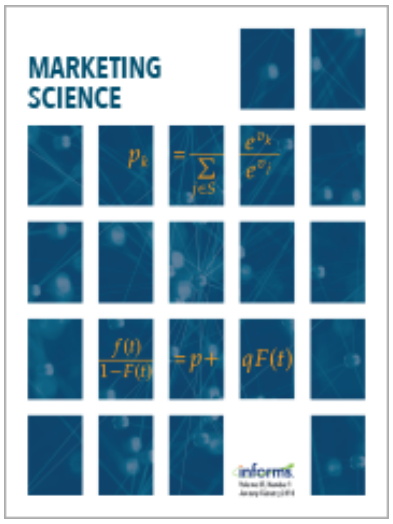


Marketing Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Signaling Quality Through Specialization

Ajay Kalra, Shibo Li,

To cite this article:
Ajay Kalra, Shibo Li, (2008) Signaling Quality Through Specialization. Marketing Science 27(2):168-184. https://doi.org/10.1287/mksc.1070.0300

MARKETING SCIENCE
Vol. 27, No. 2, March–April 2008, pp. 168–184
ISSN 0732-2399 | EISSN 1526-548X | 08 | 2702 | 0168

informs

DOI 10.1287/mksc.1070.0300

Signaling Quality Through Specialization

Ajay Kalra
Tepper School of Business, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213, kalra@andrew.cmu.edu

Shibo Li
Kelley School of Business, Indiana University, Bloomington, Indiana 47405, shili@indiana.edu

Firms frequently position themselves as specialists. An implication of specialization is that the firm has forgone alternative opportunities. In the context of effort-intensive categories, we show that a firm can signal quality to consumers by specializing. In the model, a firm must decide to provide one service offering or to market two services. By entering a single category, the firm incurs an opportunity cost of not entering the secondary profitable category, but may attain reduced costs. The net cost is the signaling cost that a high-quality type firm incurs to signal quality over a low-quality type firm. We show that in homogenous markets, a high-quality type firm signals its high-quality type by specializing in one category. When consumers are heterogeneous, the firm can signal its high-quality type by using prices alone in both the primary and secondary categories. However, specialization can be used as a secondary signal of quality in heterogeneous markets because of lower signaling costs. We also find that signaling using specialization is more likely in the presence of competition.

Key words: specialization; signaling
History: This paper was received July 19, 2004, and was with the authors 21 months for 4 revisions; processed by Venky Shankar.

1. Introduction

Imagine a consumer who needs to get the interior of her house painted. One firm claims it is the "paint and wallpaper specialists," whereas another firm advertises that it provides carpentry, paint, and landscaping services. Or consider a consumer whose car has brake problems and must choose between a repair chain that advertises "We Do it All" whereas the second headlines that they are the "brake people." Which supplier does the consumer select? Growth strategies that expand a firm's product mix have been of considerable interest to practitioners and academics alike. However, it is interesting to observe that several firms communicate to consumers that they provide a single product offering. For example, Americaquest advertises that it is the "mortgage specialist," whereas Pethealth claims to focus on "health insurance for pets." A cursory examination of advertisements shows that in several categories, firms headline that they have focused service offerings. Among others, these categories include insurance, investment and commercial banking, hospitals, and travel agencies. Clearly, the intent of this approach is to indicate quality. By stating that they are focused or specialized, these firms communicate that they eschew alternative opportunities. We examine how such specialization can be a signal of quality. We also examine the conditions under which it may be better for a firm to adopt a single service strategy.

The meaning of the term "specialist" differs across contexts. In the strategy literature (e.g., Carroll 1984), firms operating in narrow niche segments have been referred to as specialists, although the general usage of the term refers to acquiring advance education (e.g., medical specialists). For the purpose of this paper, we want to define "specialization" clearly to distinguish it from its usage in other literature and that of common parlance. Here, specialization by a firm refers to the number of service categories that it markets. We consider a firm to be a specialist if it markets a narrow number of services (e.g., insurance only) as compared to a firm that offers services in more categories (e.g., insurance and financial advice).

1.1. Effort-Intensive Services

A key issue is to identify the contexts in which specialization can signal quality. Production costs consist of human capital costs (labor) and nonhuman capital costs (machinery and tools). Increasing empirical evidence suggests that in product-oriented firms where the proportion of nonhuman capitals costs is high, a wider product mix does not necessarily result in increased manufacturing costs (e.g., Anderson 1995, Banker and Johnston 1993, Datar et al. 1993, Foster and Gupta 1990, Ittner and MacDuffie 1995, Kekre and Srinivasan 1990).

In the services domain, however, the results so far are quite different. The argument on the increasing returns from specialization for human capital

inputs is well established (e.g., Becker and Murphy 1992, Rosen 1983). In service-oriented firms, employing personnel who can provide multiple services has been determined not to be optimal (e.g., Agnihotri et al. 2003, Chevalier and Tabordon 2003). Generally, workers proficient in several domains tend to receive higher salaries than those who have narrower skill sets. Also, expanding the skill set of employees by cross training is expensive. Service providers who work in several domains may be of lower quality than those who specialize, because although they develop a larger skill set, they are not proficient in any specific area (Pinker and Shumsky 2000). This is particularly true in situations in which quality is based on acquired expertise. Increasing evidence also suggests that specialization reduces costs in effort-intensive areas that involve high human capital inputs such as hospital specialization (Easthaugh 2001, Farely and Hogan 1990), insurance (Adams 1997) as well as banking (Maudos et al. 2002), brokerage services, and credit cards (Porrino 2002).

A broad generalization is that, from the cost perspective, effort-intensive firms where human capital inputs are high, such as many services or knowledge-intensive products, may find it more optimal to signal quality through specialization than would manufacturing firms where human capital inputs are low. The results of this paper, therefore, are pertinent to effort-intensive categories such as insurance, banking, brokerage, tax preparation, and auto repairs, among others.

One of the well-known differentiating characteristic of services from products is simultaneity of production and consumption. An implication of a high level of simultaneity is that scalability becomes very difficult (e.g., Zeithaml and Bitner 2000). In addition, if heterogeneity in the quality of the service delivered is high, the problem becomes exacerbated when the firm enters multiple categories. There is evidence in the services literature that choice among services is perceived as riskier than choices among products (e.g., Iacobucci 1998, Iacobucci and Ostrom 1996). In signaling terms, the prior probability that the service is of high quality is low. In these situations, the need for a high-quality firm to signal quality is high. Together, theses characteristics make signaling through specialization relatively more important in effort-intensive service industries, and also more credible.

1.2. Model Intuition and Main Results

We consider a stylized model where a firm has the resources and ability to simultaneously enter two categories. The firm can either be a high-quality firm or a low-quality firm. Consumers are uncertain of the quality of the firm. As in any signaling model, the high-quality firm wants to separate from a possible "ghost" low-quality firm. That is, the strategy must reveal to the uncertain consumers that it is indeed the high-quality firm. To successfully separate, the high-quality type firm must employ a strategy that is too costly for the low-quality type firm to mimic. In such a separation, the low-quality firm is better off revealing its true low-quality. On observing the strategy, consumers correctly infer that the firm's quality is high.

Costs play a key role in whether a firm will signal quality by specializing (i.e., entering only one category). By specializing, the firm incurs opportunity costs of the forgone market. On the positive side, there are cost savings from specialization. The net of these costs are the signaling costs. We begin by considering homogeneous consumers, which serves as a benchmark for the more general heterogeneous case. We show that the firm will specialize even in situations in which it has access to other signals, such as price. The intuition behind the main result of the paper is as follows: When consumers are homogeneous, to signal its high quality, the firm enters only one category (i.e., specializes), and by doing so, sacrifices the potential profit from the second category but also accrues some cost savings from specialization. If the low-quality firm mimics the high-quality firm by specializing, it too will suffer net losses, which are the opportunity costs from the second category minus the cost savings from specialization. First, due to its lower unit cost, the low-quality firm will incur greater opportunity costs when it mimics the high-quality firm by specializing. Second, the high-quality firm reduces its costs more by specializing than does the low-quality firm. Therefore, for every extra unit of net loss suffered by the high-quality firm through specialization, the low-quality firm will have to suffer more than one unit of net loss to mimic. Hence, by entering only one category, the profit forgone in the second category is higher and cost savings are lower for the low-quality than for the high-quality firm. Therefore, the low-quality firm is better off entering both categories and revealing its true low quality to consumers.

When consumers are heterogeneous, the high-quality firm can signal its high quality using prices. The price signaling required is through the mechanism of distorting prices for both offerings rather than the price of one service alone. Even when prices are sufficient to signal quality, we show that the high-quality firm will still specialize and enjoy higher profits. It does so because, by specializing, the price that it can charge in its primary category is nearer to the first-best prices (the prices that the high-quality firm would charge if there was no consumer uncertainty regarding the high quality). The use of an additional signal as a useful supplement to price has also been

discussed in Moorthy and Srinivasan (1995). We show that these main results continue to hold when the monopolist assumption is relaxed. Interestingly, we also show that it is also more likely for the high-quality entrant to use specialization to separate from the low-quality entrant in the presence of competition from an existing incumbent.

Signaling quality is not the only reason firms specialize. In some categories like microbreweries, large-size firms may be inconsistent with the perception of craftlike production methods. Alternatively, firms may simply lack sufficient resources to enter multiple service categories. Thus, our results are applicable only to those situations in which firms have the resources but actively decide not to pursue additional categories. Specialists also may exist in markets in which they can provide objective competitive advantage with no uncertainty. For example, firms that offer only oil changes may be faster than firms that perform general repairs. Furthermore, firms might specialize to attract different segments in the market. We examine the specific conditions in which the segmentation argument is consistent with our model and show that when the size of a novice segment is small or the difference in the quality valuation between segments is large, then the segment characteristics can result in specialization regardless of quality uncertainty. Conversely, if the size of the novice segment is large or the difference in quality valuations between segments is low, the firm will specialize to signal quality.

Because empirical evidence indicates that they are more prevalent, we first consider scenarios in which specialization reduces costs. Later, we examine other scenarios in which unit costs decrease when firms broaden their product mix. Two factors can impact unit cost decreases. First, large firms with broad resources or high capacity may enjoy positive economies of scope. Second, there may be synergies in the two service categories that could lead to cost reduction (e.g., investment and tax planning). Therefore, we also discuss situations in which firms are likely to separate and signal using specialization versus those in which we are likely to observe pooling equilibrium.

The results of our model are most applicable when consumers know that a firm specializes and that it has foregone opportunities. Specialization is therefore more likely to indicate quality when consumers can easily observe different firms using multiple strategies—that is, some firms specialize, whereas other do not.

1.3. Implications and Contributions

Quality-signaling literature has identified several mechanisms that a firm can use to separate itself, such as price (e.g., Desai and Srinivasan 1995, Srinivasan 1991), advertising (e.g., Nelson 1974, Milgrom and Roberts 1986), umbrella branding (Wernerfelt 1988), retailer reputation (Chu and Chu 1994), money back guarantees (Moorthy and Srinivasan 1995), slotting allowance and advertising (Desai 2000), cheap talk (Li 2005), online word of mouth (Mayzlin 2006), and salesforce compensation (Kalra et al. 2003). We add to this literature by examining how specialization can be used to signal quality in effort-intensive industries. In addition, by comparing specialization with price as an alternative signaling mechanism, we also add to the growing literature on the efficiency of alternative signaling mechanisms (e.g., Desai 2000).

