Consumer Entry: Impact on Expert's Pricing and Overcharging Behavior

Qijun Qiu[1], **Li Jiang**[2]

[1] School of Management Science and Engineering, Nanjing University of Information Science & Technology, Nanjing, China; qiu-qijun@163.com

[2] Faculty of Business, The Hong Kong Polytechnic University, Hong Kong SAR, China; l.jiang@polyu.edu.hk

Abstract

In a credence goods market, a consumer (he) is unaware of his true need, which can be either intense or minor. An expert (she) designs a menu that either charges a uniform price to both services, termed pooling pricing, or varies charges according to service types, termed differential pricing. Learning the menu offered by the expert and anticipating her behavior in serving consumers, a consumer weighs the expected utility of service provision against the cost incurred in transportation to decide whether to visit the expert, termed entry decision. Upon arrival of a consumer, the expert discerns his true need and recommends a service along with the associated charge. Under the liability assumption, the expert provides a service to satisfy the consumer's need. However, the consumer is unable to discern the nature of the service actually provided. This can induce the expert who adopts differential pricing to recommend intense service to a consumer with minor need, termed overcharging. We investigate the effects of consumers' entry decision on the expert's optimal pricing strategy and the occurrence of overcharging, and study the robustness of the main results to practical features.

Keywords: Credence goods, consumer entry, overcharging, pricing, competition

1 Introduction

Credence goods are the services or products whose providers determine consumers' needs and are prevalent in daily lives. A consumer who visits a hospital, a repair shop or an advisory body usually lacks the knowledge of his true service need. The expert is able to discern, through a diagnosis, the consumer's true need and decides the type of service to perform. Under the liability assumption, the expert serves the consumer to fit his true need. However, the consumer is unable to tell the nature of the service actually performed. This inherent information asymmetry can incentivize the expert to conduct opportunistic or even unethical behavior. Specifically, the expert may recommend a service that is more intense than a consumer's true need, benefiting from receiving a higher revenue from service provision. This has been termed overcharging in prior literature. In the healthcare market, according to a study in Health Affairs, U.S. hospitals have charged patients (or their insurers) 3-4 times what federal government expects standard procedures can cost (Khazan, 2015).

Prior literature has explored overcharging in canonical settings. Pitchik and Schotter (1987) develop a classical model, in which an expert serves consumers whose needs are either intense (E-consumer) or minor (I-consumer) but consumers are unaware of their true needs. With exogenous service charges, the expert recommends either an intense or a minor service to an I-consumer, but only recommends an intense service to an E-consumer. A consumer can accept or decline the service recommended by the expert. They characterize a mixed equilibrium in which the expert randomly advises service to an I-consumer; thus, overcharging can occur. Pitchik and Schotter (1993) embed competition among experts, and their finding reinforces the statement that dishonest behavior can exist when service charges are exogenously given.

The above result changes diametrically when the expert is authorized to set charges. Framed in the same setting as in Pitchik and Schotter (1993), Wolinsky (1993) demonstrates that a mixed recommendation strategy is unsustainable in the situation where service charges are endogenously chosen. He establishes an equilibrium, where some experts only serve consumers with minor need but other experts only serve consumers with intense need. As such, competition causes the experts to specialize in service provision. Nevertheless, no unethical behavior occurs. In a monopolistic setting with endogenized pricing, Fong (2005) asserts that the expert refrains from overcharging consumers. Authorized to manage charges, the expert has an incentive to charge a high price for intense service, which puts consumers on alert to the acceptance of intense service, deterring the expert from behaving unethically.

The previous results are premised on the assumption that total demand is given. This has been adopted in relevant works on credence goods markets (e.g. Jiang et al., 2014; Liu, 2011). The optimal service charges shown in these works are high. Specifically, a monopolistic expert sets the charge for a service of a certain type to equal the corresponding value. A high price is, however, not common in reality because it discourages consumers from patronizing the expert. In this work, we look into a mechanism that draws experts of credence goods to lower service charges. A factor that consumers often consider before visiting experts is the transportation cost to occur. For instance, before sending vehicles for a maintenance checkup or taking a trip to seek consultation for insurance policies, which have typical credence characteristics, consumers weigh distance before hitting road. In the healthcare industry, as outpatients decide which healthcare units (clinics, hospitals, etc) to visit, geographical location along with the effort exerted in transportation is likewise an important consideration factor. Competition can further clamp down on the charges levied by experts.

Embedding consumers' decision to visit the expert, which we call entry decision, we study its impact on the expert's service charges and demand. The specific research question is how experts of credence goods should manage charges in consideration of consumers' entry decisions. Importantly, to what extent price-driven demand generation impacts the expert's incentive to overcharge arriving consumers?

To shed light on these issues, we analyze a setting that is similar to Fong (2005) but allow the demand to be dependent on, and negatively affected by, the service charges levied by the expert. We consider a monopolistic expert who serves a continuum of consumers distributed along a line. The expert can adopt either pooling pricing (to charge a uniform price to all consumers) or differential pricing (to vary charges according to service types). Learning the expert's menu and anticipating her behavior, a consumer weighs the expected utility received from service against the cost incurred in transportation to decide whether to visit the expert. In deciding service charges, in addition to the inherent trade-off between a high charge for intense service and a low chance of overcharging, the expert faces an additional layer of trade-off: an increase in service charge deters consumers from visiting the expert and thus lowers her demand. These two layers of trade-offs intricately interplay to influence experts' pricing and servicing behavior.

Similar to that stated in prior literature premised on a fixed demand size (usually normalized to one), we demonstrate that, considering the pressure arising from consumers' entry decision, the expert adopts pooling pricing when expected service value is high but differential pricing otherwise. Under pooling pricing, compared to that in the corresponding situation with a fixed demand size, a monopolistic expert lowers the charge to attract arrivals. As the expert adopts differential pricing, she charges less for minor service to attract more demand but stabilizes the charge for intense service. As a consequence, consumers' entry decision is inconsequential to the occurrence of overcharging by a monopolistic expert who, however, faces a reduction in demand. This result prevails in the presence of competing experts, while competition forces experts to further adjust charges for minor service. Circumstances exist where competition causes the experts to charge more. The effects of consumers' entry decision on experts' overcharging behavior are robust when experts incur asymmetric costs in service provision, when consumers follow a general distribution pattern, or when the market consists of a number of experts.

2 Model Preliminaries and Analysis

We consider a monopolistic expert who provides service in a market that has a size of 1. Consumers are uniformly distributed on the line $[0, 1]$ and the expert is located at 0. Each consumer has either an intense need (s) or a minor (m) need, but he is unaware of his true need. The prior belief is that his need is intense with probability $\alpha \in (0, 1)$. The values of intense and minor services are l_s and l_m, respectively, with $l_m < l_s$ and $\triangle_l = l_s - l_m$ indicating the difference in the values of the two types of services. The expected service value is $E(l) = (1-\alpha)l_m + \alpha l_s$. The consumer receives zero utility by declining service. The consumer located at $d \in [0, 1]$ incurs a disutility td to transport to the expert, where t is the marginal spatial disutility. The utility to a consumer who is located at d and perceives value l at service charge p is $u(p, d) = l - p - td$. The consumer visits the expert when $E(u(p, d)) \geq 0$, where the expectation is based on his anticipation of the expert's behavior in service recommendation. An increase in marginal spatial disutility presses the expert to lower price to attract consumers. The expert designs a menu $p = (p_m, p_s)$, where p_m (p_s) is the charge for minor (intense) service. She engages in pooling pricing by setting $p_m = p_s$ or differential pricing by setting $p_m \neq p_s$.

