Second opinions and online consultations

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Abstract

Consumers increasingly obtain direct consultations from experts, thanks to the prevalent use of Information Technology and the Internet. Motivated by the online consultation practices of reputed institutions such as Harvard University hospitals and the Cleveland Clinic, we develop a duopoly model and study the strategies of high-quality experts in business-to-consumer consultation markets. Experts decide whether to provide first or second opinions and serve face-to-face and/or online. The experts’ skills and the offered quality levels differ. We show that both the elimination of transaction costs and the reduction in the diagnostic accuracy in online markets impact the profitability of selling second opinions more favorably relative to that of selling first opinions, providing incentives for high-quality experts to specialize as second opinion providers. We also show that high-quality experts can charge higher face-to-face prices by adopting the online channel.

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1. Introduction

Consider the following scenario: After being diagnosed with a serious health condition, a patient learns that one of the top experts in the country works at a research hospital. She can either make a potentially long trip to the hospital, or she can get an online consultation. According to the reports, an increasing number of consumers prefer the latter approach; 37% of the adult Internet users are willing to pay to communicate online with their physicians, which corresponds to a $4 billion market in 2002 [11,16,18,19,26]. Experts at many institutions offer online access to their first and second opinion services. For example, more than 4000 physicians offer online first opinions via RelayHealth.com. Others affiliated with well-known institutions such as Harvard Medical School and the Cleveland Clinic provide online second opinions. Several leading oncologists render second opinions for as much as $2800 (see Table 1). In addition to medical consultations, a growing number of consumers seek legal, tax, accounting, investment, and business related opinions.

Information-intensive channels create significant opportunities both for experts and consumers in many diverse fields where consumers try to reduce risks before committing to a course of action. Ease of search and advanced communication technologies help consumers in appreciating the value of expertise and realizing the associated risks and benefits. Prevalent use of information-intensive environments may also allow experts to differentiate themselves better.
We focus on the situations where online consultations can be employed effectively without any serious implementation problems. For example, online consultations cannot be used for emergencies and other time-sensitive issues such as chest pain, shortness of breath, suicidality, and bleeding. Also, since an expert needs to have a clear understanding about a consumer’s problem in order to propose a solution, he or she may prefer a rich and personal channel when information cannot be easily communicated via the Internet [5,13,22]. Using online consultations in inappropriate situations may otherwise lead to possible negative consequences. With this in mind, we ask the following research questions: When would experts benefit from specializing in second opinions? When would they adopt the Internet as a separate service channel, and how would this affect their market (first or second opinion) choices? How would expert strategies change with respect to experts’ qualities and the online channel’s effectiveness?

We analyze these questions using a duopoly model that features a competitive market in which experts can serve face-to-face and online. The experts are differentiated based on their diagnostic qualities (or, accuracies) and their locations. They maximize their profits by choosing the type of the opinion they provide (first or second), channel mix (face-to-face and/or online channel), and pricing for each channel. Since experts can obtain more information via face-to-face interaction, their diagnostic accuracies may be lower online. Consumers incur heterogeneous transaction costs when receiving face-to-face services from the experts. To maximize surplus, consumers sequentially decide on which expert to visit and which channel to use.

We show that the Internet affects the profitability of the first and second opinions differently, and outline the circumstances under which well-known (high-quality) experts may profitably specialize in second opinions. Specifically, as the Internet reduces the diagnostic accuracy of the first opinion provider, the online provision of first opinions supports the delivery of second opinions. Furthermore, because the value of the first opinion depends solely on the accuracy of its provider while the value of the second opinion depends on the accuracies of both experts, the ineffectiveness of the online channel has a more negative effect on the value of the first opinion. Also, the reduction of transaction costs via the Internet increases the profitability of second opinions more because second opinion customers incur a higher transaction cost (e.g., located farther away) than first opinion customers. In summary, we find significant analytical evidence that more second opinions may be provided with the emergence of the Internet.

The rest of the paper is organized as follows. We discuss the related literature in the next section and setup the model in Section 3. In Section 4, we start with an analysis of the value of first and second opinions and then continue with the solution of the game and a discussion of the findings. We tie our results to past literature and conclude in Section 5.

2. Literature review

Two streams of literature are related to our research questions: multi-channel management and expert services. The literature on multi-channel management typically focuses on retail goods and examines when firms should expand their distribution network to the Internet [3,15,27,29,31], and how online and traditional channels could be used for consumer segmentation and product differentiation [12,23]. The similarity of this stream of research to our context is that experts also confront the problem of how to manage face-to-face and online channels simultaneously. However, the expert services are profoundly different from retail goods. Experts provide an information good (professional opinion) whose value depends on its reliability (accuracy) and the level of consumer uncertainty. Another difference of our context is that consumers search expertise sequentially, and they may purchase multiple opinions depending on their experience with experts. In contrast, the multi-channel management literature presumes that consumers make a single purchase to satisfy a need.

Economists explore various aspects of expert services. The economics literature typically focuses on information problems that beset the relationship between an expert and his or her customers. In some circumstances the customer may not observe the service quality, which may allow the expert to defraud the customer by misrepresenting a low-cost service as a costly one [21,30]. In other circumstances, the customer may observe the actual service quality, but cannot judge
whether the costly service was really needed [6,8,10,28]. Also, the diagnostic effort and the success of the expert may not be observable/verifiable [20]. While these information problems are important in their own right, such topics are relatively well understood. Consequently, recent work abstracts away the potential of fraud and unobservable quality to isolate more complex features of expert markets [2,9,25]. In addition, the existence of information-intensive channels and online communities help in establishing reputations of experts, which, in turn, may limit such fraudulent behavior.