Furthermore, we provide implications for cross selling, an area that continues to receive more attention (e.g., Kamakura et al. 2003, Li et al. 2005). The literature suggests normative strategies for matching consumers with new services that can be cross-sold. A message of our paper is that in effort-intensive industries, the product markets in which a firm elects to compete affect consumers' perceptions of quality. This implication is of substantive interest. For example, there have been more than 380 acquisition transactions between banks and insurance firms since the passage of the Gramm-Leach-Billey Act (1999), which eliminated the separation between banking and other financial services. Much of the impetus for such acquisitions has been for the potential for cross selling. However, the potential for cross selling was not realized for most banks (e.g., *The American Banker* 2001, Wepler et al. 2004, *Credit Card Management* 2002). The popular press has speculated that this failure was caused by the lack of managerial expertise and staff training. We provide what we believe to be one alternative convincing argument of why cross selling by banks and insurance firms has failed.

Finally, we contribute to the strategy literature on diversification. Prior literature in strategy advocates firm growth strategies like diversification by claiming major benefits such as reduction in risk, higher efficiency, and higher performance (e.g., Brush 1996, Panzar and Willig 1981, Penrose 1959, Porter 1985, Schilling and Steensma 2002). Much of this literature advocates that firms diversify if they have enough resources, particularly if the resources are shared across different markets. We sound a cautionary note regarding such prescriptive strategies. Our results suggest that such diversification may be less likely to succeed in effort-intensive industries, specifically from a consumer perceptions perspective.

2. Model

Consider a firm that can simultaneously enter a new category (Category 1 with new Service 1) and also another market category (Category 2 with new Service 2). The firm has the resources and capability to

enter both at the same time. For example, a start-up home repair firm might enter the plumbing (Category 1) and the air conditioner installation and repair category (Category 2) at the same time, or an auto repair firm could enter both the body shop category (Category 1) and brake repair (Category 2) markets. As in any signaling model, the firm can be a high-quality type or a low-quality type firm that is exogenously selected by nature. As is standard, consumers are uncertain about the quality type.

We denote the high-quality firm as the type h firm, and the low-quality firm as the l type firm. For reasons of brevity and exposition, we consider cases where the firm is either high quality in both categories or low quality in both categories. Theoretically, it is possible that the firm is high quality in one category only, but this restriction does not alter the main results.[1]

2.1. Market

We now discuss the markets and the production of the services. The model considers two offerings and therefore two different categories. The demand for the two services is assumed to be independent. Consider, for example, the markets for brokerage account and insurance. The demand for one category is independent of the other. Without loss of generality, we set up Category 1 as the primary category for the firm. There are N consumers in Category 1 and M consumers in Category 2. We denote the categories as i ($i = 1$ or 2) where $i = 1$ is the primary category and $i = 2$ the secondary category. Without loss of generality, N is normalized to be 1 and M is normalized to be δ (δ may be less than, equal to, or greater than 1). Each consumer can buy at most one unit of the service in each market. Consumer's willingness to pay for the two services is assumed to be uniformly distributed over the interval $[0, 1]$ for the primary category and $[0, \delta]$ for the secondary category. As is standard, we assume that consumer's utility from purchasing service i ($i = 1$ or 2) from a type j ($j = h$ or l) firm is given by $U_i^j = \theta_i q_i^j - P_i^j$, where q is the quality and P is the price charged. θ_i is a parameter that captures consumer heterogeneity and $\theta_1 \sim \text{Uniform}[0, 1]$ and $\theta_2 \sim \text{Uniform}[0, \delta]$. As usual, consumers also have a "no purchase" option, and therefore will not buy if the utility of purchasing the service is less than some threshold value. Without loss of generality, the threshold value is normalized to be zero so that consumers will buy service i as long as $\theta_i q_i^j - P_i^j \geq 0$. We summarize the notation in Table 1.

[1] We discuss the reasoning in the intuition section following Proposition 1.

Table 1 Notations

Notation	Explanation
i	Category (1 = primary category, 2 = secondary category)
j	Firm type (h = high-quality, l = low-quality)
δ	Relative size of the secondary category
θ_i	Consumer's quality preference for service i ($i = 1, 2$)
α	Cost dependency between specialization and multiple market entry
s	Specialization
m	Multiple categories
λ (Λ)	Consumer's prior (posterior) probability that the firm is a high-quality firm
n	No uncertainty about quality type
a	Signaling through prices alone
I	Incumbent firm
E	Entrant firm
P_{im}^{j*} (P_{is}^{j*})	Complete-information optimal prices of service i for type j in the heterogeneous consumers model under multiple categories (specialization), $i = 1, 2$, $j = l, h$
Π_m^{j*} (Π_s^{j*})	Complete-information optimal profits for type j in the heterogeneous consumers model under multiple categories (specialization), $j = l, h$
P_{ima}^{j*}	Optimal prices of service i for type j in the separating equilibrium under prices alone, $i = 1, 2$, $j = l, h$
Π_{ma}^{j*}	Type j firm's expected profit in the separating equilibrium with prices alone

2.2. Demand and Profit

By definition, the high-quality firm's quality is higher than that of the low-quality firm ($q_i^h > q_i^l$). The consumer utility function is given by $U_i^j = \theta_i q_i^j - P_i^j$ for $i = 1$ or 2, $j = h$ or l. The firm's demand functions are given by $D_1^j = 1 - \min\{\theta_1\colon\ \theta_1 \geq p_1^j/q_1^j\}$ and $D_2^j = \delta - \min\{\theta_2\colon\ \theta_2 \geq p_2^j/q_2^j\}$, $j = h$ or l. The firm's profit functions are given by $\Pi_i^j = D_i^j(p_i^j - C_i^j)$ for $i = 1$ or 2, $j = h$ or l, where C_i^j denotes the unit service cost for type j in market i. Following common practice in signaling literature (e.g., Moorthy and Srinivasan 1995, Kalra et al. 2003), we normalize the firm's fixed costs to be zero and assume that the high-quality firm has higher unit production cost ($C_i^h > C_i^l$). Following the literature, we also assume that costs are convex in quality (e.g., Desai and Srinivasan 1995, Fine 1986, Montgomery and Wernerfelt 1992, Tellis and Wernerfelt 1987). The unit service costs in two markets can be correlated based on the relative synergies between the two categories. We denote the unit cost with multiple market entry as a function of the unit cost with specialization. That is, $C_{im}^j = \alpha C_{is}^j$, where α captures the potential dependency as independent ($\alpha = 1$), negative ($\alpha > 1$), or positive ($\alpha < 1$) economies of scope. Because it is uninteresting if the second category is unprofitable, we consider only the cases in which the firm can generate positive profits from Category 2 regardless of the type. That is, $\Pi_2^j > 0$ for $j = h$ or l.

In large part, we assume that unit cost when a firm specializes is lower than when the firm does

not ($\alpha > 1$). There is considerable empirical support for this assumption. In a study of medical services, Farely and Hogan (1990) examine the impact of hospital specialization using case-mix proportions and find strong evidence that specialization lowers costs. Similarly, in a study of 219 nonacute-care hospitals, Easthaugh (2001) reports that a 30.6% rise in specialization lead to an 8.2% reduction in units costs. In a study of Spanish banks, Maudos et al. (2002) classify banks as either universal banks, which have an evenly balanced structure, or as belonging to three subtypes of specializations based on the type of market focus. They find that total costs as a percentage of total assets were highest for the nonspecialized universal banks (9.14%) as compared to the other three categorizations where the cost percentage ranged from 8.64% to 9.09%. Adams (1997) also finds that reduced product-mix in the life insurance industry results in lower actuarial costs. A study of 50 financial services firms conducted by Ernst & Young (Porinno 2002) argues that specialization "often results in lower unit costs." The study categorizes services firms into banks, insurance, and other financial services such as credit card companies, investment banks, and broker-dealers. They find strong correlations between specialization and the price/book ratios for all three categories. Because the price/book ratio reflects a component of operational efficiency, it provides indirect evidence that specialization reduces costs. Given this evidence, we initially assume that $\alpha > 1$. Later, we discuss situations where $\alpha < 1$.

The game works as follows: At the first stage, nature selects the firm's quality type. Given its quality type, the firm moves by deciding whether to enter both categories or to enter only one category (specialize). If it decides to specialize, it will only enter Category 1. Then the firm selects the corresponding prices (p) for the service(s). In the second stage, consumers observe whether the firm has elected to enter both categories or specialize, and also observes the prices(s). They then decide whether or not to buy. The prior probability of the firm being high-quality type is assumed to be λ ($0 \le \lambda \le 1$), and hence the prior probability of the firm being low-quality type is $1 - \lambda$. As is standard in signaling models, the approach used here is to determine the pure-strategy Perfect Bayesian Equilibrium that satisfies the intuitive criterion (Tirole 1988).

We begin our analysis by examining the situation where consumers are homogeneous. To investigate whether prices and specialization can serve as quality signals, we examine the asymmetric information case in which homogeneous consumers are uncertain about the quality. Next, we look at the situation where consumers are heterogeneous and then compare the cases in which consumers are completely informed of the quality of the services and the case where there is quality uncertainty.

3. Model

We briefly discuss the case of homogeneous consumers, which serves as a benchmark, and then discuss heterogeneous consumers.

3.1. Homogeneous Consumer Model: Specialization Can Serve as a Quality Signal, Whereas Prices Alone Cannot

As stated earlier, without loss of generality, we assume that Category 1 is the primary category, and hence the firm always chooses to enter Category 1 if it specializes. The profits in both Category 1 and Category 2 are assumed to be nonnegative. Therefore, it is possible for the firm to enter two categories at the same time. When consumers know the quality of both the offerings with certainty, the firm will always enter both categories regardless of the quality types as long as the cost savings from specialization do not offset the opportunity costs from the second category.

We now consider the incomplete-information case where the firm knows its quality although consumers are uncertain. We show that prices alone cannot serve as quality signals when consumers are homogeneous, but specialization can.

When consumers are homogeneous, price cannot signal quality. Consider the situation when both types of firm enter both categories. Following the logic of Moorthy and Srinivasan (1995), in any separating equilibrium, the maximum price that can be charged is the consumers' reservation price. Necessarily, the prices charged by both types have to be lower than the reservation prices because any price higher results in zero sales. The low-quality firm has to set prices at the reservation price because any price lower is dominated. If the high-quality firm charges a price higher than that of the low-quality firm, the low-quality firm has an incentive to mimic. Conversely, if the low-quality firm charges a price higher than the high-quality firm, the high-quality firm has an incentive to mimic. Therefore, prices alone cannot signal quality in a homogeneous market.

Now we examine whether specialization can serve as a quality signal. The high-quality firm solves the following maximization program with two mimicking constraints. The first is that the low-quality firm will not mimic the high-quality firm by specializing in the primary category and charging the high-quality firm's equilibrium price P^h_{1s}. The second is that the high-quality firm will not mimic the low-quality firm by entering both markets and charging the low-quality firm's equilibrium prices.

$$\begin{aligned} \max_{P^h_{1s}} \quad & \Pi^h_{1s} = P^h_{1s} - C^h_{1s} \\ \text{s.t.} \quad & P^h_{1s} - C^l_{1s} \le \Pi^{l*}_m \\ & q^l_1 - \alpha C^h_{1s} + \delta(q^l_2 - \alpha C^h_{2s}) \le \Pi^h_{1s} \end{aligned} \tag{1}$$

We obtain the following proposition (see proof in the Technical Appendix 1) at http://mktsci.journal.informs.org.

