^1$:

[25] Note the slight change in the Δ-notation: When we consider an arbitrary number n of problems we insert commas between the different treatments to avoid confusion; that is, we write $\Delta_{1,2,...,n-1,n}$ instead of $\Delta_{12...n-1n}$ and $\Delta_{1,..,k-1,0,k+1,...,n}$ instead of $\Delta_{1...k-10k+1...n}$.

if the difference between the 'best' and the 'worst' type is large relative to the efficiency gain of treating the worst type then the non-discriminating expert will again demand prices such that some consumers decide to remain untreated. The result of Proposition 2 generalizes as follows to the $n > 2$ case:

Proposition 4 *Consider the extended basic model with $n \geq 2$ degrees of problem and with consumers who differ in their probabilities of needing different procedures only. Suppose that some consumers remain unserved under the conditions of Proposition 1 (where the expert is restricted to post a single tariff only).*[26] *Then, in any subgame-perfect equilibrium of the game in which discriminatory pricing is allowed, the expert will post a menu in which at least two tariffs attract types, one with equal mark-ups, and at least one tariff with lower mark-ups for cheaper treatments.*[27] *In total all consumers are served. Low cost consumers are served under the former tariff and always get honest diagnosis and appropriate treatment, high cost consumers are served under (one of) the latter(s) and are never under- but sometimes overtreated.*

Proof. See the Appendix. ■

Proposition 4 confirms that our main result that price discrimination entails potential overtreatment of high cost consumers extends to the setting with $n > 2$ degrees of problem: Again, low cost consumers are efficiently served under an equal mark-up tariff and the rest of the market gets unnecessary procedures with strictly positive probability. Also again, no kind of undertreatment is observed in equilibrium; that is, under all tariffs offered, each customer will always get an intervention that fixes his problem.

The most important change when moving from the two to the more than two types of problem setting is that there is no longer a guarantee that the price-discriminating expert will post exactly two tariffs, one with equal mark-ups and one with a higher mark-up for the most advanced intervention. The only guarantee we have is that the expert will post in addition to the equal mark-up tariff at least one other tariff, and that each posted contract other

[26] In opposition to the basic model this condition is needed to make sure that price discrimination is observed in equilibrium. The reason is, that in the current setting the boundary solution has $\Delta_{1,2,\ldots,n-1,n} = v - C^1 > v - d - c_n$, while the boundary solution in the basic model has $\Delta_{12} = v - C^1 = v - d - c_2$.

[27] Again, the menu may contain some redundant tariffs too, i.e., some tariffs that attract no consumers.

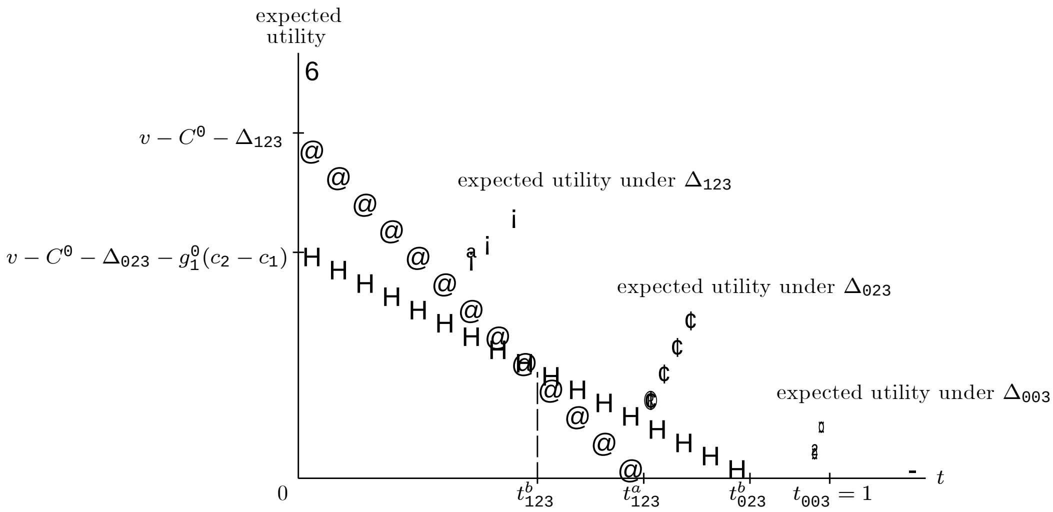

Figure 4: Type Dependent Expected Utilities under $C^t = \sum_{k=1}^{3} g_k^t c_k + d$