Researchers in healthcare economics and human resources disciplines explore whether physicians induce patients’ demand and thereby contribute to the rise in healthcare costs [4,7,14,17,24]. Rossiter and Wilensky [24] and Lien et al. [17] argue that the magnitude of the so-called “physician-induced demand” is typically small and insignificant.

3. Model formulation

Consumers are uniformly located on a unit line that extends from zero to one. Each point on the unit line identifies a consumer. There are two experts in the market with differing diagnostic accuracies. The high-quality expert has a high diagnostic accuracy and is located at zero. The low-quality expert has a lower diagnostic accuracy and is located at one. Both experts can serve both face-to-face and online, and they seek to maximize their profits by offering first or second opinions and by charging a separate price on each channel they utilize. Consumers aim to maximize their surpluses by sequentially deciding whether and which expert to visit, and which channel to use.

Each consumer is in an unknown state, which may be either good (g) or bad (b) with equal (1/2) prior probability. The state corresponds to a good versus bad health or no liability versus liability for medical, legal, or tax consultations. The prior probability of the state is common knowledge. Consumers obtain a normalized utility of one when maintaining the good state; bad state results in losing the unit utility (e.g., due to illness or additional debt), unless the consumer consults an expert and takes a preventive action. Upon a correct diagnosis, a consumer avoids the associated unit loss by taking the preventive action. Experts prescribe a preventive action only after diagnosing the bad state. Let $c$ capture the cost to the consumer for taking the preventive action, where $c < 1$. The cost of the preventive action includes any monetary expenditure (except the price paid to the expert) and the related discomfort (e.g., going through a series of chemotherapy sessions, changing contracts, conducts, forms).

To obtain a face-to-face (f) consultation, consumers need to incur a transaction cost that represents the cost of search, travel, the opportunity cost of time, and the implicit cost of inconvenience. The amount of transaction cost a consumer incurs depends on her distance from the expert. A consumer located at $x \in [0,1]$ incurs $tx$ and $f(1-x)$ to visit the high- and low-quality experts, respectively. The transaction cost for the online (o) channel is typically low and is normalized to zero for simplicity. That is, consumers do not incur a transaction cost for online consultations regardless of their locations on the unit line. Upon obtaining a first opinion, the consumer takes the expected surplus maximizing decision and considers the following three alternatives: (i) take the expert’s suggestion and incur $c$, (ii) do not take the expert’s suggestion and obtain a second opinion (online or face-to-face) by paying the second expert’s price and incurring the related transaction cost, and (iii) do not take the expert’s suggestion and do not obtain a second opinion.

Without loss of generality, suppose that one of the experts is “better” than the other. This asymmetry may represent a difference in reputation or levels of experience for producing information, and it is assumed to be exogenous and common knowledge. In certain cases, observing and communicating the quality of consultation may not be difficult. These situations often involve a professional opinion that is generated with a specific piece of equipment or research technology whose diagnostic characteristics are well known and understood (e.g., a computerized tomography scanner). Then, an expert having access to such technologies (e.g., a sophisticated medical lab) can offer superior service on the basis of these technologies’ reliabilities [25]. In medicine, for example, the high-quality expert may work at a more reputable institution or have better credentials. When the quality of service cannot be easily observed through such technologies, the perceptions of quality may develop over time. However, superior information exchange and information-intensive communities enable observing and sharing the true quality rather quickly. To capture the quality asymmetry between experts, the experts are assumed to be characterized by their diagnostic accuracies. While both experts may err, the high-quality (h) expert predicts the consumer’s true state with a higher probability than
the low-quality (l) expert on a given channel. Let the subscript i denote the expert type, \( i \in \{h,l\} \), subscript j denote the channel choice, \( j \in \{f,o\} \), and \( a_{ij} \) denote the diagnostic accuracy of expert \( i \) on channel \( j \). The worst possible diagnostic accuracy is randomization; that is, experts predict the state correctly with at least 0.5 probability. Since the high quality expert is more accurate than the low-quality expert, 0.5 \( \leq a_{lj} \leq a_{hl} \leq 1 \) for \( j \in \{f,o\} \). The choice of serving face-to-face and/or online may impact experts’ diagnostic accuracies. Since physical inspection of consumers is not possible online, experts may receive fewer signals from a distance, potentially reducing the diagnostic accuracy. For example, diagnosing a patient’s problem online may be relatively difficult when a physical exam (rather than a digital X-ray film) is needed. We capture the online channel’s effectiveness with \( \gamma = \frac{a_{o}}{a_{f}} \) for \( i \in \{h,l\} \). We focus on the more interesting and realistic case, where \( \gamma \leq 1 \). The minimum level of online channel effectiveness is attained when the low quality expert’s online accuracy equals to randomization: \( \frac{1}{2a_{f}} \leq \gamma \leq 1 \).

An expert of type \( i \in \{h,l\} \) can handle at most \( m_i \) consultations. The scarcity of good experts in real life can be captured by supposing that \( m_l \gg m_h \). Also, both to conform to the reality and to simplify the analysis, there are more consumers in the market than experts can handle (\( m_h + m_l \leq 1 \)), and experts work at capacity. Shortage of experts is typically the norm in all sectors. For example, there is a net shortage of doctors in the U.S. as in many other countries. For simplicity, we suppose that the capacity of experts do not change based on consumers’ channel decisions. However, in some cases, experts may be able to cater to more consumers via the Internet. Assuming a higher online capacity would further strengthen our results.

