ABSTRACT

We investigate the optimal online channel adoption strategy of a high-quality expert in the presence of a potential entry by an online expert. We find that the high-quality expert does not have the incentive to adopt the online channel unless new entry is imminent. If the incumbent high-quality expert cannot offer a sufficiently high quality online service, the expert accommodates entry and provides only a face-to-face service. However, a satisfactory level of online quality allows the incumbent expert to deter entry and to limit what would otherwise be a more intense competition. The paper thus establishes an entry deterrence role for the adoption of the online channel in expert markets. In addition, the results partially explain the reasons behind the quick adoption of the online channel in tax preparation services and physicians’ reluctance to offer online consultations.

Key words: Expert services, competition, Internet, online channel, entry deterrence
INTRODUCTION

The Internet has emerged as an alternative channel for experts to market their expertise. Using advanced application interfaces and live telecommunication tools, content experts can interactively diagnose customer problems and identify solutions that generate revenue. For example, H&R Block, the largest U.S. tax preparer, currently charges $74.95 online for full-service tax preparation with one free tax advice session with a real tax professional. In the health care industry, several online consultation services have been introduced lately and are gaining consumer acceptance as a source of both first and second opinions. For example, doctors at the popular site Ask a Doctor Now provide consultations on a variety of medical issues and charge typically between $2 to $3 per minute. EasyHealthMD offers monthly and pay-as-you-go virtual consultation plans for non-emergent cases to individuals, families, and businesses. Legalzoom.com provides an easy-to-use and affordable online service that helps its customers create their own legal documents, such as wills and trusts. At geeksquad.com, computer experts fix computer problems online for half the offline fee ($49.99 vs. $99.99).

While these are encouraging developments in terms of the accessibility various kinds of expert services, many experts have still not come online as of yet. In fact, expert service providers have typically lagged other sectors of the economy in adopting the Internet as a new channel of service delivery. As the Internet infrastructure, applications and business models mature, however, many experts across a variety of service classes are now inevitably asking the same kind of questions about whether and when to venture into the online domain that early adopters of the Internet in other sectors did. Arguably, these questions are especially pressing for the experts who are top-notch in their respective fields, as the stakes for them are much higher
than for others. This study is an attempt to provide insights and guidance regarding what should drive their decisions.

In this paper, we examine when a high-quality expert should introduce an online channel to deliver, for example, investment advice, tax-preparation help, or health consultation. Because of the special nature of expert services, the sophistication of technology frequently plays a vital role in facilitating (or hindering) their delivery and therefore is a key feature of the analysis. We use a stylized game theoretic model in which there are two incumbent offline experts. Customers need expert advice for a satisfactory solution to their problems. Obtaining a satisfactory solution may require purchasing different alternatives [13, 17], searching for a match [8], or seeking second opinions [35]. Customers obtain a common value if they are satisfied with the service they receive; a non-satisfactory service has no value. Our analysis applies only to situations where the stakes (i.e., reservation prices) are sufficiently high for consumers such that they are willing to seek additional, higher quality services until a satisfactory solution is obtained.

Our analysis focuses on services that satisfy the following conditions: (i) customers may be dissatisfied with a specific service in which case they seek the services of another provider, (ii) customers pay a fee each time they receive a service, (iii) similar versions of the service can be delivered with reasonable levels of effectiveness both offline and online, and (iv) the online version of the service is typically of equal or lower quality than the offline version. Among others, services such as routine consultations with a doctor, preparation of simple legal documents, tax advice, and computer maintenance satisfy all of these conditions. However, medical consultations that require a physical checkup as well as emergency cases are beyond the

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1 Consumers may pay multiple times for tax advice on the same year’s return. For example, H&R Block looks at previous years’ returns to see if the taxpayer missed any refund opportunities (see www.hrblock.com/offices/tax-services-second-look-review.html).
scope of this paper, and so are legal services that require a meaningful face-to-face interaction with a lawyer.

In our model, there are two traditional experts with a brick-and-mortar presence. These traditional experts are differentiated with respect to their location in the market and the probability by which their service leads to a successful outcome, which we call quality. The high-quality expert always satisfies the customer, whereas the low-quality expert may not always be able to provide a satisfactory service. We assume that there is equal probability that the low-quality expert will provide a satisfactory solution or an unsatisfactory one. In addition to these incumbent firms, an expert with just an online presence can enter the market, and the high-quality incumbent expert may anticipate such an entry. The quality of the online service is potentially lower than the offline one due to a lack of face-to-face interaction and technological constraints. We focus on the pure strategy equilibrium where experts set prices to maximize profits while customers maximize expected surpluses. We examine the conditions under which a high-quality traditional expert will augment its offline channel by offering an online version of its services.

The results reveal several interesting insights on the market for expert services. First, consistent with practice but different from extant literature on product markets, we find that high-quality service providers will obtain a lower market share than low-quality providers. In particular, most consumers will visit a low-quality provider first and visit a high-quality one only upon an unsatisfactory outcome. The incumbent high-quality expert will introduce online services if its quality is sufficiently high. Interestingly, we also find that the high-quality expert adopts the Internet only to deter entry. Thus, our results suggest that experts may introduce online channels mainly as a defensive measure. When the high-quality expert adopts the online
channel in addition to its face-to-face channel, customers benefit from an increase in the number of alternatives and seek multiple services more, thereby increasing the overall market demand. However, experts’ prices drop due to the limited differentiation among their services and the intensified competition. In the presence of a threat of entry and when the online service quality is relatively poor (e.g., due to the limitations of information technology), the high-quality expert accommodates entry and provides only a face-to-face service. On the other hand, a sufficiently high level of online service quality creates significant strategic advantages for the high-quality expert. Adopting the Internet in this case allows the expert to deter entry and limit what would otherwise be a more intense competition.

The above results help explain why online delivery of expert services lags in the health care industry where barriers to entry are high and online service quality is relatively low, and why incumbents have quickly adopted the Internet in tax return business where barriers to entry are low and online service quality is comparable to the offline counterpart. A corollary of our results is that in certain markets further technological advances may be required to achieve a critical threshold level of online service quality for incumbent experts to adopt online consultations. However, once entry is deterred, improving the quality of the online service further would cannibalize the face-to-face service and reduce profits. Therefore, the relationship between online service quality and provider profit resembles an inverted U.

**LITERATURE REVIEW**

Although both services and their online delivery represent an ever increasing percent of the B2C economy, online service delivery has its own challenges [25], and there has been only a limited
focus on the profitability of adopting online channels especially in the case of service-intensive businesses and expert markets.

Expert services exhibit different characteristics compared to other traditional branded offerings. Many of these services fall under the category of private information goods. Information systems researchers have previously examined public information goods (such as software, music, and movies) which require a significant sunk cost to produce but only a negligible cost to reproduce [1, 6, 11]. In contrast, a private information good is typically procured for a specific consumer, with the intent of diagnosing a problem and then suggesting a service to eliminate the problem when necessary. Accordingly, private information goods do not exhibit the cost structure that characterizes public information goods.

One branch of economics literature extensively analyzes the intricacies associated with expert services. This literature primarily focuses on the information asymmetries in expert markets and effective mechanisms to resolve these asymmetries. For example, the consumer may not observe the quality of a service, which may allow the expert to defraud the consumer by misrepresenting a low-cost service as if it were a costly one [33, 43]. Wolinsky [43] shows how information asymmetries and consumer search for multiple opinions can give rise to an equilibrium in which some experts specialize in different levels of service. This specialization eliminates the possibility of fraud that the experts may engage in, as the consumers do not observe the actual service quality. Another potential issue is that consumers may observe the actual service quality, but they may not judge whether the costly service was indeed needed [9, 14, 15, 38]. In addition, the diagnostic effort and the success of the expert in providing the service may not be observable or verifiable [32]. We abstract away the issues of fraud [4, 30, 31, 35]. The availability of the Internet and information-intensive channels, customer interactions
and networking sites, and online reputation systems alleviate such concerns [34] to some extent. In contrast, our focus is on quality and channel choices when the experts are both horizontally and vertically differentiated.

The adoption of the online channel may improve a firm’s competitiveness in the long run and raise its market standing by fending off competitors (e.g., see [5]). Thus, our work is also related to previous research on entry deterrence [12, 37]. Experts can prevent entry by increasing their product lines [36]. Entry deterrence may also increase market share and prices [21, 24] and brand loyalty [22]. Fixed costs, developing loyal clienteles can also work as entry deterrence mechanisms [41]. We contribute to this literature by demonstrating that experts can also use new channels as an entry deterrence mechanism. Finally, our work is related, albeit tangentially, to studies that investigate the effect of branded variants [10, 19], advertising, and R&D [20] on competition.

In a recent empirical study on the banking sector, Campbell and Frei [5] find that the adoption of online banking is associated with an increase in total transaction volume, a decrease in short-term customer profitability, and an increase in long-term customer retention. We believe that a similar investigation (both analytical and empirical) is warranted in the market for expert services. In this context, similar to Campbell and Frei [5], the adoption of the Internet as a new service channel leads to an increase in the utilization of expert services in our setting. Our research provides additional testable hypotheses that can be investigated by future empirical research.

The rest of the paper proceeds as follows. In the next section, we consider a duopoly market where there is no threat of entry. This model represents situations where government regulation, high fixed costs, and other entry barriers render any entry unprofitable. We first
analyze the optimal prices and the high-quality expert’s channel strategy in this market. Next, we develop an extended model that allows entry by an online expert. We summarize and conclude in the last section.

THE MARKET WITH NO ENTRY THREAT

The Base Model

Following the tradition of past information systems research [10, 39, 42], consider a spatially differentiated market. Two experts with brick-and-mortar presences are located at the opposite ends of a Hotelling line with range (0,1). Let the expert E₀ be located at zero and E₁ be located at one. The customers are uniformly located in between the experts, and the location of a customer identifies the customer. Customers incur transportation costs when visiting experts. Transportation costs may include the cost of time, travel, and inconvenience of waiting. Each customer can visit either (or both) of the experts by incurring a transportation cost \( t_x \), where \( x \) is the distance of the customer from the expert that she visits. In addition to the customer’s location, the transportation cost of visiting an expert depends on a sensitivity parameter \( t \). A higher \( t \) implies that customers are willing to pay more for the ideally located expert. In other words, as transportation cost sensitivity increases, the experts become more differentiated based on their physical location.