PROPOSITION 1. *In the separating equilibrium, the high-quality firm specializes and chooses the first-best price* q_1^h *if* $\underline{P}_{1s}^h \le q_1^h \le \bar{P}_{1s}^h$ (*chooses* $\bar{P}_{1s}^h$ *if* $q_1^h > \bar{P}_{1s}^h$). *The low-quality firm enters both the primary and secondary categories and chooses its first-best prices* $P_{1m}^{l^*} = q_1^l$ *and* $P_{2m}^{l^*} = q_2^l$, *respectively, for its two services.*

The intuition behind Proposition 1 is as follows. By specializing, the high-quality firm incurs the opportunity costs of forgoing the secondary market. On the other hand, the high-quality firm also enjoys some cost savings by focusing on the primary market. The net cost is the signaling cost. By mimicking the high-quality firm, the low-quality firm will also incur opportunity costs, but these costs are higher than those of the high-quality type because its unit costs are lower. Similar to the high-quality firm, the low-quality firm also reduces costs by specializing. Because costs are convex in quality, the high-quality firm reduces its costs more than the low-quality type can through specializing. By mimicking the high-quality firm, the low-quality firm therefore incurs higher opportunity costs as well as accrues smaller cost reduction benefits by specializing. Therefore, it is better off for the low-quality firm to reveal its true type and enter both categories.

As stated in the proposition, the high-quality firm can separate using specialization and achieve its first-best price in the primary category. This occurs when the quality level of the high-quality firm is "medium" (i.e., $\underline{P}_{1s}^h \le q_1^h \le \bar{P}_{1s}^h$). When the quality level of the high-quality firm is "high" (i.e., $q_1^h > \bar{P}_{1s}^h$), separation still takes place by specializing. However, when the quality level of the high-quality firm is "high," its first-best price is also high, leading to high profitability in the primary category. The incentive for the low-quality firm to mimic therefore increases. This results in the high-quality firm charging less than its first-best price in the primary category.

The separating equilibrium described in Proposition 1 is supported by the following consumer's posterior beliefs. (1) If $\underline{P}_{1s}^h \le q_1^h \le \bar{P}_{1s}^h$: $\Lambda(q_1^h, \textit{specialization}) = 1$, $\Lambda(P_1, P_2, \textit{multiple entry}) = 0$, for any P_1 and P_2, and $\Lambda(P_1, \textit{specialization}) = \lambda$, for any $P_1 \neq q_1^h$. (2) If $q_1^h > \bar{P}_{1s}^h$: $\Lambda(\bar{P}_{1s}^h, \textit{specialization}) = 1$, $\Lambda(P_1, P_2, \textit{multiple entry}) = 0$, for any P_1 and P_2, and $\Lambda(P_1, \textit{specialization}) = \lambda$, for any $P_1 \neq \bar{P}_{1s}^h$.

As in Cho and Kreps (1987), Desai (2000), and Moorthy and Srinivasan (1995), we adopt the intuitive criterion to eliminate unrealistic beliefs. Under this criterion, consumers believe that a firm will only deviate from equilibrium if it can profit from the deviation given the most favorable consumer beliefs. However, for some deviations the intuitive criterion may eliminate both quality types or may not eliminate either type. In these cases, we follow Simester (1995), where consumers maintain their prior beliefs about the deviating firm's quality type, unless only one quality type can benefit from deviation given those prior beliefs. If only one quality type can gain by deviating, then consumers will believe that a deviating firm is the quality type for which such a deviation may be profitable. This is also termed "passive conjectures" in the game theory literature (e.g., Fudenberg and Tirole 1983, Guedes and Thompson 1995, Rasmusen 2001, Stefanadis 1998, Waehrer 1999).

For the sake of brevity, we discuss the potential pooling equilibrium for multiple entry or specialization in Technical Appendix 2.

So far we have assumed that the high-quality firm is of high quality in both services. The results of the model apply even when the firm is high quality only in one service. The reason is that the single-crossing property continues to hold in the latter case. Note that the signaling cost includes both the opportunity costs from the forgone secondary market and the cost saving via specialization. There are two important features about the signaling cost. First, due to its lower unit cost, the low-quality firm will incur greater opportunity cost when it mimicks the high-quality firm by specializing. Second, the high-quality firm reduces its costs more by specializing than does the low-quality firm. Now consider the case where there are four possible types of firms (i.e., high-high, high-low, low-high, and low-low quality in the two categories respectively) in the market. The focal issue then becomes whether the high-high quality firm can signal through specialization and separate itself from the other three types. Because of the two features of the signaling cost, all the other three types of firm (i.e., high-low, low-high, and low-low type firm) will incur either higher opportunity costs or accrue smaller cost saving (or both) when they mimick the high-high quality firm. Thus, signaling costs are higher for all the other three types of firm as compared with those of high-high quality firm. Therefore, the single-crossing property still holds.

3.2. Heterogeneous Consumer Model

We now examine the situation where consumers are heterogeneous. We begin with the case where consumers are informed of the firm's quality type, and then we consider the case where consumers are uncertain.

3.2.1. Complete-Information Case. When consumers are heterogeneous, consumer heterogeneity parameters follow uniform distributions: $\theta_1 \sim \text{Uniform}[0, 1]$ and $\theta_2 \sim \text{Uniform}[0, \delta]$. The demand, optimal prices, and optimal profits for specialization and multiple market entry are summarized in

Table 2 Complete-Information Demand, Price, and Profits for Heterogeneous Consumers

Strategy	Category	Demand	Optimal price	Optimal profits
Multiple entry	Category 1	$D^j_{1m} = 1 - \frac{p^j_{1m}}{q^j_1}$	$P^{j*}_{1m} = \frac{q^j_1 + \alpha C^j_{1s}}{2}$	$\Pi^{j*}_m = \frac{(q^j_1 - \alpha C^j_{1s})^2}{4q^j_1} + \frac{(\delta q^j_2 - \alpha C^j_{2s})^2}{4q^j_2}$
	Category 2	$D^j_{2m} = \delta - \frac{p^j_{2m}}{q^j_2}$	$P^{j*}_{2m} = \frac{\delta q^j_2 + \alpha C^j_{2s}}{2}$	
Specialization	Category 1	$D^j_{1s} = 1 - \frac{p^j_{1s}}{q^j_1}$	$P^{j*}_{1s} = \frac{q^j_1 + C^j_{1s}}{2}$	$\Pi^{j*}_s = \frac{(q^j_1 - C^j_{1s})^2}{4q^j_1}$

Table 2. Compared with the case of homogeneous consumers with complete information, the demand and the optimal prices are lower when consumers are heterogeneous.

As in the homogeneous consumer case, when consumers are heterogeneous and know the quality of both the offerings with certainty, the firm will always enter both categories regardless of the quality types as long as the cost savings from specialization cannot offset the opportunity costs from the second category. From Table 2, it is easy to see that as long as this condition is met, the profits from entering multiple markets are always greater than those from specializing.

3.2.2. Heterogeneous Consumer: Uncertainty. When consumers are homogeneous, we have demonstrated that specialization can serve as a quality signal whereas prices cannot. When consumers are heterogeneous, however, prices alone may signal service quality. We also demonstrate that specialization could be a useful supplementary signal to price signals for the high-quality firm because it can achieve higher profits and the price distortion is lower.

3.2.2.1. Prices Alone as Quality Signals. When consumers are heterogeneous, prices alone can serve as a quality signal, in which case both types of firms will choose to enter both categories. The high-quality firm solves the following maximization program with two mimicking constraints (i.e., the low-quality firm will not mimic the high-quality firm by charging the high-quality firm's equilibrium prices (i.e., $\Pi^l_{ma}(P^h_{1ma}, P^h_{2ma}) \le \Pi^{l*}_{ma}$) and vice versa (i.e., $\Pi^h_{ma}(P^{l*}_{1ma}, P^{l*}_{2ma}) \le \Pi^h_{ma}$)).

$$\begin{aligned}\max_{P^h_{1ma},\,P^h_{2ma}} \quad & \Pi^h_{ma} = \left(1 - \frac{P^h_{1ma}}{q^h_1}\right)\cdot(P^h_{1ma} - \alpha C^h_{1s}) \\ & \quad + \left(\delta - \frac{P^h_{2ma}}{q^h_2}\right)\cdot(P^h_{2ma} - \alpha C^h_{2s}) \\ \text{s.t.} \quad & \Pi^l_{ma}(P^h_{1ma}, P^h_{2ma}) \le \Pi^{l*}_{ma} \\ & \Pi^h_{ma}(P^{l*}_{1ma}, P^{l*}_{2ma}) \le \Pi^h_{ma}. \end{aligned} \tag{2}$$

We obtain the following lemma (see proof in Technical Appendix 3).

Lemma 1. *When consumers are heterogeneous, the low-quality firm as well as the high-quality firm enter both the primary and secondary categories. In the separating equilibrium, the high-quality firm distorts prices in both categories. The low-quality firm chooses its first-best prices.*

The intuition behind Lemma 1 is as follows. An increase in prices from the first-best prices hurts both types of firms as demand decreases. However, the low-quality firm suffers more by increasing prices due to its lower unit costs. For every unit loss by the high-quality firm, the low-quality firm will incur more than one unit by mimicking. Therefore, in equilibrium, the low-quality firm finds that it is more profitable to reveal its true low-quality type by charging its complete-information optimal prices. The equilibrium prices of the high-quality firm in both markets are higher than its complete-information optimal prices because of the price distortion required for signaling.

A natural question is whether the high-quality firm can separate by distorting price in only one category. For instance, the firm could charge a very high price for the primary service but a very low price for the secondary service. If the high-quality firm were to increases the price in one category while decreasing it in the other, it is easy to see that the incentive for the low-quality firm to mimic increases, thereby violating the mimicking constraint. Therefore, it is necessary that the high-quality firm distort prices in both categories. In an entry deterrence model, Srinivasan (1991) similarly discusses the use of price distortion in multiple markets.

The separating equilibrium described in Lemma 1 is supported by the following consumer's posterior beliefs.

$$\begin{aligned} &\Lambda(P^{h*}_{1ma}, P^{h*}_{2ma}, \textit{multiple entry}) = 1, \\ &\Lambda(P_1, \textit{specialization}) = \lambda, \quad \text{for any } P_1, \\ &\Lambda(P_1, P_2, \textit{multiple entry}) = \lambda, \\ &\qquad \text{for } P_i > P^{h*}_{ima} \text{ with } i = 1 \text{ and } 2, \quad \text{and} \\ &\Lambda(P_1, P_2, \textit{multiple entry}) = 0, \\ &\qquad \text{for } P_i < P^{h*}_{ima} \text{ with } i = 1 \text{ and } 2. \end{aligned}$$

3.2.2.2. Specialization as a Quality Signal. In the previous section, we showed that the high-quality firm must distort prices from first-best prices to separate from the low-quality firm. Can the firm profit more by using specialization as a complement to the price signal? We show that by specializing, the high-quality firm's profits are greater than the profits it can obtain from signaling through prices alone.