The sequence of actions in the game is as follows. First, experts decide whether to sell first or second opinions. Next, they select the channel(s) of service and price their services simultaneously while knowing the consumers’ best response. Third, having observed the experts’ market (first or second opinion), channel, and pricing decisions, consumers seek expertise sequentially as long as they obtain a positive surplus. A consumer first decides whether or not to seek a consultation and which expert to consult. The expected surplus for not consulting at all is 1/2. Only after consulting once can a consumer seek a second opinion. We solve the model by the method of backward induction and focus on the pure-strategy, subgame perfect Nash equilibria.

In the next section, we first derive the values of first and second opinions. Since the price depends on the value offered to the consumers, this analysis helps us to shape the equilibria. In Section 4.1, we solve for the benchmark case where experts serve only face-to-face in the absence of the online channel. In Section 4.2, we introduce the Internet as an additional channel and solve the full model.

4. Analysis

Let \( V_{ij} \) denote the value of the first opinion provided by expert of type \( i \) via channel \( j \). Then, the value of first opinion is given by \( V_{ij} = \frac{a_{ij} - c}{\gamma} \). That is, as expert accuracy \( (a_{ij}) \) increases and/or the cost of the preventive action \( (c) \) decreases, the value of first opinion increases. All proofs are in the Appendix.

**Lemma 1.** The value of the first opinion \( (V_{ij}) \) increases with the experts diagnostic accuracy \( (a_{ij}) \) and decreases with the cost of the preventive action \( (c) \).

Clearly, an increase in expert accuracy makes the first opinion more valuable. The cost of the preventive action also plays a significant role in determining the first opinion’s value. Experts may create value more easily when preventive costs are lower. However, as preventive costs increase, the relative importance of expert accuracy increases and experts need to diagnose consumer problems more accurately in order to create value. A further implication of Lemma 1 is that the value of an online first opinion decreases as the online channel becomes less effective.

Corollary 1 provides an explanation for why well-known experts would not sell online first opinion services. A deficient communication medium lowers the value of the more accurate expert’s first opinion to a greater extent because he has more to lose than the other expert.

**Corollary 1.** Low online channel effectiveness affects the value of the high-quality expert’s first opinion more adversely than that of the low-quality expert.

The value of the second opinion is derived in a dynamic manner by taking the difference between the expected consumer surpluses after the first and second consultations. Hence, the value of the second opinion depends on the diagnosis obtained in the first consultation. Let \( s \in \{g,b\} \) denote the state a consumer is diagnosed with in the first consultation. Also, let \( V_{ij}(s) \)
denote the value of type-\(i\) expert’s second opinion when he uses channel \(k \in \{f, o\}\) while the other expert uses channel \(k \in \{f, o\}\) to provide the first opinion. We show in the Proof of Lemma 2 that \(V_{ijk}^2\) equals \((1 - c)a_{ij}(1 - a_{ik}) - ca_{ik}(1 - a_{ij})\) and \(V_{ijk}^2\) equals \(ca_{ij}(1 - a_{ik}) - (1 - c)a_{ik}(1 - a_{ij})\) where \(-i = 1\) when \(i = h, \) and conversely. The results in the following lemma are obtained by taking the partial derivatives of these expressions with respect to \(a_{ik}\) (the accuracy of the first opinion provider) and \(c\) (the cost of the preventive action).

**Lemma 2.** The value of the second opinion increases with the likelihood that the first diagnosis is incorrect. Also, the online provision of the first opinion increases the value of the second opinion. Furthermore, the value of the second opinion increases (decreases) with the cost of the preventive action if the consumer is diagnosed with the bad (good) state in the first consultation.

In real life, consumers seek second opinions with some expectation of obtaining a professional opinion different from the one they encounter first. The more likely is the event that the first expert errs and the second one catches that mistake, the more valuable does the consumer deem a second opinion. Consider a patient that confronts a diagnosis of a medical condition that requires a costly treatment. She will likely seek another expert and will potentially pay a higher price. It is a well-known phenomenon that consumers travel long distances and pay higher prices to obtain more accurate diagnoses when they are diagnosed with serious illnesses. The opinions of experts who can detect the mistakes of their colleagues are considered very valuable in such circumstances.

As the consumers revise their beliefs based on the initial diagnosis, an additional dimension of consumer heterogeneity arises. The value of the second opinion increases (decreases) with the cost of the preventive action \((c)\) when a consumer is initially diagnosed with the bad (good) state. We show in the Proof of Lemma 2 that, when \(c > 1/2\), consumers with a “bad” initial diagnosis value a second opinion more compared to consumers with a “good” initial diagnosis \((V_{ijk}^2(g) > V_{ijk}^2(b))\). This represents the case where the consumer is told that she needs to take a costly preventive action in order to avoid the bad state. Alternatively, when \(c \leq 1/2\), consumers with a “good” initial diagnosis value a second opinion more compared to consumers with “bad” initial diagnosis \((V_{ijk}^2(g) > V_{ijk}^2(b))\). This represents the case where consumers wish to secure themselves against the potential loss by taking the low-cost preventive action, but the expert disagrees. In the rest of the analysis we only need the higher of the two valuations, which we denote as \(V_{ijk}^2 = \max \{V_{ijk}^2(g), V_{ijk}^2(b)\}\) for notational simplicity.

Taken together, Lemma 1 and Lemma 2 imply that the value of a first opinion is more sensitive to changes in the diagnostic accuracy of its provider compared to the value of a second opinion. This is because the value of a first opinion depends solely on the diagnostic accuracy of its provider, whereas the value of a second opinion depends on the diagnostic accuracies of both experts. Since a low online channel effectiveness \((\gamma)\) has a direct negative effect on an expert’s diagnostic accuracy, a low level of \(\gamma\) reduces the value of the first opinion more.