Upon arrival of a consumer, the expert discerns, through a costless diagnosis, the consumer's true need and recommends a service from the menu alongside the associated charge. Under liability assumption, the expert provides a service to satisfy the consumer's need, by incurring c_s and c_m with $c_m < c_s$ for intense and a minor service, respectively. The difference in the costs of the two service types is $\triangle_c \triangleq c_s - c_m$, and the expected cost of service provision is $E(c) = (1-\alpha)c_m + \alpha c_s$. The value of a service exceeds its cost; that is, $l_i > c_i, i = m, s$, which ensures honest service provision to be efficient. We assume $l_m < c_s$ to deter the expert from offering intense service to a consumer with minor need. Let $w_i \triangleq l_i - c_i, i = m, s$ be the social surplus of i-type service.

Upon service completion, the consumer knows that his need has been addressed but is not aware of the nature of service actually provided. This induces the expert, when adopting differential pricing, to recommend intense service to a consumer but provide a minor service. The consumer may however decline the expert's recommendation and leave the system.

Figure 1 illustrates the framework to conduct analysis. Nature determines the type of service needed by a consumer. The expert offers a menu that can stipulate a uniform charge for the two types of services (pooling pricing) or vary charges by service types (differential pricing). After learning the menu, the consumer anticipates the expert's behavior in service recommendation and weighs the cost incurred in transportation to decide whether to visit the expert. Upon arrival of a consumer, the expert discerns the consumer's true need and recommends a service, which the consumer can decline. Once the consumer accepts the recommendation, the expert performs a service that satisfies the consumer's true need. After service completion, the consumer pays for the service that he has accepted, which may not be the service actually provided, and then exits.

We analyze the service charges offered by the expert as she engages in either differential or pooling pricing, and investigate her optimal pricing strategy alongside servicing behavior. Notation-wise, we add superscript D (P, resp) on the quantities of interest when the expert adopts differential (pooling, resp) pricing.

Differential pricing

Under differential pricing, the expert may recommend a service that is more intense than needed to the consumer. Upon arrival of a consumer, the expert bases on her knowledge of the consumer's true need to recommend a service. While the expert must recommend intense service to a consumer with intense need, she can recommend either minor or intense service to a consumer with minor need. Recommended a minor service, a consumer must have minor need and accepts service if $p_m \leq l_m$. Recommended an intense service, the consumer can have either intense or minor need, receiving a positive (negative) utility when his true need is intense (minor) if $p_s < l_s$ ($p_s > l_m$). The normal game form in Table 1 presents the payoffs to the consumer and the expert as they adopt various strategy profiles.

This game has no pure-strategy equilibrium. We can follow Fong (2005) to establish a mixed-strategy equilibrium. Given demand and ser-

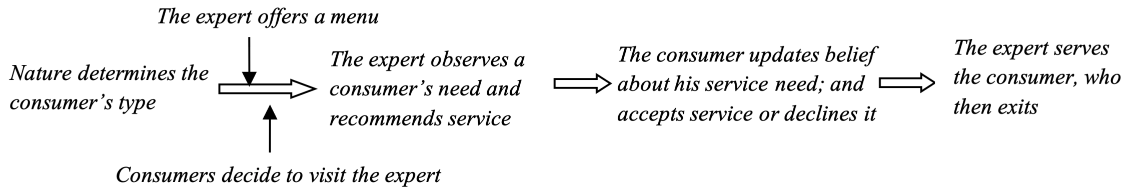

Figure 1: Decision Framework

Table 1: Normal Form

		Consumer	
		Accept (intense service)	Decline (intense service)
Expert	Honest	$(1-\alpha)p_m+\alpha p_s-E(c)$, $E(l)-(1-\alpha)p_m-\alpha p_s$	$(1-\alpha)(p_m-c_m)$ $(1-\alpha)(l_m-p_m)$
	Overcharging	$p_s-E\left(c\right),E\left(l\right)-p_s$	0,0

Notes. The payoffs under a strategic profile adopted by the expert and consumer have two elements. The first element is the payoff to the expert, and the second element is the payoff to the consumer.

vice charges p, the expert overcharges a consumer who needs minor service with probability $\beta \triangleq \frac{\alpha(l_s-p_s)}{(1-\alpha)(p_s-l_m)}$and the consumer accepts intense service with probability $r \triangleq \frac{p_m-c_m}{p_s-c_m}$. The overcharging probability β depends on, and decreases with, the charge for intense service (p_s). Thus, a higher charge for intense service reduces the experts likelihood of overcharging, which is a basic trade-off in credence goods markets.

In the expression for β, $\alpha(l_s-p_s)$ ($(1-\alpha)(p_s-l_m)$, resp) is the expected gain (loss, resp) to the consumer as the expert behaves honestly when recommending an intense service (overcharges, resp); thus, the expert overcharges to balance the expected gain and loss to the consumer when he is recommended intense service. The probability r of service acceptance by the consumer increases with the charge for minor service (p_m) but decreases with that for intense service (p_s); thus, an increase in the difference in the charges for intense and minor services weakens the consumer's incentive to accept intense service.

Given the charges offered by the expert, the consumer, anticipating the outcome at the stage of recommendation and acceptance, decides whether to visit the expert. The expected utility to a consumer who is located at $d \in [0,1]$ and visits the expert is as follows.

$$E^D(u(p,d)) = (\alpha(l_s-p_s)+(1-\alpha)\beta(l_m-p_s))r+ \\ (1-\alpha)(1-\beta)(l_m-p_m)-td.$$

The first term, $(\alpha(l_s-p_s)+(1-\alpha)\beta(l_m-p_s))r$, is the expected utility to the consumer as the expert recommends intense service. The second term, $(1-\alpha)(1-\beta)(l_m-p_m)$, is the expected utility to the consumer as the expert recommends minor service. The third term is transport disutility. Notably, $\alpha(l_s-p_s)+(1-)\beta(l_m-p_s)=0$, i.e., a consumer receives zero utility when the expert recommends intense service, in which case, the expert randomizes her overcharging behavior to make the consumer indifferent between declining and accepting service, and the reservation utility received by the consumer who declines service is zero.

Thus, the expected utility that the consumer receives from minor service influences the entry decision. Note that the consumer is unaware of his true need even after service completion, and perceives an expected utility based on his anticipation of the expert's behavior. We can simplify the second term to $(1-\frac{\alpha\triangle_l}{p_s-l_m})(l_m-p_m)$, where $1-\frac{\alpha\triangle_l}{p_s-l_m}<1-\alpha$ is the probability that a consumer with minor need receives a proper recommendation, and l_m-p_m is the marginal utility generated.

A consumer visits the expert, thus forming her demand, provided that his location satisfies that $d\leq\hat{d}^D$, where $E(u(p,\hat{d}^D))=0$. Lemma 1 characterizes the demand to the expert.

