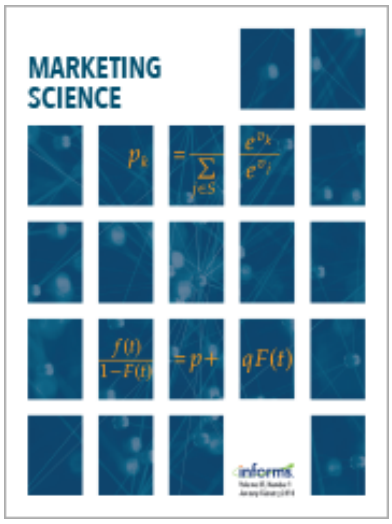

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Competing for Low-End Markets

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Recent business research points to the fortune awaiting to be tapped in low-end markets. In this paper, we investigate how the size of the low-end market influences a firm's profits and the pioneering firm's quality choice. As low-valuation consumers increase in a market, on average, consumers' willingness to pay decreases. This may lead us to expect firms' profits to decrease as the size of the low-end market increases. Our analysis shows that, if the size of the low-end market is below a threshold, an increase in the size of the low-end market may actually dampen price competition and improve profits, as firms can then strategically choose their quality levels such that their products are more differentiated. Conventional wisdom also suggests that the pioneering firm will offer a higher-quality product and earn more profits compared with the later entrant. In contrast to this notion of quality advantage, our analysis identifies circumstances in which a pioneer can offer a lower-quality product and yet earn more profits. An experimental test lends support for some of our model's predictions. We further extend the model to consider markets with multiple firms, firms with multiple products, and consumers with limited purchasing power.

Key words: low-end markets; quality leadership; pioneering advantage; vertical differentiation; experimental economics
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1. Introduction

A central finding in the literature on vertical product differentiation is that the pioneering firm will offer a higher-quality product (Lehmann-Grube 1997, Donnenfeld and Weber 1995, Tirole 1988). By offering a higher-quality product, the pioneer places itself in a better position to handle competition from a later entrant. Specifically, the pioneer can cut its price and guarantee itself profit at least equal to that of the lower-quality firm. Even in situations where it is costly to improve a product's quality, it is more profitable for a pioneer to offer a higher-quality product (Lehmann-Grube 1997). Yet in reality, the pioneering firm sometimes offers a lower-quality product. Why do we observe low-quality leadership? What factors may moderate the quality choices of pioneering firms?

A common assumption in the vertical differentiation literature is that consumers vary in their taste for quality and that their preference for quality is uniformly distributed. Prior research has examined how varying the support of the uniform taste distribution affects product differentiation (e.g., Wauthy 1996). However, income distribution and, in turn, consumer preference for quality may not be uniformly distributed, and the low-end market could be of varying size. This raises another interesting theoretical question: How does the size of the low-end market affect the product choices and profits of competing firms? The answer to this question is of practical significance because of the growing managerial interest in low-end markets (e.g., Prahalad 2006).

1.1. Overview

In this paper we begin a theoretical and empirical examination of how the size of the low-end market may shape the competitive behavior of firms. As the size of the low-end market increases, on average, consumers' willingness to pay for any product decreases. Consequently, one might naturally expect firms' profits to decrease as the size of the low-end market increases. Contrary to this intuition, we identify circumstances where firms' profits increase as the size of the low-end market increases. We note that the presence of a low-end market impels firms to change their strategic behavior so as to soften price competition. Specifically, firms choose to differentiate the qualities of their products more and compete less on prices. Thus, contrary to some of our naive intuitions, the low-end market may have a healthy effect on firms' profits, but only when its size is below a threshold. Furthermore, the threshold up to which we observe this positive effect becomes larger as the heterogeneity in consumers' valuations of quality increases.

Second, we investigate how the size of the low-end market may temper a pioneer's decision to offer a

higher-quality product. We study this issue using a sequential-move model of vertical differentiation. In the first stage of the game, the pioneer (Stackelberg leader) sets its quality; after observing the leader's quality choice, the follower sets its quality. In the second stage, both the leader and follower simultaneously set prices. The conventional theoretical view is that the pioneering firm will offer the higher-quality product and earn more profits (e.g., Tirole 1988). Some could naively argue that if the low-end market is very large, then the pioneer will offer a lower-quality product. In contrast to the conventional wisdom as well as some of our naive intuitions, we show that the Stackelberg leader may offer a lower-quality product, but only when the size of the low-end market is *moderately* large. Our analysis also highlights a need to distinguish between pioneering advantage and quality advantage. Whereas pioneering advantage may involve quality advantage in certain markets, in other markets a pioneer could well earn higher profits *without* offering a higher-quality product. Interestingly, even in the United States, we observe low-quality leadership in some markets. For example, Cuisinart entered the food processor market with a higher-quality product, but Apple entered the personal digital assistant market with a lower-quality product (see Bayus et al. 1997).[1] These empirical observations admit the possibility that the size of the low-end market may moderate the quality choices of pioneering firms.

