UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

WORKING PAPERS IN ECONOMICS

No 582

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January 2014

ISSN 1403-2473 (print)
ISSN 1403-2465 (online)

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Too Much or Too Little? Price-Discrimination in a Market for Credence Goods*

Uwe Dulleck[†], Rudolf Kerschbamer[‡], Alexander Konovalov[§]

Abstract

In markets for credence goods sellers are better informed than their customers about the quality that yields the highest surplus from trade. This paper studies second-degree price-discrimination in such markets. It shows that discrimination regards the amount of advice offered to customers and that it leads to a different distortion depending on the main source of heterogeneity among consumers. If the heterogeneity is mainly in the expected cost of efficient service, the distortion involves overprovision of quality. By contrast, if consumers differ mainly in the surplus generated whenever the consumer's needs are met, the inefficiency involves underprovision of quality.

JEL Classifications: L15, D82, D40

Keywords: Price Discrimination, Credence Goods, Experts, Discounters, Distribution Channels

*We thank Douglas Beatton, a former managing director of the sales department of HP, for helpful discussions on the development of the IT industry. Financial support from the Austrian Science Fund (FWF) through grant number P22669 is gratefully acknowledged.

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1 Introduction

A core characteristic of credence goods is that an expert seller is better informed than her customer about the quality that fits the customer's needs best. Important examples are technically advanced goods like IT equipment and complex production machinery, financial products like insurance policies and investment portfolios, health care and repair services, as well as taxi rides in an unknown city. In all these cases, the typical consumer lacks the expertise to identify the type or quality of the good that fits his needs best, while an expert seller has the ability to diagnose the customer, thereby discovering the customer's needs. The expert can then reveal this information and recommend the appropriate quality, or she can abstain from giving advice. In the latter case the customer might end up with too low or too high quality. Inefficient underprovision of quality comes at a high cost to the consumer and to society at large since scarce resources are spent without generating a compensating benefit. Similarly, overprovision is wasteful because the additional benefits to the customer from the excessive quality are less than the additional costs. Starting with the seminal contribution by Darby and Karni (1973), the search for institutions and conditions that help to contain the efficiency losses on markets for credence goods has been a central topic in the literature – see Dulleck and Kerschbamer (2006) for an overview of the theoretical literature, Dulleck et al. (2011) and Huck et al. (2012) for lab experiments, and Schneider (2012) and Beck et al. (2013) for field experiments on the effects of informational, institutional and market conditions on the behavior of customers and sellers in markets for credence and experience goods.

In this article we investigate the impact of second-degree price-discrimination on a market for credence goods characterized by market power on the supply side and heterogeneity of consumers on the demand side. We show that price-discrimination proceeds along the dimension of amount of advice offered by the expert. The expert offers the whole quality spectrum and advice on which quality fits best to a non-trivial segment of the market only and she offers no advice and only a limited quality range to the rest of the market. Interestingly, the quality range offered without advice – and therewith the equilibrium distortion on the market – depends on the main source of heterogeneity among consumers. If the heterogeneity is mainly in the expected cost needed to generate consumer surplus, the distortion involves overprovision of quality. By contrast, if consumers differ mainly in the surplus generated whenever the consumer's needs are met, the inefficiency involves underprovision of quality. We explore the conditions under which over- and underprovision of quality occur in equilibrium and discuss the welfare implications of price-discrimination.

In our theoretical model price-discrimination is implemented by a monopolistic expert via posted 'tariffs'.[1] At the outset, the expert posts a menu of tariffs. Each tariff specifies a list of prices – one price for each quality. We show that in equilibrium the expert always posts an 'efficient-service tariff' under which she commits to sell the whole spectrum of qualities and to give advice on which quality fits the consumer's needs best. In addition, she may also offer different 'no-advice tariffs'. Through the latter type of tariff only a limited range of qualities is available and no advice is given. Consumers observe the menu and decide under which tariff they wish to be served, knowing that the expert's behavior crucially depends on the type of tariff they choose. Later we argue that in realty second-degree price-discrimination on markets for credence goods can be implemented by manufacturers with market power through the choice of distribution channels. In this interpretation the efficient-service tariff corresponds to selling the whole quality spectrum through experts providing advice on which quality fits best; and a no-advice tariff corresponds to selling a limited quality range through discounters offering the good without advice.

For which sectors are our considerations relevant? A prime example of a credence goods industry where manufacturers have market power and where customers are heterogeneous is the IT industry. In this industry customers (often firms) differ according to their intended use of IT – especially the probability of needing high capacity (capacity is probably the most important quality dimension in the IT industry), as well as the benefit they derive from sufficient equipment. Insufficient equipment causes high costs because important tasks cannot be performed; and excess quality is a waste of re-

[1]Here the important property is not that a single expert serves consumers, but rather that experts have some degree of market power. In a model in which capacity is required to serve customers (as in Emons 1997 and 2001, or Richardson 1999) experts have market power (independently of the number of sellers competing for customers) whenever tight capacity constraints hamper competition. Similarly, consumer loyalty, travel costs together with location, search costs, collusion and many other factors may give rise to market power.

sources because of its high capital cost.[2] Users (ordinary households, firms, non-profit organizations) can procure IT equipment through two channels. The 'expert channel' provides the whole spectrum of qualities as well as advice on which quality fits best. The latter is referred to in the industry as 'rightsizing advice' and it is provided either by trained sales agents or through hired consultants.[3] Rightsizing advice ensures that the equipment satisfies the user's needs at minimal cost – see Day and Day (2003) for details. The 'discount channel' offers a limited selection of equipment without offering rightsizing advice – customers have to make their capacity decision themselves. The history of the IT sector reveals that large producers of equipment employed both channels, but over time the characteristics of the discount channel changed.

Two particularly well documented cases are IBM and Dell, both major players on the IT market. In the 1980s, IBM was offering high-powered mainframe-based integrated systems as well as low-powered PC-based systems through well-trained sales personnel.[4] In addition, low-powered equipment was also offered through a discount channel consisting of no-frills computer warehouses such as Computerland. Today Dell is a major player in the IT market with a market share consistently above 15% over the last years. Less known than its discount channel, Dell's expert channel serves companies and institutions such as DuPont, CoreLogic, and NIAID, designing, implementing, and optimizing IT services (Dell, 2012). While business clients using the well-known internet based discount channel usually receive high-capacity equipment (see Day and Day 2003, who document the resulting oversizing), the expert channel provides rightsizing advise. An interesting observation is that the discrimination strategy in the 1980s involved a discount channel selling low-capacity equipment while today firms sell through the discount channel equipment with a relatively high capacity while at the same time still using an expert channel. Such a pattern is predicted by our model for an industry where the heterogeneity is initially mainly in the surplus generated

[2]The IT capacity decision is a textbook example in the management literature – see Hill and Jones (2004, p. 474-479) and Brady et al. (2001, p. 26-30), the latter discussing the parameters affecting the optimal size of a SAP system.

[3]A major player in the consultancy market is Accenture. A description of their services can be found in Accenture (2013).

[4]Mendelson and Korin (2007) in their history of the computer industry point out that firms like IBM, NCR, NEC and Wang competed in vertically integrated solutions and the advice in rightsizing the equipment and implementing the system.

if the good delivers and later mainly in the expected cost needed to generate consumer surplus.

The present paper is related to several strands of previous literature. First and most importantly it is related to the literature on credence goods (or expert services). The pioneering paper here is Darby and Karni (1973), a summary of the earlier theoretical literature is provided by Dulleck and Kerschbamer (2006). An important difference to most contributions to this literature is that they investigate models with homogeneous consumers while an important feature of our model is that consumers are heterogeneous. There are a few exceptions – two early ones are Darby and Karni (1973) and Pitchik and Schotter (1993). In both papers, heterogeneity is only used to purify a mixed strategy equilibrium, however. A third contribution with heterogeneous consumers is Richardson (1999) which shares with us the feature that overprovision of quality may occur in equilibrium. However, in contrast to the model considered here, Richardson's findings result from a lack of power to pre-commit to the prices of high-quality goods and not from the expert's desire to induce self selection among consumers. The closest paper to ours regarding research question and modeling assumptions is probably Fong (2005), who assumes identifiable heterogeneity of customers and shows that a mixed strategy involving overprovision may be used in equilibrium to discriminate among customers in a setting where the expert cannot explicitly discriminate. An important difference to our model is that self-selection is not an issue in Fong's model with identifiable heterogeneity, while it drives the core results in the present paper with unobservable characteristics.

Other credence goods papers analyze substantially different settings. Emons (1997 and 2001) share with us the feature that the quality provided by the expert is verifiable for the customer and study the incentives of experts for over- and underprovision of quality to ex ante homogeneous consumers. Emons finds that whether the market mechanism induces efficient service depends on the amount of information consumers have at hand to infer experts' incentives.[5] Alger and Salanié (2006) study a homogeneous-consumer model in which the degree of verifiability of quality is a continuous variable. They identify an equilibrium in which experts keep customers uninformed, as this deters them from seeking a better price elsewhere. Pitchik and Schotter

[5]That customers' information plays a crucial role for efficient service in markets for credence goods is confirmed in a recent field experiment by Beck et al. (2013).

(1987 and 1993), Wolinsky (1993 and 1995) and Taylor (1995) assume that the quality of the good is not verifiable and analyze expert's temptation to overcharge homogeneous customers.[6] Pesendorfer and Wolinsky (2003) 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. Liu (2011) extends the model of Fong to allow for conscientious experts, and Beck et al. (2013) investigate the impact of guilt aversion on the provision and charging behavior of experts. Fong and Xu (2012) and Daughety and Reinganum (2013) consider signaling games where the expert learns the value of her service to the potential client before offering a contract.

Outside the credence goods literature, our results have close analogies in the literature on monopolistic screening. In a model in which consumers with different tastes for quality have unit demand for a good, Mussa and Rosen (1978) show that a monopolist who only knows the aggregate distribution of tastes will in general offer a menu of price-quality combinations. As compared to the first-best outcome, (i) the monopolist tends to enlarge the range of qualities offered, and (ii) almost all consumers buy lower quality products than would be socially optimal. Similar results have been obtained by Maskin and Riley (1984) and Besanko et al. (1987), among others. There are several differences between our work and the models and results in this strand of literature. The most important one regards the good under consideration. While there is a natural order in the quality-space in the models investigated in the monopolistic screening literature, there is only a partial order in this dimension in the credence goods setting considered here. In particular, high quality in the Mussa and Rosen model unambiguously corresponds to the efficient-service solution in the setting considered here. The unusual feature in the case of credence goods is that there are different (unordered) lower quality levels. As discussed above, depending on whether consumer heterogeneity is mainly in the expected cost needed to generate consumer surplus or in the surplus generated whenever the consumer's needs are met, either

[6] In theory the presence or absence of verifiability is crucial for efficiency on markets for credence goods – see Dulleck and Kerschbamer (2006) for details. Recent experimental evidence by Dulleck et al. (2011) indicates that in the lab it plays at best a minor role. Kerschbamer et al. (2013) explain the discrepancy between theory and lab experiments by experts having non-trivial distributional preferences.

a contract that involves underprovision or a contract that involves overprovision is used as a screening device. Another difference to the Mussa and Rosen model and to many other models studied in the monopolistic screening literature is that better service (higher quality in the Mussa and Rosen model; advice and efficient service in our model) is not costly in our model.[7] As Acharyya (1998) has shown, Mussa and Rosen's results heavily depend on the assumption that improving service quality involves a cost. In particular, if an improvement is not costly, the monopolist will offer only one quality – the best available one – as her optimal policy and the only source of inefficiency that remains is the familiar monopoly pricing distortion. Only for the case of multiple demand Gabszewicz and Wauthy (2002) show that quality discrimination may take place even if provision of quality involves no cost of any sort. As we will see below, consumers can have unit demand and diagnosis can be costless in the case of credence goods, and still the expert may refrain from providing advice to some customer groups.