Lemma 1. *Given service charges (p_s,p_m), the demand to the monopolistic expert is $\hat{d}^D=Min\{(1-\frac{\alpha\triangle_l}{p_s-l_m})\frac{l_m-p_m}{t},1\}$, which increases with p_s but decreases with p_m.*

Lemma 1 reveals the different roles played by the charges for intense and minor services (p_s and p_m) in demand formation. The size of consumers who visit the expert depends on two factors. One is the marginal utility to the consumer by transporting to receive a minor service, $\frac{l_m-p_m}{t}$, which depends on the charge for minor service p_m and is adjusted by the marginal spatial disutility t. An increase in p_m or an increase in t decreases the marginal utility, disincentivizing the consumer from visiting the expert. The other factor, expressed by $1-\frac{\alpha\triangle_l}{p_s-l_m}$, reflects the impact of overcharging on the consumers intention to visit and depends on the charge for intense service p_s. An increase in p_s increases demand by weakening the expert's incentive to overcharge; this demand-enhancing effect strengthens as the consumer is less likely to have intense need (α decreases) or the difference in the values from intense and minor services decreases ($\triangle_l$ decreases).

The profit for the expert by charging $p=(p_m,p_s)$is $\pi^D(p_m,p_s)=(1-\alpha)(1-\beta)(p_m-c_m))\hat{d}^D$. By substitution, we can rewrite the profit function as follows:

$$\begin{aligned}\pi^D(p_m,p_s)=&(p_m-c_m)(1-\alpha+\frac{\alpha(p_s-c_s)}{p_s-c_m})\\&Min\{(1-\frac{\alpha\triangle_l}{p_s-l_m})\frac{l_m-p_m}{t},1\}.\end{aligned}$$

Note that this profit function is separable in p_m and p_s. Lemma 2 states the experts optimal strategies to price and serve consumers when she adopts differential pricing.

Lemma 2. *In the monopolistic setting, under differential pricing, the expert sets charges $p^D=(p_m^D,p_S^D)$, where $p_m^D=\begin{cases}\frac{l_m+c_m}{2} & t\geq\frac{(1-\alpha)w_m}{2}\\ l_m-\frac{t}{1-\alpha} & t<\frac{(1-\alpha)w_m}{2}\end{cases}$, and $p_S^D=l_s$, at which she has no incentive to overcharge, i.e., $\beta=0$, and consumers accepts intense service with probability $r=\frac{w_m}{2(l_s-c_m)}$.*

Absent consumers' entry decision, Wolinsky (1993) states that a monopolistic expert who varies charges by service types should set $p^D = (l_m, l_s)$, i.e., each type of service is charged a price equal to its value. Lemma 2 states how the expert adjusts charges as consumers make entry decisions. As marginal spatial disutility is low ($t < \frac{(1-\alpha)w_m}{2}$), the market is fully covered and the expert charges $p_m^D = l_m - \frac{t}{1-\alpha}$ for minor service, which decreases as t increases. As marginal spatial disutility is high ($t \geq \frac{(1-\alpha)w_m}{2}$), the market is not fully covered and the expert fixes the charge for minor service at $p_m^D = \frac{c_m + l_m}{2} < l_m$. In either case, the expert sets a lower charge for minor service compared to that in the situation with a fixed demand size. However, considering consumer entry is inconsequential to the expert's charge for intense service and her servicing behavior. Nevertheless, the consumer has a reduced chance of accepting intense service relative to that absent consumers entry decision.

From the consumer's perspective, Lemma 2 sends a message that differs from what the classic price discrimination theory would predict. Varian (1989) analyzes a setting where two types of consumers make decisions to visit a retailer who is unable to tell consumers' types, and a low-end (high-end) consumer receives a low (high) utility from consumption. Varian (1989) states that the high-end consumer benefits from his information advantage by paying a lower price than his low-end counterpart. In a credence goods market, the expert has an information advantage over consumers on consumers' true needs and decides about the services to perform. Our result reveals that, as the expert weighs the demand pressure arising from consumers' entry decision when managing her prices, the consumer who needs minor service (and hence receives a lower value from service) is better off, but the consumer who needs intense service and hence receives a higher value from service is worse off due to a weakened tendency to accept service.

Pooling pricing

As the expert adopts pooling pricing, she sets a uniform charge p and overcharging is no longer an option. Given demand, the expert serves all arriving consumers when the uniform charge is high ($p \geq c_s$), in which case, an arriving consumer remains unaware of his true need, but forgoes consumers with intense need to only serve consumers with minor need otherwise ($p < c_s$), in which case, an arriving consumer, once served, can tell that his need is minor. The expected utility to a consumer who is located at $d \in [0, 1]$ and visits the expert can be written as follows:

$$E^p(u(p,d)) = \begin{cases} E(l) - p - td & p \geq c_s \\ (1-\alpha)(l_m - p) - td & p < c_s \end{cases},$$

where td is transportation cost.

A consumer visits the expert provided that $d \leq \hat{d}^p$, where $\hat{d}^p$satisfies $E^p(u(p, \hat{d}^p)) = 0$. It can be verified that $\hat{d}^p = Min\{\frac{E(l)-p}{t}, 1\}$when $p \geq c_s$, while $\hat{d}^p = Min\{\frac{(1-\alpha)(l_m-p)}{t}, 1\}$ otherwise.

Lemma 3. *In the monopolistic setting, under pooling pricing, referring to Figure 2, the optimal uniform charge p^p is as follows:*

Area	M_1	M_2	M_3	M_4	M_5
p^p	$\frac{E(l)+E(c)}{2}$	$E(l)-t$	c_s	$\frac{l_m+c_m}{2}$	$l_m - \frac{t}{1-\alpha}$

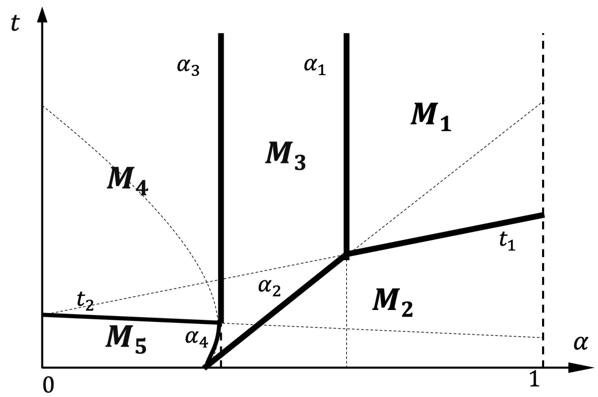

Figure 2: Optimal Pooling Pricing in the Monopolistic Setting

Notes. The expressions for $\alpha_i, i = 1, \ldots, 4, t_1, t_2$ are provided in the Appendix.

Recall that, given a fixed demand size, the expert who adopts pooling pricing charges $p^p = E(l)$ when $E(l) \geq c_s$, but $p^p = l_m$ to serve consumers with minor need when $E(l) < c_s$. Lemma 3 indicates that, considering consumers' entry decision, the expert, when adopting pooling pricing, can manage the charge to attract arrivals. Specifically, at a high need for intense service (Areas M_1 and M_2 in Figure 2), implying a high expected service value, the expert serves all consumers. At low marginal spatial disutility, the market is fully covered, and transportation disutility causes the expert to lower the charge to $E(l) - t$. At high marginal spatial disutility, the market is partially covered, and the expert fixes the charge at $\frac{E(l)+E(c)}{2}$. At a low need for intense service (Areas M_4 and M_5 in Figure 2), implying a low expected service value, the expert serves consumers with minor need only. At low marginal spatial disutility, the market is fully covered, and the expert lowers the charge to $l_m - \frac{t}{1-\alpha}$. At high marginal spatial disutility, the market is partially covered, and the expert fixes the charge at $\frac{l_m+c_m}{2}$. As a medium proportion of consumers need intense service (Area M_3 in Figure 2), the expert fixes the charge at the cost of intense service to serve all arriving consumers, though she makes no profit from serving those consumers with intense need.