Third, although casual observations seem to support some of our model's predictions, it is important to subject the model to an empirical test. However, it is challenging to perform a causal test of the model in a field setting because it is difficult to exogenously vary the size of the low-end market while controlling for contextual factors. Hence, we take an initial step in testing some of the model's predictions by conducting an experiment in a laboratory setting. Specifically, we assess whether or not the Stackelberg leader will be sensitive to the size of the low-end market and respond by varying the relative quality of its product as predicted by our model. In our experiment, we find leaders offering lower-quality products as predicted by our model. More importantly, leaders' quality choices and prices vary in a manner that is directionally consistent with the equilibrium predictions. However, followers' products were not differentiated from those of the leaders as much as the theory predicts. What could potentially explain this low level of differentiation? To gain some insight into these issues, we estimated the response function that guided the choices of our participants and compared it to the equilibrium best-response function. This analysis shows that followers tend to anchor their quality choices more on those of the leader and insufficiently adjust away from the leader's quality. Furthermore, in the price-setting stage, our participants are more focused on their own product's quality and pay less attention to the competing firm's product quality. This finding suggests that even in competitive decision-making contexts, we can see some trace of anchoring and adjustment bias (Epley and Gilovich 2006) and egocentric bias (Van Boven et al. 2000, Panayiotou and Vrana 2004).

In an attempt to assess the robustness of the theoretical findings, we later extend the model in a few directions. First, we consider an oligopoly composed of three firms. Our analysis shows that the pioneer can offer a lower-quality product and yet earn more profits compared with the early follower (second mover). In several markets, firms offer multiple products. When we extend our model to allow the leader and follower to offer two products each, we still find support for pioneering advantage, not quality advantage. In emerging markets such as Brazil, India, and China, several products may be beyond the purchasing power of some consumers, implying that these markets may not be fully covered. On examining the strategic implications of a low-end segment in such partially covered markets, we find that the pioneer does not have to offer a higher-quality product to earn more profits.

1.2. Related Literature and Contribution

Our research builds on the seminal work on vertical product differentiation (e.g., Mussa and Rosen 1978, Gabszewicz and Thisse 1979, Shaked and Sutton 1982). An important finding in this literature is that a multiproduct monopolist may selectively lower the quality of the product offered to low-valuation customers to reduce cannibalization of the more profitable higher-quality product (e.g., Mussa and Rosen 1978, Moorthy 1984). In duopoly models of vertical differentiation, it is well established that the first mover in a market offers the higher-quality product and earns more profits (e.g., Tirole 1988, Lehmann-Grube 1997). Our analysis helps to disentangle pioneering advantage from quality advantage. We show that a pioneer can produce a lower-quality product and yet earn higher profits. Our framework differs from prior research on vertical differentiation models in an important way. We allow for a flexible distribution of consumer valuation so that we can investigate the effect of the size of the low-end

[1] One can possibly offer several context-specific reasons for why a pioneer might offer a higher- or lower-quality product. Potential supply-side explanations include a lack of access to new technology, a low-quality manufacturer's pursuit of new markets, declining development costs, and poor managerial decision making. We, on the other hand, focus on a demand-side explanation.

market.[2] Jing (2006) shows that it may be profitable for a firm to produce a lower-quality product if its relative cost efficiency is higher (see also Chambers et al. 2006). In contrast to Jing's supply-side explanation, we identify conditions on consumer demand that could lead to low-quality leadership.

Our work is related to the marketing literature on entry of low-end firms. For example, Ishibashi and Matsushima (2009) show that when multiple low-end firms enter a market, high-end firms might be motivated to exit the low-end market and cater only to the high-end market. However, this result is not applicable if there is only one high-end firm in the market. Furthermore, their model is based on an aggregate demand formulation and relies on the assumption that consumers in the low-end market are indifferent between higher-quality and lower-quality products. In contrast to Ishibashi and Matsushima (2009), we develop a micro-model where all consumers value a higher-quality product more and study a duopoly where one firm offers a higher-quality product and the other a lower-quality product. Thus, our formulation is in the tradition of vertical differentiation models.

In an interesting piece of research, Bayus et al. (1997) show that when the cost of quality declines over time, a firm may enter a market early and offer a lower-quality product. In contrast to this supply-side explanation, we provide a consumer-level explanation for the phenomenon. Furthermore, we analyze both the quality choices and the prices of the competing duopolists in a two-stage game.[3]

Finally, although there is a large body of theoretical literature on product differentiation, the experimental literature on this topic is small and confined to testing models of horizontal product differentiation (see Huck et al. 2002, Barreda-Tarrazona et al. 2011). In many of these experiments, participants decided only on location, not location and price. Our work takes the first step in testing models of vertical differentiation and provides richer behavioral insights into participants' decisions on both quality levels and prices. Our analysis holds the promise that although some biases in individual decision making, such as anchoring and adjustment (Epley and Gilovich 2006) and excessive self-focus (Van Boven et al. 2000, Panayiotu and Vrana 2004), extend into the competitive decision-making context, the observed aggregate behavior might yet be consistent with the qualitative predictions of the equilibrium solution.

In sum, our work adds to the marketing literature by showing that an increase in the size of the low-end market can sometimes improve firms' profits by softening price competition. Also, in contrast to the conventional theoretical view as well as some of our intuitions, we establish that the pioneering firm will offer a lower-quality product if the size of the low-end market is *moderately* large. Our experimental analysis constitutes one of the early experimental tests of a vertical differentiation model, and it lends support for the notion of pioneering advantage but not quality advantage. We also extend the model to consider markets with multiple firms, firms with multiple products, and consumers with limited purchasing power.