than the equal mark-up tariff will provide the expert with incentives to never under- and to sometimes overtreat customers (i.e., the intervention provided is always sufficient to fix the problem but sometimes a more expensive intervention is provided when a cheaper one would have been sufficient to solve the problem). To get sharper results we would need more information on the shape of the distribution functions and on the cost differential between the different treatments. To see why, look at Figure 4. This figure illustrates the $n = 3$ case. Let us start with a non-discrimination setting in which low cost consumers (with $t \leq t_{123}^a$) are efficiently served under the equal mark-up tariff Δ_{123} while high cost consumers (with $t > t_{123}^a$) remain untreated. If we now introduce a Δ_{003} tariff that leaves zero rents to customers ($\Delta_{003} = v - d - c_3$) then the expert's profit is unambiguously increased. The reason is, that the Δ_{003} contract is flat in the expected-utility/type space; that is, it provides the same utility to all consumers. So all consumers attracted by this contract can be held to their reservation utility. Using a Δ_{023} tariff instead of Δ_{003} has one advantage and one disadvantage. The advantage is, that it is more profitable than the Δ_{003} contract since it entails a smaller inefficiency. The disadvantage is that the tariff is not flat; that is, it offers rents to lower cost consumers. So some consumers (in the figure the market segment $[t_{123}^b, t_{123}^a]$) who would choose the equal mark-up tariff Δ_{123} under the two contract menu (Δ_{123}, Δ_{003}) will switch to the less profitable Δ_{023} contract if this tariff is also available. (Here notice that if Δ_{123}, Δ_{023} and Δ_{003} attract types, then $\Delta_{123} > \Delta_{023} > \Delta_{003}$.) So, whether it is profitable to post the Δ_{023} tariff in addition to (or instead of) the Δ_{003} contract depends on the magnitude of the two effects, and the magnitude of the two effects depends on the shape of $G^0(.)$, $G^1(.)$ and $F(.)$ and on whether the cost differential $c_{k+1} - c_k$ is increasing or decreasing in k.

4.2 Differences in the Valuation: Undertreatment

Up to now we have investigated settings where consumers differ in their probabilities of needing different treatments only. Now we modify our assumptions and analyze a model where consumers differ in their valuation of a successful intervention v, but have the same probabilities of needing different procedures. More precisely, we assume that a consumer of type t has valuation $v^t = v - t$ and that consumers' types are drawn independently from the same concave distribution $F(\cdot)$, with differentiable strictly positive density $f(\cdot)$ on $\left[0, \bar{t}\right]$. Again, $F(\cdot)$ is assumed to be common knowledge, but a consumer's type is the consumer's private information.

With this specification a type t consumer's expected utility under Δ_{12} is $v^t - C - \Delta_{12}$, where $v^t = v - t$. Similarly, a type t consumer's expected utility under Δ_{02} is $v^t - C - \Delta_{02} - g_1(c_2 - c_1)$. Finally, a type t consumer's expected utility under Δ_{10} is $v^t - C - \Delta_{10} - g_2(v - t - c_2 + c_1)$.

As is easily verified, Proposition 1 continues to hold if we replace the condition $c_2 - c_1 > v - d - c_2$ by $v - C - \bar{t} < \bar{t}$: if the difference between the 'best' and the 'worst' type is large relative to the efficiency gain of treating the worst type then the non-discriminating expert will again post prices such that some consumers decide to remain untreated. Proposition 2 changes to:

Proposition 5 *Consider the basic model with two degrees of problem and two treatment qualities. Suppose that consumers differ in their valuation of a successful intervention v (rather than in their probabilities of needing different treatments). Then, if price discrimination is observed in equilibrium, it is performed via a menu containing two tariffs, one with equal mark-ups, and one with a higher mark-up for the cheaper treatment. High valuation consumers are served under the former tariff and always get serious diagnosis and appropriate treatment; lower valuation consumers are served under the latter and always get the cheap treatment, sometimes inefficiently.*