The next section introduces the model and Section 3 studies the benchmark case without price-discrimination. Section 4 explores the effects of price-discrimination, first for heterogeneity in the expected cost of efficient service, and then for heterogeneity in the value derived from receiving sufficient quality. Section 5 discusses the world where consumers differ in both dimensions. Section 6 revisits several of our modeling assumptions and discusses alternatives. In this section we also re-interpret the different tariffs offered in the single-expert model as different distribution channels chosen by a monopolistic manufacturer. Section 7 concludes. All proofs can be found in the appendix.

2 A Credence Goods Model with Heterogeneous Consumers

On the demand side of the market there is a continuum with mass one of risk-neutral consumers. Each consumer (he) needs either a low-quality good,

[7]The rationale for assuming zero diagnosis cost is that, if the expert finds it profitable to refrain from providing diagnosis to some consumers when diagnosis costs are zero, then, *a forteriori,* she will do so with positive diagnosis costs.

Customer's utility		Customer gets		
		c_1	c_2	no
Customer needs	c_1	v^s	v^s	0
	c_2	xv^s	v^s	0

Table 1: Utility from a Credence Good

c_1, or a high-quality good, c_2.[8] The customer knows that he has a need, but he does not know which quality is sufficient to satisfy it. He only knows that he has an *ex ante* probability of t that only high quality is sufficient to satisfy his need and a probability of $(1-t)$ that the low quality is sufficient. The consumer gets utility v^s from the good when it does deliver, and he gets $xv^s < v^s$, with $0 \leq x < 1$, if it fails to deliver.[9] To make sure that it is efficient to satisfy the need of the consumer, the variable x has to be sufficiently low such that

$$(1-x)v^s > c_2 - c_1. \tag{1}$$

Failure is observable but not verifiable. This means that payments cannot be conditioned on success. However, quality is observable and verifiable so that payments can be conditioned on the quality provided.

On the supply side of the market there is a single risk-neutral expert (she). This expert is able to discover the quality a consumer needs by performing a costless diagnosis.[10] She can then recommend the appropriate or the wrong quality. The cost of the high-quality good is c_2 and the cost of the low-quality good is c_1, with $c_2 > c_1$. For convenience, both the quality of the good and the associated cost is denoted by c_i.

Consumers are heterogeneous. In Section 4 we consider two sources of heterogeneity. First we assume that consumers differ only in the ex ante probability of needing the high-quality good, t, but receive the same gross valuation if

[8] An earlier version of this paper has investigated a model that allows for more than two types of needs and more than two qualities of the good. The results – available upon request – are qualitatively the same as in the simpler environment considered here.

[9] If a user needs a high-capacity PC and receives only a low-capacity one, he is still able to use it for some purposes.

[10] We discuss the case where the expert has to invest effort in diagnosis to detect the need of a consumer in Section 6.

the good does deliver, v^s. Each consumer is then characterized by his type t. Consumers' types are drawn independently from the same log-concave c.d.f. $F(\cdot)$, with strictly positive density $f(\cdot)$ on $[0,1]$.[11] $F(\cdot)$ is common knowledge, but a consumer's type is the consumer's private information. Next, we analyze a model where consumers differ only in their gross valuation if the good does deliver, v^s, but have the same ex ante probability of needing the high-quality good, t. In this case each consumer is characterized by his type s and a consumer of type s receives a valuation $v^s = v - s$ if the good does deliver. Consumers' types are drawn independently from the same log-concave c.d.f. $G(\cdot)$, with strictly positive density $g(\cdot)$ on $[0, \overline{s}]$. Again, $G(\cdot)$ is assumed to be common knowledge, but a consumer's type is the consumer's private information. In Section 5 we discuss a world where consumers differ in both dimensions and present our results for that case.

Each consumer incurs a sunk cost c if he visits the expert independently of whether or not he chooses to be served. This cost represents the time and effort incurred by the consumer in visiting the seller. Consumers are maximizers of expected utility. The utility of a consumer if the good does deliver (does not deliver, respectively) is his gross valuation v^s (is x times v^s, respectively) minus the price paid for the good minus the sunk cost c. The utility of a consumer who has not been served is his reservation payoff, which we normalize to zero (see Table 1), and the utility of a consumer who has visited the expert but has decided not to buy the good is -c. The expert maximizes expected profit. The expert's profit is the sum of revenues minus costs over the customers she served.

The interaction between consumers and the expert is sketched in Figure 1 for the special case where the monopolistic expert courts a single consumer whose type is known with certainty. At the outset, the expert posts take-it-or-leave-it tariffs. Each tariff specifies the 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, in the model she might post arbitrary many tariffs. The consumer observes the tariffs and then decides whether, and if yes, under which tariff he wants to be served. If he decides for service, a random move by nature determines his need. Now the expert learns the customer's need and then recommends either the low-quality or the high-quality good. Next,

[11] By log-concavity we mean that $F(\cdot)/f(\cdot)$ is a non-decreasing function. This assumption is not crucial for our analysis, but simplifies the proofs.

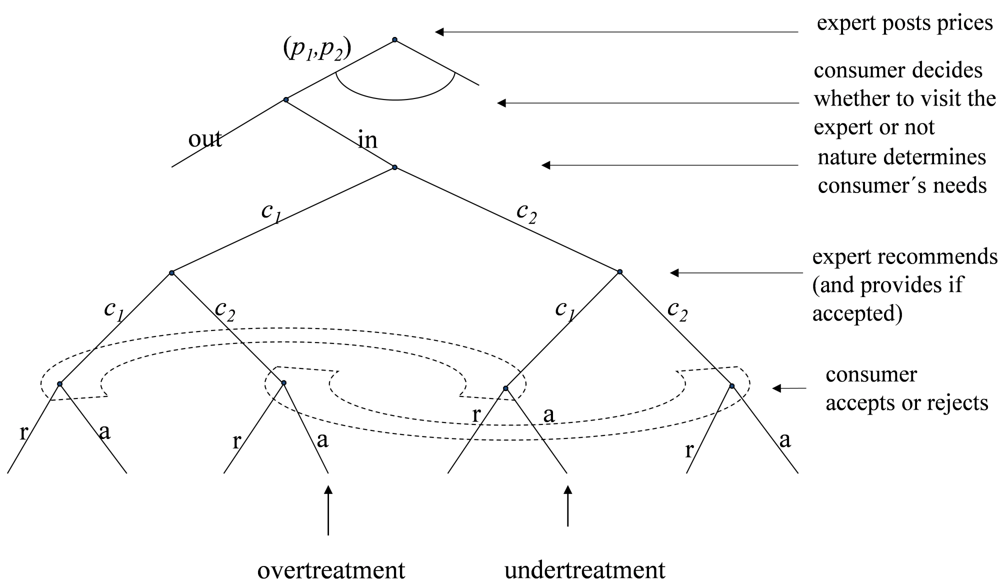

Figure 1: Game Tree for the Basic Model ($t = \bar{t}$ for all consumers).

the consumer decides whether to accept or reject the recommendation. If the consumer accepts, the expert provides the recommended quality and charges the price posted 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.

Throughout, we restrict attention to situations where the following two conditions hold

$$v^s - c > c_2, \tag{2}$$

$$c \geq (1-t)(c_2 - c_1), \tag{3}$$

where condition (2) is assumed to hold for any realization of s and condition (3) for any realization of t. Condition (2) says that it is efficient to satisfy each of the two needs. Condition (3) entails that the expert and the consumer are in effect tied together once the diagnosis has been made. Relaxing this latter restriction complicates the analysis without generating qualitatively different results (provided $c > 0$).[12]

[12]See Section 6 for a discussion.

Before starting with the formal analysis it is important to notice that a tariff (p_1, p_2) determines the relative profitability of selling the two qualities for the expert. Three classes of tariffs are to be distinguished, tariffs that contain a higher mark-up for the high-quality good ($p_2 - c_2 > p_1 - c_1$), tariffs that have a higher mark-up for the low-quality good ($p_2 - c_2 < p_1 - c_1$), and tariffs with equal mark-ups ($p_2 - c_2 = p_1 - c_1$). We denote tariffs in the first class by Δ_2, tariffs in the second by Δ_1, and tariffs in the third class by Δ_{12}, and we will sometimes refer to tariffs in the third class as 'equal-mark-up' tariffs. It is clear that the expert has an incentive to always sell the low-quality good under a Δ_1 contract and that she has an incentive to always sell the high-quality good under a Δ_2 contract.[13] By contrast, under a Δ_{12} tariff, where the difference in the prices reflects the difference in costs, the expert is indifferent between a) always selling the low quality, b) always selling the high quality, and c) always selling the appropriate quality. She is therefore prepared to randomize between those three policies. From these observations it follows that for any perfect Bayesian equilibrium (PBE) of our game there is a payoff-equivalent PBE in which the expert offers a menu of equal-mark-up tariffs, one for each type of consumer, and under each of those tariffs randomizes among policies according to three probabilities that designate, respectively, the probability of providing only the low-quality good ($\mu_1 \geq 0$), the probability of offering only the high-quality good ($\mu_2 \geq 0$) and the probability of offering the appropriate quality ($\mu_{12} \geq 0$).[14] Therefore, the equilibrium behavior of the expert can, without loss of generality, be characterized by a pair $(\Delta(.), \mu(.))$, where $\mu(.) = (\mu_1(.), \mu_2(.), \mu_{12}(.))$, and $(\Delta(\tau), \mu(\tau))$ is the tariff selected by the type τ consumer in equilibrium. Of course, $\mu_1(\tau) + \mu_2(\tau) + \mu_{12}(\tau) = 1$ for each τ. Thus, one of the μ-functions is redundant. Below we will refer to contracts where $\mu_{12} = 1$ as efficient-service tariffs, to contracts where $\mu_1 = 1$ as underprovision tariffs, and to contracts where $\mu_2 = 1$ as overprovision tariffs.

[13] We use the terms tariff, price-vector and contract interchangeably. For convenience we will often denote not only a specific tariff but also the implied mark-up by Δ. That is, the term Δ will then stand for the mark-up on the quality that is provided under the respective contract ($\Delta = \max\{p_1 - c_1, p_2 - c_2\}$).

[14] To see this, note that any tariff that contains a higher mark-up for the high quality ($\Delta_2 = p_2 - c_2 > p_1 - c_1$) is payoff-equivalent to an equal-mark-up tariff Δ_{12} with $\Delta_{12} = \Delta_2$ and $\mu_2 = 1$, and that any tariff that has a higher mark-up for the low quality ($p_2 - c_2 < p_1 - c_1 = \Delta_1$) is payoff-equivalent to an equal-mark-up tariff Δ_{12} with $\Delta_{12} = \Delta_1$ and $\mu_1 = 1$.

3 No Price-Discrimination

We start by presenting a benchmark result for a setting in which the expert cannot price-discriminate among consumers. Without price-discrimination, the expert posts an efficient-service tariff, where the consumer receives advice and appropriate service. If the efficiency gain from serving the type with the highest expected cost (the lowest valuation for sufficient quality) is sufficiently high, all types are served. Otherwise, prices are such that some consumers do not consult the expert 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 trade as possible but, because of heterogeneous consumers, she puts up with the risk of losing some consumers in order to extract more surplus from the remaining ones. We record the monopoly pricing result in Proposition 1.

Proposition 1 *Suppose the monopolistic expert cannot price-discriminate among consumers. Then, in any PBE the expert offers an efficient-service tariff, where the consumer receives advice and appropriate service* ($\mu_{12} = 1$).