Proposition 1. *In the monopolistic setting, the expert prefers pooling pricing when expected service value is high, but differential pricing otherwise. That is,*

$$\pi^p \geq \pi^D \text{ when } E(l) \geq c_s + \begin{cases} \frac{w_m^2}{4\triangle_c} & t \geq \frac{(1-\alpha)w_m}{2} \\ \frac{t(w_m - \frac{t}{1-\alpha})(1-\frac{\alpha\triangle_c}{l_s - c_m})}{(1-\alpha)\triangle_c} & t < \frac{(1-\alpha)w_m}{2} \end{cases} \text{ and } \pi^p < \pi^D \text{ otherwise.}$$

Proposition 1 states the optimal pricing strategy of a monopolistic expert in consideration of consumers' entry decision. Specifically, she adopts pooling pricing when the expected service value is high but differential pricing otherwise. This is structurally similar to that stated in prior literature. Notably, considering consumer's entry decision weakens the incentive of the expert to adopt pooling pricing, which is more prominent as marginal spatial disutility increases so that the pricing pressure weakens on the expert.

Consumers' entry decision influences the expert's service charges, but it is inconsequential to her behavior in serving consumers. Under pooling pricing, the expert lowers the uniform charge, to an extent depending on marginal spatial disutility (which influences market coverage) and expected service value (which is adjusted by the composition of consumers in terms of service needs). Under differential pricing, the expert lowers the charge for minor service but stabilizes that for intense service, and she has the same incentive for overcharging as that in the situation with a fixed demand size, despite a strengthened incentive of consumers to decline intense service.

3 Expert Competition

Next, we introduce competition by considering two experts, indexed as $k = 1, 2$, who are located at the two ends of line $[0, 1]$, with retailer 1 located at 0 and retailer 2 located at 1 (Hotelling, 1929). An expert k designs menu $p_k = (p_{m,k}, p_{s,k})$, where $p_{m,k}$ and $p_{s,k}$ are the charges for minor and intense services, respectively. She engages in differential pricing by setting $p_{m,k} \neq p_{s,k}$, in which case she may overcharge consumers, or pooling pricing by setting $p_{m,k} = p_{s,k}$. The experts incur the same costs in service provision, i.e., $c_{m,1} = c_{m,2} = c_m$ and $c_{s,1} = c_{s,2} = c_s$, with $c_m < c_s$. A consumer located at $d \in [0, 1]$ perceives utility $u_1(p, d) = l_1 - p_1 - td$ by visiting expert 1 and $u_2(p, d) = l_2 - p_2 - t(1 - d)$ by visiting expert 2, by learning their charges and anticipating their behavior. The consumer visits expert 1, forming her demand, when $E(u_1(p, d)) \geq E(u_2(p, d))$, but visits expert 2 otherwise. Premised on the assumption that the expert aims to minimize the consumer's cost, Fong (2005) finds that competition between experts adopting differential pricing causes them to charge less, but it has no influence on their incentive for overcharging. We assume that the expert is self-interested and maximizes individual profit. Moreover, Fong (2005) assumes exogenous demand that follows a two-point distribution, whereby experts either serve the entire market or face no customers. In contrast, the demand in our model is a continuous function of service charges.

The interaction between an expert and an arriving consumer at the stage of recommendation and acceptance is the same as that discussed in the monopolistic setting. We analyze experts' pricing strategies and servicing behavior, and explore the effects of competition. In the situation where both experts adopt differential pricing, Lemma 4 states the equilibrium outcomes.

Lemma 4. *In the competitive setting, as both experts adopt differential pricing, expert $k = 1, 2$ sets charges $p_k^D = p^D = (p_m^D, p_s^D)$, where:*

$$p_m^D = \begin{cases} \frac{l_m + c_m}{2} & t \geq (1-\alpha)w_m \\ l_m - \frac{t}{2(1-\alpha)} & \frac{2(1-\alpha)w_m}{3} \leq t < (1-\alpha)w_m \\ \frac{t}{1-\alpha} + c_m & t < \frac{2(1-\alpha)w_m}{3} \end{cases}$$

and $p_s^D = l_s$.

Neither expert overcharges consumers, who accept intense service by either expert with probability $r^D = \frac{t}{(1-\alpha)(l_s - c_m)}$.

Same as that in the monopolistic setting, competing experts who adopt differential pricing keep the charges for intense service at $p_s^D = l_s$, i.e., the presence of competition is inconsequential to the role of the charge for intense service in influencing demand. The experts keep this charge high to extract consumer surplus, which, in turn, forces them to behave honestly in recommending services. In contrast, the experts manage charges for minor service to compete for demand, with the specific adjustments depending on the marginal spatial disutility that affects the extent of market coverage.

At low marginal spatial disutility, the market is fully covered, and the experts face intense competition. Compared with that in a monopolistic setting, competition causes the experts to charge less for minor service. At medium marginal spatial disutility, the experts split the market, in which case, they charge a higher price for minor service than that by a monopolistic expert, i.e., competition boosts experts' charges. At high marginal spatial disutility, the market is partially covered, and each expert serves its local market at a fixed charge for minor service ($\frac{l_m+c_m}{2}$), which is the same as that levied by a monopolistic expert. Notably, consumers have a strengthened incentive to accept intense service as marginal spatial disutility increases and experts face more intense pricing pressure, and their incentive is stronger than that in the monopolistic setting when the marginal spatial disutility is sufficiently high ($t > \frac{(1-\alpha)w_m}{2}$).

In the situation where both experts engage in pooling pricing, Lemma 5 states their uniform charges.

Lemma 5. *In the competitive setting, as both experts adopt pooling pricing, referring to Figure 3, the uniform charge by expert k is $p_k^P = p^P, k = 1, 2,$ where p^P is presented as follows:*

Area	D_1	D_2	D_3	D_4
p^p	$\frac{E(l)+E(c)}{2}$	$E(l) - \frac{t}{2}$	$t + E(c)$	c_s

Area	D_5	D_6	D_7	D_8
p^p	c_s	$\frac{l_m+c_m}{2}$	$l_m - \frac{t}{2(1-\alpha)}$	$\frac{t}{1-\alpha} + c_m$

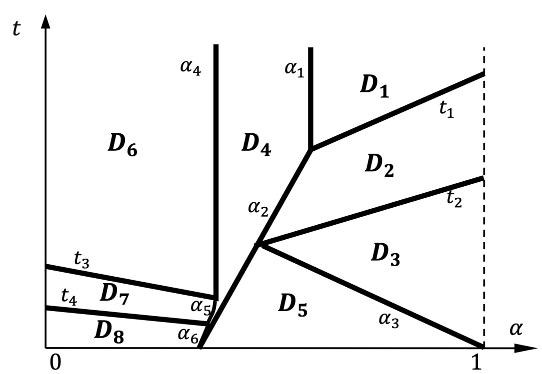

Figure 3: Uniform Charges under Pooling Pricing in the Competitive Setting

Notes. The expressions for $t_i, i = 1, \ldots, 4$ and $\alpha_i, i = 1, \ldots, 6$ are provided in the Appendix.