Suppose there exists a separating equilibrium such that the high-quality firm specializes in its primary category, whereas the low-quality firm enters two categories. We denote the equilibrium price as P_{1s}^h for the high-quality firm, and P_{1m}^l and P_{2m}^l for the low-quality firm. In such equilibrium, the profits from signaling through specialization must be at least the same as the profits from signaling with prices alone ($\Pi_{ma}^{h^*}$). For specialization to signal quality, the high-quality firm needs to maximize its profits ($\Pi_s^h = (1 - P_{1s}^h/q_1^h) \cdot (P_{1s}^h - C_{1s}^h)$) subject to two necessary conditions (i.e., mimicking constraints). The first necessary condition is that the low-quality firm must not mimic the high-quality firm by specializing in its primary category and charging the high type's equilibrium price P_{1s}^h. That is, $\Pi_m^{l^*} \geq \Pi_s^l(P_{1s}^h)$. The second necessary condition is that the high-quality firm must not mimic the low-quality firm by entering both categories, and generate at least the profits it can guarantee itself through signaling through prices alone, $\Pi_{ma}^{h^*}$. That implies $\Pi_s^h \geq \Pi_{ma}^{h^*}$. Mathematically, the high-quality firm needs to solve the following profit maximization problem.

$$\begin{aligned} \max_{P_{1s}^h} \ & \Pi_s^h = \left(1 - \frac{P_{1s}^h}{q_1^h}\right) \cdot (P_{1s}^h - C_{1s}^h) \\ \text{s.t.} \ & \Pi_s^l(P_{1s}^h) = \left(1 - \frac{p_{1s}^h}{q_1^h}\right)(p_{1s}^h - C_{1s}^l) \leq \Pi_m^{l^*} \\ & \Pi_{ma}^{h^*} \leq \Pi_s^h. \end{aligned} \tag{3}$$

We obtain the following proposition (see proof in the appendix).

Proposition 2. *There exists a separating equilibrium in which the high-quality firm will specialize. In the separating equilibrium, the high-quality firm specializes and distorts price in the primary category. The price distortion is less than the distortion when signaling using only prices. The low-quality firm enters both the primary and secondary categories and chooses its first-best prices for both services.*

The intuition for the separating equilibrium in Proposition 2 is similar to that of Proposition 1. By specializing, the high-quality firm incurs opportunity costs by forgoing the secondary market, but enjoys some cost savings by focusing on the primary market. By mimicking the high-quality firm, the low-quality firm would incur higher opportunity costs due to its lower unit costs. It also accrues smaller cost reduction benefits by specializing. Therefore, it is better for the low-quality firm to reveal its true type and enter both categories by charging its complete-information optimal prices.

Compared to signaling with prices alone, signaling with specialization results in lower price distortion and higher profitability for the high-quality firm. We discuss the intuition next.

In our analysis of specialization as a signal, the high-quality firm has to maximize profits subject to two necessary conditions. The first is standard: that the low-quality firm cannot mimic the high-quality firm by specializing. In the second condition, the first component is that the high-quality firm must generate at least the profits it can guarantee itself by signaling through prices alone (i.e., $\Pi_s^h \geq \Pi_{ma}^{h^*}$). The second component also is standard: that the high-quality firm must not mimic the low-quality firm by entering the two markets and charging the low-quality firm's first-best prices ($\Pi_s^h \geq \Pi_{ma}^h(P_{1ma}^{l^*}, P_{2ma}^{l^*})$). Note that the second component is subsumed in the first component. The reason is as follows: Because $\Pi_{ma}^{h^*}$ is the high-quality firm's equilibrium profit by signaling using prices alone, it must satisfy the condition that the high-quality firm should not mimic the low-quality firm (the second necessary condition in Lemma 1 (i.e., $\Pi_{ma}^{h^*} \geq \Pi_{ma}^h(P_{1ma}^{l^*}, P_{2ma}^{l^*})$). When the first component is satisfied, it is apparent that the second component will be satisfied too because we have the condition that profits from signaling through specialization are greater than the profits from signaling using prices alone, which are greater than the profits if the high-quality firm mimics the low-quality firm $\Pi_s^h \geq \Pi_{ma}^{h^*} \geq \Pi_{ma}^h(P_{1ma}^{l^*}, P_{2ma}^{l^*})$.

When the firm signals using prices alone, in the separating equilibrium, the high-quality firm has to distort prices in both markets. Note that the prices charged by the high-quality firm are not its first-best prices (see Lemma 1).

When comparing the price distortion in the separating equilibrium of the two cases (prices alone versus specialization), we can explain the intuition by discussing the mimicking incentive of the low-quality firm. Consider the case in which the high-quality firm separates using prices alone. In equilibrium, both types of firm enter both categories. When the high-quality firm charges high prices in both markets, the low-quality firm has a strong incentive to mimic because the total profit gain from mimicking the high-quality firm in two markets could be high. Therefore, to separate itself, the high-quality firm has to distort prices upwards enough in both markets to a point that the low-quality firm prefers not to mimic

because, with increasing prices, there is a corresponding large decrease in demand.

Now consider the case where the high-quality firm uses specialization as a supplementary signal to price. When mimicking, the low-quality firm has to specialize in the primary category and forgo all the potential profits from the secondary market. Hence, the profit gain through mimicking the high-quality firm comes from the primary market only, and this profit gain is relatively low compared to the case of signaling through prices alone. This results in lower incentive for the low-quality firm to mimic when specialization is used as a supplementary signal. Therefore, the high-quality firm does not need to distort its price as much as it does in the case of signaling through prices alone in the primary market. As compared to signaling using prices alone, when signaling through specialization, the separation equilibrium price of the high-quality firm is closer to the first-best price and thus yields higher total profits.

Signaling through specialization is more likely when the relative market size or the profitability rate of the secondary market is not high. Implicitly, the incentive for the low-quality firm to mimic is affected by the price sensitivity of consumers. When the high-quality firm distorts prices upward, demand also decreases. In a market where consumers are very price sensitive, separation through specialization is more likely to occur. Another factor that impacts the specialization strategy is the consumer prior that the firm is of high quality. When the prior is low and hence consumers' reservation price is low, deviation from the separating equilibrium is less likely to occur, so the firm is more likely to separate using specialization. In general, effort-intensive services industries are perceived as riskier and therefore more prone to consumers' having low priors (Iacobucci 1998, Iacobucci and Ostrom 1996). Within effort-intensive industries, the higher the level of uncertainty regarding quality, the more apt signaling through specialization is.

The separating equilibrium described in Proposition 2 is supported by the following consumer's posterior beliefs.

$$\Lambda(P_{1s}^{h^*}, \textit{specialization}) = 1,$$

$$\Lambda(P_1, P_2, \textit{multiple entry}) = 0, \quad \text{for any } P_1 \text{ and } P_2, \quad \text{and}$$

$$\Lambda(P_1, \textit{specialization}) = \lambda, \quad \text{for any } P_1 \neq P_{1s}^{h^*}.$$

For brevity, we discuss the potential pooling equilibrium in multiple entry or specialization in Technical Appendix 4.

3.2.2.3. Segmentation and Specialization. An alternative explanation for why some firms specialize may be that some target a specific segment. For example, an auto repair shop that specializes in auto transmissions may target only knowledgeable consumers who can correctly identify that the problem with their car is a transmission problem, whereas other firms that provide multiple services may target those consumers who are not as knowledgeable.[2] Our objective is to determine the conditions in which specialization results from target market characteristics rather than from the objective of quality signaling. We first consider the case of complete information and then examine the quality uncertainty case.

The existence of segments can be incorporated as discrete cases of consumer heterogeneity (θ) in the model. In each of the primary and secondary markets, we assume that there exist two segments, a knowledgeable segment (k) and a novice segment (n). That is, $\theta_k > \theta_n$. For simplicity, we let β be the proportion of the knowledgeable segments in both markets. The firm's decision now includes both the specialization decision and the decision about which segment to serve.

We first examine the conditions in which specialization results from the target segment characteristics. The demand, optimal prices, and optimal profits under different scenarios in the complete information case are given in Table 3. From Table 3, we can see that if in both markets the size of the "knowledgeable" segment is large (β is high) or consumers in the knowledgeable segment are very different than the novices (θ_k is relatively higher than θ_n), the high-quality firm will set a relatively high equilibrium price (i.e. $\theta_k q_i^j$) so that only the knowledgeable segment will purchase the service. Given these segment characteristics and prices, the high-quality firm serves only the knowledgeable segment and specializes when $\delta(\theta_k q_2^h - \alpha C_{2s}^h) \leq (\alpha - 1)C_{1s}^h$. That is, the high-quality firm enjoys sufficiently high profits from the knowledgeable segment in the primary category and is willing to forgo the profits from the same segment in the secondary category as well as those profits from the "novice" segment in both categories.

The low-quality firm will set a relatively low price (i.e., $\theta_n q_i^j$) to attract both the segments and generalizes if $\delta(\theta_n q_2^l - \alpha C_{2s}^l) \geq (\alpha - 1)C_{1s}^l$. Otherwise, it mimics the high-quality firm and specializes.

When quality uncertainty exists, as before, if the size of the knowledgeable segment is large in both markets (β is high) or the difference between the segments is relatively large (θ_k is relatively higher than θ_n), the high-quality firm sets a relatively high equilibrium price to attract the knowledgeable segment only, whereas the low-quality firm sets relatively low prices to attract both segments. In the separating equilibrium, the low-quality firm will always generalize, whereas the high-quality firm will specialize under certain conditions.

[2] We thank an anonymous reviewer for suggesting this example.

Table 3 Complete-Information Demand, Price, and Profits for Heterogeneous Consumers with Two Segments

Strategy	Category	Segment	Demand	Optimal price	Optimal profits
Multiple entry	Category 1	Both k and n	$D^j_{1m}=1$	$P^{j*}_{1m}=\theta_n q^j_1$	Serving both segment k and n:
		Segment k only	$D^j_{1m}=\beta$	$P^{j*}_{1m}=\theta_k q^j_1$	$\Pi^{j*}_m=\theta_n q^j_1-\alpha C^j_{1s}+\delta(\theta_n q^j_2-\alpha C^j_{2s})$
	Category 2	Both k and n	$D^j_{2m}=\delta$	$P^{j*}_{2m}=\theta_n q^j_2$	Serving segment k only:
		Segment k only	$D^j_{2m}=\beta\delta$	$P^{j*}_{2m}=\theta_k q^j_2$	$\Pi^{j*}_m=\beta(\theta_k q^j_1-\alpha C^j_{1s})+\beta\delta(\theta_k q^j_2-\alpha C^j_{2s})$
Specialization	Category 1	Both k and n	$D^j_{1s}=1$	$P^{j*}_{1s}=\theta_n q^j_1$	$\Pi^{j*}_s=\theta_n q^j_1-C^j_{1s}$
		Segment k only	$D^j_{1s}=\beta$	$P^{j*}_{1s}=\theta_k q^j_1$	$\Pi^{j*}_s=\beta(\theta_k q^j_1-C^j_{1s})$

Now we examine the conditions where specialization results not from segmentation, but instead from quality signaling. When there is no quality uncertainty, the firm always generalizes (i.e., enters both markets) regardless of its quality type if the profits from the secondary market can offset the cost saving from specialization ($\delta(\theta_g q^j_2-\alpha C^j_{2s})\geq(\alpha-1)C^j_{1s}$, for segment $g=k$ or n, and firm type $j=h$ or l). If in both markets the size of the knowledgeable segment is small (β is low) or consumers in the knowledgeable segment are not very different from novices (θ_k is only slightly higher than θ_n), both the high-quality firm and the low-quality firm will set a relatively low price (i.e., $\theta_n q^j_i$) to attract both consumer segments.