The remainder of this paper is organized as follows. In §2, we introduce a simultaneous-move model of vertical differentiation where a fraction of the market comprises of low-end consumers, and we analyze its theoretical implications. We then examine a sequential-move version of the same model. Section 3 presents an empirical test of some of our model's predictions. Finally, §4 summarizes the key findings and concludes the paper by providing directions for further research.

2. Model

In this section, we develop a model to investigate how the size of a low-end market segment might shape the strategic behavior of firms, especially its choice of product qualities and prices. Later, we extend the model to understand when a pioneer may offer a lower-quality product.

Consider a duopoly where firm i $(i = 1, 2)$ offers a product of quality q_i at price p_i. Note that if both the firms produce products of the same quality, they will compete away all potential profits. Without loss of generality, we assume that $q_1 > q_2 > 0$ and that $p_1/q_1 > p_2/q_2 > 0$, implying that the firm offering the higher-quality product will charge a higher price. In the tradition of the literature on vertical product differentiation, we hereafter refer to the firm offering the higher-quality product as the *high-quality firm* and the one offering the lower-quality product as the *low-quality firm*. The marginal cost of producing a product depends on its quality level, and we let $c(q_i) = q_i^2$ (see Moorthy 1988 or Motta 1993 for a similar

[2] In the context of a horizontally differentiated market, Ansari et al. (1994) investigate how nonuniform consumer preferences affect firms' competitive positions in a horizontally differentiated market. They show that if preferences are sufficiently concentrated, one may not obtain the standard maximal differentiation result. We, on the other hand, focus on a vertically differentiated market and examine how the size of the low-end market affects competing firms' quality choices.

[3] Bayus et al. (1997) analyze the open-loop equilibria, where a firm commits to a policy at the outset of the game and adheres to it, to understand the quality choices of the leader and follower in a continuous-time game. We investigate the subgame-perfect equilibrium, where firms could vary prices after observing the quality choices of their competitor. Our formulation lends itself well to study both the quality choices and the prices of the competing firms.

assumption).[4] Furthermore, the market comprises two segments: a low-end market and a high-end market.

Low-end market: Consumers in the low-end market are heterogeneous in their valuation of quality. They are indexed by a preference parameter θ, which indicates their sensitivity to quality. We assume that θ is distributed uniformly over the interval $[b, b+k]$, where b is the lowest valuation of quality and k is the range of consumers' valuation of quality. In this formulation, an increase in k raises the heterogeneity in consumers' valuation of quality. Let the size of this market segment be α $(0 < \alpha < 1)$.

High-end market: Consumers in this market segment value quality more, and their preference for quality θ is distributed uniformly over the interval $[b+k, b+2k]$. The size of the high-end segment is $1-\alpha$.

Consumers' willingness to pay for a product from firm i depends not only on its quality q_i but also on the preference parameter θ. Consequently, the (indirect) utility derived by a consumer from purchasing a product from firm i is given by $U_i(\theta) = \theta q_i - p_i$. Each consumer buys one unit of the product from either of the two firms, and hence the market is fully covered. To ensure this property, we assume that the lowest consumer valuation of quality—namely, b—is greater than $(7/2)k$. The marginal consumer who is indifferent between the two products is represented by $\theta_m = (p_1 - p_2)/(q_1 - q_2)$, and this marginal consumer could lie in the high-end market (Region 1) or the low-end market (Region 2). Depending on the location of the marginal consumer, the demand for each firm's product is given by

$$z_1 = \begin{cases} \left(\dfrac{1-\alpha}{k}\right)\left(b + 2k - \dfrac{p_1 - p_2}{q_1 - q_2}\right) \\ \quad \text{if } b + k \le \theta_m \le b + 2k \quad \text{(Region 1)}, \\ 1 - \dfrac{\alpha}{k}\left(\dfrac{p_1 - p_2}{q_1 - q_2} - b\right) \\ \quad \text{if } b \le \theta_m \le b + k \quad \text{(Region 2)}; \end{cases} \tag{1}$$

$$z_2 = \begin{cases} 1 - \left(\dfrac{1-\alpha}{k}\right)\left(b + 2k - \dfrac{p_1 - p_2}{q_1 - q_2}\right) \\ \quad \text{if } b + k \le \theta_m \le b + 2k \quad \text{(Region 1)}, \\ \dfrac{\alpha}{k}\left(\dfrac{p_1 - p_2}{q_1 - q_2} - b\right) \\ \quad \text{if } b \le \theta_m \le b + k \quad \text{(Region 2)}. \end{cases} \tag{2}$$

[4] Letting the fixed costs be zero is a standard assumption in the literature (Mussa and Rosen 1978; Tirole 1988, see also Lehmann-Grube 1997). This assumption implies that the market is attractive enough for both firms to enter, and no firm faces any technological impediment to entering the market.

The corresponding firm's profits are given by $z_i(p_i - q_i^2)$. Using this parsimonious formulation, we investigate how the size of the low-end market affects a firm's profits.