**Corollary 2.** The value of the first opinion \((V_{ij}^1)\) is more sensitive to changes in online channel effectiveness than the value of the second opinion \((V_{ij}^2)\).

4.1. The benchmark case: experts serve face-to-face only (no online channel)

We present the equilibrium outcomes when only the face-to-face channel is available. There are two possible outcomes. The low-quality expert sells first opinions in both of these outcomes, whereas the high-quality expert sells either first or second opinions.\(^6\) Recall that, according to Lemmas 1 and 2, the high-quality expert is more likely to offer second opinions when the low-quality expert errs frequently, because a lower \(a_{ij}\) increases the difference between \(V_{ij}^2\) (the value of high-quality expert’s face-to-face second opinion) and \(V_{ij}^1\) (the value of high-quality expert’s face-to-face first opinion). Interestingly, in such a case the presence of the low-quality expert may allow the high-quality expert to extract a higher (second opinion) profit compared to his monopoly (first opinion) profit. However, the sale of second opinions can have negative implications on the overall consumer surplus. A total of \(m_h + m_l\) consumers

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5 An expert can provide second opinions to consumers with either a good or a bad initial diagnosis. He cannot decrease price to serve both consumer types because doing so would render the first consultation redundant and its value zero, prohibiting the sale of the first consultation. Since second opinions can be sold only with the sale of first consultations, the expert who is interested in selling second opinions can cater only to the ex post high-value consumer type as part of his optimal strategy.

6 Given the quality difference between experts, Lemma 2, and Corollary 1, the low-quality expert has fewer incentives to offer second opinions than the high-quality expert. Thus, an outcome in which the high-quality expert serves first opinions while the low-quality expert serves second opinions cannot be pareto optimal. Also, the low-quality expert is further limited by the number of second opinions he can sell, given the difference in the capacities of experts \((m_h < m_l)\). We therefore do not consider such an outcome.
obtain a consultation when both experts sell first opinions, whereas only $m_l$ consumers receive expert services when the high-quality expert provides second opinions.

**Proposition 1.** When face-to-face is the only service channel, the low-quality expert sells first opinions, charges $p_{lj}^* = V_l^{ij} - m_l t$, and earns $\prod^*_l = m_l (V_l^{ij} - m_l t)$.

a. If $t > \frac{V_{lf}^2 - V_{lf}^1}{1 - m_l + m_h}$, the high-quality expert sells first opinions, charges $p_{hf}^* = V_{hf} - m_h t$, and earns $\prod^*_h = m_h (V_{hf} - m_h t)$.

b. If $t < \frac{V_{hf}^2 - V_{hf}^1}{1 - m_l + m_h}$, the high-quality expert sells second opinions, charges $p_{hf}^* = V_{hf} - (1 - m_l + 2m_h) t$, and earns $\prod^*_h = m_h [V_{hf}^2 - (1 - m_l + 2m_h) t]$.

According to Proposition 1, the expert prefers selling second opinions if $t < \frac{V_{hf}^2 - V_{hf}^1}{1 - m_l + m_h}$. In other words, an increase in transaction cost affects the profitability of the second opinion strategy more negatively because of the difference in the locations of the high-quality expert’s customers in the two scenarios. The high-quality expert serves to consumers located between 0 and $m_h$ when selling first opinions and those between $1 - m_l$ and $1 - m_l + 2m_h$ when selling second opinions (since $m_h < m_l$, $1 - m_l + 2m_h < 1$). Therefore, second opinion customers are more adversely affected from increases in transaction costs. We formalize this discussion with the following corollary.

**Corollary 3.** Transaction costs have a more adverse effect on the profitability of face-to-face second opinions than on the profitability of face-to-face first opinions.

In reality, good experts are typically rare to find. Well-known medical experts review cases only after a patient is diagnosed with a problem. Law professors from Northwestern, Yale, and other top schools are oftentimes called upon for a second opinion at prices starting from $150 to $700 per hour, all indicating the viability of the second outcome in Proposition 1.

### 4.2. Experts serve both face to face and online

With the emergence of the Internet as an additional channel, experts can offer face-to-face and online services at different prices. We find that the Internet may provide the high-quality expert additional incentives to specialize in second opinions because of its effect on diagnostic accuracies of experts and the transaction cost. First, according to Corollary 1, to the extent that online delivery reduces the diagnostic accuracy of the first opinion, it increases the value of the second opinion. Second, according to Corollary 2, the value of the first opinion loses its value at a greater rate than the second opinion as the online channel becomes less effective. And third, according to Corollary 3, transaction costs have a more adverse effect on the profitability of face-to-face than online second opinions. Therefore, the elimination of transaction costs via the online channel benefits the profitability of second opinions more. All three imply that the Internet has a more positive effect on the profitability of second opinions than that of first opinions.

**Proposition 2.** The emergence of the online channel has a more positive effect on the profitability of second opinions than of first opinions.

The online channel allows experts to engage in second-degree price discrimination by offering services via two channels at separate prices. Consumers self-select the service they value more based on their location, a mechanism that allows the expert to charge more to those who opt for the face-to-face service. In this dual-channel environment, the high-quality expert can embark on five strategies. Specifically, he can sell (a) only face-to-face first opinions, (b) both face-to-face and online first opinions, (c) only face-to-face second opinions, (d) both face-to-face and online second opinions, and (e) only online second opinions. As we show in Proposition 3, the high-quality expert prefers selling online consultations in the first opinion market if the transaction cost is sufficiently high compared to the reduction in the value of first opinion due to online delivery ($t > \frac{V_{lf}^2 - V_{lf}^1}{2m_h}$). Similarly, the expert prefers selling online consultations in the second opinion market if the transaction cost is sufficiently high compared to the reduction in the value of his second opinion due to online delivery ($t > \frac{V_{hf}^2 - V_{hf}^1}{1 - m_l + 4m_h}$). If the transaction cost is even higher ($t > \frac{V_{hf}^2 - V_{hf}^1}{1 - m_l + 4m_h}$), then the expert prefers selling only online consultations in the second opinion market. The high-quality expert’s best

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8 At the optimum, the high-quality expert never offers only online first opinions because, given $\gamma \leq 1$, he can always charge a face-to-face price greater than or equal to his online price and still find customers willing to visit him physically.
strategy is determined by the comparison between the optimal profits in the first and second opinion markets. Proposition 3 characterizes the equilibria that produce these five outcomes.