In the presence of competition, the experts, when adopting pooling pricing, charge uniform prices to serve all consumers when expected service value is high (Areas D_1, D_2, D_3 in Figure 3), only serve consumers with minor need when expected service value is low (Areas D_6, D_7, D_8 in Figure 3), but fix the charge at the cost for intense service when expected service value is medium (Areas D_4, D_5 in Figure 3). This is structurally similar to that in the counterpart situation with a monopolistic expert. Competition draws the competing experts, when adopting pooling pricing, to adjust their uniform charges. At low marginal spatial disutility t, the market is fully covered, and competition entices the experts to lower uniform charge when t is sufficiently low but to increase the charge otherwise. At medium marginal spatial disutility, the experts equally share the market and each of them levies a uniform charge higher than that by a monopolistic expert. At high marginal spatial disutility, the market is partially covered and each expert fixes the same uniform charge as that by a monopolistic expert. All this echoes how the competing experts adjust their charges for minor service as they both engage in differential pricing.

Proposition 2. *In the presence of competition, the experts prefer pooling pricing when expected service value is high, but differential pricing otherwise. That is, $\pi^p > \pi^D$ when $E(l) \geq c_s + \frac{w_m^2(l_s-c_m-\alpha\triangle_c)}{4\triangle_c(l_s-c_m)}$ if $t \geq (1-\alpha)\,w_m$,* *or when* $E(l) \geq c_s + \frac{t(2(1-\alpha)w_m - t)(l_s - c_m - \alpha\triangle_c)}{4(1-\alpha)^2\triangle_c(l_s-c_m)}$ *if* $\frac{2(1-\alpha)w_m}{3} < t < (1-\alpha)\,w_m$*, or when* $E(l) \geq c_s + \frac{t^2(l_s-c_m-\alpha\triangle_c)}{2(1-\alpha)^2\triangle_c(l_s-c_m)}$ *if* $t \leq \frac{2(1-\alpha)w_m}{3}$*; otherwise,* $\pi^p < \pi^D$.

Hence, competing experts prefer pooling pricing when the expected service value is high but differential pricing otherwise, and they have a stronger preference for differential pricing as marginal spatial disutility increases. All this is consistent with the preference of a monopolistic expert. Upon adoption of pooling pricing, competition causes the experts to tailor uniform charges to the expected service value adjusted by the composition of consumers in terms of service needs and price pressure influenced by marginal spatial disutility. Upon adoption of differential pricing, competition causes the experts to manage the charges for minor service to compete for demand but fix the charges for intense service. The experts refrain from overcharging, while the incentive of arriving consumers to accept intense service is influenced by, and increases with, marginal spatial disutility. Compared to the situation with a monopolistic expert, competition between experts can strengthen the incentive of consumers to accept intense service when the marginal spatial disutility is sufficiently high, in which case, the pricing pressure on the experts is low.

4 Extensions

In this section, we examine the robustness of the effect of consumers entry decision on occurrence of overcharging by experts who adopt differential pricing to vary charges by service types.

4.1 Asymmetric Costs in Service Provision

Consider the situation in which competing experts incur asymmetric costs in service provision. To be specific, an expert k incurs $c_{s,k}$ and $c_{m,k}$, respectively, in performing intense and minor services, with $c_{m,k} < c_{s,k}$ and $c_{i,k} \neq c_{i,3-k}, i \in m, s$, and the expected cost in service provision is $E(c_k) = \alpha c_{m,k} + (1-\alpha)\, c_{s,k}, k = 1, 2$. Proposition 3 states the optimal service charges as the experts adopt differential pricing.

Proposition 3. *In the competitive setting, as both experts adopt differential pricing, expert* k *sets charges* $p_k^D = (p_{m.k}^D, p_{s,k}^D)$*, where* $p_{m,k}^D = \frac{l_m + c_{m,k}}{2}$ *if* $t \geq \frac{(1-\alpha)(2l_m - c_{m,k} - c_{m,3-k})}{2}$*;* $p_{m,k}^D = l_m - \frac{t}{2(1-\alpha)} + \frac{c_{m,k} - c_{m,3-k}}{6}$ *if* $\frac{(1-\alpha)(2l_m - c_{m,k} - c_{m,3-k})}{3} \leq t < \frac{(1-\alpha)(2l_m - c_{m,k} - c_{m,3-k})}{2}$*; and* $p_{m,k}^D = \frac{t}{1-\alpha} + \frac{2c_{m,k} + c_{m,3-k}}{3}$ *if* $t < \frac{(1-\alpha)(2l_m - c_{m,k} - c_{m,3-k})}{3}$,

and $p_{k,s}^D = l_s$*, at which, neither expert has an incentive to overcharge, i.e.,* $\beta_k^D = 0$*, and the consumer accepts an intense service by an expert with probability by expert* k *with probability* $r_k^D = \frac{3t - (1-\alpha)(c_{m,k} - c_{m,3-k})}{3(1-\alpha)(l_s - c_{m,k})}, k = 1, 2$.

Asymmetric costs incurred by experts in providing services are manifested in their charges for minor service relative to each other. Specifically, the more efficient expert, who incurs a lower cost, charges less for minor service, enabling her to attract more consumers. In contrast, despite the difference in their costs in providing intense service, the experts maintain their charges for intense service at $p_{s,k} = l_s, k = 1, 2$, and neither of them has an incentive for overcharging. The asymmetric costs in service provision influences service acceptance by consumers, who are more likely to accept intense service provided by the more efficient expert. All this reinforces our finding as the consumer makes utility-based decisions to visit experts who vary charges by service types in credence goods markets: the charge for minor service influences consumer demand, while the charge for intense service plays a stable role in regulating the experts behavior in serving arriving consumers. In the presence of competition, asymmetric costs in service provision by experts affect their charges for minor service only.

4.2 General Location Distribution by Consumers

Our analysis thus far is on the premise that consumers are uniformly distributed along $[0,1]$. This has facilitated the analysis to yield tractable results. Prior literature points out that consumers' location distribution is an important factor in retailers' decision making (e.g. Carpenter, 1989; Shugan, 1987). We next generalize consumers' location distribution. In particular, with the two experts located at the two ends of the line, we assume that consumers are distributed according to a general distribution.

Proposition 4. *In the competitive setting with general location distribution by consumers, each expert sets the charge for intense service at* $p_{s,k} = l_s, k = 1, 2$, *neither expert has an incentive to overcharge, that is,* $\beta_k = 0, k = 1, 2$, *and the consumer accepts intense service with probability* $r_k = \frac{p_{m,k} - c_m}{l_s - c_m}, k = 1, 2$.

Proposition 4 states that compared to when consumers are distributed according to a uniform distribution, general location distribution by consumers only influences experts' charges for minor service. Notably, the experts utilize their charges for minor service to fit location disparity among consumers. In contrast, they keep the charges for intense service at $p_{s,1} = p_{s,2} = l_s$, and behave honestly in making service recommendations.

To shed more light on experts' pricing strategies, we analyze the scenario where consumers are distributed along $[0,1]$ according to a distribution function with PDF $f(d)$ and CDF $F(d)$ that satisfies the property of increasing hazard rate, i.e., $\frac{\partial}{\partial d}(\frac{F(d)}{f(d)}) \geq 0$. It can be verified that the charges for minor service levied by the experts are $p_{m,1} = c_m + \frac{2t}{1-\alpha}\frac{F(\hat{d})}{f(\hat{d})}$ and $p_{m,2} = c_m + \frac{2t}{1-\alpha}\frac{1-F(\hat{d})}{f(\hat{d})}$, where $\hat{d} = \frac{t-(1-\alpha)(p_{m1}-p_{m2})}{2t}$. In the case where location distribution is symmetric, the experts set charges for minor service at $p_{m,k} = c_m + \frac{t}{1-\alpha}\frac{1}{f(1/2)}, k = 1, 2$. With asymmetric location distribution, however, they would set differential charges for minor service.