Experts are further differentiated based on their level of expertise, which we call quality. The quality defines the probability of obtaining a satisfactory outcome with an expert. For example, a customer who visits a tax professional for advice may either find her questions or concerns being addressed or be unhappy with the service level. While it is impossible for consumers to evaluate an expert’s quality precisely, certain indications can allow them to
estimate the level of that quality. Prior education, experience, word-of-mouth, established brand, size and longevity of business can all serve as such indications.

Let $E_1$ and $E_0$ represent a high-quality and a low-quality expert, respectively. A visit to the high-quality expert $E_1$ guarantees a satisfactory outcome, whereas there is a random (fifty percent) chance of obtaining a satisfactory outcome with the low-quality expert $E_0$. In case of an unsatisfactory outcome with an expert, the customer considers visiting a second expert with a higher service quality, since revisiting the same expert would not change the outcome. A customer who receives a satisfactory outcome receives a surplus given by:

$$CS_k(x_k; \text{satisfied}) = r - tx_k - p_k,$$

where $r$ is the common reservation value, $p_k$ is the price and $x_k$ is the distance to expert $E_k$, $k \in \{0, 1\}$. In the case of an unsatisfactory outcome, the customer receives no value from the service but still incurs the transportation cost and pays the price. We assume the reservation price is sufficiently high (i.e., $r$ is greater than the threshold $r$) to warrant seeking multiple services. Thus, unlike the traditional models, total demand is not fixed in our framework and depends on the experts’ prices and offerings.4

Customers choose the experts in order to maximize expected surplus. Consider a customer who is located at $y$. One of her alternatives is to visit the low-quality expert $E_0$. Upon an unsatisfactory outcome, the customer visits the high-quality expert $E_1$. We represent this decision by $(0, 1)$. The numbers in the parenthesis represent the customer decision for the

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2 Note that this probability reflects the maximum level of uncertainty for the customers.

3 A sufficiently high reservation price ensures that the customers do not quit after an unsatisfactory visit to a low quality expert and continue to seek service. See the solution in the Appendix for the specific expression of the threshold reservation price.

4 Note that in a duopoly with spatial differentiation the market size is fixed in traditional Hotelling models when the market is covered. The endogeneity of second visits in our framework changes the overall demand.
alternatives and their respective orders; the first visit is represented by 0 which stands for E₀, and the second visit is represented by 1 which stands for E₁. This decision provides an expected surplus of \( r - p_0 - ty - 0.5[p_1 + t(1 - y)] \). Alternatively, the customer may visit the high-quality expert first, which is denoted by the decision \( 1 \). Let \( y_{(1)}^{(0,1)} \) denote the location of the customer who is indifferent between decisions \( 0, 1 \) and \( 1 \). Then,

\[
r - p_0 - ty_{(1)}^{(0,1)} - 0.5[p_1 + t(1 - y_{(1)}^{(0,1)})] = r - p_1 - t(1 - y_{(1)}^{(0,1)}) ,
\]

and we obtain

\[
y_{(1)}^{(0,1)} = \frac{(p_1 - 2p_0 + t)}{3t} .
\]

The demand for the low-quality expert \( d_0 \) equals \( y_{(1)}^{(0,1)} \). The demand for the high-quality expert \( d_1 \) equals \( 1 - 0.5y_{(1)}^{(0,1)} \). The high-quality expert provides an initial service to \( 1 - y_{(1)}^{(0,1)} \) customers and also serves \( 0.5y_{(1)}^{(0,1)} \) customers who do not get a satisfactory service from the low-quality expert. Note that, unlike traditional models based on the Hotelling framework, total market size in the current model is greater than one and equals \( 1 + 0.5y_{(1)}^{(0,1)} \) because of multiple visits.

While the experts know the overall customer distribution, they cannot perfectly discriminate among customers. The profit of expert \( E_k \) is therefore given by:

\[
\Pi_k = d_k(p_k - c_k) ,
\]

where \( k \in \{0, 1\} \), and \( c_1 \) and \( c_0 \) represent the costs associated with high and low quality experts. We let \( c_1 > c_0 \geq 0 \). For expositional ease, we normalize \( c_0 \) to 0. In order to consider cases in
which market is fully covered, we assume that \( \tilde{c}_1 < 1 \), where \( \tilde{c}_1 \) denotes \( c_1 / t \). Both experts set their prices simultaneously to maximize their profits.

**Proposition 1.** The high-quality expert charges a higher price and obtains a smaller share of the market than the low-quality expert.

The solution details and the proof of Proposition 1 are provided in the Appendix.

Simultaneous maximization of profit equations (Equation 3) result in the equilibrium solution. The equilibrium prices for the low-quality and high-quality experts are \((7t + 2c_1) / 6\) and \((11t + 2c_1) / 3\), respectively. As expected, the high-quality expert charges a higher price but obtains a smaller market share than the low-quality expert. We find that the demands for the low-quality and high-quality experts equal \(7 / 9 + \tilde{c}_1 / 9\) and \(11 / 18 - \tilde{c}_1 / 18\), respectively.

Note that the demand for the low quality expert is always greater than \(7 / 9\). Thus, most of the customers \((7 / 9)\) prefer to visit the low-quality expert first. We should note that if second visits were not allowed, the results would change dramatically. The demand for the low-quality expert would be zero when \(r > 6t + 2c_1\) and between zero and \(1 / 3 + \tilde{c}_1 / 9\) when \(r < 6t + 2c_1\) at the optimum. That is, the market share of the low-quality expert would never exceed \(4 / 9\). When second visits are allowed, the increased demand due to multiple visits helps the experts to better extract customer surplus and maximize profits. The equilibrium solutions are provided in Table 1. The optimal solution for the base model is given in Column I, Table 1.

**The Base Model with the Online Channel**

Now, consider the case where the high-quality expert \(E_1\) may adopt the online channel in addition to its face-to-face channel. For simplicity, we normalize the cost of setting up a Web
site to zero. This assumption can be easily relaxed without changing the qualitative nature of the results. The lack of face-to-face interaction during an online visit is likely to reduce the probability of a satisfactory outcome. Let $\gamma$ represent the high-quality expert’s probability of satisfying customers online, where $0.5 < \gamma < \overline{\gamma} < 1$. Despite the sophistication of today’s telecommunication tools, it is typically difficult, if not impossible, to replicate the physical interaction that characterizes face-to-face consultations. In certain cases (e.g., health care), the lack of physical interaction can be problematic, but in other cases (e.g., tax advice) it may not be so. Cho [7] argue that online channels provide significant hurdles in communication vis-à-vis face-to-face channels for some experts. Regardless of the context, however, whatever an expert can accomplish from a distance, he can do the same and likely more face-to-face.

The online customers incur a fixed transaction cost (denoted by $\mu$) that includes setting up the equipment (e.g., computer), logging on to the expert interface, learning to use the specific online interactive tools as well as time spent while filling out the forms and executing commands. Cognitive costs due to Web site delay, poor style, errors, incompleteness and other factors may also contribute to the online transaction cost [16, 18]. Note that increases in $\mu$ renders the online channel less attractive. On the other hand, as $t$ increases, the online channel becomes more attractive (relative to the online channel) since consumers incur relatively lower costs when using the online channel. The ratio $\mu/t$, which we denote with $\tilde{\mu}$, represents the relative attractiveness of the traditional channel for consumers, since the traditional channel becomes more favorable as $\tilde{\mu}$ increases. We assume a positive market share for the high-quality expert’s online service ($\tilde{\mu} < \mu$) and face-to-face service ($\mu < \tilde{\mu}$).
Let $p_i$ and $p_{ii}$ represent the face-to-face and online prices of the expert, respectively. A customer located closer to the low-quality expert $E_0$ may prefer to visit this expert first. Upon an unsatisfactory outcome, the customer visits the high-quality expert online and then face-to-face. This decision sequence is denoted by $(0,1,1)$, where $0$ represents the first visit to the low-quality expert $E_0$, $1$ represents the second visit to the high-quality expert $E_1$ online, and $1$ represents the third visit to $E_1$ face-to-face. Alternatively, the customer may follow the decision $(1i,1)$. The location of the customer indifferent between following decisions $(0,1,1)$ and $(1i,1)$ is given by $y_{(0i,1)}^{(0,1,1)}$, where

$$y_{(0i,1)}^{(0,1,1)} = \frac{p_1 + p_{ii} + t + \mu - 2p_0 - \gamma (p_1 + t)}{t(3 - \gamma)}.$$  (4)

In a similar fashion, the location of the customer who is indifferent between going online first $(1i,1)$ and directly visiting $E_1$ face-to-face $(1)$ is given by $y_{(1i,1)}^{(1i,1)}$, where

$$y_{(1i,1)}^{(1i,1)} = \frac{\gamma (p_1 + t) - \mu - p_{ii}}{\gamma t}.$$  (5)

Given this setup, the demand for $E_0$ is $d_0 = y_{(0i,1)}^{(0,1,1)}$. The low-quality expert’s profit is

$$\Pi_0 = d_0p_0.$$  (6)

The high-quality expert’s profit equals

$$\Pi_1 = d_{ii}p_{ii} + d_1(p_1 - e_1),$$  (7)

---

5 Given $0.5 < \gamma$, visiting $E_0$ after visiting $E_1$ online is always dominated by visiting $E_1$ offline from the perspective of the customer, and thus $(1i,0,1)$ cannot be an optimal consumption path. The intuition is that, the customer always finds it optimal to seek a higher quality service after an unsuccessful service outcome.
where $d_{1i} = y_{(i1)}^{(1i, 1)} - 0.5y_{(i1)}^{(0, 1i, 1)}$ and $d_{4i} = 1 - y_{(i1)}^{(1i, 1)} + (1 - \gamma)d_{4i}$. The term $d_{1i}p_{ii}$ in the high-quality expert’s profit function in Equation (7) represents the contribution of the online channel.