If consumers differ only in the probability of needing the high-quality good, t*, then high-cost consumers decide to remain un-served provided*

$$c_2 - c_1 > (v - c - c_2)f(1). \tag{4}$$

Otherwise all consumers are efficiently served.

If consumers differ only in their gross valuation for sufficient quality, v^s*, then low-valuation consumers decide to remain un-served provided*

$$1 > (v - \bar{s} - c - c_1 - t(c_2 - c_1))g(\bar{s}). \tag{5}$$

Otherwise all consumers are efficiently served.

4 One-Dimensional Price-Discrimination

For the rest of the paper we allow the expert to post more than one tariff. In this section, we analyze the two one-dimensional cases assuming that consumers differ either only in the probability of needing the high quality or only in the valuation of sufficient quality, postponing the two-dimensional case to the next section.

4.1 Differences in the Expected Cost: Overprovision

Since consumers' tastes differ, the monopolist could – in principle – offer a specific tariff for each type of consumer, or at least different tariffs to different consumer groups. However, in the absence of information about the type of a consumer the expert must make sure that each consumer indeed chooses the tariff designed for him and not the tariff designed for other consumers. This puts self-selection constraints on the set of tariffs offered by the monopolistic expert. Proposition 2 provides a full characterization of the equilibrium for a setting where consumers differ in the expected cost of efficient service and where the expert is allowed to post arbitrary many tariffs.

Proposition 2 *Suppose that consumers differ in their probability of needing the high-quality good, t, but have the same gross valuation for sufficient quality, $v^s = v$. Further suppose that the expert can price-discriminate among consumers (rather than being restricted to post a single tariff only). Then, in any PBE, the expert posts two tariffs, an efficient-service tariff, where the consumer receives advice and appropriate service ($\mu_{12} = 1$), and an overprovision tariff, where the consumer receives the high-quality good without advice ($\mu_2 = 1$).*[15] *Both tariffs attract customers and in total all consumers are served. Low-cost consumers are served under the former tariff while high-cost consumers choose the latter.*

The equilibrium described in Proposition 2 features several interesting details. A first important characteristic is that the expert finds it optimal to use only two of the three pure types of contract – an efficient-service tariff, where the consumer receives advice and appropriate service, and an overprovision tariff, where the consumer receives the high quality good without advice. The intuition for why consumers are never served under an underprovision tariff is that such a contract would be especially attractive for the most profitable market segment, a segment that would otherwise self-select into the efficient-service contract. To attract the most profitable market segment with an underprovision tariff, the mark-up on low quality in that contract has to be lower than the mark-up under the efficient-service tariff because consumer's expected gross utility is lower under the former. Hence offering

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

such a contract is less profitable to the expert and given that no customer is lost by not offering this contract the expert will refrain from posting it. Figure 2 displays the expected utility of a customer of type t under the three pure forms of contract (with $\Delta_{12} > \max\{\Delta_1, \Delta_2\}$ to guarantee that each of the contracts attracts consumers). Customers with $t < t_1$ would self-select into the underprovision contract, if offered. By not offering it the expert increases her expected profit. Regarding the efficient-service contract (with $\mu_{12} = 1$), observe that some customers would receive less than their outside option by choosing it (in the figure, this is the case for customers with $t > t_{12}$). These customers can be served by the overprovision tariff, which is unattractive for the most profitable market segment. Hence, discrimination using an efficient-service and an overprovision tariff is attractive to separate customers with a high t (who do not suffer much from receiving the high quality without advice) from those with a low t (who would suffer more from always buying the high quality).

A second important observation is that the expert never has an incentive to randomize between pure types of contracts. To grasp the intuition for this result, first notice that the surplus that can be extracted from the most profitable customer group is increasing in μ_{12}. Thus, setting μ_{12} equal to 1 maximizes the profit that the expert can extract from that group. Secondly, the mark-up is bounded from above by the incentive constraint that deters the most profitable customers from using the overprovision tariff. More low-cost consumers would switch to that contract if it would contain a positive probability of efficient service. Thus, to make separation as profitable as possible, the expert will set the probability μ_{12} in the overprovision tariff equal to 0.

Another interesting feature of the equilibrium characterized in Proposition 2 is that all consumers are served under price-discrimination. This results from the fact that all types receive the same utility under the overprovision contract regardless of their t. This means that the indirect utility is flat under this contract implying the existence of a positive mass of types whose surplus is fully extracted in equilibrium by the expert. In that case, a small increase in the mark-up would lead to leaving this mass un-served, which would cause a significant drop in the expert's profit. Such discontinuity is the driving force of the no-exclusion result. A similar no-exclusion result is obtained, for example, by Severinov and Deneckere (2006) who have customers with heterogeneous valuations and different abilities to hide the

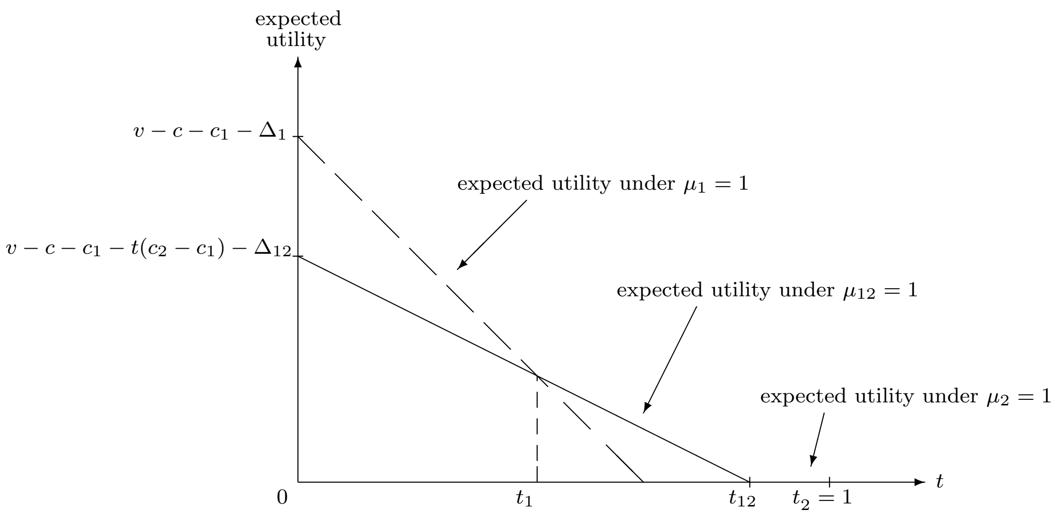

Figure 2: Type Dependent Expected Utilities under Differences in the Expected Cost.

private information of their willingness to pay. They show that a password mechanism which screens for non-strategic customers can lead to a market where all customers are served.

The mark-up in the efficient-service 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 without price-discrimination the expert's trade-off is between increasing the mark-up charged to served customers and losing some types to the unprofitable segment of un-served customers, while the trade-off here is between increasing the mark-up charged from customers served under the more profitable efficient-service tariff and losing some types to the segment of customers served under the less profitable overprovision tariff. An immediate consequence is that some consumers who receive advice and appropriate quality under the conditions of Proposition 1 necessarily receive (with strictly positive probability) too high quality when the expert can price-discriminate among consumers. If the expert serves all consumers if price-discrimination is not permitted, then allowing discrimination unambiguously reduces welfare. 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 served consumers and providing advice and appropriate quality to served customers. Overall efficiency might increase or decrease with price-discrimination, depending on the shape of the distribution function $F(\cdot)$, the valuation v, the sunk cost c 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 $v - c$ and decreases in the cost differential $c_2 - c_1$. At the same time, the mass of consumers not served under non-discrimination, but served under discrimination decreases in the net valuation and increases in the cost differential. Therefore, price-discrimination is *ceteris paribus* more likely to be efficiency enhancing if consumers' valuation of an efficient quality is small and if the cost differential is large.

Proposition 3 *Suppose that consumers differ in their probability of needing the high-quality good, t, but have the same gross valuation for sufficient quality, $v^s = v$.*

(i) If $c_2 - c_1 \leq (v - c - c_2)f(1)$, then price-discrimination decreases the mass of consumers who are served efficiently while leaving the mass of served consumers unaffected. Thus, under this condition price-discrimination unambiguously reduces welfare.

(ii) If $c_2 - c_1 > (v - c - c_2)f(1)$, then price-discrimination decreases the mass of consumers who are served efficiently and increases the mass of consumers who are served. Welfare may increase or decrease because of price-discrimination depending on the parameters of the problem. Let $1 - F(t^N)$ stand for the mass of consumers that are not served under non-discrimination and served under discrimination. Similarly, let $F(t^N) - F(t^D)$ stand for the mass of consumers that are efficiently served under non-discrimination and inefficiently under discrimination. Then $1 - F(t^N)$ increases in c and in c_2 and decreases in v and in c_1, while $F(t^N) - F(t^D)$ decreases in c and in c_2 and increases in v and in c_1.

The ambiguity of the effect of price-discrimination is illustrated by the following example.

Example 1 *Suppose the distribution function $F(.)$ is given by $F(x) = x^{1/y}$ for $y \geq 1$. Then $t^N = \min\{(v-c-c_1)/[(y+1)(c_2-c_1)], 1\}$ and $t^D = 1/(y+1)$. If $v = 25$, $c = 8$, $c_1 = 1$, $c_2 = 9$, and $y = 1$, then statement (i) of the proposition applies and the non-discriminating expert will serve all consumers* *under the efficient-service tariff* $\Delta^N = 8, \mu_{12} = 1$. *If she is allowed to price-discriminate, then she serves half of the population under the efficient-service tariff* $\Delta_{12}^D = 12, \mu_{12} = 1$, *and the other half under the overprovision tariff* $\Delta_2^D = 8, \mu_2 = 1$.[16] *In this situation welfare is lower under discrimination because in the non-discrimination case all consumers are served efficiently, whereas in the case of discrimination customers in the interval* $t \in (1/2, 1]$ *are potentially overprovided, that is, with probability* $(1 - t)$ *they receive the high-quality good although low quality quality would have been sufficient. If we take* $v = 20$ *instead, then the parameters are such that statement (ii) of the proposition applies. Now the non-discriminating expert serves 68,75% of the consumers efficiently* $(t^N = 11/16)$ *and the rest remains un-served. Welfare is higher under discrimination because the gain of customers not served under non-discrimination outweighs the loss of consumers that are efficiently served under non-discrimination and inefficiently under discrimination (those in the interval* $(1/2, 11/16]$*). On the other hand, if* $v = 22.5$ *(implying that we are again in part (ii) of the proposition), then the non-discriminating expert serves 84.375% of the consumers efficiently* $(t^N = 27/32)$ *and the rest remains un-served. Now welfare under non-discrimination is higher than that under discrimination.*

The welfare results provide important new insights for the credence goods literature. Discrimination of customers based on the amount of advice offered can be welfare improving as well as welfare deteriorating. This stands in sharp contrast to existing results in the credence goods literature (see, for example, Emons, 1997 and 2001 and Dulleck and Kerschbamer, 2009) arguing that experts should be provided with incentives to invest in diagnosis to prevent them from providing high quality without advice. The comparative statics provided in Proposition 3 indicate the direction of research needed by competition authorities to identify whether a certain type of discrimination leads to a reduction of welfare or not. Even a restriction to consumer surplus only does not provide a clear answer.

[16] That Δ^N and Δ_2^D are equal is due to the fact that all consumers are served under non-discrimination. Whenever some customers remainun-served under non-discrimination, mark-ups differ.

4.2 Differences in the Valuation: Underprovision

Consider now the setting where consumers differ in their valuation for sufficient quality, but have the same probability of needing the high-quality good. Proposition 4 fully characterizes the equilibrium with price-discrimination for this case.