4.3 Oligopoly Competition with n Experts

In reality, a multitude of experts can exist and compete in serving consumers. We extend our analysis to the setting that has n experts who are located evenly on a circle, with a distance of $\frac{1}{n}$ between two successive experts (Salop, 1979). Consumers are distributed on the circle with density function $f(d)$. A consumer located at $d \in [\frac{k}{n}, \frac{k+1}{n}], k = 1, 2, \ldots, n$ with $\frac{k+1}{n} = \frac{1}{n}$ when $k = n$, incurs a disutility of td to purchase from expert k but $t(\frac{1}{n} - d)$ from expert $k+1$. The utilities that he receives by visiting the two experts are, respectively, $u_k(p_k, d) = l_k - p_k - td$

and $u_{k+1}(p_{k+1}, d) = l_{k+1} - p_{k+1} - t(\frac{1}{n} - d)$, where p_k is expert k's price.

Proposition 5. *In a competitive setting with n experts and general distribution by consumers, expert k sets the charge for intense service at $p_{s,k} = l_s, k = 1, \ldots, n$; neither expert has an incentive to overcharge, i.e., $\beta_k = 0, k = 1, \ldots, n$, and the consumer accepts an intense service by an expert k with probability $r_k = \frac{p_{m,k} - c_m}{l_s - c_m}, k = 1, \ldots, n$.*

Hence, our main result is still valid in an oligopolistic market with n experts. The experts set the charges for minor service to attract consumer arrivals and cater to their location distribution. As before, they maintain the charges for intense service at the corresponding service value, i.e., $p_{s,k} = l_s, \forall k$, and refrain from overcharging, but the consumer may decline the recommendation for intense service by an expert.

To quantify experts' charges for minor service, we can show that, when consumers' location distribution satisfies certain regularity condition, the charges for minor service are: $p_{m,k} = c_m + \frac{2t}{1-\alpha} \frac{F(\hat{d}_{kr}) - F(\hat{d}_{kl})}{f(\hat{d}_{kr}) + f(\hat{d}_{kl})}, k = 1, \ldots, n-1$ and $p_{m,n} = c_m + \frac{2t}{1-\alpha} \frac{1 + F(\hat{d}_{nr}) - F(\hat{d}_{nl})}{f(\hat{d}_{nr}) + f(\hat{d}_{nl})}$, where $\hat{d}_{k,r} = \frac{kt - n\triangle p_{m,k} + n\alpha\triangle_l[\frac{l_m - p_{mk}}{l_m - p_{sk}} - \frac{l_m - p_{m,k+1}}{l_m - p_{s,k+1}}]}{2tn}$, $\hat{d}_{k,l} = \frac{(k-1)t - n\triangle p_{m,k-1} + n\alpha\triangle_l[\frac{l_m - p_{m,k-1}}{l_m - p_{s,k-1}} - \frac{l_m - p_{mk}}{l_m - p_{sk}}]}{2tn}$, and $\triangle p_{m,k} = p_{m,k} - p_{m,k+1}$. In the special case where consumers are uniformly distributed, the charges for minor service are $p_{m,k} = c_m + \frac{t}{(1-\alpha)n}, k = 1, \ldots, n$, i.e., the experts offer the same service charges and equally share demand.

5 Concluding Remarks

Prior literature has investigated overcharging, which is prevalent in credence goods markets. A key message is that an expert has an incentive to overcharge consumers with minor need when service charges are exogenously given but behaves honestly when they are endogenously chosen. In past works, the endogenized service charges are high (equal to the corresponding value of service), which are not often seen in reality. As an effort to better connect to reality, we include a practical feature whereby a consumer decides whether to visit the expert, termed entry decision, by weighing the transportation cost and anticipating the expert's behavior in recommending services. We study the expert's optimal strategies to price and serve consumers in consideration of the pressure arising from their entry decisions that influence demand formation.

We demonstrate that, considering consumers' entry decision, a monopolistic expert applies optimal pricing strategy in a way similar in structure to that when demand size is fixed, but is more likely to adopt differential pricing. Weighing this decision by consumers causes the expert to lower the uniform charge in the situation where she adopts pooling pricing. As the expert adopts differential pricing, the charges for minor and intense services play distinct roles in demand formation and the occurrence of overcharging. Specifically, she lowers the charge for minor service but maintains the charge for intense service. Consequently, weighing consumer entry is inconsequential to the expert's incentive for overcharging but benefits consumers with minor need with lower service charges. In the presence of competition, the experts adjust uniform charges to compete for demand when they adopt pooling pricing, but manage the charges for minor service to compete for demand when they adopt differential pricing, in which case, they refrain from overcharging. The main findings on the effects of consumers entry decision on the occurrence of overcharging as experts adopt differential pricing are robust when competing experts incur asymmetric cost in service provision, consumers follow a general location distribution or the market comprises more than two experts.

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Appendix: Mathematical Proofs

Proof of Lemma 1.

Consumers decide to visit the expert provided that $E(u(p,d)) = E(l_i - p_i) - td \geq 0$. Therefore, the demand $\hat{d}$ satisfies that $\alpha r(l_s - p_s) + (1-\alpha)\beta r(l_m - p_s) + (1-\alpha)(1-\beta)(l_m - p_m) - t\hat{d} = 0$. Substituting $\beta = \frac{\alpha(l_s - p_s)}{(1-\alpha)(p_s - l_m)}$ and $r = \frac{p_m - c_m}{p_s - c_m}$, we have $\hat{d} = (1 - \frac{\alpha\triangle_l}{p_s - l_m})\frac{l_m - p_m}{t}$, where $\triangle_l = l_s - l_m$. In the expression, $\frac{l_m - p_m}{t}$ can be interpreted as the demand to the expert when only consumers with minor need exist in the market. Since $\frac{\partial\hat{d}}{\partial p_s} = \frac{\alpha\triangle_l(l_m - p_m)}{(l_m - p_s)^2 t} > 0$ and $\frac{\partial\hat{d}}{\partial p_m} = -(1 - \frac{\alpha\triangle_l}{p_s - l_m})\frac{1}{t} < 0$, demand increases with the charge for intense service but decreases with the charge for minor service. □

Proof of Lemma 2.