A portion of $y_{(i1)}^{(1i, 1)} - y_{(i1)}^{(0, 1i, 1)}$ customers prefer to visit online channel first, while $0.5y_{(i1)}^{(0, 1i, 1)}$ of them obtain an unsatisfactory outcome upon visiting the low-quality expert and then visit the high-quality expert online, and $1 - y_{(i1)}^{(1i, 1)}$ customers directly visit the high-quality expert face-to-face. As expected, some customers do not get a satisfactory outcome with the high-quality expert’s online service and visit the expert face-to-face. Both experts maximize their profits and set their prices simultaneously. The equilibrium solution of this case is given in Column II, Table 1; see the Appendix for details.

We find that the high-quality expert’s profit is higher when the high quality serves only face to face than when it also serves online. That is, $\Pi_1^*$ in Column I (No Online) of Table 1 is higher than $\Pi_1^*$ in Column II (Online by E1). This leads to our next proposition.

**Proposition 2.** *The high-quality expert does not adopt the online channel in the absence of an entry threat.*

This is potentially an interesting result that is peculiar to expert markets. The intuition is that, the negative effect of (i) lower service quality online and (ii) increased competition with the other incumbent expert for first visits dominates the positive effect of increased market reach of the Internet. This is partially due to a peculiar characteristic of expert markets. Sarvary [35] explains why competing information sellers, under certain conditions, prefer to sell only first or second opinions. He shows that, rather than competing directly to sell first opinions, the experts can split the business through temporal differentiation and thereby alleviate competition in the
market in a way that would improve the profitability of all firms. In our context, because the adoption of the Internet expands the reach of the high-quality expert, it inevitably intensifies the competition between the two incumbents for first visits, and this both limits temporal differentiation and leads to a drop in prices, which drag down the profits. Consequently, the high-quality expert is better off not serving online.

THE MARKET WITH THREAT OF ENTRY

The Extended Model

We have so far considered a market characterized by two experts. In this section, a third expert with an online offering considers entry. We assume that the quality of the online expert is the same as that of the low-quality expert. Thus, we look at the case where the entrant mainly competes with the low-quality expert, although our results do not depend on this assumption.

We consider a three stage game that is played as follows. In the first stage, the high-quality expert announces whether it will offer online services. In the second stage, the online expert decides whether to enter the market. If entry occurs, experts play a triopoly game and set their prices simultaneously. Otherwise, only the high and low-quality experts compete in the market. In the last stage, customers make their decisions and pay the corresponding prices for the services they receive. We solve for subgame perfect equilibrium.

First, consider the post entry case with three experts where the high-quality expert only provides a face-to-face service. Upon entry, customers who are located farther away from both E_0 and E_1 prefer to first visit the online expert E_i. Note that, since both the low-quality incumbent and the online entrant have the same service quality, an unsatisfactory outcome with either of them leads a customer to visit the high-quality incumbent. Let \( p_i \) denote the price
charged by the online expert and $y_{i,1}^{(0,1)}$ denote the customer who is indifferent between visiting
the low-quality expert first $(0,1)$ and visiting the online expert first $(i,1)$. The index $i$
represents the visit to the online entrant. We find:

$$y_{i,1}^{(0,1)} = \frac{p_i + \mu - p_0}{t},$$

(8)

Similarly, let $y_{i,1}^{(i,1)}$ denote the customer who is indifferent between visiting the online expert
first and visiting the high-quality expert face-to-face first. Then,

$$y_{i,1}^{(i,1)} = \frac{p_i - 2p_i - 2\mu + t}{t}.$$  (9)

The entrant incurs an entry cost $F$, a positive number sufficiently small that it doesn’t preclude
entry altogether. The online expert’s profit equals

$$\Pi_i = d_i p_i - F,$$

(10)

where $d_i = y_{i,1}^{(1)} - y_{i,1}^{(i,1)}$. The profits of expert $E_0$ and $E_1$ equal

$$\Pi_0 = d_0 p_0,$$

(11)

$$\Pi_1 = d_1 (p_1 - c_1),$$

(12)

where $d_0 = y_{i,1}^{(0,1)}$ and $d_1 = 1 - 0.5y_{i,1}^{(i,1)}$. The optimal solution is given in Column III, Table 1;
the solution details are provided in the Appendix.

Next, consider the case where the online expert enters the market while the high-quality
expert also offers an online service. Following a similar methodology as before, we find three
indifferent customer locations at \( y^{(0,1,1)}_{(i,ii,1)} \), \( y^{(i,1,1)}_{(i,ii,1)} \) and \( y^{(1,1)}_{(i)} \). The superscript \( (0,1,1) \) represents the consumption path of visiting the low-quality expert first, and on unsatisfactory outcomes, visiting the high-quality expert online and then face-to-face. The profit of the online expert equals:

\[
\Pi_i = d_i p_i ,
\]

where \( d_i = y^{(i,1,1)}_{(i,ii,1)} - y^{(0,1,1)}_{(i,ii,1)} \). The profit of the low-quality expert equals:

\[
\Pi_0 = d_0 p_0 ,
\]

where \( d_0 = y^{(0,1,1)}_{(i,ii,1)} \). The profit of the high-quality expert equals

\[
\Pi_1 = d_{1i} p_{1i} + d_i (p_i - c_i) ,
\]

where \( d_{1i} = y^{(1,1)}_{(i)} - y^{(i,1,1)}_{(i,ii,1)} + 0.5y^{(i,1,1)}_{(i,ii,1)} \), \( d_i = 1 - y^{(1,1)}_{(i)} + (1 - \gamma) d_{1i} \). The optimal solution is given in Column IV, Table 1. The details are in the Appendix.

The Solution and Analysis

In deciding whether to adopt the online channel, the high-quality expert takes into account the response of the online expert. First, consider the accommodation strategy. We find that the high-quality expert makes a higher profit when offering only a face-to-face service compared to offering both online and face-to-face services (\( \Pi_1^* \) in Column III of Table 1 is higher than \( \Pi_1^* \) in Column IV). Then, the optimal strategy for the high quality expert calls for providing a face-to-face service only. By not offering an online service as part of the accommodation strategy, the
high-quality expert benefits from a superior differentiation and the ability to charge a higher price. With a face-to-face service only, the profit is maximized although the demand is limited. Accommodation can only be profitable when the entry cannot be profitably deterred. For entry deterrence to be optimal, two conditions should be satisfied: (1) the profit ($\Pi_i^*$) while offering the online service (Column II, Table 1) should be greater than the profit ($\Pi_i^*$) when the Internet is left to the online expert (Column III, Table 1), and (2) the online expert’s profit ($\Pi_i^*$) upon entry should be negative or zero when it enters (Column IV, Table 1). A quick check reveals that $\Pi_i^*$ in Column II of Table 1 is always greater than $\Pi_i^*$ in Column III. Therefore, for entry deterrence to work, the only condition is that the online expert should not claim any positive profit when the high-quality expert serves online (i.e., $\Pi_i^*$ in Column IV should be negative). This condition is satisfied if

$$\Pi_i^* = \frac{(3 - \gamma) p_i^{*2}}{(1 - \gamma) t} - F < 0,$$

(16)

where

$$p_i^* = \frac{3(1 - \gamma) + (\bar{c}_i - 2\bar{\mu}) - (\bar{c}_i - \bar{\mu})\gamma}{3(3 - \gamma)},$$

(see Column IV in Table 1). We will only consider the case where the fixed cost of entry is neither too high nor too low. As the online quality $\gamma$ increases, the price of the online expert drops, and the condition in Equation (16) holds. However, as $\gamma$ decreases, $\Pi_i^*$ becomes positive and the high-quality expert accommodates the online expert. See the Appendix for the proof of Proposition 3.

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6 When $F$ is too low, entry always occurs; when $F$ is too high entry never occurs.
Proposition 3. The high-quality expert accommodates the entry of the online expert if the online quality is below a threshold. The equilibrium accommodation strategy calls for the high-quality expert to use only face-to-face channel.

Figure 1 illustrates the parameter values for which the accommodation strategy is optimal. The solution is valid in the parameter space that lies within the scaffold outlined by ABCDEFGH. When both the entrant and the high-quality expert offer online services, the parameters should lie (i) below the plane ABCD \( (p^*_i > 0) \) in order for the entrant to have a positive market share and (ii) above the plane EFGH \( (\frac{y_{(11,1)}^{(i,1)}}{y_{(1,1)}^{(i,1)}} > 0) \) to guarantee a positive online market share for the high-quality expert. The parameter space above the plane CDEF \( (\frac{y_{(11,1)}^{(i,1)}}{y_{(1,1)}^{(i,1)}} > 0) \) ensures that there exists a positive demand for the high-quality expert when it offers an online service. The parameters space below the plane ABGH \( (1 - y_{(1)}^{(i,1)} > 0) \) ensures that there exists a positive demand for first time face-to-face visits when only the entrant offers the online service.

The plane abcd represents the set of parameters that satisfy \( H(\gamma) = \tilde{\mu} \), where \( H(\cdot) \) is a decreasing function of \( \gamma \). The accommodation condition is satisfied below the plane abcd \( (H(\gamma) > \tilde{\mu}) \). The entry is successfully deterred above abcd. Entry is accommodated inside the space bounded by the planes abcd and EFGH, and only the entrant offers online services.

Consistent with our results, experts in the health care and law industries have largely chosen not to offer their services online. In the health care industry, very few physicians actually provide consultations online, and the online firms such as easyhealthmd.com that fill the vacuum provide only a small set of services compared with what is available offline. In the law industry,
online consultations can hardly be found, if at all. The notable exception is the recently successful online firm legalzoom.com which specializes in the preparation of basic legal documents such as wills and trusts. In both sectors, the traditional customer-expert encounter involves a rich information exchange through physical interaction that is simply too hard to replicate using information technology from a distance. In our model, this corresponds to a low $\gamma$ value that leads to the outcome presented in Proposition 3.

[Insert Figure 1 here.]