Proposition 4 *Suppose that consumers differ in their gross valuation for sufficient quality, v^s, but have the same probability of needing the high-quality good, $t > 0$. Further suppose that the expert can price-discriminate among consumers (rather than being restricted to post a single tariff only). Then, if price-discrimination is observed in equilibrium, it is performed via a menu containing two tariffs, an efficient-service tariff, where the consumer receives advice and appropriate service ($\mu_{12} = 1$), and an underprovision tariff, where the consumer receives the low-quality good without advice ($\mu_1 = 1$). High-valuation consumers are served under the former tariff while lower-valuation consumers opt for the latter.*

Proposition 4 tells us that in the model where consumers differ in their valuation for a successful match, but have the same expected cost of efficient service, price-discrimination may entail underprovision of quality to low-valuation consumers. An explanation is easily provided. Since consumers are homogeneous in the expected cost of efficient service, an overprovision tariff, if attractive for low-valuation consumers, will also attract high-valuation ones and hence cannot be used for discriminatory purposes, see Figure 3 for an illustration. Given that customers accepting Δ_2 would also accept Δ_{12} and $\Delta_2 < \Delta_{12}$ the former contract will not be offered. An underprovision tariff, on the other hand, is unattractive for high-valuation consumers because they have more to lose if the good fails to deliver while low-valuation customers are willing to take the gamble given the lower mark-up. It is therefore potentially, but not necessarily, useful for discrimination.

Regarding welfare consequences of price-discrimination the equivalent to Proposition 3 now reads:

Proposition 5 *Suppose that consumers differ in their gross valuation for sufficient quality, v^s, but have the same probability of needing the high-quality*

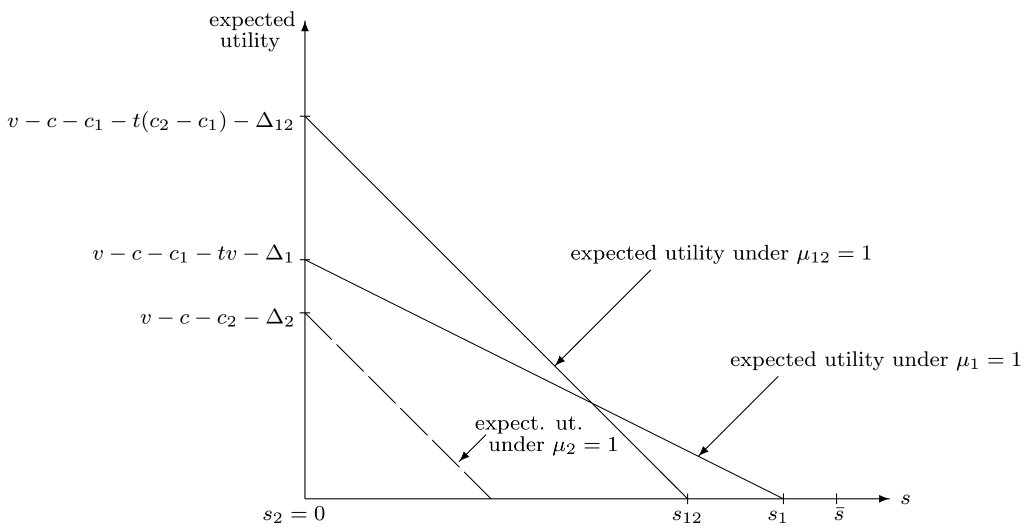

Figure 3: Type Dependent Expected Utilities under Difference in the Valuation.

good, $t > 0$. Further suppose that price-discrimination is profitable under the conditions of Proposition 4.

(i) If $[v - \bar{s} - c - c_1 - t(c_2 - c_1)]g(\bar{s}) \geq 1$, then price-discrimination decreases the mass of consumers who are served efficiently while leaving the mass of served consumers unaffected. Thus, under this condition price-discrimination unambiguously reduces welfare.

(ii) If $[v - \bar{s} - c - c_1 - t(c_2 - c_1)]g(\bar{s}) < 1$, then price-discrimination increases the mass of consumers who are served and decreases the mass of consumers who are served efficiently. Welfare may increase or decrease because of price-discrimination depending on the parameters of the problem.

The following examples illustrates the result:

Example 2 *Take the main parameters of Example 1 but assume now that t is fixed at $t = 1/2$ while s is distributed according to the distribution function $G(s) = (s/\bar{s})^{1/y}$ on $[0, \bar{s}]$ for $y \geq 1$. Then $s^N = \min\{[\ v - c - c_1 - t(c_2 - c_1)]/(1 + y),\ \bar{s}\}$, and, if price-discrimination is profitable, then $s_{12}^D = [v(1-x) - c_2 + c_1]/[(1+y)(1-x)]$ and $s_1^D = \min\{[\ v(1-t+tx) - c - c_1]/[(1+y)(1-t+tx)],\ \bar{s}\}$. If $v = 35$, $c = 8$, $c_1 = 1$, $c_2 = 9, x = 0.5$, $\bar{s} = 10$ and $y = 1$, then* *statement (i) of the proposition applies and the non-discriminating expert serves all consumers under the efficient-service tariff* $\Delta^N = 12, \mu_{12}^a = 1$. *If she is allowed to price-discriminate, then she serves 95% of the population under the efficient-service tariff* $\Delta_{12}^D = 12.125, \mu_{12}^b = 1$, *and the rest of customers under the underprovision tariff* $\Delta_1^D = 9.75, \mu_1 = 1$. *With these parameter values welfare is lower under discrimination. The reason is that under non-discrimination all consumers are served efficiently, whereas under discrimination customers with an s in the interval* [9.5, 10] *are potentially underprovided, that is, with probability t they receive the low-quality good although high quality would have been necessary to generate consumer surplus. If* v *is* 30 *instead, then the parameters are such that statement (ii) of the proposition applies. Now the non-discriminating expert serves 85% of the consumers efficiently* ($s^N = 8.5$) *and the rest remains un-served. Welfare is higher under discrimination because the gain of customers not served under non-discrimination but served under discrimination (those in the interval* $[8.5, 9]$*) outweighs the loss of consumers that are efficiently served under non-discrimination and inefficiently under discrimination (those in the interval* [7, 8.5]*). On the other hand, if* $v = 32.5$ *(implying that we are again in part (ii) of the proposition), then the non-discriminating expert serves 97,5% of the consumers efficiently and the rest remains un-served, while the discriminating monopolist serves all consumers but only 82,5% of them efficiently. In this case welfare is higher under non-discrimination.*

Similar to the previous welfare result we observe that prohibiting price-discrimination is not necessarily welfare enhancing. While discrimination leads to tariffs that induce the expert to provide the low quality without taking the customer's actual condition into account, it may also lead to more consumers being served. This insight is again new in the credence goods literature. A standard solution to the credence good problem is the introduction of a liability rule which rules out underprovision (see Dulleck and Kerschbamer, 2006, for the theoretical argument and Dulleck et al., 2011, for experimental evidence regarding the power of liability as a solution for the credence goods problem). Introducing such a rule in the setting considered her would have the same effect as ruling out price-discrimination which might reduce welfare if fewer customers are served in equilibrium.

5 Two-Dimensional Price-Discrimination

In this section we discuss the framework where consumers differ in both, the expected cost of efficient service and the valuation of sufficient quality. Although this general setting does not allow for a complete characterization of the tariffs used under price-discrimination, we are able to show that the expert still finds it always optimal to serve some customers under an efficient-service tariff. Moreover, our analysis indicates that if price-discrimination is allowed, the expert may offer in equilibrium an elaborate menu of tariffs which may include contracts with over- and underprovision of quality and, possibly, contracts where she randomizes between different policies.

The main obstacle in analyzing the two-dimensional case is dealing with the self-selection constraints. For screening problems that are one-dimensional in both types and instruments, the difficulty is resolved for there is a particularly simple characterization of the set of implementable decision functions μ.[17] Specifically, in the presence of the single-crossing condition, μ is implementable if and only if it is monotonic. This is no longer true when consumers have multiple characteristics. In the multidimensional case, the difficulty can sometimes be circumvented by characterizing the set of all implementable indirect utilities – see Carlier (2001) for details. For example, if utility is linear in types, an indirect utility function is implementable if and only if it is convex. Unfortunately, such characterizations are known only for very specific classes of utility functions. The general solution of the problem is still out of reach – see Basov (2005) for a fairly detailed discussion and Figalli et al. (2011) for some recent theoretical advances in the area.

The problem is especially difficult if a consumer's utility is non-linear in types, as it is in our model.[18] Nevertheless, there are two results which we are able to show for the general case. First, we show that in the absence of price-discrimination the expert will post an efficient-service tariff, just as in the two one-dimensional cases. Second, we show that once price-discrimination

[17] A decision function μ is implementable if it satisfies the self-selection constraints under an appropriate set of tariffs.

[18] For the relaxed problem – where the incentive compatibility constraints are replaced by the corresponding envelope theorem conditions of the consumer's maximization problem – we can show that the generic solution is to offer (at most) three deterministic contracts: an efficient-service tariff, an underprovision tariff and an overprovision tariff. However, the solution to the relaxed problem does not have to be a solution of the complete problem.

is permitted and the menu of contracts offered by the expert is finite, there is always a positive mass of consumers that is induced to choose an efficient-service tariff. In deriving these two results, we assume that each consumer is characterized by a pair (s,t) and that a consumer of type (s,t) has valuation $v^s = v - s$ and needs high quality with probability t. Consumers' types are drawn independently from the same joint c.d.f. $H(s,t)$, with strictly positive density $h(\cdot)$ on $[0,\bar{s}] \times (0,1)$. $H(\cdot)$ is common knowledge, but a consumer's type is the consumer's private information. As in the one-dimensional cases we start with the non-discrimination result:

Proposition 6 *Suppose that consumers differ in both dimensions, in their probability of needing the high-quality good, t, and in their gross valuation for sufficient quality, v^s. Further suppose the monopolistic expert cannot price-discriminate among consumers. Then, in any PBE the expert offers an efficient-service tariff, where the consumer receives advice and appropriate service ($\mu_{12} = 1$). The prices in the contract are such that some consumers decide to remain un-served ($\Delta > v - \bar{s} - c - c_2$).*

The intuition for the statement that the contract offered without price-discrimination will always be an efficient-service tariff carries through the cases with one-dimensional as well as two-dimensional heterogeneity. A key difference to the one-dimensional case is that in the latter case some group of strictly positive mass always remains inefficiently un-served. Such an exclusion result is standard in the multidimensional screening literature – see Armstrong (1996), for instance. It does not bear much economic significance, however, but rather follows from the technical assumption that the distribution is non-atomic.[19] If we assume instead that the distribution is discrete, then no-exclusion becomes possible in the two-dimensional case as well, as the example below shows.

Proposition 7 *Suppose that consumers differ in both, in their probability of needing the high-quality good, t, and in their gross valuation for sufficient quality, v^s. Further suppose that the monopolistic expert can price-discriminate among consumers by offering a finite menu of tariffs. Then, in*

[19]Specifically, in the two-dimensional case the analog of the density in conditions (4) and (5) is a curvilinear integral of density along the boundary separating served and unserved consumers. Since in the limit case such a boundary consists of a single point $(\bar{s}, 1)$, the integral is zero, and the two-dimensional analog of conditions (4) and (5) is always satisfied.

any PBE, there is always a positive mass of types who are attracted by an efficient-service tariff.