Proof. First observe that any arbitrary menu of tariffs partitions the type-set into (at most) three subintervals delimited by cut-off values t_{02}, t_{12} and t_{10} with $0 \leq t_{02}, t_{12} \leq t_{10} \leq 1$ and either $t_{02} = 0$ or $t_{12} = 0$ (or both) such that (i) either the optimal strategy of types in $[0, t_{02})$ is to choose a Δ_{02} tariff (if $t_{02} > 0$), or the optimal strategy of types in $[0, t_{12})$ is to choose a Δ_{12} tariff (if $t_{12} > 0$), (ii) the optimal strategy of types in (t_{12}, t_{10}) is to decide for a Δ_{10} tariff, and (iii) the optimal strategy of types in $(t_{10}, 1]$ is to remain untreated. This follows from the fact that the expected utility under any of these tariffs is strictly decreasing in t, and from the fact that the Δ_{12} and the Δ_{02} function have exactly the same steepness in the expected-utility/type space and that they are both strictly steeper than the Δ_{10} function (see Figure 5 below). The rest of the proof is similar to that of Proposition 2 the only exception being that the Δ_{10} function is not completely flat so that price discrimination may not be observed in equilibrium even if some consumers are excluded under the conditions of Proposition 1 (where the expert is restricted to post a single tariff only). ■

Proposition 5 tells us that in the model where consumers differ in their valuation of a successful intervention, price discrimination entails potential undertreatment of low valuation consumers; that is, low valuation consumers are induced to buy the simple procedure without a serious diagnosis.

The following example (displayed in Figure 5) illustrates the result:

Example: Each consumer has the minor problem with probability $g_1 = 0.5$ and the major one with probability $g_2 = 0.5$. Consumers differ in their valuation of a successful intervention. A consumer of type t has valuation $v^t = 20 - t$. Consumers' types are independently drawn from an uniform distribution on $[0, 10]$. The cost of the expensive treatment is nine ($c_2 = 9$), and the cost of the cheap treatment is one ($c_1 = 1$). There are no diagnosis costs ($d = 0$). If the expert can post a single price vector only, then she serves 3/4 of the consumers ($t_{12}^a = 7.5$) with the equal mark-up tariff $\Delta_{12}^a = 7.5$ (see Figure 5). With this policy she earns an expected profit of 5.625 per customer. If the expert is allowed to price-discriminate among consumers then she increases her expected profit (to 5.8375 per customer) by posting two tariffs, the equal mark-up tariff $\Delta_{12}^b = 7.75$ and an 'undertreatment tariff' with mark-up $\Delta_{10}^b = 4.5$. High valuation consumers (consumers of type $t < t_{12}^b = 5.5$) are efficiently served under the equal mark-up tariff, lower valuation consumers (consumers of type $t \in [t_{12}^b = 5.5, t_{10}^b = 9]$) are potentially undertreated under the second tariff, and very low valuation consumers

(consumers of type $t > t^b_{10} = 9$) remain unserved.