**Proposition 4.** *In the accommodation equilibrium, the total market size increases as the relative attractiveness of traditional channel ($\bar{\mu}$) decreases. Compared to the low-quality expert, the online expert charges a lower price; it also obtains a higher profit when $\bar{\mu} < 0.45 + 0.15c_1$.***

The proof is provided in the Appendix. The first part of the proposition shows that online entry increases the total market in situations where consumers incur lower costs for using the online channel ($\bar{\mu}$). We see that a decrease in $\bar{\mu}$ results in a lower demand for the traditional experts and a higher demand for the online expert. However, since the overall market demand rises as $\bar{\mu}$ decreases, the increase in the online expert’s demand outweighs the loss of demand to the traditional experts. The second part of the proposition shows that, for moderate values of $\bar{\mu}$, the online entrant charges a lower price and yet makes a higher profit than the traditional expert. It is interesting to note that in this case, the online entrant charges a lower price despite having the same level of quality as the low-quality incumbent expert. However, as the online channel becomes more attractive in terms of lower transaction costs, the online entrant charges a higher price than the low-quality incumbent and still makes a higher profit.
The above result suggests that recent advances in information technology may increase the threat of online entry as customers find the Internet more convenient. Interestingly, entry may also expand the size of the market. The possibility of multiple visits and availability of additional experts increase the number of customers who seek additional expert services while providing a downward pressure on traditional experts’ prices. Still, online experts may enjoy higher profits with lower prices compared to their brick-and-mortar competitors.

As the high-quality expert’s online quality increases beyond a critical level such that $H(\gamma) < \tilde{\mu}$, the high-quality expert adopts the online channel. The entry deterrence equilibrium outcomes are given in Column II, Table 1. By deterring entry, the high-quality expert increases both its price and overall demand compared to those in the accommodation equilibrium. With the entry deterrence strategy, the high-quality expert discounts its face-to-face price (see $p_i^*$ in Column II, Table 1) with respect to its online price (see $p_{iu}^*$ in Column II, Table 1). Recall that the expert uses only the face-to-face channel when accommodating entry. Even the high-quality expert’s discounted online price in the entry deterrence equilibrium is higher than its face-to-face price in the accommodation equilibrium, yet the expert still enjoys higher demand because of the limited competition. This leads to our next proposition.

**Proposition 5.** When the online quality is sufficiently high such that $\tilde{\mu} > H(\gamma)$, the high-quality expert adopts the online channel to deter entry and limit competition. The high-quality expert charges a higher price and serves more customers compared to the accommodation strategy.

Figure 1 illustrates the set of parameter values where the entry deterrence strategy is optimal. Between the planes LMNOP and ABCD, the high-quality expert adopts the online
channel and deters entry while increasing its profit. While its profit when deterring entry is less than its profit in the benchmark (no-threat-of-entry) case, it is more than the profit in the accommodation equilibrium. In other words, while the Internet lowers the profitability of the high-quality expert in the absence of an entry threat, it may potentially improve profitability in the presence of it. Note that the high-quality expert is more likely to adopt the online channel as the difference between the marginal costs for online and offline visits increases (i.e., when the online channel is more cost-effective for the incumbent expert with respect to the offline channel).

In contrast to, say, examining a medical ailment from a distance, sorting out and fixing computer issues can be handled much more easily with today’s telecommunication tools and remote desktop applications. Computer experts can remotely take control of customers’ hardware and run diagnostic tools to understand and fix the issues that their customers are having. The lack of a physical interaction with the customer poses virtually no problem to the resolution of the customer’s issue. Similarly, most tax preparation questions can be appropriately addressed without a physical interaction with a real tax professional using a combination of Web technology and decision support systems. Thus, it is no coincidence that major service providers of computing support (e.g., Geek Squad) and tax preparation (e.g., H&R Block) in the offline world are also very active in the online world, in line with Proposition 5.

Proposition 6 outlines the comparative statics results for the entry deterrence equilibrium. The proof is available in the Appendix.

**Proposition 6.** In the entry deterrence equilibrium, the prices and profits of the incumbent experts \((E_0 \text{ and } E_1)\) increase with \(t\). The price and profit of the low-quality incumbent \((E_0)\)
increase with $\mu$. As the online quality $\gamma$ increases, the high-quality expert’s online price increases while its face-to-face price and overall profit decrease.

The increased transportation cost has two opposing effects on the expert’s profit. First, it increases the location differentiation and helps the expert to charge higher prices (positive effect). Second, it increases the opportunity for online profits (negative effect). Overall, as the transportation cost increases, the positive effect dominates the negative effect, and thus the high-quality expert increases its profit. In contrast, an increase in the online transaction cost $\mu$ benefits the low-quality incumbent. Some of the customers who are close to the low-quality expert prefer to use the high quality expert’s online service as it charges a price lower than that of the low-quality expert, and the low-quality expert benefits from a higher online transaction cost that its competitor’s customers incur when receiving the online service.

We find that the quality of the online service ($\gamma$) has two opposing effects on the high-quality expert’s profit in the entry deterrence equilibrium. On one hand, a high online quality benefits the expert as it differentiates itself from the low-quality expert and allows the expert to charge a high online price. On the other hand, a high quality online service cannibalizes the expert’s offline service and reduces its profit potential because of the necessity to charge a lower price online than offline. Interestingly, the negative cannibalization effect dominates the positive service differentiation effect, and the high-quality expert’s profit decreases as the online quality increases. In other words, as long as the online service of the high-quality expert exhibit a sufficient quality level to deter entry, increasing quality beyond this level decreases the high-quality expert’s profit. While a low online quality is detrimental in that it renders entry deterrence strategy ineffective, a high online quality can also be harmful as it leads to the
cannibalization of the face-to-face service. Our next and final proposition compares the equilibrium outcomes of the basic and extended models.

**Proposition 7.** Compared to the benchmark (no-threat-of-entry) case, the high-quality expert serves fewer customers and charges a lower price in the accommodation equilibrium. Compared to the benchmark case, the expert charges a lower face-to-face price and an even lower online price (than the face-to-face price), and serves more customers in the entry deterrence equilibrium.

A comparison between the accommodation equilibrium and the benchmark case reveals that the high-quality expert charges a lower price and serves fewer customers upon entry. Intuitively, entry results in increased competition, which leads to reduced prices and demand for the high-quality expert. We also find that the high-quality expert charges a lower face-to-face price and faces a higher demand in the entry deterrence equilibrium case than in the benchmark case.

**DISCUSSION AND CONCLUSIONS**

We model the competition of quality-differentiated experts in a multi-channel setting and analyze how the online channel affects expert strategies. We find that, in contrast to models for traditional goods, in a market for expert services a high-quality expert charges a higher price but obtains a lower market share than the low-quality expert. In the absence of a threat of entry, an incumbent high-quality expert does not have an incentive to adopt the Internet as a new service channel. However, the expert would adopt the online channel under a threat of entry, mainly to render the move unprofitable for the entrant. An intricate relationship exists between the online service quality and profits. When information technology and the online service quality are
limited, an incumbent high-quality expert finds it beneficial to focus on its face-to-face service. When the online quality reaches a critical level, the adoption of the online channel allows a high-quality expert to increase its prices, serve more customers, and limit competition. However, further improvements in online service quality may in fact reduce overall profits due to the cannibalization of the more profitable face-to-face channel and therefore are unlikely to be sought after by a high-quality expert.

These results may partially explain why physicians have been reluctant to offer online consultations. The secure online messaging portal Medem, the first of its kind with a backing from the AMA, never really took off. Although 99 percent of physicians use the Internet, only about a third of them engage in some form of electronic messaging with their patients [28]. Most of such messaging is via email (for medical and administrative purposes), and the percent of physicians conducting synchronous online consultations is much lower. In light of our findings, physicians’ reluctance is better understood considering the high barriers to entry (due to the limited number of graduates from medical schools and state licensing requirements) and the highly interactive nature of a typical face-to-face consultation that is difficult to replicate via information technology.

In contrast, online tax services have been quickly embraced by major incumbent experts in the sector. For example, H&R Block’s prices for online retail services vary from zero for a simple federal return to $49.95 for a premium tax preparation service for the self-employed and rental property owners (the average fee per client was about $189 during the tax season in 2010). The profits of the company took a nose dive after its incursion into online services, however, as its total net income has dropped consistently from about $700 million in 2003 to

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7 See [http://taxes.about.com/od/findataxpreparer/a/prices.htm](http://taxes.about.com/od/findataxpreparer/a/prices.htm).
about $420 million in 2011, despite the surge in the number of clients served online during that period.\(^8\) This exemplifies the case where barriers to entry is low and online service quality is sufficiently high such that the incumbent expert adopts the online channel, yet its profit drops compared to the benchmark case (no Internet). The online tax preparation market is a great example of entry deterrence as well: according to comScore, “the top three do-it-yourself online tax preparation providers [Intuit/TurboTax, InfoSpace/TaxAct, and H&R Block] dominated the category with a combined 92 percent of all online filings.”\(^9\) Clearly, the incumbent high-quality service providers in this market have eliminated any new online entry threat through their own online offerings.

In the equilibria characterized here, online services are either provided by the entrant or the incumbent high-quality expert (i.e., not simultaneously by both, which is not optimal as we have shown) due to the impact of adoption on the intensity of competition. This is in line with the well-known fierce nature of competition on the Internet [40]. Noe and Parker [29] document anecdotal evidence on this issue and show that the “winner take all” type of competition is a predictable consequence of the Internet.

Unlike other strategies such as pricing which can be easily and quickly altered, channel choices are long-term decisions and are more strategic and credible in nature. This paper reaffirms that channel decisions can be used as an entry deterrence mechanism. The possibility of the use of the online channel as an entry deterrence mechanism has recently been suggested in the context of product markets where price consistency across channels is typically a marketing necessity [26]. In such markets, a brick-and-mortar retailer may be able to deter an e-tailer’s

entry by refraining from online expansion given a sufficiently high cost of entry for the e-tailer. In contrast, in service markets where customers can buy the service multiple times from different experts and where prices across channels need not be the same, we show that an incumbent expert can credibly block entry by introducing the online channel.