2.1. Effect of the Size of Low-End Market on Profits

Because consumers in the low-end market segment have a lower willingness to pay, we may expect a firm's profits to decline as the size of the low-end market increases. To closely scrutinize this issue, consider a simple two-stage game. In the first stage, each firm simultaneously decides on the quality q_i of its product. In the second stage, after observing the quality choice of its competitor, each firm simultaneously sets its price p_i. To understand equilibrium behavior, we first analyze the price-setting subgame, assuming that the qualities are fixed, and then solve for the equilibrium qualities.

Proposition 1. (a) *If firms enter the market simultaneously, both firms' profits increase as the size of the low-end market segment increases for all* $\alpha \le \alpha^0$, *where* α^0 *is implicitly defined by*

$$\frac{k\sqrt{192\alpha^4 - 560\alpha^3 + 609\alpha^2 - 304\alpha + 64}}{4\alpha(1-\alpha)} - b = 0.$$

(b) *The size of* α^0 *increases with the range of consumers' valuation of quality* (k) *but decreases with the lowest valuation of quality* (b).

In Appendix A of the electronic companion, available as part of the online version that can be found at http://mktsci.pubs.informs.org/, we present the proof for this proposition, and we also demonstrate that it is not profitable for a firm to unilaterally deviate from the pure-strategy equilibrium in the price-setting subgame or in the quality-setting stage of the game. An implication of Proposition 1 is that the firm producing the higher-quality product can see its profits increase when the relative size of the low-end market increases. To understand the intuition for this result, note that as α increases, we have a greater mass of consumers with low willingness to pay, and this may potentially dampen firms' profits. There is also a countervailing force at play here, however: firms could change their competitive behavior in response to the increased size of the low-end market.

To better appreciate the strategic behavior of firms, first consider the case where the low-end market is small. In this case, the marginal consumer (θ_m) who is indifferent between the two products lies in the high-end market, implying that a fraction of the high-end market is consuming the lower-quality product. This is a consequence of the lower-quality product's price and quality being closer to those of the higher-quality product. The resulting profits are low for both

firms in this case. Next, consider the case where the low-end market segment grows a little larger so that the marginal consumer lies around the center of the market. Now the higher-quality product will primarily cater to the high-end market segment, and the lower-quality product will be consumed mostly by consumers in the low-end market. In this case, the quality difference and the price difference between the two firms are larger, thus improving each firm's profits.[5] Thus, although an increase in the size of the low-end market, on average, reduces consumers' willingness to pay and in turn has a direct (nonstrategic) negative effect on profits, the strategic effect is positive and dominates the direct effect when $\alpha \leq \alpha^0$. This finding suggests that a seemingly negative development in the business environment can sometimes have a positive impact on equilibrium profits because of strategic considerations.

To understand the second part of the proposition, note that an increase in k raises the heterogeneity in consumers' valuation of quality and provides firms with a greater opportunity to differentiate their products. In such situations, therefore, firms' profits continue to increase as the size of the low-end segment increases, even to a larger threshold α^0. On the other hand, an increase in the lowest consumer valuation of quality—namely, b—produces the opposite effect. Notice that for a given k, an increase in b reduces the relative value of highest consumer valuation compared with the lowest consumer valuation; that is, $(b+2k)/b$ decreases. Because this reduces the opportunity for differentiation, the threshold α^0 decreases when b increases. Next we proceed to explore how the size of the low-end market may affect the pioneering firm's quality choice.

2.2. Effect of Low-End Market on Quality Leadership

Conventional wisdom is that the pioneering firm will offer a higher-quality product and earn more profits. For example, Tirole (1988) shows that if consumers' taste for quality is uniformly distributed, the pioneer will offer a higher-quality product. In Tirole's model, it is costless to improve the quality of a product, and one may wonder whether relaxing this assumption will create scope for low-quality leadership. Even if we allow for a quadratic cost function for improving product quality, the leader never strictly prefers to offer a lower-quality product. We prove this claim in Appendix A of the electronic companion.

In reality, however, we see evidence of pioneers offering lower-quality products. As a first step in understanding the theoretical rationale for such behavior, we focus on a fully covered market and seek to answer the following question: Can consumers' taste distribution help explain why we observe low-quality leadership in some markets? Specifically, what conditions on consumers' taste distribution could motivate a pioneer to produce a lower-quality product?[6] To answer these questions, we analyze a sequential-move model of vertical differentiation. In the first stage of the game, the pioneer (Stackelberg leader) sets its quality; after observing the leader's quality choice, the follower sets its quality. In the second stage, both the leader and follower simultaneously set prices.[7] As in our earlier formulation, the size of the low-end market is $0 < \alpha < 1$. Furthermore, low-end consumers are heterogeneous in their preference for quality, and the preference parameter is uniformly distributed over the interval $[b, b+k]$. The size of the high-end segment is $1-\alpha$, and the preference for quality—namely, θ—is uniformly distributed over the interval $[b+k, b+2k]$. On investigating the pure-strategy equilibrium of this sequential-move model of vertical differentiation, we have the following proposition.