The profit for the expert under differential pricing can be written as $\pi = (\alpha(p_s - c_s)r + (1-\alpha)\beta(p_s - c_m)r + (1-\alpha)(1-\beta)(p_m - c_m))\hat{d} = (p_m - c_m)(1 - \alpha + \frac{\alpha(p_s - c_s)}{p_s - c_m})min\{(1 - \frac{\alpha\triangle_l}{p_s - l_m})\frac{l_m - p_m}{t}, 1\}$, where the second equation is obtained by substituting β, r and $\hat{d}$. It can be verified that $\frac{\partial\pi}{\partial p_s} = \frac{\partial\hat{d}}{\partial p_s}(p_m - c_m)(1 - \alpha + \frac{\alpha(p_s - c_s)}{p_s - c_m}) + (p_m - c_m)(1 - \frac{\alpha\triangle_l}{p_s - l_m})\frac{\alpha k_c(l_m - p_m)}{(l_m - p_s)^2 t} > 0$ and $\frac{\partial\pi}{\partial p_m} = (1 - \alpha + \frac{\alpha(p_s - c_s)}{p_s - c_m})(1 - \frac{\alpha k_l}{p_s - l_m})\frac{l_m + c_m - 2p_m}{t}$ when $(1 - \frac{\alpha k_l}{p_s - l_m})\frac{l_m - p_m}{t} < 1$ and $\frac{\partial\pi}{\partial p_m} = 1 - \alpha + \frac{\alpha(p_s - c_s)}{p_s - c_m}$ when $(1 - \frac{\alpha k_l}{p_s - l_m})\frac{l_m - p_m}{t} \geq 1$, so $p_s = l_s$ and $p_m = \frac{c_m + l_m}{2}$ when $(1-\alpha)\frac{l_m - c_m}{2t} < 1$ and $p_m = l_m - \frac{t}{1-\alpha}$ when $(1-\alpha)\frac{l_m - c_m}{2t} \geq 1$. Substituting $p = (\frac{c_m + l_m}{2}, l_s)$ into β and r, we have $\beta = 0$ and $r = \frac{l_m - c_m}{2(l_s - c_m)}$. Substituting $p = (l_m - \frac{t}{1-\alpha}, l_s)$ into β and r, we have $\beta = 0$ and $r = \frac{l_m - c_m - \frac{t}{1-\alpha}}{l_s - c_m}$. Hence the claim in the statement. □

Proof of Lemma 3.

The profit for the expert under pooling pricing can be written as: $\pi = (p - E(c))Min\{\frac{E(l) - p}{t}, 1\}$ if $p \geq c_s$, and $\pi = (1-\alpha)(p - c_m)Min\{(1-\alpha)\frac{(l_m - p)}{t}, 1\}$ if $p < c_s$.

By the first-order condition, we have:

$p = \begin{cases} \frac{E(l)+E(c)}{2} & t \geq t_1 \\ E(l) - t & t < t_1 \end{cases}$ when $p \geq c_s$; and $p = \begin{cases} \frac{l_m + c_m}{2} & t \geq t_2 \\ l_m - \frac{t}{1-\alpha} & t < t_2 \end{cases}$ when $p < c_s$,

where $t_1 = \frac{E(l) - E(c)}{2}$ and $t_2 = \frac{(1-\alpha)(l_m - c_m)}{2}$.

We then consider the restrictions imposed by the conditions $p \geq c_s$ and $p < c_s$.

$\frac{E(l)+E(c)}{2} > c_s \Longleftrightarrow \alpha > \alpha_1 = \frac{2c_s - l_m - c_m}{l_s + c_s - l_m - c_m}$, and $E(l) - t > c_s \Longleftrightarrow \alpha > \alpha_2 = \frac{t + c_s - l_m}{l_s - l_m}$.

$\frac{l_m+c_m}{2} < c_s$ and $l_m - \frac{t}{1-\alpha} < c_s$ always hold by our assumptions.

By the above analysis, the expert can either serve all customers or only those consumers with minor need when α is large. To identify the optimal profit, we compare the profit when the expert serves all customers and only customers with minor need.

$\pi(p = c_s) > \pi\left(p = \frac{l_m+c_m}{2}\right) \iff \alpha > \alpha_3 = \frac{(c_m-2c_s+l_m)^2}{(c_m+l_m)^2-4c_ml_s+4c_s\triangle_l}$,
$\pi(p = c_s) > \pi(p = l_m - \frac{t}{1-\alpha}) \iff \alpha > \alpha_4 = \frac{tw_m+\triangle_c(c_s-l_m+\triangle_l)}{2(c_s-c_m)(l_s-l_m)} - \frac{\sqrt{4\triangle_c(t-\triangle_c)(t+c_s-l_m)\triangle_l+(tw_m+\triangle_c(c_s-l_m+\triangle_l))^2}}{2(c_s-c_m)(l_s-l_m)}$.

By the above comparison, we can obtain the optimal pooling price. □

Proof of Proposition 1.

The results can be readily obtained by comparing the profits for the expert by differential pricing and pooling pricing. We omit the details for brevity. □

Proof of Lemma 4.

Similar to that in the monopolistic setting, we first analyze the experts' servicing strategy for given demand and charges in the duopolistic setting. The chance of overcharging by expert k is $\beta_k = \frac{\alpha(l_s-p_{s,k})}{(1-\alpha)(p_{s,k}-l_m)}$. The consumer accepts an intense service recommendation with probability $r_k = \frac{p_{m,k}-c_m}{p_{s,k}-c_m}$. The customer prefer to visit expert 1 when $d \leq \hat{d}_1 = (1-\frac{\alpha\triangle_l}{p_{s,1}-l_m})\frac{l_m-p_{m,1}}{t}$, and expert 2 when $d \geq \hat{d}_2 = 1-(1-\frac{\alpha\triangle_l}{p_{s,1}-l_m})\frac{l_m-p_{m,1}}{t}$. When $\hat{d}_1 < \hat{d}_2$, the two experts behave like two monopolists, and the price is the same as that in the monopoly case.

When $\hat{d}_1 > \hat{d}_2$, the position of the consumer who is indifferent between visiting expert 1 and expert 2 must satisfy that $E\left(u_1\left(p, \hat{d}_k\right)\right) = E(u_2\left(p, \hat{d}_k\right))$. Substituting β_k, we can show that the demand to expert k is $\hat{d}_k = \frac{t-p_{m,k}+p_{m,3-k}+\frac{\alpha\triangle_l(l_m-p_{m,k})}{l_m-p_{s,k}}+\frac{\alpha\triangle_l(l_m-p_{m,3-k})}{p_{s,3-k}-l_m}}{2t}$. It can be easily verified that $\frac{\partial\hat{d}_k}{\partial p_{s,k}} = \frac{\alpha\triangle_l(l_m-p_{m,k})}{(l_m-p_{s,k})^2t} > 0$. Competition has no influence on the expert's decision on the charge for intense service. This is consistent with that in the monopolistic setting in that an increase in this charge enlarges demand but weakens the expert's incentive for overcharging. The optimal charges can be obtained as in the proof for Lemma 2. □

Proof of Lemma 5.

The profits for the experts under pooling pricing can be expressed as follows: $\pi_i = (p_i - E(c))Min\{\frac{E(l)-p_i}{t}, \frac{t-p_i+p_{3-i}}{2t}\}$ if $p \geq c_s$ and $\pi_i = (1-\alpha)(p_i-c_m)Min\{(1-\alpha)\frac{(l_m-p_i)}{t}, \frac{t-p_i+p_{3-i}}{2t}\}$ if $p < c_s$.

By the first-order conditions, we have:
$p_i = \begin{cases} \frac{E(l)+E(c)}{2} & t \geq t_1 \\ E(l) - \frac{t}{2} & t_{D2} \leq t < t_1 \\ t + E(c) & t < t_2 \end{cases}$ when $p_i \geq c_s$, and $p_i = \begin{cases} \frac{l_m+c_m}{2} & t \geq t_3 \\ l_m - \frac{t}{2(1-\alpha)} & t_4 \leq t < t_3 \\ \frac{t}{1-\alpha}+c_m & t < t_4 \end{cases}$ when $p_i < c_s$, where $t_1 = E(l)-E(c), t_2 = \frac{2(E(l)-E(c))}{3}, t_3 = (1-\alpha)(l_m-c_m)$ and $t_4 = \frac{2(1-\alpha)(l_m-c_m)}{3}$.