Experts may improve their competitiveness and limit potential entry by employing other strategies not considered in this study [14, 15]. For example, we have not considered the roles of market access and loyalty. Decisions such as limiting the level of market coverage may also increase profits [2]. In addition, the Internet may lead to monopoly prices with loyalty [23], and price sensitivity may depend on the cost of search [27]. Furthermore, we assumed that the consumers had perfect information about their expert service options and qualities in the market. In a real world context, consumers may not be aware of all such information, and hence online presence can help in building brand awareness, which can attract both online and offline consumers. Our results should be interpreted with these limitations in mind. The analyses of these factors in the context of expert markets are promising directions for future research.

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APPENDIX: SOLUTIONS AND PROOFS OF PROPOSITIONS

Solution of the Benchmark Case (No Internet) and Proof of Proposition 1

Given the profit functions in Equation (3), the experts simultaneously maximize their profits. By plugging in the demand equations, we have 
\[ \Pi_0 = (p_1 - 2p_0 + t) / 3t \] p_0 \) and 
\[ \Pi_1 = (1 - (p_1 - 2p_0 + t) / 6t)(p_1 - c_1) \]. Note that both profit equations are concave with respect to the prices, and second order derivatives are negative. We find the profit maximizing prices using first order conditions and simultaneously solving for the prices.

\[ \frac{d}{dp_0} \Pi_0 = (p_1 - 4p_0 + t) / 3t = 0, \text{ or } p_0 = (p_1 + t) / 4. \]

\[ \frac{d}{dp_1} \Pi_1 = 1 - (2p_1 - 2p_0 - c_1 + t) / 6t = 0, \text{ or } p_1 = (5t + 2p_0 + 2c_1) / 2. \] Accordingly, the optimal prices and profits for the high-quality expert E_1 are

\[ (p_1^*, \Pi_1^*) = ((11t + 2c_1) / 3, (11t - c_1)^2 / 54t), \] \hspace{1cm} (A1)

and for the low-quality expert E_0 are

\[ (p_0^*, \Pi_0^*) = ((7t + 2c_1) / 6, (7t + c_1)^2 / 54t). \] \hspace{1cm} (A2)

By plugging in the optimal prices from Equations (A1) and (A2) in Equation (2), we find the demand for the low-quality expert as 
\[ d_0 = \gamma_1^{(0,1)} = 79 / 9 + c_1 / 9t. \] Hence, \( 2 / 9 - c_1 / 9t \) of the customers who are located close to the high-quality expert first visit the high-quality expert while the rest visit the low-quality expert first. The overall demand for the high-quality expert is 
\[ 11 / 18 - c_1 / 18t. \] For all the customers to attain a satisfactory outcome in equilibrium, the indifferent customer located at \( \gamma_1^{(0,1)} \) should obtain a non-negative surplus:
\[ r - p_1 - t \left(1 - y_{(1)}^{(0,1)} \right) \geq 0. \] Thus, the reservation price should be greater than the threshold \[ r \geq r = \left(\frac{7}{9} + c_1 / 9t\right)5t. \] In equilibrium, the high-quality expert charges a higher price than the low-quality expert \[ \left\{ p_1 - p_0 = \frac{5t + c}{2} > 0 \right\} \] and obtains a smaller market share \[ \left\{ d_1 - d_0 = -\frac{t + c}{6t} < 0 \right\}. \]

No Second Visits. When second visits are not allowed, the indifferent customer is located at \( y \) where:

\[ 0.5r - p_0 - ty = r - p_1 - t(1 - y). \] (A3)

Rearranging terms, we obtain \( y = (p_1 - p_0 + t - 0.5r) / 2t. \) The respective profit functions are \( \Pi_0 = ((p_1 - p_0 + t - 0.5r) / 2t) p_0 \) and \( \Pi_1 = (1 - (p_1 - p_0 + t - 0.5r) / 2t)(p_1 - c_1). \) The best response prices are obtained from the first order conditions as 

\[ p_0^* (p_1) = \frac{p_1 + t - 0.5r}{2} \] and 

\[ p_1^* (p_0) = \frac{p_0 + c_1 + t + 0.5r}{2}. \] Simultaneously solving these best response price functions for prices, we find the following optimal outcomes: 

\[ p_0^* = t - r / 6 + c_1 / 3, \]
\[ p_1^* = t + r / 6 + 2c_1 / 3, \] and \( y = (t - r / 6) / 2t + c_1 / 6t. \) Optimal profits are \( \Pi_0^* = \frac{(t - r / 6 + c_1 / 3)^2}{2t} \) and \( \Pi_1^* = \frac{(t + r / 6 - c_1 / 3)^2}{2t}. \) Note that there is no demand for the low-quality expert when \( r > 6t + 2c_1. \) Hence, \( r < 6t + 2c_1 \) needs to hold for the low-quality expert to remain in the market. In addition, \( r > 2t + 2c_1 / 3 \) should hold in order for the customers to obtain a positive surplus. We find the maximum demand for the low-quality expert by setting \( r = 2t + 2c_1 / 3 \) and plugging it in the demand equation \( y = (t - r / 6) / 2t + c_1 / 6t, \) which gives us \( 1 / 3 + c_1 / 9t. \) When the low-quality expert is in the market, we find that the
high-quality expert charges a lower price and obtains a lower profit compared to the case where second visits are allowed (Equation A1).

The Solution of the Extended Model (with the Internet) and Proof of Proposition 2

We first solve for the case where the high-quality expert offers an online service. Then, we compare the profits in this case with those in the benchmark case.

The customer who is indifferent between the consumption paths $(0,1,i)$ and $(1,i)$ is located at

$$ y_{(1,i)}^{(0,1,i)} = \frac{r - p_0 - ty_{(1,i)}^{(0,1,i)} - 0.5\left(p_{ii} + \mu + (1 - \gamma)\left[p_i + t\left(1 - y_{(1,i)}^{(0,1,i)}\right)\right]\right)}{p_0} $$

Similarly, the customer located at $y_{(1,i)}^{(1,i)}$ solves the equality

$$ r - p_{ii} - \mu - (1 - \gamma)\left[p_i + t\left(1 - y_{(1,i)}^{(0,1,i)}\right)\right] = r - p_i - t\left(1 - y_{(1,i)}^{(0,1,i)}\right) $$

where $y_{(1,i)}^{(0,1,i)}$ is given in Equation (4).

The experts maximize their profit functions given in Equations (6) and (7). Plugging in the expressions for $y_{(1,i)}^{(0,1,i)}$ and $y_{(1,i)}^{(1,i)}$ (Equations 4 and 5), we obtain

$$ \Pi_0 = \frac{p_i + p_{ii} + t + \mu - 2p_0 - \gamma\left(p_1 + t\right)}{t(3 - \gamma)}p_0 $$

and

$$ \Pi_1 = \left(\frac{\gamma\left(p_1 + t\right) - \mu - p_{ii}}{\gamma t} - \frac{p_i + p_{ii} + t + \mu - 2p_0 - \gamma\left(p_1 + t\right)}{2t(3 - \gamma)}\right)p_{ii} + d_i(p_1 - c_i) $$

where

$$ d_i = 1 - \frac{\gamma\left(p_1 + t\right) - \mu - p_{ii}}{\gamma t} + (1 - \gamma)\left(\frac{\gamma\left(p_1 + t\right) - \mu - p_{ii}}{\gamma t} - \frac{p_i + p_{ii} + t + \mu - 2p_0 - \gamma\left(p_1 + t\right)}{2t(3 - \gamma)}\right). $$

The low-quality expert maximizes with respect to $p_0$ and the high-quality expert maximizes with respect to $p_{ii}$ and $p_i$. Both profit equations are concave with respect to the
prices. In specific, the second derivatives of $\Pi_1$ with respect to $p_{1i}$ and $p_1$ equal $\frac{\gamma - 6}{t\gamma(3 - \gamma)}$ and 

$$-\frac{1 - 4\gamma + \gamma^2}{t(3 - \gamma)},$$

and are both negative. The second derivative of $\Pi_0$ with respect to $p_0$ equals 

$$-\frac{4}{t(3 - \gamma)} < 0.$$ The first order conditions provide us with three equations with three unknowns, and we obtain the optimal outcomes by simultaneously solving these equations for prices. The optimal face-to-face price, online price and profit for the high-quality expert are

$$p_1^* = \frac{22 + \tilde{\mu} - 6\gamma + (4 - \gamma)\tilde{c}_i}{6}t$$

$$p_{1i}^* = \gamma p_1^* - \frac{\gamma \tilde{c}_i + \tilde{\mu}}{4}t \quad (A4)$$

$$\Pi_1^* = \frac{2(11 - 3\gamma)(\gamma(2\tilde{c}_i - 3) + 11 - 2(\tilde{c}_i + \tilde{\mu}))}{36(3 - \gamma)}t + \frac{\tilde{c}_i^2(-7\gamma^2 + 23\gamma + 2)}{36(3 - \gamma)}t - \frac{\tilde{\mu}_i(25 - 7\gamma)}{18(3 - \gamma)}t + \frac{\tilde{\mu}_i^2(27 - 7\gamma)}{36(3 - \gamma)}t$$

We find that $p_{1i} < p_1$. The optimal face-to-face price and profit for the low-quality expert are

$$p_0^* = \frac{7 + \tilde{\mu} - 3\gamma + (1 - \gamma)\tilde{c}_i}{6}t$$

$$\Pi_0^* = \frac{(7 + \tilde{\mu} - 3\gamma + (1 - \gamma)\tilde{c}_i)^2}{18(3 - \gamma)}t \quad (A5)$$

Plugging in the optimal prices from Equations (A4) and (A5) into Equations (4) and (5), we find the location of the indifferent customers. Given $d_0 = y^{(0,1)}_{i(i,1)}$, $d_{1i} = y^{(1,1)}_{(1)} - 0.5y^{(0,1)}_{i(i,1)}$ and 

$$d_1 = 1 - y^{(1,1)}_{(1)} + (1 - \gamma) d_{1i} \quad (see \ the \ discussions \ below \ Equations \ 5 \ to \ 7),$$

we obtain the
demands. Each respective demand should be positive, and thus $0 < y_{(0,1,1)}^{(0,1,1)} < y_{(1,1)}^{(1,1)} < 1$.