Proposition 2. *When firms enter the market sequentially, the leader offers a lower-quality product and earns more profits if* $\alpha_1 < \alpha \leq \alpha_2$, *where* $\alpha_1 = 0.5$ *and* $\alpha_2 = 0.6245$.

The proof for this result is presented in Appendix A of the electronic companion. Proposition 2 shows that the pioneering firm will produce a lower-quality product, but only when the size of the low-end market is moderately large. This may make one wonder why the pioneer does not offer a lower-quality product when the low-end market is very large. To appreciate the intuition for Proposition 2, first consider the case when $\alpha = 1$. In this case, the leader chooses an optimal quality level anticipating the follower's quality choice. Then the follower is left to differentiate itself by either undercutting the leader's quality and price or overshooting the leader's quality and price. In either case, the follower is squeezed to cater to a smaller market at the tails of the preference distribution and earns fewer profits. Note that quality ordering is determined by the relative quality chosen by the follower, and in this specific case, the pioneer does not care about its relative quality.

[5] Specifically, we find that $\partial \Delta p/\partial \alpha > 0$ and $\partial \Delta q/\partial \alpha > 0$ if $0 < \alpha \leq \alpha^0$. We prove these claims in Appendix A of the electronic companion.

[6] In Appendix B of the electronic companion, we also examine these issues in the context of a partially covered market.

[7] When both firms sequentially set prices, the second mover can always take the entire market by choosing a price such that its price per each unit of quality is slightly lower than that of the first mover. For this reason, traditionally in the vertical product differentiation literature, firms are allowed to simultaneously set prices (see Prescott and Visscher 1977).

Next, consider the case when the size of the low-end market is a bit larger than α_2. Here again, we do not have a pure-strategy equilibrium where the pioneer offers a lower-quality product. To understand the rationale for this behavior, note that in the low-quality equilibrium, the leader squeezes the follower to serve only a small fraction of the high-end market. When the size of the low-end market is even a little larger than α_2, the follower can avoid this situation by unilaterally decreasing its price and gaining the entire high-end market and a fraction of the low-end market as well.[8] The resulting gain in demand more than offsets the loss in margin, and hence we do not have a pure-strategy equilibrium where the leader offers a lower-quality product when $\alpha > \alpha_2$. However, when the size of the low-end market is moderately large such that $\alpha_1 < \alpha \leq \alpha_2$, the low-quality equilibrium will prevail because there is now no incentive for the follower to deviate from the equilibrium price in the price-setting stage. Finally, consider the case where the size of the low-end market is reduced further (i.e., when $\alpha_3 \leq \alpha < \alpha_1$ with $\alpha_3 = 0.3755$), and the high-end market becomes more important. In such situations, the pioneer focuses its efforts on catering to the high-end market, and hence we do not observe low-quality leadership.[9]

It is useful to note that the leader earns more than the follower even when it offers a lower-quality product, suggesting a need to distinguish between pioneering advantage and quality advantage. Whereas pioneering advantage may involve quality leadership in some markets, in certain other markets, the pioneer could well offer a lower-quality product and still earn higher profits.

2.3. Discussion

In sum, our analysis shows that the presence of a low-end market can sometimes improve profits by softening price competition. Furthermore, we identify circumstances when a pioneer may offer a lower-quality product and earn more profits. Thus, we see support for pioneering advantage, not quality advantage. Later we show that this finding holds if we consider markets with multiple firms, firms with multiple products, and consumers with limited purchasing power. The additional analysis is summarized in §4, and the details are provided in Appendix B of the electronic companion. In the next section, we confront our theoretical predictions with empirical data to assess their descriptive validity.

3. Empirical Analysis

Our model assumes that players have perfect foresight about the price-setting subgame while making their quality choices. Moreover, the leader accurately anticipates the quality choice of the follower while determining its own quality level. In reality, however, players are only boundedly rational and may not evince such a high level of strategic thinking. This raises the empirical question: Will firms modify their strategic behavior in the presence of a low-end market as predicted by theory? To answer this question, there is a need to confront the model with data. However, it is a challenge to perform a causal test of the model in a field setting, because it is difficult to exogenously vary the size of the low-end market while controlling for contextual factors. In a laboratory, on the other hand, it is possible to manipulate the demand conditions and study firm behavior (e.g., Lim et al. 2007).

Prior experimental literature is silent on vertical differentiation models, although there are a few tests of horizontal differentiation models. Most of the experimental investigations of horizontal differentiation models examine location choices, not location and prices. These tests suggest that participants may fail to sufficiently differentiate on location choices (e.g., Huck et al. 2002, Barreda-Tarrazona et al. 2011). Our work thus makes a beginning in testing a vertical differentiation model. We investigate not only the quality choices but also how participants set prices conditional on the observed quality levels.

Our experimental investigation assesses the predictive accuracy of Proposition 2.[10] Specifically, we address the following three empirical questions about the aggregate behavior of competing duopolists.

1. *Will the rank order of the quality choices of leaders and followers be consistent with the equilibrium prediction*? According to Proposition 2, the leader should offer a lower-quality product compared with the follower when $\alpha_1 < \alpha \leq \alpha_2$ but should shift to offering a higher-quality product if $\alpha_3 \leq \alpha < \alpha_2$.