**Proposition 3.** The low-quality expert sells both face-to-face and online first opinions if \( \frac{V_F - V_O}{2m_h} < t \); otherwise he sells only face-to-face first opinions. Then, the high-quality expert provides

- a. only face-to-face first opinions, charges \( p_{hf}^* = V_{hf} - m_h \), and earns \( \prod_h = m_h (V_{hf} - m_h) \), provided \( m_h (V_{hf} - m_h) > \frac{m_h V_{ho}^2}{8t} \) if \( V_{hf} - (1-m_1)t < V_{ho}^2 \)
  \[ \frac{m_h V_{ho}^2}{8t} + \frac{(V_{hf} - (1-m_1)t - V_{ho}^2)^2}{8t} \]  \( \quad \) if \( V_{hf} - (1-m_1)t > V_{ho}^2 \)
  \[ \frac{m_h V_{ho}^2}{8t} + \frac{(V_{hf} - (1-m_1)t - V_{ho}^2)^2}{8t} \]  \( \quad \) and \( \frac{V_{hf} - V_{ho}^2}{1-m_1 + m_h} < t < \frac{V_{ho}^2 - V_{ho}^2}{2m_h} \).

- b. both face-to-face and online first opinions, charges \( p_{hf}^* = \frac{V_{hf} + V_{ho}}{2} \), \( p_{ho}^* = V_{ho} \), and earns \( \prod_h^* = \frac{(V_{hf} - V_{ho})^2}{4t} + \frac{m_h V_{ho}^2}{2m_h} \), provided \( \prod_h^* = m_h (V_{hf} - (1-m_1 + 2m_h)t) \) if \( \frac{V_{hf} - (1-m_1)t - V_{ho}^2}{8t} \)
  \[ \frac{m_h V_{ho}^2}{8t} + \frac{(V_{hf} - (1-m_1)t - V_{ho}^2)^2}{8t} \]  \( \quad \) if \( V_{hf} - (1-m_1)t > V_{ho}^2 \)
  \[ \frac{m_h V_{ho}^2}{8t} + \frac{(V_{hf} - (1-m_1)t - V_{ho}^2)^2}{8t} \]  \( \quad \) and \( m_h (V_{hf} - (1-m_1 + 2m_h)t) \geq \frac{(V_{hf} - V_{ho}^2)^2}{4t} + m_h V_{ho}^2 \).

- c. only face-to-face second opinions, charges \( p_{hf}^* = V_{hf}^2 (1-m_1 + 2m_h)t \), and earns \( \prod_h^* = m_h (V_{hf} - (1-m_1 + 2m_h)t) \), provided \( t \min \left\{ \frac{V_{hf}^2 - V_{ho}^2}{1-m_1 + 2m_h}, \frac{V_{hf}^2 - V_{ho}^2}{1-m_1 + 4m_h} \right\} \) and \( m_h (V_{hf} - (1-m_1 + 2m_h)t) \geq \frac{(V_{hf}^2 - V_{ho}^2)^2}{4t} \) \( \quad \) and \( m_h V_{ho}^2 \) > \( \prod_h^* = m_h V_{ho}^2 \) provided \( m_h V_{ho}^2 \) > \( \frac{m_h V_{ho}^2}{1-m_1} \).

A comparison of equilibrium prices for outcomes a and b and outcomes c and d reveals that the high-quality expert can charge a higher face-to-face price after introducing his online service. Note that neither expert sells only online first opinions because, no matter how effective the online channel is, there exists a closely located customer who is willing to pay more for a face-to-face service.9 This is not the case in the second opinion market due to the fact that even the closest customer travels considerably (at least \( 1 - m_i \)) for a face-to-face visit, making it feasible for the high-quality expert to specialize in the sale of online second opinions. Recall that doctors affiliated with high-profile medical institutions such as Harvard Hospitals and the Cleveland Clinic use online consultations for second opinions only. The strategy they have chosen exemplifies the outcomes outlined in Proposition 3d and e.

For illustrative purposes, we present the equilibrium outcomes of Proposition 3 in Fig. 1, where \( h \) and \( l \) stand for high- and low-quality experts, while \( F2F \) and \( O \) stand for face-to-face and online consultations, respectively. Fig. 1 depicts optimal expert strategies for different levels of online channel effectiveness and transaction cost. Since the low-quality expert’s diagnostic accuracy (\( a_L \)) affects the high-quality expert’s optimal profit in the second opinion market (see the discussions leading to Lemma 2), we take two different values of \( a_L \) to conceptualize two situations where second opinions are profitable in one (Fig. 1a) and not too profitable in the other (Fig. 1b). The value we take for \( a_L \) is lower in the first case (0.6) than in the second (0.75). Although observing a low-quality expert with such a high accuracy in Fig. 1b (\( a_L = 0.75 \)) may be too extreme, we present both cases for the sake of completeness. We use the following parameter values to designate the optimal strategies of experts in each region: \( a_L = 0.95 \), \( c = 0.6 \), \( m_h = 0.1 \), and \( m_l = 0.5 \). In drawing the figures, we first determine where each profit function is valid and then compare the values of valid profit functions across all \( \gamma \) and \( t \) value pairs.