Plugging in the optimal values, the solution space should ensure $0 < \frac{2p_0^*}{t(3-\gamma)} < 1 - \frac{\mu - \gamma c_1}{2\gamma t} < 1$.

Initially, $\frac{7 + \tilde{\mu} - 3\gamma + (1 - \gamma)\tilde{c}_1}{3(3-\gamma)}$ customers visit the low-quality expert, and

$$y_{(1,1)}^{(1,1)} - y_{(0,1,1)}^{(0,1,1)} = \frac{4\gamma - (9 - \gamma)\tilde{\mu} + (7 - \gamma)\gamma\tilde{c}_1}{6\gamma(3-\gamma)}$$

customers visit the high-quality expert online. For the latter expression to be positive, $\tilde{\mu}$ should be sufficiently low such that

$$\tilde{\mu} < \frac{(7 - \gamma)\tilde{c}_1 + 4)\gamma}{9 - \gamma}.$$ Additionally, $\frac{\tilde{\mu} - \gamma\tilde{c}_1}{2\gamma}$ customers visit the high-quality expert face-to-face. This expression is positive when $\frac{\tilde{\mu}}{\gamma} > \tilde{c}_1$. To summarize, the demand expressions are positive when $\frac{(7 - \gamma)\tilde{c}_1 + 4)\gamma}{9 - \gamma} > \tilde{\mu} > \gamma\tilde{c}_1$. Since $\frac{(7 - \gamma)\tilde{c}_1 + 4)\gamma}{9 - \gamma} - \gamma\tilde{c}_1$ equals $\frac{(2 - \tilde{c}_1)2\gamma}{9 - \gamma} > 0$, there always exists a $\tilde{\mu}$ that satisfies this condition.

We find that the high-quality expert’s online price is higher than the price of the low-quality expert. The price differential equals $-\left(\frac{4 - \gamma}{6}\right)\mu - \frac{(1 - \gamma)^2}{6}c_1 + \frac{25\gamma - 6\gamma^2 - 7}{6}t$ which decreases with $\mu$ and $c_1$. When we evaluate the difference at the highest values for $\mu$ and $c_1$, we obtain $\frac{55\gamma - 7\gamma^2 - 5}{12}t$ which is always positive.

The high-quality expert’s profits with and without the online channel are

$$\Pi_1^* = \frac{2}{36(3-\gamma)}(\gamma(2\tilde{c}_1 - 3) + 11 - 2(\tilde{c}_1 + \tilde{\mu}))t + \frac{\tilde{c}_1^2(-7\gamma^2 + 23\gamma + 2)}{36(3-\gamma)}t - \frac{\tilde{\mu}\tilde{c}_1(25 - 7\gamma)}{18(3 - \gamma)}t + \frac{\tilde{\mu}^2(27 - 7\gamma)}{36\gamma(3 - \gamma)}t$$
(see Equation A4) and \( \frac{(11 - \bar{c}_1)^2}{54} \) (see Equation A1), respectively. The derivative of the difference in profits with respect to \( \bar{c}_1 \) is proportional to

\[
\frac{(62 - 18\gamma)\gamma + (71 - 21\gamma)\gamma \bar{c}_1 + (21\gamma - 75)\bar{\mu}}{54(3 - \gamma)}
\]

which is positive; that is, the difference is maximized when we set \( \bar{c}_1 \) at the upper bound (above, we already discussed \( \bar{\mu} / \gamma > \bar{c}_1 \)). Even then, the difference in profits is

\[
-\frac{\gamma(77\gamma - 27\gamma^2 + 4\bar{\mu}) - \bar{\mu}^2}{54(3 - \gamma)}
\]

which is always negative. Hence, serving online is not optimal.

Additionally, the derivative of the difference in profits with respect to \( \bar{\mu} \) is

\[
\frac{(-22 + 6\gamma)\gamma + (-25 + 7\gamma)\gamma \bar{c}_1 + (-7\gamma + 27)\bar{\mu}}{18(3 - \gamma)\gamma}
\]

which is negative within the feasible parameter space. Thus, as the online transaction cost increases, the difference between the profits of the high-quality incumbent in the two scenarios increases. \( \square \)

**Proof of Proposition 3.**

The proof requires the comparison of profits in two scenarios upon entry: when the online service is provided by the entrant (\( E_i \)) only and when the online service is provided by both the online entrant and the high-quality incumbent (\( E_1 \)).

**Solution (Post entry, online service by \( E_i \) only).** In this case there are three experts in the market. First, we find the respective demands. The customer who is indifferent between the consumption paths \((0,1)\) and \((i,1)\) is located at \( y_{(i,1)}^{(0,1)} \) where

\[
r - p_0 - ty_{(i,1)}^{(0,1)} - 0.5\left[p_1 + t\left(1 - y_{(i,1)}^{(0,i,1)}\right)\right]
\]

\[
= r - p_i - \mu - 0.5\left[p_1 + t\left(1 - y_{(i,1)}^{(0,i,1)}\right)\right].
\]

The solution results in Equation (8). Similarly, the
customer located at \( y^{(i, 1)} \) where \( r - p_i - \mu - 0.5 \left[ p_1 + t \left( 1 - y^{(i, 1)} \right) \right] = r - p_1 - t \left( 1 - y^{(i, 1)} \right) \), resulting in Equation (9). Plugging in the corresponding values in the profit equations (Equations 10, 11 and 12), we obtain

\[
\Pi_i = \frac{p_1 + t - 3p_i - 3\mu + p_0}{t} p_i, \quad \Pi_0 = \frac{p_i + \mu - p_0}{t} p_0
\]

and

\[
\Pi_1 = \left( \frac{-p_1 + t + 2p_i + 2\mu}{2t} \right) (p_1 - c_1). \quad \text{The second order conditions are satisfied and the profit equations are concave with respect to the prices. Using the first order conditions and solving the three equations simultaneously for the prices we find the optimal values given in Column III, Table 1. The equilibrium calls for}
\]

\[
\left( p_1^*, \Pi_1^* \right) = \left( \frac{11c_1 + 12\bar{\mu} + 15}{18} t, \quad \frac{12\bar{\mu} + 15 - 7c_1}{2t} \right)
\]

\[
\left( p_0^*, \Pi_0^* \right) = \left( \frac{6\bar{\mu} + c_1 + 3}{18} t, \quad \frac{6\bar{\mu} + c_1 + 3}{2t} \right)
\]

\[
\left( p_i^*, \Pi_i^* \right) = \left( \frac{c_1 - 3\bar{\mu} + 3}{9} t, \quad \frac{c_1 - 3\bar{\mu} + 3}{2t} - F \right)
\]

We plug in the optimal prices in Equations (8) and (9) to find the indifferent customers’ locations and thereby derive the respective demands. For the experts to have positive market shares, the indifferent customers’ locations should satisfy \( 0 < y_{(i,1)}^{(0,1)} < y_{(i,1)}^{(i,1)} < 1 \). In this equilibrium, initially \( 1 - y_{(i,1)}^{(i,1)} = \frac{2\bar{\mu}}{3 - 7c_1/18 - 1/6} \) of the customers who are located close to the high-quality incumbent visit this expert, and a positive market share for first-time face-to-face visits is achieved given \( c_1 < 12\bar{\mu}/7 - 3/7 \). (Note that when \( \bar{\mu} \) is small enough and less than
3/5, this region also satisfies the condition \( \tilde{c}_1 < \tilde{\mu} < \mu / \gamma \). In addition, \( \tilde{c}_1/18 + \tilde{\mu}/3 + 1 / 6 \) customers visit the low-quality expert (whose market share is always positive), and the rest of the customers \( (1 - \tilde{\mu} + \tilde{c}_1/3) \) visit the online expert, whose market share is positive given \( \tilde{c}_1 > \tilde{\mu} - 1 \). Note that since \( 12\tilde{\mu}/7 - 3/7 > \tilde{\mu} - 1 \), there always exist a \( \tilde{\mu} \) that satisfies the demand conditions.

**Solution (Post entry, online by both E and E).** The customer close to the low-quality incumbent who is indifferent between the consumption paths \((0,1,1)\) and \((i,1,1)\) is located at

\[
y_{(i, 1, 1)}^{(0, 1, 1)} \text{ where } r - p_0 - t y_{(i, 1, 1)}^{(0, 1, 1)} - 0.5 \left[ p_i + \mu + (1 - \gamma) \left( p_i + t \left( 1 - y_{(i, 1, 1)}^{(0, 1, 1)} \right) \right) \right] = r - p_i - \mu - 0.5 \left[ p_i + \mu + (1 - \gamma) \left( p_i + t \left( 1 - y_{(i, 1, 1)}^{(0, 1, 1)} \right) \right) \right].
\]

Solving for \( y_{(i, 1, 1)}^{(0, 1, 1)} \), we have

\[
y_{(i, 1, 1)}^{(0, 1, 1)} = \frac{p_i - p_0 + \mu}{t}.
\]

The customer who is indifferent between the consumption paths \((i,1,1)\) and \((1,1)\) is located at \( y_{(1, 1)}^{(i, 1, 1)} \) where

\[
r - p_i - \mu - (1 - \gamma) \left( p_i + t \left( 1 - y_{(i, 1, 1)}^{(1, 1, 1)} \right) \right) = r - p_i - \mu - (1 - \gamma) \left( p_i + t \left( 1 - y_{(i, 1, 1)}^{(1, 1, 1)} \right) \right).
\]

Solving for \( y_{(1, 1)}^{(i, 1, 1)} \), we have

\[
y_{(1, 1)}^{(i, 1, 1)} = \frac{(1 - \gamma)(p_i + t) + p_i - \mu - 2p_i}{t(1 - \gamma)}.
\]

Finally, the customer who is indifferent between the consumption paths \((1,1)\) and \((1)\) is located at \( y_{(1)}^{(1, 1)} \) where

\[
r - p_{1i} - \mu - (1 - \gamma) \left( p_i + t \left( 1 - y_{(1, 1)}^{(1,1)} \right) \right) = r - p_i - \mu - (1 - \gamma) \left( p_i + t \left( 1 - y_{(1)}^{(1,1)} \right) \right).
\]