2. *Will the pricing behavior of duopolists be directionally consistent with the equilibrium solution*? In comparison to the follower, the leader should offer a lower-priced product if $\alpha_1 < \alpha \leq \alpha_2$ and should sell a higher-priced product if $\alpha_3 \leq \alpha < \alpha_2$.

[8] To see this, note that the location of the marginal consumer when the leader offers a lower-quality product is given by $(p_f - p_l)/(q_f - q_l)$, where p_f and q_f are the follower's price and quality, while p_l and q_l are the leader's price and quality. Now, if the follower unilaterally reduces its price, then the marginal consumer will move left, increasing the demand for the follower's higher-quality product.

[9] We prove this claim for $\alpha_3 \leq \alpha < \alpha_1$ as well as the claim for $\alpha = 1$ in Appendix A of the electronic companion.

[10] In the simultaneous-move game, theory is silent about the identities of firms offering higher-quality and lower-quality products. Consequently, it becomes difficult to separate pure-strategy behavior from the mixed-strategy equilibrium behavior.

3. *Will the pioneer earn more profits even when offering a lower-quality product*? Proposition 2 predicts that the pioneer will earn more profits irrespective of its relative quality. Thus we should see support for the notion of pioneering advantage but not quality advantage.

To facilitate this empirical investigation, we consider a laboratory setting where low-end consumers' sensitivity to quality—namely, θ—is uniformly distributed between 3.5 and 4.5, whereas the θ for high-end consumers is uniformly distributed between 4.5 and 5.5. According to Proposition 2, when the size of the low-end market is 0.6 ($\alpha_1 < \alpha = 0.6 \leq \alpha_2$), we should observe low-quality leadership. Specifically, the leader should offer a product of quality 21.25 at price 65.99 and earn 138.89, whereas the follower should offer a product of quality 33.75 at price 124.32 and earn 34.72.[11] In the laboratory, we attempt to contrast this treatment against a case where the size of the low-end market is small (namely, $\alpha_2 \leq \alpha = 0.4 < \alpha_1$), and we should observe high-quality leadership. In particular, when the size of the the low-end market reduces to 0.4, leaders should offer a product of quality 23.75 at price 77.24 and earn 138.89, whereas followers should sell a product of quality 11.25 priced at 23.07 and earn 34.72. Thus, our experiment considers two sizes of the low-end market—namely, $\alpha \in \{0.6, 0.4\}$. Interestingly, as predicted by Proposition 2, in our experiment, leaders offer a lower-quality product when $\alpha = 0.6$ ($\alpha_1 < \alpha < \alpha_2$) but shift to producing a higher-quality product when $\alpha = 0.4$. However, followers do not differentiate from the leaders as much as our theory predicts.

3.1. Participants

Graduate and undergraduate students were recruited to participate in the study. They were paid a show-up fee of \$5 and an additional monetary reward contingent on their performance. On average, they earned \$25.00 in the study.

3.2. Experimental Design

In our experiment, we treat the size of the low-end market as a between-participant variable. In two groups the size of the low-end market is low ($\alpha = 0.4$), and in another two groups it is high ($\alpha = 0.6$). Each group comprises 10 participants (five duopolies), with five participants playing the role of leaders and another five playing the role of followers. Thus, the role of players is also a between-participant variable. Participants play the game for 40 trials, with their competitor changing from trial to trial but their role remaining fixed. Such a random pairing of players over the several iterations of the game gives participants an opportunity to learn about the structure of the game without creating scope for building any reputation. This practice of allowing participants to play multiple replications of a game is a standard procedure in experimental economics (e.g., Carare et al. 2007, Amaldoss and Jain 2005).

3.3. Procedure

In our experiment, participants play the role of firms, and the computer plays the role of consumers.[12]

3.3.1. Consumers. Consumers differ in how much they value product quality, and there are two segments of consumers.

Low-End Market. In this segment, consumers' willingness to pay varies from 3.5 to 4.5 times the quality of a product. As the willingness to pay is uniformly distributed between 3.5 and 4.5 times quality, the average willingness to pay is four times quality, implying that 50% of the consumers in this segment are willing to pay below four times quality. The low-end segment accounts for α fraction of the overall market, with α being 0.4 in one treatment and 0.6 in the other.

High-End Market. Consumers in the high-end market value product quality more. Their willingness to pay is uniformly distributed between 4.5 and 5.5 times quality. The average willingness to pay in this segment is five times quality, suggesting that 50% of the consumers in this segment are willing to pay above five times quality. The high-end segment accounts for $(1 - \alpha)$ fraction of the market.

3.3.2. Firms. The two competing firms are labeled type A and type B firms. Participants are assigned the role of either firm type A or firm type B, and their role remains fixed throughout the length of the experiment.

The game is played in two stages. In the first stage, each type A player first sets her product quality. After observing the quality of type A player's product, each type B player chooses the quality level of his product. Thus type A participants play the role of *leaders*, whereas type B participants play the role of *followers*. In the tradition of the experimental economics literature, however, we do not use labels such as leader and follower while describing the experiment to participants. In the second stage of the game, participants observe the qualities of both products and then simultaneously set the prices for their products. Based on the prices and qualities of the two competing products, the profits of each player are computed and announced at the end of the trial.