However, when quality uncertainty exists, in the separating equilibrium, the low-quality firm will always enter both categories, whereas the high-quality firm will specialize under certain equilibrium conditions. The high-quality firm will set the equilibrium price to separate and maximize profits. Again, if in both markets the size of the knowledgeable segment is small (β is low) or consumers in the knowledgeable segment are not very different than the novices (θ_k is only slightly higher than θ_n), both the high-quality firm and the low-quality firm will set a relatively low price (i.e., $\theta_n q^j_i$) to attract both segments.

Returning to the transmission example, if there is a sufficiently high proportion of knowledgeable consumers or if the difference in quality valuation between the knowledgeable and novice consumers is large, then the high-quality firm is more likely to specialize in response to consumer characteristics. Otherwise, it is more likely that specialization will occur to signal quality.

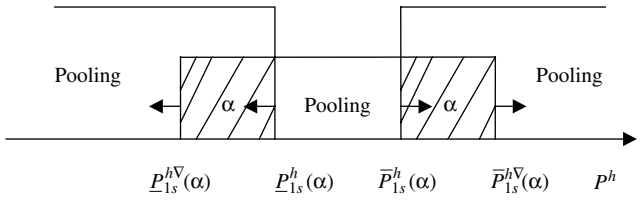
3.2.2.4. Separating Equilibrium: Impact of Economies of Scope. So far, we have considered the cases in which costs decrease when the firm specializes. As discussed earlier, empirical evidence suggests that this scenario represents most effort-intensive situations. We now consider two factors that may impact the cost dependencies between the categories that the firm enters. Recall that the cost dependency between categories is captured by the parameter α, whose range is between 0 and ∞ where $\alpha>1$ indicates negative economies of scope, $\alpha<1$ indicates positive economies of scope, and $\alpha=1$ indicates independence. One factor that may impact α is the size of the firm. A global firm such as Citi or Cigna clearly possesses the resources to enter new categories more efficiently than do smaller firms. These global firms face lower capacity constraints due to their broad-scale operations and therefore can enter new categories with fewer cost implications than a more specialized firm such as GEICO. The second factor that impacts cost dependency between categories is synergy between the categories. The economies of scope likely will be much less negative when a firm enters two related categories (e.g., brakes and muffler repair) compared with when it enters relatively unrelated categories (e.g., brakes and body work). Categories such as tax planning and financial advice are other examples where there are likely to be positive economies of scope ($\alpha<1$).

We first consider the situation in which α is "moderately greater than 1." For the low-quality firm, the profit reduction entailed by entering the secondary category will not be very high because its costs do not increase too much. In addition, when the low-quality firm enters both categories, the reduced profits from the primary category because of the lack of specialization are moderate. For the high-quality firm, however, the profit reduction in both categories could be high due to the cost convexity. Together, the incentive for the low-quality firm to mimic decreases and a separating equilibrium in which the high-quality firm specializes is more likely to exist.

When α is high, regardless of quality types, the cost of entering both markets typically is extremely high, and therefore both types enter only the primary market. For example, physicians and lawyers rarely enter multiple markets because the cost of acquiring multiple skills is too high. Therefore, both the high-and low-quality firms enter only one market.

Finally, when ($\alpha\leq 1$), the positive economies of scope result in lower costs incurred by a firm that generalizes. Therefore, pooling equilibrium in multiple

Figure 1 Impact of Cost Dependency on Separating Equilibrium Conditions



entries is more likely. Such categories include plumbing and heating firms or tax planning and financial advice.

We illustrate the separating equilibrium conditions on specialization as a quality signal in Figure 1. As shown in Technical Appendix 5, the key necessary conditions for the separating equilibrium are: the high-quality firm's equilibrium price has to lie in the range $[\underline{P}^{h\nabla}_{1s}(\alpha), \underline{P}^{h}_{1s}(\alpha)]$ or $[\bar{P}^{h}_{1s}(\alpha), \bar{P}^{h\nabla}_{1s}(\alpha)]$, i.e., the two shaded areas in Figure 1. If the high-quality firm's price is too high (greater than $\bar{P}^{h\nabla}_{1s}(\alpha)$) or too low (less than $\underline{P}^{h\nabla}_{1s}(\alpha)$), the low-quality firm will mimic the high-quality firm and specialize. Intuitively, if the high-quality firm's price is too high, the incentive for the low-quality firm to mimic increases due to higher profits. If the high-quality firm's price is too low, the low-quality firm's incentive to mimic will also increase as demand (and profits) increase. If the high-quality firm's price is in the middle range (greater than $\underline{P}^{h}_{1s}(\alpha)$ but less than $\bar{P}^{h}_{1s}(\alpha)$), the high-quality firm will mimic the low-quality firm and enter both categories.

We now examine how the cost dependency parameter (α) affects the separating equilibrium. As shown in Technical Appendix 5, the derivatives with respect to α of the two cutoff points $\bar{P}^{h\nabla}_{1s}(\alpha)$ and $\bar{P}^{h}_{1s}(\alpha)$ are positive, whereas those for $\underline{P}^{h}_{1s}(\alpha)$ and $\underline{P}^{h\nabla}_{1s}(\alpha)$ are negative. That implies that when there is a moderate cost increase associated with entering two categories, the two separating equilibrium areas, i.e., the two shaded areas in Figure 1, shift outwards. This results in a larger price distortion from the high-quality firm's complete-information optimal price. Therefore, signaling through specialization is more likely. When the firm size is large or when there is synergy between the two categories, α is very low. This leads to an inward shifting of the two separating equilibrium areas and results in lower price distortion in equilibrium. Therefore, pooling equilibrium in multiple entries is more likely.

4. Impact of Firm Competition

In this section, we examine whether the results of our model hold when we relax the monopolist assumption. Similar to Kalra et al. (1998), we consider a stylized model in which an incumbent firm faces competitive entry.[3] The incumbent operates in both the primary and secondary categories because its profits are positive in both. Consumers know the quality of the incumbent, but are uncertain about the quality of the entrant, whereas the incumbent can correctly evaluate the quality of the entrant using research and reverse engineering. The consumer model is the same as in the monopolist case, and we consider Category 1 the primary category for the firm. As earlier, we assume that consumer's utility from purchasing service i ($i = 1$ or 2) from the incumbent or the entrant is given by $U_i = \theta_i q_{ki} - P_{ki}$, where $k = I$ (incumbent) or E (entrant), q is the quality, and P is the price charged. θ_i is a parameter that captures consumer heterogeneity, and $\theta_1 \sim$ Uniform$[0, 1]$ and $\theta_2 \sim$ Uniform$[0, \delta]$. Consumers purchase from the firm that gives them the highest nonnegative surplus.

The demand for the two services is again assumed to be independent. We follow the demand model setup of Kalra et al. (1998) for both markets. The first case is when the entrant is of higher quality than the incumbent. Here, the following conditions have to be satisfied for both the firms to have nonzero market shares: $q_{Ei} > q_{Ii}$, $P_{Ii} < P_{Ei}$, and $q_{Ei}/P_{Ei} < q_{Ii}/P_{Ii}$.[4] In this case, the set of consumers who purchase the entrant's service in the primary and secondary categories is of the form $[\theta_1^{**}, 1]$ ($[\theta_2^{**}, \delta]$, respectively, with $\theta_1^{**} = \min\{\theta_1\colon 0 \le \theta_1 \le 1, \theta_1 q^j_{E1} - P^j_{E1} \ge \theta_1 q_{I1} - P_{I1}, \theta_1 q^j_{E1} - P^j_{E1} \ge 0\}$ for $j = h$ or l ($\theta_2^{**} = \min\{\theta_2\colon 0 \le \theta_2 \le \delta, \theta_2 q^j_{E2} - P^j_{E2} \ge \theta_2 q_{I2} - P_{I2}, \theta_2 q^j_{E2} - P^j_{E2} \ge 0\}$). The set of consumers purchasing the incumbent's service is of the form $[\theta_i^*, \theta_i^{**}]$ with $0 < \theta_i^* < \theta_i^{**} < 1$, $\theta_1^* = \min\{\theta_1\colon 0 \le \theta_1 \le 1, \theta_1 q^j_{E1} - P^j_{E1} \ge 0\}$, and $\theta_2^* = \min\{\theta_2\colon 0 \le \theta_2 \le \delta, \theta_2 q^j_{E2} - P^j_{E2} \ge 0\}$ for $j = h$ or l. The set of consumers who do not purchase is $[0, \theta_i^*]$. The demand functions and optimal pricing strategies facing the incumbent and entrant are given in Table 4. The entrant's profit functions are $\Pi^j_{iE} = D^j_{iE}(p^j_{iE} - C^j_{iE})$, and those for the incumbent are $\Pi_{iI} = D_{iI}(p_{iI} - C_{iI})$ where $i = 1$ or 2, $j = h$ or l, and C^j_i denotes the unit service cost for type j in market i. Again, we assume that the high-quality firm has a higher unit production cost ($C^h_i > C^l_i$) and that the unit cost when a firm specializes is lower than when the firm does not ($\alpha > 1$).

In the second case, the incumbent's quality is higher than that of the entrant (i.e., $q_{Ei} < q_{Ii}$). For both firms to attain nonzero market share, we need $q_{Ei} < q_{Ii}$, $P_{Ii} > P_{Ei}$, and $q_{Ei}/P_{Ei} > q_{Ii}/P_{Ii}$ to be satisfied. The

[3] Our focus is on whether the high-quality new entrant can signal its service quality through specialization in the postentry period. Thus, we abstract away from the incumbent's strategic considerations such as limit pricing, entry deterrence, and signal jamming (Kalra et al. 1998, Milgrom and Roberts 1982, Srinivasan 1991).

[4] Please see Kalra et al. (1998) for complete details.

Table 4 Demand and Optimal Prices Facing the Incumbent and Entrant

Firm	Strategy	Category	Demand	Optimal price
Entrant	Multiple entry	Category 1	$D^j_{1Em} = 1 - \frac{P^j_{1Em} - P_{1\mathrm{Im}}}{q^j_{1E} - q_{1I}}$	$P^{j*}_{1Em} = \frac{2q^j_{1E}(q^j_{1E} - q_{1I})}{4q^j_{1E} - q_{1I}} + \frac{q^j_{1E}(2\alpha C^j_{1Es} + C_{1I})}{4q^j_{1E} - q_{1I}}$
		Category 2	$D^j_{2Em} = \delta - \frac{P^j_{2Em} - P_{2\mathrm{Im}}}{q^j_{2E} - q_{2I}}$	$P^{j*}_{2Em} = \frac{2\delta q^j_{2E}(q^j_{2E} - q_{2I})}{4q^j_{2E} - q_{2I}} + \frac{q^j_{2E}(2\alpha C^j_{2Es} + C_{2I})}{4q^j_{2E} - q_{2I}}$
	Specialization	Category 1	$D^j_{1Es} = 1 - \frac{P^j_{1Es} - P_{1Is}}{q^j_{1E} - q_{1I}}$	$P^{j*}_{1Es} = \frac{2q^j_{1E}(q^j_{1E} - q_{1I})}{4q^j_{1E} - q_{1I}} + \frac{q^j_{1E}(2C^j_{1Es} + C_{1I})}{4q^j_{1E} - q_{1I}}$
Incumbent	Multiple entry	Category 1	$D_{1\mathrm{Im}} = \frac{q_{1I}P^j_{1Em} - q^j_{1E}P_{1\mathrm{Im}}}{q_{1I}(q^j_{1E} - q_{1I})}$	$P^*_{1\mathrm{Im}} = \frac{2q^j_{1E}C_{1I}}{4q^j_{1E} - q_{1I}} + \frac{q_{1I}(q^j_{1E} - q_{1I} + \alpha C^j_{1Es})}{4q^j_{1E} - q_{1I}}$
		Category 2	$D_{2\mathrm{Im}} = \frac{q_{2I}P^j_{2Em} - q^j_{2E}P_{2\mathrm{Im}}}{q_{2I}(q^j_{2E} - q_{2I})}$	$P^*_{2\mathrm{Im}} = \frac{2q^j_{2E}C_{2I}}{4q^j_{2E} - q_{2I}} + \frac{q_{2I}(\delta q^j_{2E} - \delta q_{2I} + \alpha C^j_{2Es})}{4q^j_{2E} - q_{2I}}$

demand functions and optimal pricing strategies facing the incumbent and entrant can be derived easily as in the previous case. Whether the entrant or the incumbent has higher quality mainly impacts how the two firms divide up the market in each category. It does not alter the main signaling separation results. For brevity, we only focus on the case in which the entrant is of superior quality (i.e., $q_{Ei} > q_{Ii}$).