Solving for \( y_{(1)}^{(1, 1)} \), we have

\[
y_{(1)}^{(1, 1)} = \frac{\gamma(p_i + t) - p_{1i} - \mu}{\gamma t}.
\]

Note that the online entrant’s profit is \( \Pi_i = d_i p_i \), where

\[
d_i = y_{(1, 1)}^{(i, 1, 1)} - y_{(1, 1)}^{(1, 1, 1)}.
\]

The profit of expert \( E_0 \) equals \( \Pi_0 = d_0 p_0 \), where \( d_0 = y_{(i, 1, 1)}^{(0, 1, 1)} \), and
the profit of the high-quality expert equals $\Pi_1 = d_{1i}p_{1i} + d_{1i}p_1$, where $d_{1i} = \gamma^{(1,1)} - 0.5\gamma^{(1,1)}$

and $d_1 = 1 - \gamma^{(1,1)} + (1 - \gamma)d_{1i}$. We obtain the optimal values by plugging in the expressions for the indifferent customers into the profit equations and solving the first order conditions for prices. We find that the optimal price for the entrant is $p_i^* = \frac{3(1 - \gamma) + (\bar{c}_i - 2\bar{\mu}) - (\bar{c}_i - \bar{\mu})\gamma}{3(3 - \gamma)}t$,

the optimal price for the low-quality expert ($E_0$) is $p_0^* = \frac{3(1 - \gamma) + (\bar{c}_i + 7\bar{\mu}) - (2\bar{\mu} + \bar{c}_i)\gamma}{6(3 - \gamma)}t$,

and the optimal face-to-face price ($p_{1i}^*$) and online price ($p_{i1}^*$) for the high-quality expert ($E_1$) are

$$p_{1i}^* = \frac{3\gamma(1 - \gamma)(5 - \gamma) - 9\bar{\mu} + (2\bar{c}_i + 17\bar{\mu} - 2(\bar{c}_i + 2\bar{\mu})\gamma)\gamma}{6(3 - \gamma)}t$$

Given these optimal values, we solve for the locations of the indifferent customers. Note that the solution requires the following set of conditions for all demand expressions to be positive.

$$0 < y_{(0,1,1)}^{0,1,1} < y_{(1,1,1)}^{(1,1,1)} < y_{(1,1,1)}^{(1,1,1)} < 1.$$  \hspace{1cm} (A9)

Plugging in the optimal values, the solution space should satisfy

$$0 < \frac{p_0^*}{t} < \frac{(7 - 3\gamma)(3t + c)}{6(3 - \gamma)t} - \frac{(5 - \gamma)\mu}{6(3 - \gamma)(1 - \gamma)t} < 1 - \frac{\mu - \gamma\bar{c}_1}{2\gamma t} < 1.$$  \hspace{1cm} (A9)

We find the demand for first visits to be $\frac{p_0^*}{t}$ for $E_0$ and $y_{(1,1,1)}^{(1,1,1)} - y_{(1,1,1)}^{(0,1,1)} = \frac{(3 - \gamma)p_i^*}{(1 - \gamma)t}$ for $E_i$. We confirm that

$$y_{(1,1,1)}^{(1,1,1)} - y_{(1,1,1)}^{(0,1,1)} = \frac{(3 - \gamma)p_i^*}{(1 - \gamma)t} > 0$$  \hspace{1cm} (A9)

as long as $p_i^* > 0$. The high-quality incumbent has positive
demand for first visits as long as \( y^{(1,1)} - y^{(2,1)} = \frac{2c - 3t(1 - \gamma)}{6(3 - \gamma)t} - \frac{(9 + 4\gamma^2 - 17\gamma)\mu}{6(3 - \gamma)(1 - \gamma)\gamma t} > 0 \) for the online channel and \( \frac{\mu - \gamma c_1}{2\gamma t} > 0 \) for the face-to-face channel.

Suppose that the high-quality expert aims to deter the entry of the online expert by offering its online service and making the market more competitive. For this to be the optimal strategy, the high-quality expert should profit more when it is the only online service provider

\[
\Pi^\text{deter}_1 = \frac{2(11 - 3\gamma)(\gamma(2\hat{c}_1 - 3) + 11 - 2(\hat{c}_1 + \bar{\mu}))}{36(3 - \gamma)} - \frac{\bar{\mu}(25 - 7\gamma)}{18(3 - \gamma)} + \frac{\bar{\mu}^2(27 - 7\gamma)}{36\gamma(3 - \gamma)}
\]

compared to the case where only the online expert serves via the Internet

\[
\Pi^\text{accommodate}_1 = \frac{(12\bar{\mu} + 15 - 7\hat{c}_1)^2}{648} t.
\]

We find that, within the parameter space where the solutions are valid, \( \Pi^\text{deter}_1 - \Pi^\text{accommodate}_1 > 0 \). However, entry deterrence can be the equilibrium strategy only if the online expert does not find it beneficial to enter the market because of the high-quality incumbent’s online offering: \( \Pi^\text{deter}_1 < 0 \). This condition holds when \( \frac{(3 - \gamma)p_i^r}{(1 - \gamma)t} - F < 0 \). It is possible to show that the derivative of the entrant’s gross profit, \( \frac{(3 - \gamma)p_i^r}{(1 - \gamma)t} \), with respect to \( \gamma \) is negative. Let the function \( H(\gamma) \) represent \( \frac{(3 - \gamma)p_i^r}{(1 - \gamma)t} \). \( H(\gamma) = F \) is characterized by the plane \( \text{abcd} \) in Figure 1. The parameter space that satisfies \( H(\gamma) > F \) is the one marked with Accommodation, below the plane \( \text{abcd} \) in Figure 1. For these parameter values, the online expert enters the market and the incumbent expert serves only face-to-face. Within the parameter space
that satisfies \( H(\gamma) < F \) (i.e., the region marked with entry deterrence, above the plane \( \text{abcd} \) in Figure 1), entry is deterred and the incumbent serves both online and face-to-face. □

**Proof of Proposition 4.** The total market size in the accommodation equilibrium is given by

\[
TMS = y_{(i,1)}^{(0,1)} + \left( y_{(i,1)}^{(i,1)} - y_{(i,1)}^{(0,1)} \right) + \left( 1 - y_{(i,1)}^{(i,1)} + y_{(i,1)}^{(i,1)} / 2 \right) = 57 / 36 - (12\mu + 7c) / 36t .
\]

Differentiating with respect to \( \mu \) we obtain \( \frac{dTMS}{d\mu} = -\frac{1}{3t} < 0 \). We also find:

\[
\frac{dp_0^*}{d\mu} = \frac{1}{3} > 0 , \quad \frac{d\Pi_0^*}{d\mu} = \frac{3 + 6\tilde{\mu} + \tilde{c}_1}{27} > 0 ,
\]

\[
\frac{dp_i^*}{d\mu} = \frac{2}{3} > 0 , \quad \frac{d\Pi_i^*}{d\mu} = \frac{15 + 12\tilde{\mu} - 7\tilde{c}_1}{27} > 0 ,
\]

\[
\frac{dp_i^*}{dt} = -\frac{1}{3} < 0 , \quad \frac{d\Pi_i^*}{dt} = -\frac{2(3 + \tilde{c}_1 - 3\tilde{\mu})}{9} < 0 ,
\]

\[
\frac{dp_i^*}{dt} = \frac{1}{3} > 0 , \quad \frac{d\Pi_i^*}{dt} = \frac{(\tilde{c}_1 - 3\tilde{\mu} + 3)^2}{27} > 0 .
\]

The prices and profits of the high- and low-quality experts in the accommodation equilibrium drop compared to the benchmark (no-threat-of-entry) case, with the differences in prices being \( \frac{17t}{6} - \frac{c_1}{18} + \frac{2\mu}{3} < 0 \) and \( -t - \frac{c_1}{9} + \frac{\mu}{3} < 0 \) for the high- and low-quality experts, respectively.

In the accommodation equilibrium, the difference between the prices of the entrant and the low-quality incumbent is \( p_i^* - p_0^* = \left( -\frac{2\mu}{3} + \frac{1}{6} + \frac{c_1}{18} \right) t \). Accordingly, \( p_i^* < p_0^* \) if and only if

\[
\frac{2\tilde{\mu}}{3} + \frac{1}{6} + \frac{\tilde{c}_1}{18} < 0 .
\]

Even when \( \tilde{c}_1 \) takes its maximum value within the feasible parameter space
(see the solution of the case “Post entry, online service by Eᵢ only” for the upper bound of \( \tilde{c}_1 \)),

this expression is still negative \( \left\{ -\frac{4}{7} \mu + \frac{1}{7} < 0 \right\} \) which guarantees \( p_i^* < p_0^* \). The online expert

profits more than the low-quality expert when \( \frac{(\tilde{c}_1 - 3\mu + 3)^2 t}{27} > \frac{(6\mu + \tilde{c}_1 + 3)^2 t}{324} \), or

alternatively, \( \mu < 0.45 + 0.15\tilde{c}_1 \), given a negligible entry cost \( F \). □

**Proof of Proposition 5**

The first part of the proof follows from Proposition 3. We have already seen in proof of

Proposition 3 that entry deterrence is more likely to work when the online service of the high-

quality expert is of high quality. Therefore, here we only need to compare the price and market

size of the high-quality expert in the entry deterrence and accommodation equilibria. The prices

of the expert for face-to-face service in entry deterrence and accommodation equilibria are

\[
\frac{22 + \mu - 6\gamma + (4 - \gamma)\tilde{c}_1}{6} t \quad \text{and} \quad \frac{(11\tilde{c}_1 + 12\mu + 15)}{18} t,
\]

respectively. We find that the former

expression is greater than the latter if \( \gamma < \frac{51 + \tilde{c}_1 - 9\mu}{3(\tilde{c}_1 + 6)} \), which is satisfied given \( \gamma \leq 1 \).