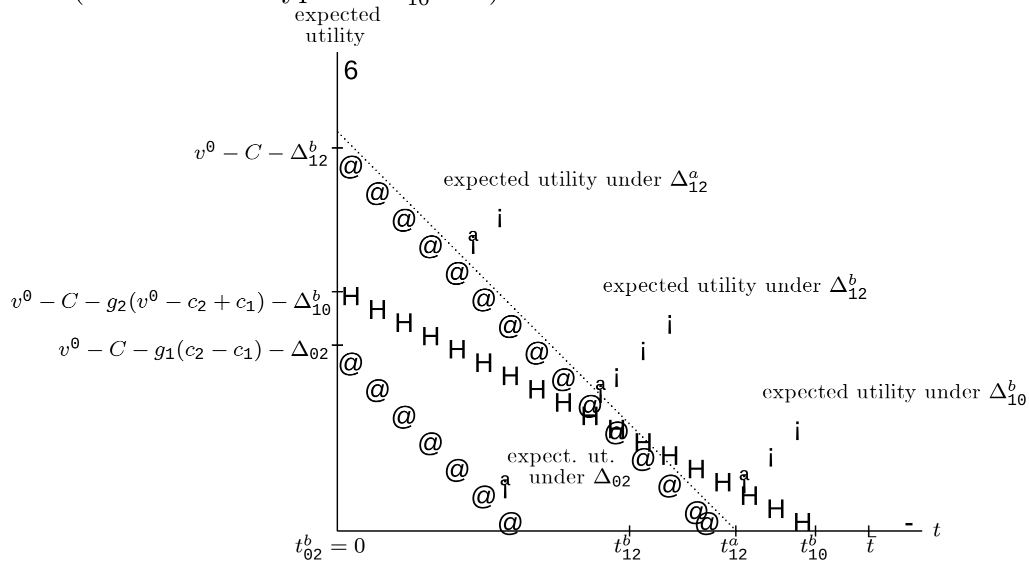

Figure 5: Type Dependent Expected Utilities with $v^t = v - t$

Notice that in contrast to the setting where consumers differ in their probabilities of needing different interventions only, price discrimination is not necessarily observed in equilibrium even if some consumers are excluded under the conditions of Proposition 1 (where the expert is restricted to post a single tariff only). The reason is similar to the one given in the previous subsection for the imprecise result of Proposition 4: If we start with a non-discriminating setting in which the expert posts an equal mark-up tariff Δ_{12} only, and introduce Δ_{10} as a second tariff (the Δ_{02} tariff is strictly dominated and will therefore never be posted in equilibrium) then the expert profits because some new consumers (those in the interval $[t^a_{12}, t^b_{12}]$) are attracted. At the same time the expert loses because some consumers (those in the interval between intersection of the dotted line with the Δ^b_{10}-curve and t^a_{12}) who used to buy under the more profitable equal mark-up tariff Δ^a_{12} switch to the less profitable Δ^b_{10} tariff. Whether the overall effect is positive or negative depends on parameter constellations, that is, on the shape of the distribution function $F(.)$, on the size of the valuation v and on the intervention costs c_1 and c_2.

4.3 Two Dimensional Type Set: Over- and Undertreatment

Our previous results suggest that in a setting with a two-dimensional type set over- and undertreatment might coexist in equilibrium. This is indeed the case as the (discrete) example below shows. Before considering this example we first show that even in a two-dimensional world the expert will always treat at least a subset of consumers efficiently.

Proposition 6 *Consider the basic model with two degrees of problem and two treatment qualities. Suppose that consumers differ in their valuation of a successful intervention and in their probabilities of needing different treatments. Further suppose that each consumer has a strictly positive probability of having each of the different problems.*[28] *Then, in any subgame-perfect equilibrium the expert will post a menu in which an equal mark-up tariff attracts a nonempty subset of types.*

Proof. To see that an optimal menu must have an equal mark-up tariff which attracts a strictly positive measure of types, suppose to the contrary that there is no such contract. Then, among the tariffs chosen by a strictly positive measure of types, take the one with the highest mark-up for the provided treatment and denote it by Δ_h. Two cases have to be distinguished:

If Δ_h is an 'overtreatment tariff' (that is, a tariff of the Δ_{02} variety) denote the type with the *lowest* g_1 among the types attracted by Δ_h by t_h. Then replace Δ_h by an equal mark-up tariff Δ_{12} such that type t_h is exactly indifferent between Δ_h and Δ_{12}; that is, $\Delta_{12} = \Delta_h + g_1^{t_h}(c_2 - c_1)$. Since consumers with a higher g_1 gain more by the replacement than the critical type t_h, all types attracted by Δ_h under the original menu will be attracted by Δ_{12} under the new menu. Types not attracted by Δ_h under the original menu will either switch to the more profitable Δ_{12} tariff or will choose the same tariff as before the replacement. Thus, since $\Delta_{12} > \Delta_h$ the new menu yields a strictly higher profit.

[28] If consumers need the cheap procedure for sure ($g_1^t = 1$) then the tariffs Δ_{10} and Δ_{12} are indistinguishable from an efficiency point of view. Similarly, for consumers who need the expensive treatment for sure ($g_2^t = 1$) Δ_{02} and Δ_{12} are indistinguishable from an efficiency point of view. So, to guarantee that the expert will post a menu in which an equal mark-up tariff attracts a nonempty subset of types at least some consumers must have $g_1^t \in (0, 1)$.