When the low-quality expert has a relatively low diagnostic accuracy (Fig. 1a), the high-quality expert always sells second opinions at the optimum. Channel decisions in this case are made in the following fashion. If transaction costs are low and the online channel is not effective (Region I in Fig. 1a), both experts use only the face-to-face channel. As transaction costs and online channel effectiveness increase, the experts start to offer online consultations. Specifically, the low-quality expert

9 For example, the consumer located at zero does not travel to visit the high-quality physically. Therefore, only in the limiting case where the online channel is as effective as the face-to-face-to-face one (\( \gamma = 1 \)) does this consumer value online and face-to-face first opinions of the high-quality expert equally. Otherwise (\( \gamma < 1 \)), she values a face-to-face first opinion more.
provides both online and face-to-face first opinions in Regions II, III, and IV, while the high-quality expert offers both online and face-to-face second opinions in Region III and only online second opinions in Region IV of Fig. 1a. In contrast, when the low quality expert has a relatively high diagnostic accuracy (Fig. 1b), the high-quality expert in most cases sells first opinions at the optimum. Similar to the previous case, experts serve face-to-face for low transaction cost and online channel effectiveness. Because of the additional incentives the Internet provides for second opinions, however, the high-quality expert may prefer selling online second opinions for high transaction costs and intermediate levels of $\gamma$ (Region III in Fig. 1b). Even in such a tough market with a proficient low-quality expert, the high-quality expert specializes in second opinions and benefits from the online channel. The expert sells only face-to-face first opinions in Regions I and II and both face-to-face and online first opinions in Region IV of Fig. 1b. In this market, experts provide only first opinions in the absence of the Internet. Hence, the emergence of the online channel makes the provision of second opinions more likely.

5. Discussion and conclusions

Expert markets exhibit unique features such as the sale of multiple opinions for the same consumer problem. The literature on expert services examines the incentives of high-quality experts to specialize in second opinions and finds that the competition between a low-quality expert may allow a high-quality expert to extract a higher profit compared to his monopoly profit [25]. We observe a similar phenomenon in our setting as well. Our main contribution, however, is the analysis of optimal channel management in an expert market. In a dual-channel environment, we focus on the provision of first and second opinions to consumers who rely on experts to identify and remedy an uncertain personal problem. We show that a low diagnostic accuracy of the first opinion provider and a high cost of the suggested preventive action increase the value of a second opinion. Therefore, to the extent that the Internet reduces the diagnostic accuracies of experts, the online provision of first opinions supports the delivery of second opinions. Furthermore, since the value of the first opinion depends solely on the accuracy of its provider while the value of the second opinion depends on the accuracies of both experts, a relatively low online channel effectiveness has a more negative effect on the value of the first opinion. The reduction of transaction costs via the Internet increases the profitability of second opinions more because second opinion customers incur a higher transaction cost than first opinion customers. In short, we find significant analytical evidence that more second opinions should be provided with the emergence of the Internet. Second opinion services, online or face-to-face, may be expected to proliferate only in situations where consumers confront a major, costly decision problem for which they may hear widely differing opinions from experts.

This article is also related to the literature on multi-channel management. There too, some of the main
questions concern the manner in which Internet can be used to segment consumers to optimize the provision and distribution of retail goods. For example, Balasubramanian [1] shows that the Internet can be used to segment consumers horizontally, while Riggins [23] and Hitt and Frei [12] emphasize the profitability of vertical segmentation through selling high-quality products to high-value customers online and low-quality products to low-value customers in the physical store. In contrast, our setting features both horizontal and vertical differentiation. The experts segment consumers horizontally by serving closely located consumers face-to-face and those located farther away online. In addition, experts engage in vertical differentiation as the low-quality expert serves first opinions and the high-quality expert sells second opinions to ex-post high-value consumers. However, one crucial difference is that the product sold on the Internet is of higher quality in retail markets whereas it is of lower quality in expert markets.

We make simplifying assumptions in the model that pose some limitations. The model allows for a maximum of two opinions. While consumers can seek third or fourth consultations, the likelihood that an additional opinion may change consumers’ optimal strategy decreases with the number of consultations. We assume that consumers pay the full price of a consultation. Experts would be able to charge higher prices if consumers pay only a fraction of the full price (e.g., due to insurance). Each expert is assumed to suggest the same preventive action. When an expert employs a better (or less costly) treatment technology, his second opinion would be valued more. Thus, heterogeneity in preventive actions may provide yet another reason as to why top experts may specialize in selling second opinions.

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Appendix A

Table A1

<table>
<thead>
<tr>
<th>i</th>
<th>Expert type. i ∈ {h,l}; h=high-quality, l=low-quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>a_{ij}</td>
<td>Diagnostic accuracy of expert type i ∈ {h,l} on channel j ∈ {f,o}</td>
</tr>
<tr>
<td>γ</td>
<td>Online channel effectiveness</td>
</tr>
<tr>
<td>c</td>
<td>The cost of preventive action to the consumer</td>
</tr>
<tr>
<td>t</td>
<td>Transaction cost parameter</td>
</tr>
<tr>
<td>m_i</td>
<td>The capacity of expert type i ∈ {h,l}</td>
</tr>
</tbody>
</table>

Table A1 (continued)

| p_{ij} | The price charged by the expert of type i ∈ {h,l} via channel j ∈ {f,o} |
| y_{i,j} | The value of the type-i expert’s first opinion offered via channel j ∈ {f,o} |
| y_{i,k} | The value of type-i expert’s second opinion when he uses channel j and the other expert uses channel k to provide the first opinion |