While a full characterization of the equilibrium for the two-dimensional version of our model is out of reach, the discrete version of the expert's maximization problem can be readily solved numerically. This follows from the observation that the consumer's utility is linear in instrument variables μ. Below we use a simple discrete example to highlight the differences between the two one-dimensional cases on the one hand and the multidimensional setting on the other. In the two-dimensional setting, it may be optimal for the expert to offer more than two contracts, and sometimes it is optimal for her to offer a random contract.[20]

Example 3 *Suppose that each consumer is characterized by his two-dimensional type* (s,t) *and that consumers' types are independently drawn from an equal probability distribution on the discrete support* $\{(0.5,0.5), (2.2,0.2), (1.0,0.9), (2.2,0.5)\}$*. The parameter values are* $v=5$*,* $c=c_2=1$*,* $c_1=0$ *and* $x=0$*.*

Case (i). If the expert can post a single tariff only, then she serves all consumers under the efficient-service contract $\Delta^N=1.3$*. With this policy she earns the expected profit of 1.3 per consumer.*

Case (ii). If the expert can price-discriminate among consumers but her choice is confined to the class of deterministic tariffs, then she can increase her expected profit to approximately 1.435 per consumer by posting three tariffs, the efficient-service contract $\Delta^D_{12}=2.5$*,* $\mu_{12}=1$*, the overprovision tariff* $\Delta^D_2=2.0$*,* $\mu_2=1$*, and the underprovision tariff* $\Delta^D_1=1.24$*,* $\mu_1=1$*. In this case,* $(0.5,0.5)$*-consumers receive advice and appropriate quality,* $(1.0,0.9)$*-consumers are induced to buy high quality without advice under* Δ^D_2*,* $(2.2,0.2)$*-consumers are induced to buy low quality without advice under* Δ^D_1*, and* $(2.2,0.5)$*-consumers remain un-served.*

Case (iii). If the expert can price-discriminate without being confined to the class of deterministic tariffs, it is still optimal for her to exclude type $(2.2,0.5)$ *and to induce types* $(0.5,0.5)$ *and* $(1.0,0.9)$ *to choose the same contracts as in case (ii). However, type* $(2.2,0.2)$ *is now induced to take the random*

[20]The solutions are found using the program Mathematica.

contract $\tilde{\Delta}_1^D = 1.37$, $\mu_1 = 0.65$, $\mu_2 = 0$, *which increases the expected profit of the expert to about 1.47 per sonsumer.*[21]

Why is randomization optimal in the settting considered in Example 3? In case (ii), three constraints are binding in equilibrium: the participation constraints for types $(1.0, 0.9)$ and $(2.2, 0.2)$, and the incentive compatibility constraint where type $(1.0, 0.9)$ is "almost envied" by type $(0.5, 0.5)$. For the contract intended for type $(2.2, 0.2)$, an increase in μ_{12} accompanied by a decrease (of equal size) in μ_1 allows to increase the mark-up without violating the (binding) participation constraint for $(2.2, 0.2)$. This is locally profitable because the extra surplus extracted from type $(2.2, 0.2)$ directly increases the expert's profit. The expert can proceed this way (i.e., increasing μ_{12} at the cost of μ_1) to the point where the random contract becomes attractive for another type. Indeed, in case (iii) the random contract has the property that type $(2.2, 0.2)$ is "almost envied" by type $(0.5, 0.5)$; that is, in equilibrium the incentive compatibility constraint preventing $(0.5, 0.5)$ from taking the contract designed for $(2.2, 0.2)$ is binding. The example is robust in the sense that small changes in the parameters of the model result only in small changes in equilibrium tariffs.

Let us discuss the differences to the results for the two one-dimensional cases in more detail. Suppose first that consumer heterogeneity is in t only. Then one of the μ-instruments is redundant – this can be seen from the inequality $\frac{\partial^2 u}{\partial \mu_1 \partial t} \leq 0$. That is, if starting with a contract that features $\mu_1 > 0$ we increase μ_{12} at the cost of μ_1 then the utility of consumers served under the contract increases. However, the utility increase is higher for the less than for the more profitable types. It follows that if some type t – type $\hat{t}$, say – is served in equilibrium under some contract with strictly positive μ_1, the contract can be replaced by the expert by one with $\mu_1 = 0$. This would allow her to extract higher surplus from type $\hat{t}$, leaving this type indifferent between the old and the new contract. Moreover, the expert's profit will increase since only less profitable types, who opt for contracts that feature a lower mark-up than that intended for type $\hat{t}$ may have an incentive to switch to the new contract (with $\mu_1 = 0$). Thus, it follows that the expert finds it optimal to use only contracts featuring $\mu_1 = 0$ to maximize her profit. With only one instrument (represented by the probability μ_{12}, say) it is always optimal for her to use only two deterministic contracts: one with

[21] The numbers are rounded off.

$\mu_{12} = 1$ and $\mu_2 = 0$ to extract the highest possible surplus form the most profitable segment of consumers, and the other with $\mu_{12} = 0$ and $\mu_2 = 1$ to make separation as profitable as possible. A way to see this is to recall the well-known fact that in equilibrium all local upward incentive compatibility constraints are binding together with the participation constraint of the least profitable served type. In total, there are as many binding constraints as served types in equilibrium. These binding constraints allow us to exclude all Δ variables from the expert's maximization program and to reformulate it as the problem of maximizing the linear function $\sum_t \alpha(t)\mu_{12}(t)$, where the α coefficients depend on the parameters of the model but not on Δ and μ. The remaining constraints are the requirements that the function $\mu_{12}(.)$ is non-increasing and takes its values between 0 and 1. The generic solution of this maximization problem is a vertex of the cube $[0,1]^n$, where n is the number of types. Such a solution corresponds to a menu of deterministic contracts. The fact that the contracts are deterministic together with the uniqueness of the instrument imply that there will be only two contracts offered by the expert – an efficient-service tariff (featuring $\mu_{12} = 1$) and an overtreatment contract (with $\mu_2 = 1$). The same logic holds for the case where consumers differ only in s due to inequality $\frac{\partial^2 u}{\partial \mu_2 \partial s} \leq 0$. Here the expert never uses a contract with strictly positive probability μ_2 but rather posts two deterministic tariffs – an efficient-service tariff and an underprovision tariff.

The situation changes dramatically if consumers differ in both dimensions. Then the two inequalities $\frac{\partial^2 u}{\partial \mu_i \partial t} \leq 0$ and $\frac{\partial^2 u}{\partial \mu_i \partial s} \leq 0$ never hold together for any $i \in \{1,2\}$. That is, neither of the instruments is redundant in this case. This is also intuitively clear from the fact that both one-dimensional situations are the limit cases of the general case. Also, it is no longer true that the number of binding constraints is equal to the number of participating types. In the example above, there are two binding incentive compatibility constraints for the most profitable type $(0.5, 0.5)$ and two binding participation constraints for the other two served types $(1.0, 0.9)$ and $(2.2, 0.2)$. It follows, that the solution of the maximization problem is not necessarily a vertex of the cube but may correspond to a menu that includes at least one random contract. Thus, the occurrence of a random contract in the two-dimensional model is a consequence of the more sophisticated structure of the system of binding self-selection constraints and not a non-generic consequence of the parameter constellation used in constructing the example.

It is also worth noting that separation is not always optimal in the two-dimensional discrete case. If we change the distribution in Example 3 making type $(2.2, 0.5)$ more frequent, no exclusion and no discrimination become optimal. With regard to welfare, we can only say that given that there is no exclusion in the no-discrimination case – as in Example 3 – price-discrimination necessarily reduces welfare. Examples of welfare-increasing price-discrimination can also be constructed. In fact, as the variance in t or s becomes small, the situation becomes similar to one of the two one-dimensional cases, so the ambiguous effects of various parameters on welfare are also present in the two-dimensional case.

6 Discussion

In this section we revisit some of the modeling assumptions and discuss alternatives.

Positive Diagnosis Cost – Diagnosis Effort Verifiable

The model assumes that the expert can identify the appropriate quality without incurring any cost. The justification for assuming zero diagnosis cost is that, if the expert finds it profitable to refrain from giving advice to some consumers when diagnosis costs are zero, then, *a forteriori,* she will do so with positive diagnosis costs. So, in studying price-discrimination, there is no loss of generality in this assumption. Here we verify that this intuition is correct. With positive diagnosis costs it is clear that the expert might wish to offer under- or overprovision tariffs if there are enough consumers who should efficiently be served under such contracts. To exclude such trivial cases we concentrate on parameter-constellations for which performing a diagnosis and consuming the diagnosed quality of the good is the efficient policy. This is the case if and only if the diagnosis cost d satisfies $d \leq \min\{(1-t)(c_2-c_1), t[(1-x)(v-s)-c_2+c_1]\}$. For the setting where consumers differ only in their probability of needing the high-quality good, but receive the same gross valuation if the good does deliver this condition is equivalent to $t \in [t_1(d), t_2(d)]$, where $t_1(d) = d/[(1-x)v-c_2+c_1]$ and $t_2(d) = [c_2-c_1-d]/(c_2-c_1)$.[22] Intuitively, performing diagnosis and providing

[22] Here we assume that $d < (c_2-c_1)[v(1-x)-c_2+c_1)/v(1-x)$ so that $t_1(d) < t_2(d)$.

the diagnosed quality is the efficient solution if the cost of diagnosis is sufficiently low and if the likelihood of needing the high-quality good is neither too close to zero nor too close to one. Concentrating on t values satisfying those conditions the appendix contains a formal proposition (Proposition 8) showing that our main results continue to hold for costly and verifiable diagnosis effort. In this case a (fair) diagnosis price (of $p = d$) can be imposed on the customer for performing it.[23] The case where diagnosis is not contractible is discussed below.

Unobservable Diagnosis Effort

As argued in the previous paragraph, assuming a positive diagnosis cost does not affect our results if diagnosis effort is observable. For the IT example in the introduction positive and verifiable diagnosis effort seems to be a plausible assumption. Employees of specialized retailers do have to investigate what the right system for each consumer is. Since this information is customer-specific, it seems natural to think that the expert has to acquire that information at a cost. And since the diagnosis is performed in the presence of the consumer, it seems plausible to assume that he can assess whether the agent of the specialized retailer invests time and effort to find out what he needs or not, and whether the agent is competent or not. In other industries it may be more difficult to assess whether diagnosis effort has been invested or not.

What happens if diagnosis effort is not observable? If effort to make a costly diagnosis is not contractible, the need to provide balanced incentives for efficient service (i.e. equal-mark-ups for different qualities) does not provide any incentives for the expert to invest effort in performing a diagnosis. One could argue, that in reality an expert would feel guilty if she provides an inappropriate quality to a consumer under a ($\mu_{12} = 1$)-tariff (where she implicitly promises to provide advice and appropriate quality), but not if she provides an inappropriate quality under a ($\mu_1 = 1$)-, or a ($\mu_2 = 1$)-tariff (where there is no such implicit promise). Introducing such a guilt disutility could solve the expert's moral hazard problem (providing diagnosis when

If this assumption is violated performing a diagnosis is inefficient for any t.

[23] In equilibrium the price of diagnosis is indeterminate, implying that this assumption is without loss of generality: If the consumer is served under a Δ_{12} tariff then he pays $p_2 = c_2 + \Delta_{12} + p$ for the high-quality and $p_1 = c_1 + \Delta_{12} + p$ for the low-quality good, thus, setting $p = d$ is among the feasible solutions.

diagnosis effort is not contractible), however, it would also affect other details of the analysis.[24] If the guilt cost is sufficiently high, then the expert can commit to a ($\mu_{12} = 1$)-policy even under price vectors that differ significantly from equal-mark-up tariffs. In the limit she can even charge a constant price for both qualities and still recommend and provide the appropriate quality. If this is the case and if consumers differ in t only, then the expert can extract all the surplus (even without price-discrimination) simply by charging $p_1 = p_2 = v - c$. In the model where consumers differ in s but have the same t no such simple solution exists. As in Subsection 4.2, profitable price-discrimination would be performed via a menu containing an efficien-service tariff and an underprovision tariff, the only difference being, that there is now more flexibility in the price-list of the efficient-service tariff. However, that flexibility would have no effect at all on our main results. For the two-dimensional case an implication of our arguments is that with a high guilt cost (or a largeimpact of reputation effects) only two types of contracts are observed in equilibrium, an efficient-service tariff with a higher constant price and an underprovision tariff with a lower constant price.