If Δ_h is an 'undertreatment tariff' (that is, a tariff of the Δ_{10} variety) denote the type with the *lowest* $g_2(v - c_2 + c_1)$ among the types attracted by Δ_h by t_h. Then replace Δ_h by an equal mark-up tariff Δ_{12} such that type t_h is exactly indifferent between Δ_h and Δ_{12}; that is, $\Delta_{12} = \Delta_h + g_2^{t_h}(v^{t_h} - c_2 + c_1)$. Since consumers with a higher $g_2(v - c_2 + c_1)$ gain more by the replacement than the marginal type t_h, all types attracted by Δ_h under the original menu will be attracted by Δ_{12} under the new menu. Types not attracted by Δ_h under the original menu will either switch to the more profitable Δ_{12} tariff or will choose the same tariff as before the replacement. Thus, since $\Delta_{12} > \Delta_h$ the new menu yields a strictly higher profit.[29] ■

Let us now discuss the example announced earlier. In this example all consumers are efficiently served under equal mark-up prices if the expert can post a single tariff only. With price discrimination the expert uses an equal mark-up contract to skim off high valuation / low cost consumers, a tariff with a higher mark-up for the cheap treatment to undertreat low valuation / low cost consumers, and a price vector with a higher mark-up for the expensive treatment to overtreat high valuation / high cost consumers. Low valuation / high cost consumers remain unserved with price discrimination although treating them would be efficient.

Example: There are two degrees of problem ($n = 2$). Each consumer is characterized by his two-dimensional type (g_2^t, v^t). Consumers' types are independently drawn from an equal probability distribution on the discrete support $\{(0.6, 1.95), (0.2, 2.0), (0.9, 3.0), (0.5, 3.5)\}$. There are no diagnosis costs ($d = 0$). The cost of the expensive treatment is one ($c_2 = 1$), and the cost of the cheap treatment is zero ($c_1 = 0$). If the expert can post a single tariff only, then she serves all consumers under the equal mark-up contract $\Delta_{12} = 1.35$. With this policy she earns an expected profit of 1.35 per consumer. If the expert can price discriminate among consumers then she increases her expected profit to 1.525 per consumer by posting three price vectors, the equal mark-up tariff $\Delta_{12} = 2.5$, the 'overtreatment tariff' $\Delta_{02} = 2.0$, and the 'undertreatment tariff' $\Delta_{10} = 1.6$. High valuation/medium cost consumers are served efficiently under the equal mark-up tariff, high valuation/high cost customers are potentially overtreated under Δ_{02}, low valuation/low cost consumers are potentially undertreated under

[29] Here notice that the same proof-technique could be used to prove that the result continues to hold if we allow for an arbitrary number of problems and an arbitrary number of interventions.

Δ_{10} and low valuation/medium cost customers remain untreated.

5 Concluding Remarks

Research on credence goods markets typically assumes that consumers are homogeneous. The present article has studied the consequences of dropping this assumption in a model where an expert has some degree of market power in providing diagnosis and interventions. With heterogeneous consumers and market power price discrimination may emerge in equilibrium. In the case of experts markets, where the expert observes the intervention that a consumer needs to fix his problem and also provides a treatment, price discrimination proceeds along the dimension of quality of advice offered. High quality diagnosis and appropriate treatment is sold to the most profitable market segment only. Less profitable consumers are induced to demand a procedure without a serious diagnosis, or get no service at all. The welfare consequences of price discrimination are ambiguous: On the one hand, price discrimination increases the number of consumers that get an intervention. On the other hand, some consumers that are efficiently served under non-discrimination get the wrong procedure if the expert can discriminate among customers.

Our argument hinges on some sort of market power for experts. We belief that such an assumption is not to hard to defend in the case of experts markets. Specialization in the expertise (for example medical specialists), capacity constraints, consumer loyalty (the expert already knows the history of repairs, the doctor knows the 'Krankengeschichte' of the client), travel costs together with location, search costs and many, many other factors might give rise to market power in credence goods markets.

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6 Appendix

Proof of Proposition 4

The proof proceeds in four steps. In *Step 1* we show that an optimal menu of contracts must have an equal mark-up tariff that attracts a strictly positive measure of types, in *Step 2* that in an optimal menu the equal mark-up tariff must attract the lowest segment of types and yield the highest profit per customer and that all other tariffs must be such that successively higher types choose successively less profitable tariffs (more precisely, if two types s and t with $s < t$ choose two different contracts, then the one chosen by s must be more profitable than the one chosen by t). Our strategy is then to show (in *Step 3*) that the expert has never an incentive to post a menu where a tariff that implies potential undertreatment attracts types, and to show in the end (*Step 4*) that the expert has indeed always a strict incentive to cover a strictly positive interval with at least one tariff that implies potential overtreatment. Before beginning notice that, relative to the universe of all possible menus of tariffs, no loss of generality is imposed by restricting attention to menus that contain (at most) a single representative of each of the $2^n - 1$ classes of tariffs discussed in the main text. This follows from the observation that a consumer who decides for a contract in a given class will always decide for the one with the lowest Δ. Also notice that a given contract cannot attract two disjunct subsets of types. This follows from the fact that the expected utility under $\Delta_{0,0,....,0,n}$ is type-independent, while the expected utility under each other vector is linearly decreasing in t.[30] In what follows we denote the highest type that chooses contract Δ_x by t_x. Obviously, if the expected utility under Δ_x is steeper than that under Δ_y and if both contracts attract types then $t_x < t_y$.[31]

[30] We ignore menus containing type-attracting contracts that have exactly he same steepness and exactly the same position in an expected-utility/type diagram since such menus are always (at least weakly) dominated.