Comparing the market shares of the high-quality incumbent in the two scenarios, the

market share when deterring entry is greater than the market share in the accommodation

equilibrium if \( \frac{(-63 + 61\gamma - 12\gamma^2)\tilde{c}_1}{36(3 - \gamma)} - \frac{8\gamma\mu - 18\gamma + 29\gamma - 29\gamma^2 + 6\gamma^3}{12\gamma(3 - \gamma)} t < 0 \). Since this

expression increases when \( \tilde{c}_1 \) decreases, it is maximized when \( \tilde{c}_1 \) is set to its minimum value

(zero). Even then, the expression is still negative since \( -(8\gamma\mu - 18\gamma + 29\gamma - 29\gamma^2 + 6\gamma^3) < 0 \).
Thus, the market share of the high-quality incumbent is larger when it deters entry than when it accommodates it. □

**Proof of Proposition 6**

These results follow from the following comparative statics analysis:

\[
\frac{dp_0^*}{dt} = \frac{7 - 3\gamma}{6} > 0, \quad \frac{dp_i^*}{dt} = \gamma \left( \frac{11}{3} - \gamma \right) > 0, \quad \frac{dp^*}{dt} = \frac{11}{3} - \gamma > 0.
\]

\[
\frac{d\Pi_0^*}{dt} = \frac{(7 - 3\gamma)^2 - (1 - \gamma)\tilde{c}_1 - \bar{\mu}}{18(3 - \gamma)} > 0.
\]

\[
\frac{d\Pi_i^*}{dt} = \frac{242\gamma - 132\gamma^2 + 18\gamma^3 - (27 - 7\gamma)\bar{\mu}^2 + ((50 - 14\gamma)\bar{\mu} + (7\gamma^2 - 2 - 23\gamma)\tilde{c}_1)\gamma\tilde{c}_i}{36\gamma(3 - \gamma)}.
\]

Across the parameter space where the results are valid, we find \( \frac{d\Pi_i^*}{dt} > 0 \).

We also find

\[
\frac{dp_0^*}{d\mu} = \frac{dp_i^*}{d\mu} = \frac{1}{6} > 0, \quad \frac{d\Pi_0^*}{d\mu} = \frac{(7 + (1 - \gamma)\tilde{c}_1 + \bar{\mu} - 3\gamma)}{(3 - \gamma)} > 0 ,
\]

\[
\frac{dp_i^*}{d\gamma} = t \left( \frac{11}{3} - 2\gamma \right) + \frac{\bar{\mu}}{6} - \frac{(2\gamma - 1)}{6} \tilde{c}_1 > 0, \quad \frac{dp_i^*}{d\gamma} = -t - \frac{\tilde{c}_1}{6} < 0.
\]

\[
\frac{d\Pi_i^*}{d\gamma} = t \left( -\frac{18 - (12 + 7\tilde{c}_1)\tilde{c}_1}{36} - \frac{\bar{\mu}^2}{4\gamma^2} + \frac{(2 + 2\tilde{c}_1 - \bar{\mu})^2}{18(3 - \gamma)^2} \right).
\]

We investigate using Maple’s `implicitplot3d` function across all the valid parameter space and find that \( \frac{d\Pi_i^*}{d\gamma} < 0 \). □
Proof of Proposition 7. In the absence of a threat of entry, the high-quality expert serves only face-to-face and charges \( \frac{(11 + 2\tilde{c}t)t}{3} \) to a market of size \( \frac{11 - \tilde{c}}{18} \). With the accommodation strategy, he serves only face-to-face and charges \( \frac{(11\tilde{c} + 12\tilde{\mu} + 15)t}{18} \) to a market of size \( \frac{15 + 12\tilde{\mu} - 7\tilde{c}}{36} \). The former price is greater than the latter since \( \frac{(11 + 2\tilde{c})t}{3} - \frac{(11\tilde{c} + 12\tilde{\mu} + 15)t}{18} \)

\[ = \frac{51 + \tilde{c} - 12\tilde{\mu}}{18} t > 0. \] Similarly, the former market share is greater than the latter since

\[ \frac{11 - \tilde{c}}{18} - \frac{15 + 12\tilde{\mu} - 7\tilde{c}}{36} = \frac{7 + 5\tilde{c} - 12\tilde{\mu}}{36} > 0. \]

The online and face-to-face prices with entry deterrence are \( \gamma p^*_1 - \frac{\gamma\tilde{c}_1 + \tilde{\mu}}{2} t \) and \( \frac{22 + \tilde{\mu} - 6\gamma + (4 - \gamma)\tilde{c}_1}{6} t \), respectively. The online price is lower than the face-to-face price since

\[ p_1^* - p_{1i} = p_1^* - \left( \gamma p_1^* - \frac{\gamma\tilde{c}_1 + \tilde{\mu}}{2} t \right) = (1 - \gamma) p_1^* + \frac{\gamma\tilde{c}_1 + \tilde{\mu}}{2} t > 0. \] The price for the face-to-face service is greater than that in the entry deterrence if \( \frac{(11 + 2\tilde{c})t}{3} > \frac{22 + \tilde{\mu} - 6\gamma + (4 - \gamma)\tilde{c}_1}{6} t \), or equivalently, \( \tilde{\mu} < (6 + \tilde{c}_1)\gamma \), which holds given \( \gamma > \gamma > 0.5 \).

The market size of the high quality expert when deterring entry increases compared to the that in the benchmark case if

\[ \frac{(24\gamma - 28\gamma^2 + 6\gamma^3)\tilde{c}_1 + 33\gamma - 40\gamma^2 + 9\gamma^3 - 27\tilde{\mu} + 30\tilde{\mu}\gamma - 6\tilde{\mu}\gamma^2}{18(3 - \gamma)} > 0, \]

which is always positive within the feasible parameter space. Thus, lower prices ensure that the market size increases under entry deterrence strategy compared to the benchmark (no-threat-of-entry) case. □
Table 1: Optimal Solutions ( $\bar{\mu}$ and $\tilde{c}_1$ represent $\mu$ / $t$ and $c_1$ / $t$ )

<table>
<thead>
<tr>
<th></th>
<th>I: No online (No entry)</th>
<th>II: Online by $E_1$ (No entry)</th>
<th>III: Online by $E_i$ (Post entry)</th>
<th>IV: Online by $E_i$ and $E_1$ (Post entry)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_0^*$</td>
<td>$(7 + \tilde{c}_1)t$ / $6$</td>
<td>$\frac{7 + \bar{\mu} - 3\gamma + (1 - \gamma)\tilde{c}_1}{6}t$</td>
<td>$\frac{(6\bar{\mu} + \tilde{c}_1 + 3)}{18}t$</td>
<td>$\frac{3(1 - \gamma) + (\tilde{c}_1 + 7\bar{\mu}) - (2\bar{\mu} + \tilde{c}_1)\gamma}{6(3 - \gamma)}t$</td>
</tr>
<tr>
<td>$\Pi_0^*$</td>
<td>$(7 + \tilde{c}_1)^2t$ / $54$</td>
<td>$\frac{(7 + \bar{\mu} - 3\gamma + (1 - \gamma)\tilde{c}_1)^2}{18(3 - \gamma)}t$</td>
<td>$\frac{(6\bar{\mu} + \tilde{c}_1 + 3)^2}{324}t$</td>
<td>$\frac{p_0^{\gamma^2}}{t}$</td>
</tr>
<tr>
<td>$p_i^*$</td>
<td>n.a.</td>
<td>n.a.</td>
<td>$\frac{(\tilde{c}_1 - 3\bar{\mu} + 3)}{9}t$</td>
<td>$\frac{3(1 - \gamma) + (\tilde{c}_1 - 2\bar{\mu}) - (\tilde{c}_1 - \bar{\mu})\gamma}{3(3 - \gamma)}t$</td>
</tr>
<tr>
<td>$\Pi_i^*$</td>
<td>n.a.</td>
<td>n.a.</td>
<td>$\frac{(\tilde{c}_1 - 3\bar{\mu} + 3)^2}{27}t - F$</td>
<td>$\frac{(3 - \gamma)p_i^{\gamma^2}}{(1 - \gamma)t - F}$</td>
</tr>
<tr>
<td>$p_{1i}^*$</td>
<td>n.a.</td>
<td>$\gamma p_1^* - \frac{\gamma \tilde{c}_1 + \bar{\mu}}{2}t$</td>
<td>n.a.</td>
<td>$\frac{3\gamma(1 - \gamma)(5 - \gamma) - 9\bar{\mu} + (2\tilde{c}_1 + 17\bar{\mu} - 2(\tilde{c}_1 + 2\bar{\mu})\gamma)}{6(3 - \gamma)}$</td>
</tr>
<tr>
<td>$p_i^*$</td>
<td>$(11 + 2\tilde{c}_1)t$ / $3$</td>
<td>$\frac{22 + \bar{\mu} - 6\gamma + (4 - \gamma)\tilde{c}_1}{6}t$</td>
<td>$\frac{(11\tilde{c}_1 + 12\bar{\mu} + 15)}{18}t$</td>
<td>$\frac{3(1 - \gamma)(5 - \gamma) + (11\tilde{c}_1 + 14\bar{\mu}) - (5\tilde{c}_1 + 4\bar{\mu})\gamma}{6(3 - \gamma)}t$</td>
</tr>
<tr>
<td>$\Pi_i^*$</td>
<td>$(11 - \tilde{c}_1)^2t$ / $54$</td>
<td>$\frac{2(11 - 3\gamma)(\gamma(2\tilde{c}_1 - 3) + 11 - 2(\tilde{c}_1 + \bar{\mu}))}{36(3 - \gamma)}t + \frac{\tilde{c}_1^2(-7\gamma^2 + 23\gamma + 2)}{36(3 - \gamma)}t - \frac{\bar{\mu}\tilde{c}_1(25 - 7\gamma)}{18(3 - \gamma)}t + \frac{\bar{\mu}^2(27 - 7\gamma)}{36\gamma(3 - \gamma)}t$</td>
<td>$\frac{(12\bar{\mu} + 15 - 7\tilde{c}_1)^2}{648}t$</td>
<td>$d_{1i}p_{1i}^* + d_i^<em>p_i^</em>$</td>
</tr>
</tbody>
</table>
Figure 1: Entry deterrence via the Internet