Verifiability of Success

Our model assumes that failure is observable but not verifiable. This means that payments cannot be conditioned on success. An alternative would be to assume that failure is verifiable such that payments and post-sale services can be conditioned on success. Under this assumption experts can credibly commit to perform diagnosis and to recommend the appropriate quality even if diagnosis effort is both costly and unobservable and even if there is neither a guilt cost nor a reputation to be lost. This can be done by an appropriate design of mark ups and warranty payments.[25] To see this denote – as before – the diagnosis cost by d and the cost of post-sale services and transfers by w (for warranty). To make sure that the expert invests effort in diagnosis and recommends the appropriate quality, p_1, p_2 and w need to satisfy $w \geq c_2 - c_1 - (p_2 - p_1) + d/t$ and $p_2 - p_1 \leq c_2 - c_1 - d/(1 - t)$ for all $t \in [t_1(d), t_2(d)]$. The first of these conditions ensures that not performing

[24]Beck et al. (2013) formally investigate the impact of psychological guilt aversion on expert behavior in a credence goods market. An alternative to introducing a guilt disutility is to postulate reputation effects. The effect on the main results are similar to those discussed in the main text.

[25]Dulleck and Kerschbamer (2009) show this for a competitive environment.

diagnosis and blindly recommending c_1 is dominated by performing diagnosis and recommending the appropriate quality, while the second ensures that not performing diagnosis and blindly recommending c_2 is dominated. For parameter constellations for which performing diagnosis is the efficient policy, the RHS of the second condition is strictly positive implying that charging a constant price for both qualities is among the feasible solutions. Thus, the effect of introducing both, costly and unverifiable diagnosis effort and verifiability of success is similar to that of introducing both costly and unverifiable diagnosis effort and a sufficiently high guilt cost. In both cases price-discrimination in the t dimension disappears while price-discrimination in the s dimension remains profitable.

Unobservable Quality Cost

Our model also assumes that the costs to the expert of providing c_1 and c_2 are perfectly known to consumers. This assumption is important as it allows the use of equal-mark-up prices to convince the customer that the expert has no material incentive to recommend the wrong quality. Referring back to the example form the introduction, for today's IT industry, the assumption seems to be vaguely plausible as prices for the components, hardware and software are publicly available. In the earlier days, as well as for other industries, this definitely is a strong assumption. The effect of relaxing it is that the consumer can no longer perfectly infer the expert's incentives from posted prices. This leads to similar complications as introducing unobservable diagnosis effort. Again, a possible remedy is to introduce a disutility to the expert from an inefficient match, to impute reputation effects, or to assume verifiability of success. In the latter case, the expert can choose warranty payments and mark-ups in such a way that performing a costly diagnosis and recommending the appropriate quality is the most profitable strategy even for the most extreme cost realizations. That is, if from consumers' perspective c_1 is distributed according to some distribution function with strictly positive density on $[\underline{c}_1, \bar{c}_1]$, while c_2 is distributed on $[\underline{c}_2, \bar{c}_2]$, then a tariff structure satisfying $w \geq \bar{c}_2 - \underline{c}_1 - (p_2 - p_1) + d/t$ and $p_2 - p_1 \leq \underline{c}_2 - \bar{c}_1 - d/(1-t)$ for all $t \in [t_1(d), t_2(d)]$ is needed to provide appropriate incentives. Under the assumption that performing a diagnosis is the efficient policy for all cost realizations, setting $p_1 = p_2$ and $w \geq \bar{c}_2 - \underline{c}_1 + d/t_1(d)$ will do the task.

Consumers' Sunk Cost

The basic model of Section 2 assumes that each consumer incurs a sunk cost $c \geq (1-t)(c_2 - c_1)$ if he visits the expert independently of whether he is actually served or not.[26] This assumption has the effect that a consumer's option to reject a recommended quality doesn't impose a binding constraint on the expert's maximization problem. To see this, consider the model of Subsection 4.1 and suppose that the *ex post* participation constraint is not binding. Then, the maximal profit the expert can realize from serving a type t consumer with an efficient-service tariff is $v - c - c_1 - t(c_2 - c_1)$ (otherwise the consumer would refrain from visiting the expert) while equal mark-up prices require $p_2 - c_2 = p_1 - c_1$. Thus, $p_2 = c_2 + v - c - c_1 - t(c_2 - c_1) = v - c + (1-t)(c_2 - c_1)$. Now, it follows from $c \geq (1-t)(c_2 - c_1)$ that $p_2 < v$, so that the *ex post* participation constraint is indeed not binding. If we allowed for $c < (1-t)(c_2 - c_1)$ then there could be parameter constellations for which the restriction $p_2 \leq v$ becomes binding. In this case, the largest surplus that could be extracted with an efficient-service tariff would be $(1-t)[v - (c_2 - c_1)] + tv$ leading to a profit of $(1-t)[v - (c_2 - c_1) - c_1] + t(v - c_2) = v - c_2$. This profit is larger than the profit attainable with an overprovision tariff (which is $v - c - c_2$) whenever $c > 0$. Thus, allowing for $c < (1-t)(c_2 - c_1)$ (or $c < c_2 - c_1$, respectively) would complicate the analysis without providing different results (provided $c > 0$).

An Alternative Interpretation of the Model

In the model a monopolistic expert price-discriminates among consumers via a menu of tariffs. Here, we re-interpret this scenario and the results we obtained in terms of a manufacturer with market power who uses different distribution channels as an instrument of price-discrimination. A simple re-interpretation of the results of the first model we considered – where the expert posts an efficient-service tariff to skim-off low-cost consumers and an overprovision tariff to serve the rest – is that the monopolistic manufacturer sets up two types of stores, specialist outlets through which she distributes the entire quality spectrum and where the qualifications and incentives of the sales personnel are such that they diagnose customers' needs and suggest the appropriate equipment; and discount outlets through which she distributes

[26] In Subsection 4.1 and Section 5, where t is assumed to be distributed on $[0,1]$, the relevant condition is $c \geq c_2 - c_1$.

only the high-quality good. This story is not very realistic, however. A more elaborate model would have a monopolistic manufacturer that distributes her products through a competitive retail stage. The simplest version of such a model would have two types of retailers, expert shops with highly qualified sales personnel and discounters. Suppose that there are at least two retailers of each of these two types in the market. Further suppose that the manufacturer's products are only a small part of a much larger number of products handled by a typical retailer so that the manufacturer can treat the characteristics of the retail stage as given.[27] Then the manufacturer can mimic the single-expert behavior by the choice of different distribution channels. To see this, suppose that the manufacturer wants to skim-off low-cost consumers via an efficient-service tariff featuring $p_1 = c_1 + \Delta_{12}$ and $p_2 = c_2 + \Delta_{12}$ and serve the rest of the market with an overprovision tariff with $p_1 < c_1 + \Delta_2$ and $p_2 = c_2 + \Delta_{02}$. How can she do this? She offers the two qualities at wholesale prices $w_1^e = c_1 + \Delta_{12}$ and $w_2^e = c_2 + \Delta_{12}$ to at least two expert shops and she offers only the high-quality good at the wholesale price $w_2^d = c_2 + \Delta_2$ to at least two discounters. With at least two discounters carrying the high-quality good, market equilibrium yields $p_2^d = w_2^d$ by the usual price-undercutting argument. And expert retailers? Would an expert post prices violating the equal-mark-up rule, consumers would become suspicious; they would correctly infer that the expert will either always recommend the high-quality good (if $p_1^e - w_1^e < p_2^e - w_2^e$), or always recommend the low-quality good (if $p_1^e - w_1^e > p_2^e - w_2^e$), and they would adjust their willingness to pay accordingly. So, experts cannot gain from posting prices violating the equal-mark-up rule. In equilibrium, at least two experts will post efficient-service tariffs. With tariffs that induce efficient service, Bertrand competition again yields prices such that underbidding yields losses and charging more implies a loss of customers; that is, $p_1^e - w_1^e = p_2^e - w_2^e = 0$.

Note that here again the sunk cost c plays an important role in making the story consistent: For small enough c ($c < p_2^e - p_2^d$) experts would become vulnerable to competition with discounters. Why? Because discounters would then be able to attract consumers who have learned from an expert that they need a high-quality good. To avoid this, the manufacturer would have to reduce w_2^e accordingly. The rest of the story is the same as in the basic model: The profitability of price-discrimination would be reduced but price-discrimination would remain profitable as long as $c > 0$.

[27]Marvel and McCafferty (1984) make a similar assumption in a different context.

7 Concluding Remarks

Research on credence goods markets typically assumes that consumers are homogeneous. The present article has studied the consequences of allowing for heterogeneous consumers in a model where an expert (or a manufacturer) has some degree of market power. With heterogeneous consumers and market power, price-discrimination may emerge in equilibrium. We have shown, that in the case of experts markets, price-discrimination regards the amount of advice offered. The whole spectrum of qualities and advice on which quality fits the customer's needs best is sold to the most profitable market segment only. Less profitable consumers are induced to demand a given quality without receiving any advice. If consumers differ in the expected cost of efficient service, then low-cost consumers receive advice and efficient service, while high-cost consumers are potentially *overprovided*; that is, they are induced to demand high-quality equipment without receiving advice. By contrast, under heterogeneity in the valuation of sufficient quality high-valuation consumers receive advice and efficient service, while low-valuation ones are potentially *underprovided*; that is, they are induced to demand low-quality equipment independently of their actual needs.

While the equilibrium behavior outlined in the present paper is obviously an abstraction and it is probably impossible to point out an industry that features exactly this kind of price-discrimination, our results identify an element that may be present in the conduct of many credence goods markets. We discussed the evolution of the IT industry as an example in the introduction. Other credence goods markets with similar characteristics – large heterogeneity in consumers' valuation for a successful match in the beginning; large heterogeneity in the product quality with product maturation – featured a similar evolution. Examples are fitness equipment, as for instance, treadmills. At the beginning advanced machines where only available through specialized stores that also offered advice in choosing the right equipment, whereas simpler equipment was sold at warehouse outlets. Nowadays, advanced equipment is available from discounters. Similarly, better makes of digital cameras were first sold by expert stores only, whereas now also discount outlets offer advanced digital photo equipment. Digital hearing aids, stereo equipment, functional sports ware and even eyeglasses experienced a similar history.

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Appendix

Proof of Proposition 1. Suppose that customers differ only in their probability t. Under the conditions of Proposition 1,

$$(\Delta(t), \mu_1(t), \mu_2(t), \mu_{12}(t)) = (\Delta, \mu_1, \mu_2, \mu_{12})$$

for all t. We now show in the first step that $\mu_1 = \mu_2 = 0$ implying that the expert indeed posts an efficient-service tariff. To see that $\mu_1 = 0$, suppose to the contrary that $\mu_1 > 0$. Then the expert's profit is strictly increased by replacing the original tariff $(\Delta, \mu_1, \mu_2, \mu_{12})$ by the tariff $(\hat{\Delta}, \hat{\mu}_1, \hat{\mu}_2, \hat{\mu}_{12})$, where $\hat{\Delta} = \Delta + \hat{t}\mu_1[v(1-x) - c_2 + c_1]$, $\hat{\mu}_1 = 0$, $\hat{\mu}_2 = \mu_2$, $\hat{\mu}_{12} = \mu_1 + \mu_{12}$, and where $\hat{t}$ is the highest type that is served in equilibrium (if all types are served then $\hat{t} = 1$). By construction type $\hat{t}$ is indifferent between the old and the new tariff, therefore he will still buy in equilibrium. Types $t < \hat{t}$ are worse off under the new contract. However, since consumers' utility under the new contract – which is given by $u(t, \hat{\Delta}, \hat{\mu}) = v - c - c_2 - \hat{\Delta} + (1-t)\hat{\mu}_{12}(c_2 - c_1)$ – is decreasing in t and since $\hat{t}$ is willing to buy, those types are willing to buy too. Thus, since $\hat{\Delta} > \Delta$ and since at least the same mass of types is served as before, the replacement has increased the expert's profit, contradicting the optimality of the original contract. The argument for $\mu_2 = 0$ is similar. Thus, $\mu_{12} = 1$ and type t's expected utility under the contract is $u(t, \Delta, \mu) = v - c - c_1 - t(c_2 - c_1) - \Delta$. The expert maximizes $[v - c - c_1 - \hat{t}(c_2 - c_1)]F(\hat{t})$, where the maximum is taken in $\hat{t}$. As is easily verified, this problem yields an interior solution under the condition stated in the proposition and a corner solution otherwise.