The game can be considered as two periods. In the first period, the incumbent enters both markets and selects monopolist prices. In the second period, nature first selects the entrant's quality type. Given its quality type, the entrant's next move is to decide whether to enter both categories or to enter only one category (specialize). Then both firms select the corresponding prices (p) for their service(s) at the same time. In the final stage, consumers observe the actions of the two players and make a decision whether to buy, and if so, which firm to select. The major difference from the monopolist case is that each firm maximizes profits subject to the reaction function of its competitor.

The results mirror the monopolist case. When consumers are certain of the entrant's quality, the entrant will always enter both categories regardless of its quality type if the profits from the secondary market can offset the cost saving from specialization. As we expect, due to competitive effects, the entrant earns less profit than it would in the monopolist case. When consumers are uncertain about the entrant's quality, the high-quality entrant can signal its true high quality and separate from the low-quality type through price distortion alone in both markets. This leads to Lemma 2 below. (See the proof in Technical Appendix 6.)

Lemma 2. *When the entrant's quality is higher than the incumbent's, there exists a separating equilibrium with prices alone. In the separating equilibrium, both the high-quality entrant and low-quality entrant enter both the primary and secondary categories. The low-quality entrant and the incumbent choose its duopoly optimal prices given their complete-information reaction functions. In both services, the high-quality entrant distorts price from the complete-information optimal duopoly prices.*

The separating equilibrium described in Lemma 2 is supported by the following consumer's posterior beliefs.

$$\Lambda(P^{h*}_{1Ema}, P^{h*}_{2Ema}, \textit{multiple entry}) = 1,$$
$$\Lambda(P_{1E}, \textit{specialization}) = \lambda, \quad \text{for any } P_{1E}; \quad \text{and}$$
$$\Lambda(P_{1E}, P_{2E}, \textit{multipleentry}) = \lambda,$$
$$\text{for } P_{iE} > P^{h*}_{iEma} \text{ with } i = 1 \text{ and } 2. \quad \text{and}$$
$$\Lambda(P_{1E}, P_{2E}, \textit{multiple entry}) = 0,$$
$$\text{for } P_{iE} < P^{h*}_{iEma} \text{ with } i = 1 \text{ and } 2.$$

To examine specialization as a supplementary signal to price, we set up the high-quality entrant's and the incumbent's profit maximization programs as we did for the case of signaling using prices alone. The high-quality entrant's profit maximization program is:

$$\begin{aligned} \max_{P^h_{1Es}} \ & \Pi^h_{Es} = \left(1 - \frac{P^h_{1Es} - P_{1\mathrm{Im}}}{q^h_{1E} - q_{1I}}\right)(P^h_{1Es} - C^h_{1Es}) \\ \text{s.t.} \ & \Pi^l_{Es}(P^h_{1Es}) = \left(1 - \frac{P^h_{1Es} - P_{1Im}}{q^h_{1E} - q_{1I}}\right) \\ & \qquad \cdot (P^h_{1Es} - C^l_{1Es}) \le \Pi^{l*}_{Em} \\ & \Pi^{h*}_{Ema} \le \Pi^h_{Es}. \end{aligned} \tag{4}$$

The incumbent's profit maximization program is:

$$\begin{aligned} \max_{P_{1\mathrm{Im}}, P_{2\mathrm{Im}}} \Pi_I = & \frac{q_{1I}P^h_{1Es} - q^h_{1E}P_{1\mathrm{Im}}}{q_{1I}(q^h_{1E} - q_{1I})}(P_{1\mathrm{Im}} - C_{1I}) \\ & + \left[\delta - \frac{P_{2\mathrm{Im}}}{q_{2I}}\right](P_{2\mathrm{Im}} - C_{2I}) \end{aligned} \tag{5}$$

We obtain the following proposition (see the proof in Technical Appendix 7).

PROPOSITION 3. *When the entrant's quality is higher than the incumbent's in the separating equilibrium, the high-quality entrant specializes in the primary category and distorts price less than when it signals through prices alone. The low-quality entrant and the incumbent choose their duopoly optimal prices, given their complete-information reaction functions.*

The separating equilibrium described in Proposition 3 is supported by the following consumer's posterior beliefs about the entrant's type.

$$\Lambda(P_{1Es}^{h^*}, \textit{specialization}) = 1;$$

$$\Lambda(P_{1E}, P_{2E}, \textit{multiple entry}) = 0, \quad \text{for any } P_{1E} \text{ and } P_{2E}; \quad \text{and}$$

$$\Lambda(P_{1E}, \textit{specialization}) = \lambda, \quad \text{for any } P_{1E} \neq P_{1Es}^{h^*}.$$

Again, the results mirror those of the monopolist case. Is specialization as a signal of quality more or less likely in the competitive market? In comparison to the monopolist case, the low-quality entrant has a low incentive to mimic the high-quality entrant. Because the primary market is now shared with the incumbent, the potential gain by specializing to the low-quality entrant reduces when there are two players. Interestingly, therefore, it is more likely for the high-quality entrant to use specialization to separate from the low-quality entrant in the presence of competition.

5. Conclusion

Selection of the product-offering mix is one of the most important strategic issues for a firm with crucial implications for growth strategies and brand equity. The most common growth avenue that firms use is product-line expansion or brand extensions. We show, however, that when uncertainty about quality exists, firms in effort-intensive industries can signal quality to consumers by focusing on a single offering. Specialization as an indicator of quality is more useful for firms whose human inputs account for a larger component of their costs or, analogously, where the quality is determined by human-based outputs. These categories include most services and some labor-intensive products. We also examine conditions in which specialization is most likely to indicate quality and those in which it cannot.

We first considered a market with homogeneous consumers. When prices cannot be used by a high-quality firm to separate from a low-quality firm, specialization serves as a signal of quality. In the heterogeneous consumer case, the high-quality firm can separate from a low-quality firm and signal quality using prices alone. We show that the high-quality firm has to distort prices in both categories to separate instead of distorting the price of one service. As in Moorthy and Srinivasan (1995), we show that even if prices are adequate to signal quality, specialization is useful because it can serve as a profitable supplementary signal. Using specialization when consumers are heterogeneous reduces the price distortion in the primary category and thereby increases market coverage and creates higher profitability. The presence of competition increases the firm's rationale to use specialization as a signal of quality.

We also examine scenarios in which firms derive cost benefits from specialization and in which costs increase with specialization. These are likely to occur when firms are large and may benefit from economies of scope. In addition, the size of the firm itself may indicate quality to consumers. This explains the relative success of global firms such as American Express or Citi, who operate in multiple categories. Also, synergies may lead to cost reduction when the categories are related, such as tax planning and financial advice. When firms benefit from economies of scope, specialization to signal quality is less likely to occur and pooling is more likely to be observed.

We also show that consumer characteristics can drive a firm to specialize. When a sufficiently large segment of knowledgeable consumers exists or when there is a large difference in the quality valuation between novices and more knowledgeable consumers, a high-quality firm will specialize without any signaling objective.

In a dynamic setting, it can be argued that a firm can signal quality in the first period, and after being correctly identified as a high-quality firm can later diversify to enjoy increased revenue streams. Two characteristics of effort-intensive industries could preclude or delay this sequence. First, because services are intangible, true quality is intrinsically hard to verify (e.g., Kopalle and Lehmann 2006). Therefore, continuous signaling may be required. Second, effort-intensive categories are characterized by heterogeneity in quality, particularly across time. Consider the high-quality firm who knows that it is high quality, that its quality will vary in a limited range but will still be higher than any quality that can be attained by the low-quality firm. Therefore, the high-quality firm is always high quality, whereas the low-type firm is always low quality. Consumers, however, are uncertain of the quality type of the firm and are also uncertain about the extent of quality variation. Thus, in any period, they are uncertain whether the high-type firm that has successfully signaled its high quality earlier will continue to maintain high quality in the current period. In this case too, the high-quality firm will need to continue signaling using specialization. Thus, a multiperiod game with this model can be viewed as

a multiperiod game of strategic interactions.[5] In case the concerns needed to continuously signal do not arise, then the high-quality firm can signal quality by specializing, and then later diversify. In this situation, related to signaling, additional support for our theory is that a benefit of specialization is also that firms can create new markets through service innovation, and then by specializing in the category overcome service variability through a scalable business model and continuous operational innovation (Berry et al. 2006). Once scalability is achieved, then the firm can enjoy economies of scope and diversify.

Can the firm deploy alternative approaches to signal quality? We have already discussed that the firm can successfully signal using prices, but that specialization in addition to pricing is more efficient. One alternative that the firm may evaluate is advertising. In the context of our model, dissipative or uninformative advertising (e.g., Milgrom and Roberts 1986) cannot be used because it is only an added cost but does not increase demand. Because uninformative advertising costs the same for a low-quality firm to mimic the high-quality firm, it does not have the single-crossing property. Depending on the category, other alternatives that the firm can potentially use is to align with a retailer of high reputation (Desai 2000), the salespeople can inform consumers about their compensation structure (Kalra et al. 2003), or the firm can offer satisfaction-based guarantees. Also, the firm can use a combination of these or other signaling mechanisms. This issue merits further research.

Our results are more relevant for services in which employees perform multiple tasks. Is specialization still a concern when firms establish different divisions for each of the services in their product portfolio? In many situations, it is extremely difficult for consumers to determine the link between firm employees and the varied offerings, particularly when the firm has an umbrella brand name. Also, increasingly with technological change, many services do not require face-to-face interactions (e.g., insurance, mortgage, and banking). Again, the possibility that consumers will assume that firm employees perform multiple functions is quite high. We believe that as long as consumers make the assumption that the employees perform multiple functions or maintain a perception that upper-level managers manage a portfolio of service offerings, the intuition of the paper still holds. Our model provides one explanation for the lack of success of financial firms that merged but were ineffective in cross selling. From a branding perspective, firms should seek to limit the connection between subsidiary offerings, particularly in effort-intensive categories and where consumers believe that the relationship between knowledge skills required to deliver high-quality service is low.