[11] These equilibrium solutions are based on the closed-form solutions that are presented in Appendix A of the electronic companion.

[12] The instructions to participants are available from the authors upon request.

Table 1 Mean Product Quality

	Type A players (leaders)				Type B players (followers)			
α	Group 1	Group 2	Overall	Prediction	Group 1	Group 2	Overall	Prediction
0.4	25.42	24.61	25.01	23.75	21.82	20.54	21.18	11.25
0.6	17.54	19.61	18.58	21.25	23.66	23.34	23.50	33.75

In our experiment, participants remain anonymous. They are not informed about the identity of their competitor in any given trial. Furthermore, they compete against a different participant in each trial. These steps are taken to ensure that each trial is a replication of the two-stage game with no opportunity for punishing or rewarding opponents over the several iterations of the game. Participants play three practice trials to familiarize themselves with the structure of the game, and they do not receive any monetary reward for these practice trials. Then they play 40 actual trials. At the end of the experiment, participants are paid according to their cumulative earnings, debriefed, and dismissed.

3.4. Results

We first analyze the quality choices of type A players (leaders) and type B players (followers) before we investigate their prices and profits. The rank order of quality levels chosen by type A and type B players is consistent with the predictions of the model. On average, type A firms offer a higher-quality product when α is 0.4 but produce a lower-quality product when α is 0.6. The prices set by our participants also vary in the direction predicted by the model.

3.4.1. Analysis of Quality. The analysis is based on 1,600 quality choices made by our participants (2 levels of low-end market size $\times$ 2 groups $\times$ 40 trials $\times$ 2 roles $\times$ 5 participants in each role). To begin with, we assess whether the series of quality choices is stationary and whether the quality choices are independent across the 40 trials. Using the Levin-Lin-Chu unit root test for panel data, we can reject the null hypothesis that the observed series of quality choices is nonstationary (adjusted $t = -26.9729$, $p < 0.0001$; see Levin et al. 2002). Then, estimating a dynamic panel data model with two lags, we reject the null hypothesis that the quality choice at each trial is affected by previous quality choices ($z = 1.46$, $p = 0.145$ for the first lag; $z = 1.25$, $p = 0.210$ for the second lag).[13] Together, these tests permit us to analyze the time series using the absolute quality levels rather than the temporal differences in quality levels. Next, a repeated-measures analysis of the quality choices of players suggests that the group fixed effect is not significant, implying that the data can be pooled across the two groups ($F_{(1,35)} = 0.01$, $p > 0.91$). Moreover, the interaction of low-end market size and the role of players is significant, and hence the effect of α on the quality choice of leaders is qualitatively different from its effect on the quality choice of followers ($F_{(1,35)} = 34.27$, $p < 0.001$).

Table 1 presents the mean quality of type A and type B player's products and the corresponding equilibrium predictions. We also report separately the average quality of the goods produced by type A and type B players in group 1 and group 2, respectively. The rank order of the actual quality choices of type A and type B players is consistent with the theoretical predictions. Although the choices of type B players are directionally consistent with the equilibrium predictions, it seems that they do not sufficiently differentiate their products from those of type A players.

Mean Quality. The equilibrium solution makes four qualitative predictions, and we next assess the accuracy of these predictions. First, according to the equilibrium solution, a leader should offer a higher-quality product if $\alpha = 0.4$. The average quality chosen by type A players is 25.01, and the corresponding quality selected by type B players is 21.18. A repeated-measures analysis of the quality choices of the type A and type B players rejects the null hypothesis that these two mean quality levels are the same ($t = 3.68$, $p < 0.001$). A similar pattern is observed in each of the two groups.[14]

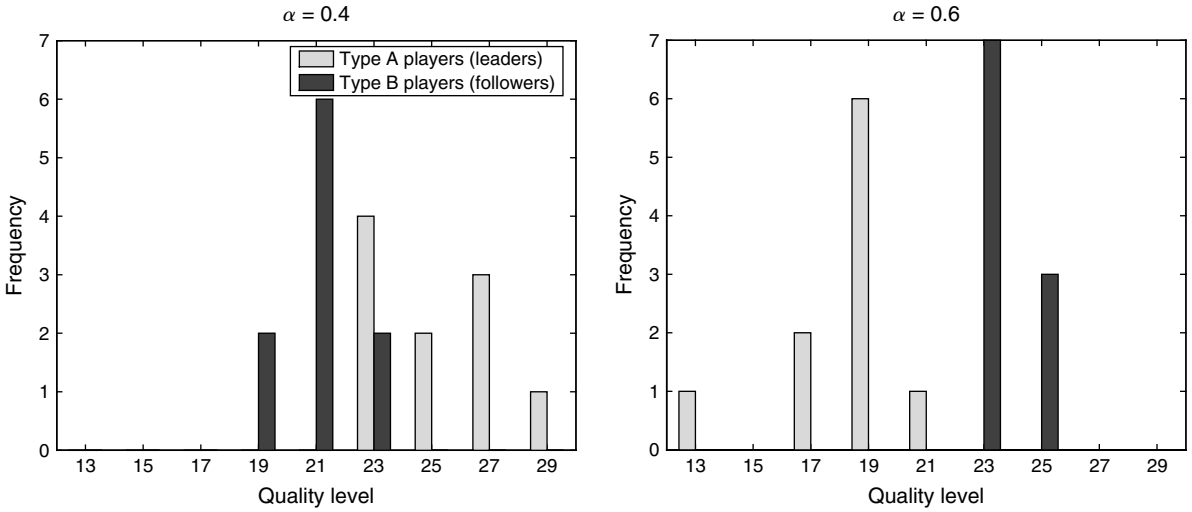
Second, in equilibrium, the leader should produce a lower-quality product when $\alpha = 0.6$. The observed quality of type A player's products is, on average, 18.58, and it is significantly lower than that of type B player's product; namely, $q_l < q_f = 23.50$ ($t = 4.72$, $p < 0.001$). This result also holds at the level of individual groups.