Proof of Lemma 1. Suppose a consumer purchases a face-to-face consultation from an expert of type i via channel j. Notice first that the consumer strategy of “consult and do not take the preventive action when suggested” is dominated by the strategy of “do not consult” because in both cases expected consumer surplus is the same (1/2) while in the former case the consumer additionally incurs a transaction cost. Thus, consumers always take the preventive action when prescribed by an expert. With probability a_{ij}/2, the expert correctly diagnoses the good state when the state is actually good, and the consumer maintains the unit utility. When the state is bad, the expert errs with probability (1 - a_{ij})/2, and the consumer loses the unit utility. Thus, the expert diagnoses the good state with probability 1/2. With the remaining probability (1/2), the expert diagnoses a bad state and suggests the preventive action, in which case the consumer obtains a surplus of 1 - c. The value of the first consultation, V_{i,j}, is obtained by subtracting the expected utility of “do not consult” strategy from the expected utility post consultation: V_{i,j} = a_{ij}/2 + (1-c)/2 - 1/2 = a_{ij} - c/2. □

Proof of Corollary 1. Given V_{i,o} = γ_{a_{ij} - c}/2, then \( \frac{\partial V_{i,o}^{1}}{\partial \gamma} = \frac{a_{h,l}}{2} > \frac{\partial V_{i,o}^{1}}{\partial \gamma} = \frac{a_{h,l}}{2}, \) implying that a reduction in \( \gamma \) has a more negative effect on \( V_{i,o}^{1} \) than on \( V_{i,o}^{1} \). □

Proof of Lemma 2. A consumer would pay for a second opinion only if she knows she would take the recommendation of the second expert should that expert disagree with the first one. The consumer seeks a second opinion after obtaining a diagnosis of either the bad state or the good state (seeking a second opinion in both cases is dominated). We next solve for the value of the second opinion after the low-quality expert diagnoses the consumer with the bad state. The solutions for the other three cases are similar. Suppose the high-quality expert serves via channel j and the low-quality expert via channel k. With 1/2 probability, the low-quality expert diagnoses the good state, upon which the consumer stops the search process and maintains the unit utility with probability a_{jk}. With 1/2 probability, the low-quality expert diagnoses the bad state, and the consumer revises the ex post probability of
the bad state to \( a_{bh} \). In the second consultation, the high-quality expert fails with probability \( 1 - a_{bh} \) when the state is actually bad, indicating an expected loss of \( a_{bh}(1 - a_{bh}) \). The expert prescribes the preventive action with probability \( a_{bh} a_{ik} + (1 - a_{bh})(1 - a_{ik}) \). Consequently, the expected utility of the consumer after the second consultation is

\[
\frac{a_{bh}(1 - a_{bh}) - a_{bh} a_{ik} + (1 - a_{bh})(1 - a_{ih})}{2} c.
\]

We subtract the expected surplus after the first consultation \((1 - c)\) from this expression to find the value of the second opinion:

\[
V_{hik}^2(b) = \frac{a_{bh}(1 - a_{bh}) - a_{bh} a_{ik} + (1 - a_{bh})(1 - a_{ih})}{2} c.
\]

Taking partial derivatives with respect to \( c, a_{ih}, \) and \( a_{bh} \):

\[
\frac{\partial V_{hik}^2(b)}{\partial c} = a_{bh}(1 - a_{bh}) + a_{ih}(1 - a_{ih}) > 0,
\]

\[
\frac{\partial V_{hik}^2(g)}{\partial c} = -a_{bh}(1 - a_{bh}) - a_{ih}(1 - a_{ih}) < 0,
\]

\[
\frac{\partial V_{hik}^2(b)}{\partial c} = a_{bh}(1 - a_{bh}) + a_{ih}(1 - a_{ih}) > 0,
\]

\[
\frac{\partial V_{hik}^2(g)}{\partial c} = -a_{bh}(1 - a_{bh}) - a_{ih}(1 - a_{ih}) < 0,
\]

\[
\frac{\partial V_{hik}^2(h)}{\partial a_{ik}} = -ca_{bh} - (1 - c)(1 - a_{ih}) < 0,
\]

\[
\frac{\partial V_{hik}^2(g)}{\partial a_{ih}} = -(1 - c)a_{bh} - c(1 - a_{ih}) < 0,
\]

\[
\frac{\partial V_{hik}^2(b)}{\partial a_{ih}} = -ca_{bh} - (1 - c)(1 - a_{ih}) < 0,
\]

\[
\frac{\partial V_{hik}^2(g)}{\partial a_{ih}} = -(1 - c)a_{bh} - c(1 - a_{ih}) < 0.
\]

**Proof of Corollary 2.** Let \(-i\) denote \( i = h, \) and conversely. The first and second opinion valuations derived in the Proof of Lemma 2 can be stated in terms of \( \gamma \) as:

\[
V_{yi}^1 = \gamma a_{yj} - c, \quad V_{hjk}^2(b) = c\gamma a_{yj}(1 - a_{-ik}) - (1 - c)a_{-ih}(1 - \gamma a_{yj}) V_{hjk}^2(g) = (1 - c)\gamma a_{yj}(1 - a_{-ik}) - ca_{-ik}(1 - \gamma a_{yj})
\]

Taking partial derivatives with respect to \( \gamma \):

\[
\frac{\partial V_{yi}^1}{\partial \gamma} = \frac{a_{yj} - c}{2}, \quad \frac{\partial V_{hjk}^2(b)}{\partial \gamma} = a_{yj}[c(1-a_{-ik}) + (1-c)a_{-ih}] \frac{\partial V_{hjk}^2(g)}{\partial \gamma} = a_{yj}[(1-c)(1-a_{-ik}) + ca_{-ih}]
\]