Holding all else constant, the greater the cost savings that accrue from specialization or analogously, the higher the costs of entering multiple categories, the greater is the incentive for a firm to signal by specializing. The scope of our model is therefore more applicable when the multiple categories being considered by a firm are both effort intensive. Although services in general tend to be more effort intensive, our results apply to product categories with a high service component (e.g., copying machines) or high-end handcrafted products that are also effort intensive. The model has considered firms that have both the resources and ability to enter multiple categories. It could be argued that some firms lack the capital to expand and may position themselves as specialized by default. We believe that this argument is valid for a subset of firms. As long as consumers observe that some firms in a category specialize whereas others do not, the implications of this model must be considered. Finally, the model pertains to market offerings where we assume the demand is independent. If offerings involve a positive utility from consolidating purchases from the same firm (e.g., brokerage accounts and investor borrowing), specialization may not provide signaling benefits.

Appendix. Proof of Proposition 2

We derive the equilibrium price for the high-quality firm to separate from the low-quality firm through specialization.

The low-quality firm maximizes its profit $\Pi_m^l = (1 - P_{1m}^l/q_1^l) \cdot (P_{1m}^l - \alpha C_{1s}^l) + (\delta - P_{2m}^l/q_2^l) \cdot (P_{2m}^l - \alpha C_{2s}^l)$ by charging its complete information optimal prices ($P_{1m}^{l^*} = (q_1^l + \alpha C_{1s}^l)/2$, $P_{2m}^{l^*} = (\delta q_2^l + \alpha C_{2s}^l)/2$) for the two services and obtains optimal profit $\Pi_m^{l^*}$.

The high-quality firm needs to solve the following profit maximization program.

$$\begin{aligned} \max_{P_{1s}^h} \quad & \Pi_s^h = \left(1 - \frac{P_{1s}^h}{q_1^h}\right) \cdot (P_{1s}^h - C_{1s}^h) \\ \text{s.t.} \quad & \Pi_s^l(P_{1s}^h) = \left(1 - \frac{p_{1s}^h}{q_1^h}\right)(p_{1s}^h - C_{1s}^l) \le \Pi_m^{l^*} \\ & \Pi_{ma}^{h^*} \le \Pi_s^h. \end{aligned} \tag{6}$$

The Lagrangean function for the high-quality firm's maximization program is given by

$$\begin{aligned} L = & \left(1 - \frac{P_{1s}^h}{q_1^h}\right) \cdot (P_{1s}^h - C_{1s}^h) + \mu_1 \left[\left(1 - \frac{p_{1s}^h}{q_1^h}\right)(p_{1s}^h - C_{1s}^l) - \Pi_m^{l^*}\right] \\ & + \mu_2 [\Pi_{ma}^{h^*} - \Pi_s^h]. \end{aligned} \tag{7}$$

The Kuhn-Tucker conditions are

$$\frac{\partial L}{\partial P_{1s}^h} = \frac{-2P_{1s}^h + q_1^h + C_{1s}^h}{q_1^h} + \mu_1 \frac{-2P_{1s}^h + q_1^h + C_{1s}^l}{q_1^h} = 0$$

$$\frac{\partial L}{\partial \mu_1} = \Pi_m^{l^*} - \left(1 - \frac{p_{1s}^h}{q_1^h}\right)(p_{1s}^h - C_{1s}^l) = 0$$

[5] We thank the AE for this point.

$$\frac{\partial L}{\partial \mu_2} < 0, \quad P_{1s}^h \frac{\partial L}{\partial P_{1s}^h} = 0, \quad \mu_1 \frac{\partial L}{\partial \mu_1} = 0, \quad \mu_2 \frac{\partial L}{\partial \mu_2} = 0$$

$$P_{1s}^h \geq 0, \quad \mu_1 < 0, \quad \mu_2 = 0.$$

At the least-cost quality separation, the mimicking constraint of the low-quality firm is binding, whereas that of the high-quality firm is not. This implies that $\mu_1 < 0$, $\partial L/\partial \mu_1 = 0$, $\mu_2 = 0$, and $\partial L/\partial \mu_2 < 0$ (Kalra et al. 1998, and Zhao 2000).

Solving the above conditions for μ_1 and P_{1s}^h and discarding an implausible solution, we get

$$P_{1s}^{h*} = \frac{1}{2}\Bigg[q_1^h + C_{1s}^l + \Bigg((q_1^h + C_{1s}^l)^2 - \frac{q_1^h(q_1^l - \alpha C_{1s}^l)^2}{q_1^l} - \frac{q_1^h(\delta q_2^l - \alpha C_{2s}^l)^2}{q_2^l} - 4q_1^h C_{1s}^l\Bigg)^{1/2}\Bigg]$$

$$\mu_1^* = \frac{2P_{1s}^{h*} - (q_1^h + C_{1s}^h)}{2P_{1s}^{h*} - (q_1^h + C_{1s}^l)}. \tag{8}$$

Because the objective function is concave in argument, the second-order conditions are also satisfied. That is, P_{1s}^{h*} is indeed the global maximum solution.

The separating equilibrium described in Proposition 2 is supported by the following consumer's posterior beliefs. $\Lambda(P_{1s}^{h*}, \textit{specialization}) = 1$; $\Lambda(P_1, P_2, \textit{multiple entry}) = 0$, for any P_1 and P_2; and $\Lambda(P_1, \textit{specialization}) = \lambda$, for any $P_1 \neq P_{1s}^{h*}$.

Consider the off-equilibrium belief

$$-\Lambda(P_1, P_2, \textit{multiple entry}) = 0,$$

$$\text{for any } P_i \neq P_{im}^{l*} \text{ with } i = 1 \text{ and } 2.$$

Both the high-quality and the low-quality firm could profit by deviating from the separating equilibrium outcome given the most favorable consumer belief, i.e.,

$$(1 - p_1^h/q_1^h)(p_1^h - \alpha C_{1s}^l) + (1 - p_2^h/q_2^h)(p_2^h - \alpha C_{2s}^l) > \Pi_m^{l*}$$

for the low-quality firm and

$$(1 - p_1^h/q_1^h)(p_1^h - \alpha C_{1s}^h) + (1 - p_2^h/q_2^h)(p_2^h - \alpha C_{2s}^h) > (1 - P_{1s}^{h*}/q_1^h)(P_{1s}^{h*} - C_{1s}^h)$$

for the high-quality firm. Therefore, the intuitive criterion does not eliminate both quality types. As a result, consumer's beliefs revert to their priors, under which the low-quality firm earns more than its equilibrium profit, whereas the high-quality firm does not. Hence, consumers believe that the deviating firm is the low-quality firm.

Now consider the off-equilibrium belief

$$\Lambda(P_1, \textit{specialization}) = \lambda, \quad \text{for any } P_1 \neq P_{1s}^{h*}.$$

If $P_1 < P_{1s}^{h*}$, because P_{1s}^{h*} is greater than the high-quality firm's complete information optimal price and its profit function is concave, the high-quality firm will profit by deviating from the separating equilibrium outcome by specializing in the primary category given the most favorable consumer belief. Similarly, the low-quality firm will also gain from the deviation from its equilibrium outcome given the most favorable consumer belief. That is, $(1 - p_1^h/q_1^h) \cdot (p_1^h - C_{1s}^l) > \Pi_m^{l*}$ for the low-quality firm and $(1 - p_1^h/q_1^h) \cdot (p_1^h - C_{1s}^h) > (1 - P_{1s}^{h*}/q_1^h)(P_{1s}^{h*} - C_{1s}^h)$ for the high-quality firm when $P_1 < P_{1s}^{h*}$. However, if $P_1 > P_{1s}^{h*}$, both quality types will not profit by deviating from the equilibrium outcome given the most favorable consumer belief. Therefore, the intuitive criterion either does not eliminate both quality types or eliminates both quality types. As a result, consumer's beliefs revert to their priors, under which neither quality type earns more than its equilibrium profit.

Next, we need to show that the high-quality firm incurs less price distortion in the primary category in the separating equilibrium when specialization is used as a supplementary signal rather than when signaling through prices alone. That is, we need to show $(P_{1s}^{h*} - P_{1m}^{h*}) - (P_{1ma}^{h*} - P_{1m}^{h*}) < 0$, where P_{1m}^{h*} is the complete-information optimal price of the high-quality firm in the primary market. Therefore, we have:

$$\begin{aligned}
&(P_{1s}^{h*} - P_{1m}^{h*}) - (P_{1ma}^{h*} - P_{1m}^{h*}) \\
&= P_{1s}^{h*} - P_{1ma}^{h*} \\
&= \frac{1}{2}\Bigg[q_1^h + C_{1s}^l + \Bigg((q_1^h + C_{1s}^l)^2 - \frac{q_1^h(q_1^l - \alpha C_{1s}^l)^2}{q_1^l} - \frac{q_1^h(\delta q_2^l - \alpha C_{2s}^l)^2}{q_2^l} - 4q_1^h C_{1s}^l\Bigg)^{1/2}\Bigg] - \frac{-d + \sqrt{d^2 - 4ce}}{2c},
\end{aligned} \tag{9}$$

where

$$a = \frac{C_{2s}^h - C_{2s}^l}{C_{1s}^h - C_{1s}^l}, \quad b = -\frac{(q_1^h + \alpha C_{1s}^l)(C_{2s}^h - C_{2s}^l)}{2(C_{1s}^h - C_{1s}^l)} + \frac{1}{2}(\delta q_2^h + \alpha C_{2s}^l),$$

$$c = \frac{1}{q_1^h} + \frac{a^2}{q_2^h}, \quad d = -\frac{q_1^h + \alpha C_{1s}^l}{q_1^h} + \frac{2ab - a(\delta q_2^h + \alpha C_{2s}^l)}{q_2^h},$$

and

$$e = \alpha C_{1s}^l + \frac{(q_1^l - \alpha C_{1s}^l)^2}{4q_1^l} + \frac{b^2 - b(\delta q_2^h + \alpha C_{2s}^l)}{q_2^h} + \delta\alpha C_{2s}^l + \frac{(\delta q_2^l - \alpha C_{2s}^l)^2}{4q_2^l}.$$

After some simple algebra, we obtain:

$$\begin{aligned}
&(P_{1s}^{h*} - P_{1m}^{h*}) - (P_{1ma}^{h*} - P_{1m}^{h*}) \\
&= P_{1s}^{h*} - P_{1ma}^{h*} \\
&= \frac{1}{2}\Bigg[q_1^h + C_{1s}^l + \Bigg((q_1^h + C_{1s}^l)^2 - \frac{q_1^h(q_1^l - \alpha C_{1s}^l)^2}{q_1^l} - \frac{q_1^h(\delta q_2^l - \alpha C_{2s}^l)^2}{q_2^l} - 4q_1^h C_{1s}^l 2\Bigg)^{1/2}\Bigg] - \frac{-d + \sqrt{d^2 - 4ce}}{2c}, \\
&= \Bigg((q_1^h + C_{1s}^l)(q_2^h + q_1^h a^2) + (q_2^h + q_1^h a^2) \\
&\quad \cdot \sqrt{(q_1^h + C_{1s}^l)^2 - \frac{q_1^h(q_1^l - \alpha C_{1s}^l)^2}{q_1^l} - \frac{q_1^h(\delta q_2^l - \alpha C_{2s}^l)^2}{q_2^l} - 4q_1^h C_{1s}^l}\Bigg) \\
&\quad \cdot (2(q_2^h + q_1^h a^2))^{-1} \\
&\quad + \frac{-q_2^h q_1^h - q_2^h \alpha C_{1s}^l + 2q_1^h ab - q_1^h a\delta q_2^h - q_1^h a\alpha C_{2s}^l - q_2^h q_1^h \sqrt{d^2 - 4ce}}{2(q_2^h + q_1^h a^2)} \\
&= \frac{(1 - \alpha)C_{1s}^l}{2} + \frac{A}{2(q_2^h + q_1^h a^2)},
\end{aligned} \tag{10}$$

where

$$A = -q_2^h q_1^h \sqrt{d^2 - 4ce} + (q_2^h + q_1^h a^2) \cdot \sqrt{(q_1^h + C_{1s}^l)^2 - \frac{q_1^h (q_1^l - \alpha C_{1s}^l)^2}{q_1^l} - \frac{q_1^h (\delta q_2^l - \alpha C_{2s}^l)^2}{q_2^l} - 4q_1^h C_{1s}^l}.$$