The arguments for the case when consumers differ only in the gross valuation are similar with the replacement of condition (4) for (5). As before, it can be shown that the non-discriminating tariff $(\Delta, \mu_1, \mu_2, \mu_{12})$ has $\mu_1 = \mu_2 = 0$ implying that type s's utility under the tariff is $u(s, \Delta, \mu) = v - s - c - c_1 - t(c_2 - c_1) - \Delta$. The expert maximizes $[v - \hat{s} - c - c_1 - t(c_2 - c_1)]G(\hat{s})$, where the maximum is taken in $\hat{s}$, implying the result.

Proof of Proposition 2. Given the selected tariff (Δ, μ) type t's expected utility can be written down as

$$u(t, \Delta, \mu) = v - c - c_2 - \Delta + (1-t)[\mu_{12} + \mu_1](c_2 - c_1) - t\mu_1[v(1-x) - c_2 + c_1].$$

Denote by M the menu of tariffs offered by the expert, then type t's expected utility in equilibrium (type t's surplus) is

$$U(t) = \max_{(\Delta,\mu)\in M} u(t,\Delta,\mu).$$

Let $(\Delta(t), \mu(t)) \in M$ be the contract chosen by type t. We follow the standard procedure introduced by Mirrlees (1971). The expert maximizes $\int_0^{\hat{t}} \Delta(t)dF(t)$, which is equivalent to maximizing

$$\int_0^{\hat{t}} \left(v - c - c_2 + (1-t)[\mu_{12}(t) + \mu_1(t)](c_2 - c_1) - t\mu_1(t)[v(1-x) - c_2 + c_1]\right) dF(t) - \int_0^{\hat{t}} U(t)dF(t)$$

in $\hat{t}$, $\mu_{12}(t)$, and $\mu_1(t)$. The second integral can be transformed using the equality $\int U(t)dF(t) = U(t)F(t) - \int F(t)dU(t)$. By the envelop theorem, $U'(t) = \partial u(t,\Delta,\mu)/\partial t$, so

$$dU = -\big(\mu_{12}(t)(c_2 - c_1) + \mu_1(t)v(1-x)\big)dt.$$

Furthermore,

$$\int_0^{\hat{t}} U(t)dF(t) = U(\hat{t})F(\hat{t}) - U(0)F(0) - \int_0^{\hat{t}} F(t)dU(t) = U(\hat{t})F(\hat{t}) + \int_0^{\hat{t}} \big(\mu_{12}(t)(c_2 - c_1) + \mu_1(t)(v(1-x))\big)F(t)dt.$$

Thus, taking into account $U(\hat{t}) = 0$,

$$\int_0^{\hat{t}} \Delta(t)dF(t) = \int_0^{\hat{t}} \Big(\mu_{12}(t)\Phi_{12}(t) + \mu_1(t)\Phi_1(t)\Big)dt + (v - c - c_2)\hat{t},$$

where $\Phi_{12}(t) = (c_2-c_1)((1-t)f(t)-F(t))$, $\Phi_1(t) = (c_2-c_1-tv(1-x))f(t) - v(1-x)F(t)$. Since $\Phi_{12}(t) > \Phi_1(t)$, it is never optimal for the expert to have $\mu_1(t) > 0$. Therefore, $\mu_1(t) = 0$ for all t. Since $F(t)$ is log-concave and $f(t) > 0$ for all t it follows that $(1-t)f(t) - F(t)$ takes both positive and negative values and $((1-t)f(t) - F(t))/F(t)$ is strictly decreasing in t. Therefore, there is a unique t_{12} such that $(1-t)f(t) - F(t)$ is positive for $t < t_{12}$ and negative for $t > t_{12}$. This implies that the expert optimally offers two tariffs: a tariff with an honest recommendation ($\mu_{12}(t) = 1$) and a tariff under which the consumer is overprovided with probability one ($\mu_{12}(t) = 0$). All consumers of type $t < t_{12}$ select the former tariff while all consumers of type $t > t_{12}$ are systematically overprovided. Moreover, the expert's profit is increasing in $\hat{t}$, therefore it is optimal to have $\hat{t} = 1$. Integrating the expression for dU one obtains

$$U(t) = \begin{cases} (c_2 - c_1)(t_{12} - t), & t \leq t_{12}, \\ 0, & t > t_{12}. \end{cases}$$

The corresponding equilibrium mark-ups are equal then to

$$\Delta(t) = \begin{cases} v - c - c_1 - t_{12}(c_2 - c_1), & t \leq t_{12}, \\ v - c - c_2, & t > t_{12}. \end{cases}$$

One can easily see that the solution satisfies the incentive compatibility constraints.

Proof of Proposition 3. Statement *(i)* of the proposition follows from the discussion above. To prove the rest, notice that t^N satisfies the first order condition of the expert's maximization problem $(\frac{v-c-c_1}{c_2-c_1} - t^N)\frac{f(t^N)}{F(t^N)} = 1$, while the highest type efficiently served under discrimination t^D without loss of generality satisfies $(1-t^D)\frac{f(t^D)}{F(t^D)} = 1$. Since $\frac{v-c-c_1}{c_2-c_1} > 1$ and f/F is decreasing, it should be $t^N > t^D$. Moreover, t^N increases in v and in c_1, and decreases in c and in c_2, while t^N depends only on $F(.)$ and not on v, c, c_1 and c_2. Thus, $1 - F(t^N)$ increases in c and in c_2 and decreases in v and in c_1, while $F(t^N) - F(t^D)$ decreases in c and in c_2 and increases in v and in c_1.

Proof of Proposition 4. Given the selected tariff (Δ, μ) type s's expected utility can be written down as

$$u(s, \Delta, \mu) = v - s - c - c_1 - \Delta - [1 - \mu_{12} - \mu_2]t(1-x)(v-s) - [t\mu_{12} + \mu_2](c_2 - c_1).$$

Let M be the menu of tariffs offered by the expert and $(\Delta(s), \mu(s)) \in M$ be the contract chosen by type s in equilibrium. Then the consumer s's surplus is

$$U(s) = u(s, \Delta(s), \mu(s)) = \max_{(\Delta,\mu)\in M} u(s, \Delta, \mu).$$

The expert maximizes $\int_0^S \Delta(s)dG(s)$, where the maximum is taken in $S, \Delta(s)$, $\mu_{12}(s)$, and $\mu_2(s)$. This is equivalent to maximizing

$$\int_0^S \{[1-t(1-x)(1-\mu_{12}(s)-\mu_2(s))](v-s)-c-c_1-[t\mu_{12}(s)+\mu_2(s)](c_2-c_1)\}dG(s)-\int_0^S U(s)dG(s).$$

As before, the second integral can be transformed using the equality $\int U(s)dG(s) = U(s)G(s) - \int G(s)dU(s)$. From the envelop condition, $dU = -[1-t(1-x)(1-\mu_{12}(s)-\mu_2(s))]ds$. Furthermore,

$$\int_0^S U(s)dG(s) = U(S)G(S) - U(0)G(0) - \int_0^S G(s)dU(s) = U(S)G(S) + (1-t+tx)\int_0^S G(s)ds + \int_0^S t(1-x)(\mu_{12}(s)+\mu_2(s))G(s)ds.$$

And, taking into account $U(S)=0$,

$$\int_0^S \Delta(s)dG(s) = \int_0^S [(1-t+tx)(v-s)-c-c_1]dG(s) - (1-t+tx)\int_0^S G(s)ds + \int_0^S \Big(\mu_{12}(s)\Psi_{12}(s)+\mu_2(s)\Psi_2(s)\Big)ds,$$

where $\Psi_{12}(s) = [t(1-x)(v-s)-t(c_2-c_1)]g(s)-t(1-x)G(s)$ and $\Psi_2(s) = [t(1-x)(v-s)-(c_2-c_1)]g(s)-t(1-x)G(s)$. Since $\Psi_{12}(s) > \Psi_1(s)$ for $t>0$, it should be $\mu_2(s)=0$ for the optimal μ. Note that the function $\Psi_{12}(s)/g(s)$ is strictly decreasing and strictly positive at zero. This means that there exists s_{12} such that $\Psi_{12}(s)$ is positive for $s < s_{12}$ and negative (or not defined) for $s > s_{12}$. Thus, for any S the optimal $\mu_{12}(s)$ is equal to 1 up to s_{12} and zero afterwards. (The case $\mu_{12}(s)=1$ for all s is also possible). Such s_{12} does not depend on the optimal S. The equilibrium utility of consumer s is given then by

$$U(s) = \begin{cases} S-s-t(1-x)(S-s_{12}), & s \le s_{12}, \\ S-s-t(1-x)(S-s), & s_{12} < s \le S, \end{cases}$$

and the corresponding mark-ups are

$$\Delta(s) = \begin{cases} v-S-c-c_1-t(c_2-c_1)+t(1-x)(S-s_{12}), & s \le s_{12}, \\ v-S-c-c_1-t(1-x)(v-S), & s_{12} < s \le S. \end{cases}$$

Again, the incentive compatibility constraints are easily verified.

Proof of Proposition 5. The non-discriminating monopolist maximizes $\pi(s) = [v-c-c_1-t(c_2+c_1)-s]\ G(s)$ s.t. $s \in [0,\bar{s}]$, where the maximum is taken in s. The solution to this problem, s^N, satisfies either $v-c-c_1-$

$t(c_2 - c_1) = s^N + G(s^N)/g(s^N)$ (if $[v - \bar{s} - c - c_1 - t(c_2 - c_1)]g(\bar{s}) \leq 1$), or $s^N = \bar{s}$ (otherwise). If price-discrimination is profitable under the conditions of Proposition 4, then the expert's maximization problem

$$\max_{s_{12}, s_1 \in [0, \bar{s}]} t[(1-x)(v-s_{12}) - c_2 + c_1]G(s_{12}) + [(1-t+tx)(v-s_1) - c - c_1]G(s_1)$$

yields a solution (s^D_{12}, s^D_1) that satisfies (a) $s^D_{12} < s^D_1 \leq \bar{s}$; (b) $v - (c_2 - c_1)/(1-x) = s^D_{12} + G(s^D_{12})/g(s^D_{12})$; and (c) either $v - (c + c_1)/[1 - t(1-x)] = s^D_1 + G(s^D_1)/g(s^D_1)]$ (if $v - \bar{s} - (c + c_1)/[1 - t(1-x)] \leq 1/g(\bar{s})$), or $s^D_1 = \bar{s}$ (otherwise). Conditions (a), (b) and (c) together imply

$$x \geq \frac{c + c_1 - (1-t)(c_2 - c_1)}{c + c_1 + t(c_2 - c_1)}$$

as a necessary condition for price-discrimination to be profitable. Combining this with the conditions that define s^N (taking into account that $s + G(s)/g(s)$ is a strictly increasing function) yields $s^D_{12} < s^N \leq s^D_1$, where the last inequality is strict for $s^N < \bar{s}$. This proves statement *(i)* and the first sentence of statement *(ii)*. The second sentence of statement *(ii)* is proven by means of an example in the end of Subsection 4.2. Furthermore, observe that the above optimality conditions imply that s^N is increasing in v, decreasing in c, c_1, c_2 and t, and constant in x; that s^D_{12} is increasing in v and c_1, decreasing in c_2 and x, and constant in c and t; and that s^D_1 is increasing in v and x, decreasing in c, c_1 and t, and constant in c_2. Here we can only conclude that the influence of these parameters on welfare is ambiguous.