[31] In an expected-utility/type diagram contracts that have no "holes" (in the sense that if $p_k - c_k \geq p_l - c_l$ for some k and all $l \in \{1, ..., n\}$ then either $p_1 - c_1 = p_2 - c_2 = ... = p_{k-1} - c_{k-1} = p_k - c_k$, or $p_k - c_k = p_{k+1} - c_{k+1} = ... = p_{n-1} - c_{n-1} = p_n - c_n$, or both) are ordered with respect to their steepness: The expected utility under $\Delta_{1,0,0,...,0}$ is at least as steep as the expected utility under $\Delta_{1,2,0,..,0}$, the expected utility under $\Delta_{1,2,0,...,0}$ is at least as steep as the expected utility under $\Delta_{1,2,3,0,..,0}$, ..., the expected utility under $\Delta_{1,2,3,...n-1,0}$ is at least as steep as the expected utility under $\Delta_{1,2,3,...n-1,n}$, the expected utility under $\Delta_{1,2,3,...n-1,n}$ is at least as steep as the expected utility under $\Delta_{0,2,3,...n-1,n}$, ..., the expected utility under $\Delta_{0,0,...,0,n-1,n}$ is at least as steep as the expected utility

Step 1 To see that an optimal menu must have an equal mark-up tariff that attracts a strictly positive measure of types, suppose to the contrary that there is no such contract. Then, among the tariffs chosen by a strictly positive measure of types, take the one with the highest mark-up for the provided treatment(s). Denote this contract by Δ_h and the highest type attracted by Δ_h by t_h. Now replace Δ_h by an equal mark-up tariff $\Delta_{1,2,\ldots,n-1,n}$ such that type t_h is exactly indifferent between Δ_h and $\Delta_{1,2,\ldots,n-1,n}$. Next remove all price-vectors that are steeper than $\Delta_{1,2,\ldots,n-1,n}$. Since the expected utility under each contract is monotonically decreasing in t, all types in $[0, t_h)$ will switch to $\Delta_{1,2,\ldots,n-1,n}$. Types in $(t_h, 1]$ will either move to $\Delta_{1,2,\ldots,n-1,n}$, or will choose the same vectors as before the replacement. Thus, since $\Delta_{1,2,\ldots,n-1,n} > \Delta_h$,[32] the new menu yields a strictly higher profit.

Step 2 That, among all tariffs that attract a strictly positive measure of types, the equal mark-up tariff must yield the highest per-customer profit follows from the shape of the expected utilities under the different kinds of contracts (see previous footnote), and that in an optimal menu the equal mark-up tariff must attract the lowest segment of types from the "remove steeper functions" argument in *Step 1* above. To see that all other type-attracting contracts must be such that successively higher types choose successively less profitable contracts (in the above mentioned sense) suppose first that there exist two subsets of types $[\underline{t}_a, \overline{t}_a]$ and $[\underline{t}_b, \overline{t}_b]$, with $\overline{t}_a < \underline{t}_b$, that choose the more profitable tariffs Δ_a and Δ_b while all types in $(\overline{t}_a, \underline{t}_b)$ choose less profitable ones. Then by removing the tariffs chosen by the types in $(\overline{t}_a, \underline{t}_b)$ the monopolist can increase her profit, as these types will switch either to Δ_a or to Δ_b.[33] This proves that successively higher types choose either successively less or successively more profitable contracts. If they would choose successively more profitable ones, then the monopolist could increase her profit by removing all price vectors except the flattest one. With an one contract menu our statement is trivially true, since different types cannot

under $\Delta_{0,0,\ldots 0,n}$. Contracts that have holes cannot be positioned in that order.