We then consider the restrictions imposed by $p_i \geq c_s$ and $p_i < c_s$.
$\frac{E(l)+E(c)}{2} > c_s \Leftrightarrow \alpha > \alpha_1 = \frac{2c_s-l_m-c_m}{\triangle_l+\triangle_c}, E(l) - \frac{t}{2} > c_s \Leftrightarrow \alpha > \alpha_2 = \frac{t+2(c_s-l_m)}{2\triangle_l}, t+E(c) > c_s \Leftrightarrow \alpha > \alpha_3 = 1-\frac{t}{c_s-c_m}$. $\frac{l_m+c_m}{2} < c_s, l_m - \frac{t}{2(1-\alpha)} < c_s$ and $\frac{t}{1-\alpha}+c_m < c_s$ always hold by our assumptions.

Like in a monopolistic setting, we compare the profits for the experts when they serve all customers and when they serve consumers with minor need as follows.

$\pi\left(p=c_s\right) > \pi(p = \frac{l_m+c_m}{2}) \Leftrightarrow \alpha > \alpha_4 = \frac{(c_m-2c_s+l_m)^2}{(c_m+l_m)^2-4c_ml_s+4c_s\triangle_l}$,

$\pi\left(p=c_s\right) > \pi(p = l_m - \frac{t}{2(1-\alpha)}) \Leftrightarrow \alpha > \alpha_5 = \frac{tw_m+2\triangle_c(c_s-l_m+\triangle_l)}{4(c_s-c_m)(l_s-l_m)} - \frac{\sqrt{4(t-2\triangle_c)\triangle_c(t+2c_s-2l_m)\triangle_l+(tw_m+2\triangle_c(c_s-l_m+\triangle_l))^2}}{4(c_s-c_m)(l_s-l_m)}$,

and $\pi\left(p=c_s\right) > \pi\left(p=\frac{t}{1-\alpha}+c_m\right) \Leftrightarrow \alpha > \alpha_6 = \frac{c_s-l_m+\triangle_l-\sqrt{(w_s^2+2t^2\triangle_l/\triangle_c)}}{2\triangle_l}$.

By the above comparisons, we can obtain the equilibrium service charges as shown in the statement. □

Proof of Proposition 2.

The results can be readily obtained by comparing the profits for the expert by adopting differential pricing and pooling pricing. We omit the details for brevity. □

Proof of Proposition 3.

In the presence of asymmetric costs in service provision by experts, the consumer's utility remains the same for given charges p. The demand to expert k is $\hat{d}_k$, as we derived in Proposition 2. Since $\frac{\partial \hat{d}_k}{\partial p_{s,k}} > 0$, the experts profit increases with the intense service charge p_s, so she will set $p_{s,k} = l_s$. By applying the first-order condition (FOC), we can obtain the optimal solution for the charge p_m for the minor service. The details are omitted for brevity. □

Proof of Proposition 4.

The proof for Proposition 4 is similar to that for Proposition 2, except that we need to prove that the demand to each expert increases with the charge for an intense service when consumers are generally distributed along the line. It is easy to see that the demands for expert 1 and expert 2 are $D_1 = F(\hat{d}_1)$ and $D_2 = 1 - F(\hat{d}_1)$. We can then show that $\frac{\partial D_1}{\partial p_{s,1}} = f\left(\hat{d}_1\right)\frac{\partial \hat{d}_1}{\partial p_{s,1}} > 0$ and $\frac{\partial D_2}{\partial p_{s,2}} = -f\left(\hat{d}_1\right)\frac{\partial \hat{d}_1}{\partial p_{s,2}} > 0$. We can then follow a procedure similar to that in the proof for proposition 2 to establish equilibrium outcomes. The details are omitted for brevity. □

Proof of Proposition 5.

We first analyze the tipping point for the consumer located at $d \in [\frac{k}{n}, \frac{k+1}{n}]$ to purchase from expert k. $E\left(u_k\left(p_k, d\right)\right) = E(u_{k+1}(p_{k+1}, d)) \Leftrightarrow \alpha l_s + \left(1-\alpha\right)l_m - \left(\alpha + \left(1-\alpha\right)\beta_k\right)p_{sk} - \left(1-\alpha\right)\left(1-\beta_k\right)p_{mk} - t\hat{d}_{kr} = \alpha l_s + \left(1-\alpha\right)l_m - \left(\alpha+\left(1-\alpha\right)\beta_{k+1}\right)p_{s,k+1} - \left(1-\alpha\right)\left(1-\beta_{k+1}\right)p_{m,k+1} - t(\frac{1}{n} - \hat{d}_{kr})$. Substituting $\beta = \frac{\alpha(l_s-p_{sk})}{(1-\alpha)(p_{sk}-l_m)}$, $\hat{d}_{kr} = \frac{\frac{t}{n}-p_{mk}+p_{m,k+1}+\frac{\alpha\triangle_l(l_m-p_{mk})}{l_m-p_{sk}}+\frac{\alpha\triangle_l(l_m-p_{m,k+1})}{p_{s,k+1}-l_m}}{2t}$. Note that when $k=n$, expert $k+1$ indicates expert 1.

Similarly, we analyze the consumer who is located at $d \in [\frac{k-1}{n}, \frac{k}{n}]$ and is indifferent between visiting the two adjacent experts, which is $\hat{d}_{kl} = \frac{\frac{t}{n}-p_{mk}+p_{m,k-1}+\frac{\alpha\triangle_l(l_m-p_{mk})}{l_m-p_{sk}}+\frac{\alpha\triangle_l(l_m-p_{m,k-1})}{p_{s,k-1}-l_m}}{2t}$. Note that when $k=1$, expert $k-1$ indicates expert n. The demand of expert k is $D_k = F(\hat{d}_k^n)$, where $\hat{d}_k^n = \hat{d}_{kr} + \hat{d}_{kl} = \frac{\frac{2t}{n}-2p_{mk}+p_{m,k-1}+p_{m,k+1}}{2t} + \frac{2\frac{\alpha\triangle_l(l_m-p_{mk})}{l_m-p_{sk}}+\frac{\alpha\triangle_l(l_m-p_{m,k-1})}{p_{s,k-1}-l_m}+\frac{\alpha\triangle_l(l_m-p_{m,k+1})}{p_{s,k+1}-l_m}}{2t}$.

It can be verified that the demand increases with the intense service charge $\frac{\partial D_k}{\partial p_{sk}} = f\left(\hat{d}_k^n\right)\frac{\partial \hat{d}_k^n}{\partial p_{sk}} > 0$. We can then follow a procedure that is similar to that in the proof for Proposition 4, by replacing $\hat{d}_1$by $\hat{d}_k^n$, to prove the proposition statement. The details are omitted for brevity. □

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Qijun QIU is an Assistant Professor in the School of Management Science and Engineering at the Nanjing University of Information Science & Technology. Prior to the current position, she was a faculty member in the Department of Decision Sciences at Macau University of Science and Technology. She obtained a PhD degree in Logistics and Supply Chain Management from the School of Business at the University of Hong Kong in 2016. Her current research interests include consumer behavior modeling, behavioral operations management, and supply chain management. Her works have appeared in major operations research journals including Naval Research Logistics, Operations Research Letters, Journal of Systems Science and Systems Engineering and Asia-Pacific Journal of Operational Research.

Li JIANG is a Professor in the Department of Logistics and Maritime Studies at The Hong

Kong Polytechnic University. He obtained PhD degree in Operations and Management Science from the Stephen M. Ross School of Business at the University of Michigan. His major teaching and research interests are operations and supply chain management.