Proof of Proposition 6. First, let us show that $\mu_1 = \mu_2 = 0$. Given the non-discriminating tariff $(\Delta, \mu_1, \mu_2, \mu_{12})$ type (s, t)'s expected utility is $u(s, t, \Delta, \mu) = v - s - c - c_1 - t(c_2 - c_1) - \Delta - \mu_1 t[(v - s)(1 - x) + c_1 - c_2]$ $-\mu_2(1-t)(c_2 - c_1) = [1 - t\mu_1(1-x)](v - s) - c - c_1 - \Delta - [\mu_2 + t(1 - \mu_1 - \mu_2)](c_2 - c_1)$. We can derive the set of consumers who are indifferent between being served and not being served by solving the equation $u(s, t, \Delta, \mu) = 0$ in s. For any $t \in [0, 1]$ the indifferent consumer is of type

$$\tilde{s}(t) = v - \frac{c + c_1 + \Delta + (\mu_2 + t(1 - \mu_1 - \mu_2))(c_2 - c_1)}{1 - t\mu_1(1-x)}.$$

Observe that $\tilde{s}(t)$ is a non-increasing function, and that it is strictly decreasing for $\mu_2 \neq 1$ (since $\mu_2 = 1$ implies $\mu_1 = 0$). Now, suppose that $\mu_2 > 0$. Then the expert's profit can be strictly increased by replacing the original tariff $(\Delta, \mu_1, \mu_2, \mu_{12})$ by the tariff $(\hat{\Delta}, \hat{\mu}_1, \hat{\mu}_2, \hat{\mu}_{12})$ with $\hat{\Delta} = \Delta + \mu_2(1-\hat{t})(c_2 - c_1)$, $\hat{\mu}_1 = \mu_1$, $\hat{\mu}_2 = 0$, $\hat{\mu}_{12} = \mu_2 + \mu_{12}$, where $\hat{t} = 1$ if $\tilde{s}(1) > 0$ and $\hat{t}$ is defined by condition $\tilde{s}(\hat{t}) = 0$ otherwise.[28] By construction, type $(\tilde{s}(\hat{t}), \hat{t})$ is indifferent between the old and the new tariff, therefore he still will buy in equilibrium. Also, by construction, $\hat{\Delta} \geq \Delta$, so the new tariff yields greater profit per consumer than the old one. Finally, the function $\tilde{s}(t)$ for the new tariff $(\hat{\Delta}, \hat{\mu}_1, \hat{\mu}_2, \hat{\mu}_{12})$ is steeper (and therefore above that for the old tariff for each $t < \hat{t}$) implying that more consumers are served. Thus, the profit under the new tariff is higher than that under the old one, contradicting the optimality of the latter. Consequently, $\mu_2 = 0$ and $\mu_1 + \mu_{12} = 1$. Next, suppose that $\mu_1 > 0$. Then the expert's profit can be strictly increased by replacing the original tariff $(\Delta, \mu_1, \mu_2, \mu_{12})$ by the tariff $(\hat{\Delta}, \hat{\mu}_1, \hat{\mu}_2, \hat{\mu}_{12})$ with $\hat{\Delta} = \Delta + \hat{t}\mu_1[(v - \tilde{s}(\hat{t}))(1-x) - c_2 + c_1]$, $\hat{\mu}_1 = 0$, $\hat{\mu}_2 = \mu_2$, $\hat{\mu}_{12} = \mu_1 + \mu_{12}$, where $\hat{t} = 0$ if $\tilde{s}(0) < \bar{s}$ and $\hat{t}$ is defined by condition $\tilde{s}(\hat{t}) = \bar{s}$ otherwise. By construction, type $(\tilde{s}(\hat{t}), \hat{t})$ is indifferent between the old and the new tariff and he will therefore still be willing to buy in equilibrium. Again, by construction $\hat{\Delta} \geq \Delta$, so that the new tariff yields greater profit per consumer than the old one. The function $\tilde{s}(t)$ for the new tariff $(\hat{\Delta}, \hat{\mu}_1, \hat{\mu}_2, \hat{\mu}_{12})$ is flatter and therefore above that for the old tariff for each $t > \hat{t}$ implying that more consumers are served. Thus, the profit under the new tariff is higher than that under the old one, contradicting the optimality of the latter. Consequently, $\mu_1 = 0$, which together with $\mu_2 = 0$, yields $\mu_{12} = 1$. Under the non-discriminating tariff $(\Delta, \mu_1 = 0, \mu_2 = 0, \mu_{12} = 1)$ type (s,t)'s expected utility is $u(s,t,\Delta,\mu) = v - s - c - c_1 - t(c_2 - c_1) - \Delta$, $\tilde{s}(t)$ is given by $v - c - c_1 - t(c_2 - c_1) - \Delta$ and the aggregate demand is given by $\int_0^1 \int_0^{\tilde{s}(t)} h(s,t)ds : dt$. The non-discriminating monopolist maximizes the product of Δ and the aggregate demand. This maximization problem is equivalent to the following one

$$\max_{\widetilde{t}} \Pi(\widetilde{t}) = \left(v - \overline{s} - c - c_1 - \widetilde{t}(c_2 - c_1)\right)\left(\int_0^1 \int_0^{\overline{s}-(t-\widetilde{t})(c_2-c_1)} h(s,t)ds : dt\right),$$

where $\widetilde{t}$ is the solution of $\tilde{s}(t) = \overline{s}$.[29] Taking the derivative of this function

[28]For obvious reasons $\tilde{s}(1) > \bar{s}$ is incompatible with profit maximization.

[29]That is, $\widetilde{t} = (v - \overline{s} - c - c_1 - \Delta)/(c_2 - c_1)$.

with respect to $\widetilde{t}$ yields

$$\Pi'(\widetilde{t}) = -(c_2 - c_1)\Big(\int_0^1 \int_0^{\overline{s}-(t-\widetilde{t})(c_2-c_1)} h(s,t)ds : dt\Big) + \Big(v - \overline{s} - c - c_1 - \widetilde{t}(c_2 - c_1)\Big)\int_0^1 (c_2 - c_1)h(\overline{s} - (t - \widetilde{t})(c_2 - c_1), t)dt.$$

If $\widetilde{t} = 1$, then the first component of this sum is strictly negative and the second component is zero. This proves that it is always optimal for the expert to leave some customers un-served. The optimal non-discriminating tariff has then prices such that $\Delta > v - \overline{s} - c - c_2$.

Proof Proposition 7. Suppose there is no $\mu_{12} = 1$ tariff which attracts a strictly positive measure of types. Then, among the tariffs chosen by a strictly positive measure of types, take one with the highest Δ and denote it by (Δ^h, μ^h). Suppose $\mu_2^h > 0$. The set of types attracted by each contract is compact by the maximum theorem. Denote the type with the *highest* t among the types attracted by (Δ^h, μ^h) by (s_h, t_h) (if (s_h, t_h) is not unique, take an arbitrary one) and replace (Δ^h, μ^h) by $(\hat{\Delta}, \hat{\mu})$ such that $\hat{\Delta} = \Delta^h + \mu_2^h(1 - t_h)(c_2 - c_1)$, $\hat{\mu}_1 = \mu_1^h$, $\hat{\mu}_2 = 0$, $\hat{\mu}_{12} = \mu_2^h + \mu_{12}^h$. By construction, types with $t = t_h$ are indifferent between the old and the new tariff and will therefore opt for the latter if the former is no longer available. For types with a lower t the new tariff is strictly more attractive than the old one implying that all types attracted by (Δ^h, μ^h) under the original menu will be attracted by $(\hat{\Delta}, \hat{\mu})$ under the new menu. Types not attracted by (Δ^h, μ^h) under the original menu will either switch to $(\hat{\Delta}, \hat{\mu})$ or will choose the same tariff as before the replacement. Thus, since $\hat{\Delta} > \Delta^h$, the new menu yields a higher profit. Now suppose that $\mu_2^h = 0$, $\mu_1^h > 0$. Then, by a similar argument, the monopolist's profit is increased by replacing (Δ^h, μ^h) by $(\tilde{\Delta}, \tilde{\mu})$, where $\tilde{\Delta} = \Delta^h + t_l\mu_1^h((v - s_l)(1 - x) - c_2 + c_1)$, $\tilde{\mu}_1 = 0$, $\tilde{\mu}_2 = 0$, $\tilde{\mu}_{12} = 1$, and where (s_l, t_l) minimizes the function $t\mu_1^h((v - s)(1 - x) - c_2 + c_1)$ among the types attracted by (Δ^h, μ^h).

Proposition 8 *Suppose that performing a diagnosis involves a cost d and that diagnosis effort is verifiable so that a (fair) diagnosis price (of $p = d$) can be imposed on the customer for performing it.*

(i) Consider the model where consumers differ in their probability t of needing the high-quality good while they receive the same gross utility $v^s = v$ if the good does deliver. Suppose that consumers' types are drawn independently from the same log-concave c.d.f. $F(\cdot)$, with strictly positive density $f(\cdot)$ on $[\underline{t}, \bar{t}]$, where $\underline{t} \geq t_1(d)$ and $\bar{t} \leq t_2(d)$. Then, if price-discrimination is observed in equilibrium, it is performed via a menu containing two tariffs, a tariff with an honest recommendation ($\mu_{12} = 1$) and a tariff in which the consumer is overprovided with probability one ($\mu_2 = 1$). Low cost consumers are served under the former tariff while high cost consumers choose the latter.

(ii) Consider the model where consumers differ in their gross valuation $v^s = v - s$ while they have the same probability t of needing the high-quality good. Suppose that consumers' types are drawn independently from the same log-concave c.d.f. $G(\cdot)$, with strictly positive density $g(\cdot)$ on $[0, \bar{s}]$, where $\bar{s} < v - c - c_2$. Further suppose that $d \leq \min\{(1-t)(c_2-c_1), t[(1-x)(v-\bar{s})-c_2+c_1]\}$. Then, if price-discrimination is observed in equilibrium, it is performed via a menu containing two tariffs, a tariff with an honest recommendation ($\mu_{12} = 1$) and a tariff in which the consumer is underprovided with probability one ($\mu_1 = 1$). High valuation consumers are served under the former tariff while lower valuation consumers opt for the latter.

Proof of Proposition 8. Here we prove part (i) of the proposition, the proof for part (ii) is similar. Using the same techniques as in the proof of Proposition 2 it can be shown that price-discrimination is profitable if and only if $\bar{t}$ is not too small (so that overprovision is not too inefficient — the relevant condition is $1 < \bar{t} + 1/f(\bar{t})$ — and that profitable price-discrimination involves serving the segment $[\underline{t}, t_{12}]$ with tariff $\Delta_{12} = v - c - d - c_1 - t_{12}(c_2 - c_1), \mu_{12} = 1$ and the segment $(t_{12}, \bar{t}]$ with tariff $\Delta_2 = v - c - c_2, \mu_2 = 1$, where t_{12} solves $(1 - t_{12})f(t_{12}) = F(t_{12})$.