[32] For instance, for $n = 3$ type t_h's expected utility under Δ_{123} is $v - C^{t_h} - \Delta_{123}$, while type t_h's expected utility under Δ_{100} is $v - C^{t_h} - \Delta_{100} - g_2^{t_h}(v - c_2 + c_1) - g_3^{t_h}(v - c_3 + c_1)$, his expected utility under Δ_{120} is $v - C^{t_h} - \Delta_{120} - g_3^{t_h}(v - c_3 + c_1)$, his expected utility under Δ_{023} is $v - C^{t_h} - \Delta_{023} - g_1^{t_h}(c_2 - c_1)$, his expected utility under Δ_{003} is $v - C^{t_h} - \Delta_{003} - g_1^{t_h}(c_3 - c_1) - g_2^{t_h}(c_3 - c_2)$, his expected utility under Δ_{103} is $v - C^{t_h} - \Delta_{103} - g_2^{t_h}(c_3 - c_2)$, and his expected utility under Δ_{020} is $v - C^{t_h} - \Delta_{020} - g_1^{t_h}(c_2 - c_1) - g_3^{t_h}(v - c_3 + c_1)$.

[33] Notice that the price vectors previously chosen by the types in $(\overline{t}_a, \underline{t}_b)$ must have been flatter than Δ_a and steeper than Δ_b.

choose different contracts.

Step 3 To see that it cannot be optimal to post a menu where a tariff that implies potential undertreatment attracts types, consider an arbitrary such vector and denote it by Δ_u. Since Δ_u leads to undertreatment, it must have $p_k - c_k > p_n - c_n$ for at least one and at most $n-1$ treatments c_k. Compare this tariff with a contract where the prices for all lower treatments are exactly as in Δ_u, but where p_n is adjusted in such a way that c_n is among the provided treatments. (That is, in an $n = 3$ framework we compare a specific Δ_{100} vector with the Δ_{103} vector that has $\Delta_{103} = \Delta_{100}$, a specific Δ_{020} vector with the Δ_{023} vector that has $\Delta_{023} = \Delta_{020}$, and a specific Δ_{120} vector with the Δ_{123} vector that has $\Delta_{123} = \Delta_{120}$.).[34] Denote this new vector by Δ_n. The new tariff has a strictly higher position than Δ_u at $t = 0$,[35] and it is strictly flatter than Δ_u everywhere.[36] This implies that in the menu under consideration (where Δ_u attracts customers) no tariff out of the Δ_n class can attract customers. Otherwise we would get a contradiction with the arguments in *Step 2* above, as the Δ_n vector would be chosen by higher types than Δ_u and be strictly more profitable. But, if no Δ_n vector attracts types while Δ_u does, then we can always get a strict increase in profit by replacing Δ_u by a Δ_n vector where the mark-up Δ_n is chosen in such a way that type t_u is indifferent between Δ_n and Δ_u. This proves that it is never optimal to post a menu where a tariff that implies potential undertreatment attracts types. So, if price discrimination is observed in equilibrium it is performed via a menu that contains at least two tariffs, one with equal mark-ups, and at least one with a lower mark-up for at least one of the cheaper treatments.

Step 4 That the expert has indeed always a strict incentive to post at least two contracts if some consumers are excluded under the conditions of Proposition 1 (where the expert is restricted to post a single tariff only) follows immediately from the arguments in *Step 4* of the proof of Proposition 2. ■

[34] Again we use the same notation for a class of contracts, for a specific member of that class, and for the implied mark-up for the provided treatment(s). No confusion should result.

[35] Consider again the $n = 3$ example. At $t = 0$, Δ_{103} is by $(g_2^0 + g_3^0)(v + c_1 - c_3)$ higher than Δ_{100}, Δ_{023} is by $g_3^0(v + c_2 - c_3)$ higher than Δ_{020}, and Δ_{123} is by $g_3^0(v + c_1 - c_3)$ higher than Δ_{120}.

[36] In the $n = 3$ example, the difference in the derivative of the expected utility with respect to t between Δ_{100} and Δ_{103} is $(\hat{g}_2 + \hat{g}_3)(v + c_1 - c_3)$, where $\hat{g}_k$ stands vor $g_k^1 - g_k^0$. Similarly, the difference in the derivative of the expected utility between Δ_{020} and Δ_{023} is $\hat{g}_3(v + c_2 - c_3)$, and the difference between Δ_{120} and Δ_{123} is $\hat{g}_3(v + c_1 - c_3)$.