According to the Proof of Lemma 2, when \( c > 1/2, V_{hjk}^2(b) > V_{hjk}^2(g) \) and thus \( V_{hjk}^2(b) \) is relevant, and conversely. Given that \( 1/2 \leq a_{-ik} \leq 1, a_{-ih} = 1/2 \) maximizes \( c(1-a_{-ik}) + (1-c)a_{-ih} \) when \( c > 1/2 \) and \( (1-c)(1-a_{-ik}) + ca_{-ih} \) when \( c < 1/2 \). Therefore, the maximum of both \( \frac{\partial V_{hjk}^2(b)}{\partial \gamma} \) and \( \frac{\partial V_{hjk}^2(g)}{\partial \gamma} \) equal \( a_{yj}/2 \), indicating that the value of the first opinion increases more with \( \gamma \) than the value of the second opinion.

**Proof of Proposition 1.** Because of the transaction cost-based heterogeneity, experts can expect a higher return from closely located consumers. They can increase their price until the last consumer that fills their capacity is indifferent between obtaining a consultation and doing nothing. Thus, the experts can charge as high as \( p_{yj} = V_{yi}^1 - m_t \) when selling first opinions. The high-quality expert serves to consumers located between 0 and \( m_h \), while the low-quality expert serves consumers located between \( 1-m_l \) and the other half with the good state (see Proof of Lemma 1), the ex post high-value consumer type has a density of 1/2 on the unit line. Consequently, when selling second opinions, the high-quality expert caters to consumers located between \( 1-m_l \) and \( 1-m_l+2m_h \), and can charge at most \( p_{yj} = V_{yi}^1 - (1-m_l+2m_h)t \). The comparison of profits (prices multiplied by \( m_h \)) for the two strategies suggest that the high-quality expert sells first opinions when \( [V_{yj}^1 - m_t]m_h > [V_{yi}^2 - (1-m_l+2m_h)t] \). 

\( m_h \). Alternatively, \( t_{yj}^* = \frac{V_{yi}^2 - V_{yj}^1}{1-m_l + m_h} \) should hold.

**Proof of Proposition 2.** This result follows from Corollaries 1, 2, and 3

**Proof of Proposition 3.** The proof involves derivation of expert profits for all possible strategies. Note first that the low-quality expert can charge as high as \( p_{yj}^* = V_{yi}^1 \) for its online service. The location of the consumer who is indifferent between obtaining a face-to-face and an
online consultation from this expert can be found by: \( V_{yst} = \frac{p_{yst} - t(1-x_1)}{2} = V_{h0} - \frac{pt_t}{2} \). Maximizing with respect to \( p_{yst} \) we obtain \( p_{yst} = V_{yst} + V_{h0} \) and \( \Pi^*_h = \frac{(V_{yst} - V_{h0})^2}{4t} + m_hV_{h0} \). This solution is optimal for \( x_1 < 1 - m_h \) or equivalently, \( V_{yst} - V_{h0} > \frac{2m_h}{t} \). For \( V_{yst} - V_{h0} < \frac{2m_h}{t} \), the low-quality expert’s optimal strategy in the first opinion market is to serve face-to-face only.

Similarly, the high-quality expert’s optimal strategy in selling first opinions is to offer both face-to-face and online consultations if \( \gamma > \frac{1}{2} \) where \( p_{yst} = \frac{V_{yst} + V_{h0}}{2} \) and \( \Pi^*_h = \frac{(V_{yst} - V_{h0})^2}{4t} + m_hV_{h0} \). Otherwise, serving only face-to-face is more profitable. Serving only online is not an option since, as long as \( \gamma < 1 \), the expert can find a segment of consumers who value his face-to-face service more than the online one.

The expert has three channel strategies in selling second opinions. He can either serve only face-to-face, both face-to-face and online, or only online. The last strategy is possible in the second opinion market because even the closest second opinion customer (located \( 1 - m_t \) away from the expert) values the convenience of an online consultation from this expert can be found by: \( \Pi^*_{ht} = \frac{(V_{h0} - V_{hfk})^2}{4t} + m_hV_{hfk} \). Similarly, this can be the equilibrium outcome (e) if the profit of this strategy is greater than the maximum that the expert can get from the first opinion market:

\[
\max\left\{ m_h(V_{h0} - m_h)\Gamma^{22/4t} + m_hV_{h0}\right\}.
\]

(2) The optimal strategy in the second opinion market is to serve online only, in which case \( \Pi^*_{ht} = \frac{(V_{h0} - V_{hfk})^2}{4t} + m_hV_{hfk} \). Similarly, this can be the equilibrium outcome (f) if the profit of this strategy is greater than the maximum that the expert can get from the first opinion market:

\[
\max\left\{ m_h(V_{h0} - m_h)\Gamma^{22/4t} + m_hV_{h0}\right\}.
\]

If \( \frac{V_{yst} - V_{h0}}{2m_h} > t \), the optimal strategy in the second opinion market is selling both face-to-face and online consultations. This can be the equilibrium outcome (b) if the profit of this strategy is greater than the maximum that the expert can get from the first opinion market:

\[
\Pi^*_h = \frac{(V_{h0} - V_{hfk})^2}{4t} + m_hV_{hfk} \quad \text{when} \quad \Pi^*_{ht} > \frac{(V_{h0} - V_{hfk})^2}{4t} + m_hV_{hfk}.
\]

\[\text{References}\]


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