Note that $\alpha > 1$ and $C_{1s}^l > 0$. Therefore, the first term in the above equation is negative. If we can show that A in the second term is also negative, then the proof will be complete. Thus, we have:

$$A = -\left(\left[(q_1^h + \alpha C_{1s}^l)(q_2^h + q_1^h a^2) \right]^2 - 4q_1^h q_2^h (q_2^h + q_1^h a^2) \cdot \left[\frac{(q_1^l - \alpha C_{1s}^l)^2}{4q_1^l} + \frac{(\delta q_2^l - \alpha C_{2s}^l)^2}{4q_2^l} + \alpha (C_{1s}^l + \delta C_{2s}^l) \right] \right)^{1/2} + \left(\left[(q_1^h + C_{1s}^l)(q_2^h + q_1^h a^2) \right]^2 - 4q_1^h (q_2^h + q_1^h a^2)^2 \cdot \left[\frac{(q_1^l - \alpha C_{1s}^l)^2}{4q_1^l} + \frac{(\delta q_2^l - \alpha C_{2s}^l)^2}{4q_2^l} + C_{1s}^l \right] \right)^{1/2}.$$

Based on our model setup, we have $\alpha > 1$ and both C and q are positive. It can be shown that

$$4q_1^h q_2^h (q_2^h + q_1^h a^2) \left[\frac{(q_1^l - \alpha C_{1s}^l)^2}{4q_1^l} + \frac{(\delta q_2^l - \alpha C_{2s}^l)^2}{4q_2^l} + \alpha (C_{1s}^l + \delta C_{2s}^l) \right] < 4q_1^h (q_2^h + q_1^h a^2)^2 \left[\frac{(q_1^l - \alpha C_{1s}^l)^2}{4q_1^l} + \frac{(\delta q_2^l - \alpha C_{2s}^l)^2}{4q_2^l} + C_{1s}^l \right].$$

Therefore, $A < 0 \Rightarrow (P_{1s}^{h*} - P_{1m}^{h*}) - (P_{1ma}^{h*} - P_{1m}^{h*}) < 0$. This proves that the high-quality firm incurs less price distortion in the primary category in the separating equilibrium when specialization is used as a supplementary signal than when signaling through prices alone.

References

Adams, M. 1997. The determinants of actuarial costs in the New Zealand life insurance industry. *Appl. Financial Econom.* **7** 1–7.

Agnihotri, S. R., A. K. Mishra, D. E. Simmons. 2003. Workforce cross-training decisions in field service. *J. Oper. Res. Soc.* **54** 410–418.

Anderson, S. W. 1995. Measuring the impact of service mix heterogeneity on manufacturing overhead cost. *Accounting Rev.* **70**(3) 363–387.

Banker, R. D., H. Johnston. 1993. An empirical study of cost drivers in the U.S. airline industry. *Accounting Rev.* **68**(3) 576–601.

Becker, G. S., K. Murphy. 1992. The division of labor, coordination costs, and knowledge. *Quart. J. Econom.* **107** 1137–1160.

Berry, L., V. Shankar, J. T. Parish, S. Cadwallader, T. Dotzel. 2006. Creating new markets through service innovation. *Sloan Management Rev.* **47**(2) 56–63.

Brush, T. H. 1996. Predicted change in operational synergy and post-acquisition performance of acquired businesses. *Strategic Management J.* **17** 1–24.

Carroll, G. R. 1984. The specialist strategy. *California Management Rev.* **26** 126–137.

Chevalier, P., N. Tabordon. 2003. Overflow analysis and cross-trained servers. *Internat. J. Production Econom.* **85** 47–60.

Cho, I. K., D. M. Kreps. 1987. Signaling games and stable equilibria. *Quart. J. Econom.* **102**(2) 179–222.

Chu, W., W. Chu. 1994. Signaling quality by selling through a reputable retailer: An example of renting the reputation of another agent. *Marketing Sci.* **13** 177–189.

Credit Card Management. 2002. Missing the boat with cross-selling. **January**(10) 10.

Datar, S., S. Kekre, T. Mukhopadhyay, K. Srinivasan. 1993. Simultaneous estimation of cost drivers. *Accounting Rev.* **68**(3) 602–614.

Desai, P. 2000. Multiple messages to retain retailers: Signaling new service demand. *Marketing Sci.* **19**(4) 381–389.

Desai, P., K. Srinivasan. 1995. Demand signaling under unobservable effort in franchising: Linear and nonlinear price contracts. *Management Sci.* **41**(10) 1608–1623.

Easthaugh, S. R. 2001. Hospital costs and specialization: Benefits of trimming product lines. *J. Health Care Finance* **28**(1) 61–71.

Farely, D. E., C. Hogan. 1990. Case-mix specialization in the market for hospital services. *Health Services Res.* **25**(5) 757–783.

Fine, C. H. 1986. Quality improvement and learning in productive systems. *Management Sci.* **32**(10) 1301–1315.

Foster, G., M. Gupta. 1990. Manufacturing overhead cost driver analysis. *J. Accounting Econom.* **12** 309–337.

Fudenberg, D., J. Tirole. 1983. Sequential bargaining with incomplete information. *Rev. Econom. Stud.* **50**(2) 221–247.

Guedes, J., R. Thompson. 1995. Tests of a signaling hypothesis: The choice between fixed- and adjustable-rate debt. *Rev. Financial Stud.* **8**(3) 605–636.

Iacobucci, D. 1998. Services: What do we know and where shall we go? A view from marketing. *Adv. Services Marketing Management* **7** 1–96.

Iacobucci, D., A. Ostrom. 1996. Perceptions of services. *J. Retailing Consumer Services* **3** 195–212.

Ittner, C. D., J. P. MacDuffie. 1995. Explaining plant-level differences in manufacturing overhead: Structural and executional cost drivers in the world auto industry. *Production Oper. Management* **4**(4) 312–334.

Kalra, A., S. Rajiv, K. Srinivasan. 1998. Response to competitive entry: A nationale for delayed defensive reaction. *Marketing Sci.* **17**(4) 380–405.

Kalra, A., M. Shi, K. Srinivasan. 2003. Salesforce compensation plans and consumer inferences. *Management Sci.* **49**(5) 655–672.

Kamakura, W. A., M. Wedel, F. de Rosa, J. A. Masón. 2003. Cross-selling through database marketing: A mixed data factor analyzer for data augmentation and prediction. *Internat. J. Res. Marketing* **20** 45–65.

Kekre, S., K. Srinivasan. 1990. Broader service line: A necessity to achieve success? *Management Sci.* **36**(10) 1216–1231.

Kopalle, P. K., D. R. Lehmann. 2006. Setting quality expectations when entering a market: What should the promise be? *Marketing Sci.* **25**(1) 8–24.

Li, S., B. Sun, R. T. Wilcox. 2005. Cross-selling sequentially ordered products: An application to consumer banking services. *J. Marketing Res.* **42**(May) 233–239.

Li, X. 2005. Cheap talk and bogus network externalities in the emerging technology market. *Marketing Sci.* **24**(4) 531–543.

Maudos, J., J. M. Pastor, F. Perez. 2002. Competition and efficiency in the Spanish banking sector: The importance of specialization. *Appl. Financial Econom.* **12** 505–516.

Mayzlin, D. 2006. Promotional chat on the Internet. *Marketing Sci.* **25**(2) 155–163.

Milgrom, P., J. Roberts. 1982. Limit pricing and entry under incomplete information: An equilibrium analysis. *Econometrica* **50** 443–460.

Milgrom, P., J. Roberts. 1986. Price and advertising signals of service quality. *J. Political Econom.* **94** 796–821.

Montgomery, C. A., B. Wernerfelt. 1992. Risk reduction and umbrella branding. *J. Bus.* **65**(1) 31–50.

Moorthy, S., K. Srinivasan. 1995. Signaling quality with a money-back guarantee: The role of transaction costs. *Marketing Sci.* **14**(4) 442–466.

Nelson, P. 1974. Advertising as information. *J. Political Econom.* **78** 729–754.

Panzar, J. C., R. D. Willig. 1981. Economies of scope. *Amer. Econom. Rev.* **71** 268–272.

Penrose, E. 1959. *The Theory of the Growth of the Firm*. Oxford University Press, Oxford, UK.

Pinker, E. J., R. A. Shumsky. 2000. The efficiency-quality trade-off of cross-trained workers. *Manufacturing Service Oper. Management* **2**(1) 32–48.

Porrino, P. 2002. The power of specialization. *Cross Currents*(Spring) 11–13.

Porter, M. E. 1985. *Competitive Strategy*. Free Press, New York.

Rasmusen, E. 2001. *Games and Information*, 3rd ed. Blackwell Publishers, Oxford, UK, 169–186.

Rosen, S. 1983. Specialization and human capital. *J. Labor Econom.* **1** 43–49.

Schilling, M. A., H. K. Steensma. 2002. Disentangling the theories of firm boundaries: A path model and empirical test. *Organ. Sci.* **13**(4) 387–401.

Simester, D. 1995. Signaling price image using advertised prices. *Marketing Sci.* **14**(2) 166–188.

Srinivasan, K. 1991. Multiple market entry, cost signaling and entry deterrence. *Management Sci.* **37**(12) 1539–1555.

Stefanadis, C. 1998. Selective contracts, foreclosure, and the Chicago school view. *J. Law Econom.* **41**(2) 429–450.

Tellis, G. J., B. Wernerfelt. 1987. Competitive price and quality under asymmetric information. *Marketing Sci.* **6**(3) 240–253.

The American Banker. 2001. Citi cites cross-sell woe in spinoff. (December 20).

Tirole, J. 1988. *The Theory of Industrial Organization*. MIT Press, Cambridge, MA.

Waehrer, K. 1999. The ratchet effect and bargaining power in a two-stage model of competitive bidding. *Econom. Theory* **13**(1) 171–181.

Wepler, J. M., T. Linn, P. T. Linnert. 2004. Banks in insurance: Acquisition, growth, and measures of success. *Bank Director Magazine*, 3rd Quarter.

Wernerfelt, B. 1988. Umbrella branding as a signal of new service quality: An example of signaling by posting a bond. *RAND J. Econom.* **19**(3) 458–466.

Zeithaml, V. A., M. J. Bitner. 2000. *Services Marketing: Integrating Customer Focus Across the Firm*, 2nd ed. Irwin and McGraw-Hill, New York.

Zhao, H. 2000. Raising awareness and signaling quality to uninformed consumers: A price-advertising model. *Marketing Sci.* **19**(4) 390–396.