Third, theory predicts that as the size of the low-end market increases, the absolute quality of the leader's product should decrease (see Table 1). In

[13] While we have summarized herein the results of the Levin-Lin-Chu unit root test for panel data as well as the estimation of a dynamic panel data model, more details about the empirical model, estimation procedure, and results can be seen in Appendix C of the electronic companion.

[14] Although we discuss in this paper results based on the data obtained by pooling both the groups, we present details of the analysis done at the level of individual groups in the electronic companion in Appendix C. The results of group-level analysis are consistent with the aggregate results reported herein.

Figure 1 Distribution of Quality



actuality, the quality of type A player's product declines from 25.01 to 18.58 as α increases from 0.4 to 0.6 ($t = 6.17$, $p < 0.001$). Finally, the quality of the follower's product should increase as the size of the low-end market increases. The average quality of the type B player's product actually improves from 21.18 to 23.50 as α increases ($t = 2.23$, $p < 0.033$).

For completeness, we next compare the observed behavior against the point predictions of the model. In equilibrium, the leader's product quality should be 23.75 when $\alpha = 0.4$. In actuality, the quality observed in the two groups is, on average, 25.01 ($t = 1.71$, $p > 0.095$). When α increases to 0.6, the leader's product quality should be 21.25. Across the two groups, the average quality of the products offered by type A players is 18.58, and the difference is statistically significant ($t = 3.62$, $p < 0.001$).

According to the equilibrium solution, followers should offer a product of quality 11.25 when α is 0.4. Across the two groups, the average quality is substantially higher than the equilibrium prediction, $q_f = 21.18$ ($t = 13.46$, $p < 0.001$). When the size of α increases to 0.6, the follower's quality choice should be 33.75. However, across the two groups, the mean quality of type B player's product, $q_f = 23.50$, is much lower than the prediction ($t = 13.89$, $p < 0.001$).

Individual Differences. Figure 1 presents the distribution of the average quality of the products offered by individual type A and type B players. The distribution of qualities is directionally consistent with the equilibrium solution.

When α is 0.4, the average quality of the products of individual type A players ranges from 22.10 to 29.79, whereas that of type B players ranges from 18.46 to 23.31. The left panel of Figure 1 makes it easy to see that the average qualities of the products offered by most type A players are higher. A nonparametric test rejects the null hypothesis that these average quality levels of type A and type B players are drawn from the same distribution (Kruskal-Wallis test: $\chi^2 = 7.41$, $p < 0.001$). When α is 0.6, the behavior of individual type A and type B players is heterogeneous with $13.94 < q_l < 21.61$ and $22.50 < q_f < 24.43$. We can see in the right panel of Figure 1 that the average qualities of the products offered by all type A players are lower. Again, we can reject the null hypothesis that the average quality levels of type A and type B players are drawn from the same distribution (Kruskal-Wallis test: $\chi^2 = 14.28$, $p < 0.001$). Heterogeneity in the behavior of individual participants has been reported in different studies (e.g., Parco et al. 2005, Lim et al. 2007, Amaldoss and He 2009). A potential explanation for these individual-level differences is that people differ in their learning abilities (Ho et al. 2007, 2008).

3.4.2. Analysis of Prices. As in the case of quality choices, we use the absolute prices rather than the differences for analysis. Furthermore, we also pool the data across the two groups.[15] A repeated-measures analysis shows that the interaction of market size and role of players is significant, suggesting that the effect of α on prices charged by leaders is qualitatively different from its effect on the prices set by followers ($F_{(1,35)} = 33.48$, $p < 0.001$). Table 2 presents the mean prices and the corresponding equilibrium solution. In general, the results are directionally consistent with

[15] The Levin-Lin-Chu panel-data unit root test rejects the null hypothesis that the series of prices set by each participant is nonstationary (adjusted $t = -30.8645$, $p < 0.0001$). Based on the estimates of the dynamic panel data model with two lags, we can reject the null hypothesis that the price choices are affected by the prices previously chosen ($z = 0.86$, $p = 0.390$ for the first lag; $z = 0.59$, $p = 0.554$ for the second lag). We also note that the fixed effect of the group is not significant ($F_{(1,35)} = 0.21$, $p > 0.64$), implying that we can pool the data across groups.

Table 2 Mean Product Price

	Type A players (leaders)				Type B players (followers)			
α	Group 1	Group 2	Overall	Prediction	Group 1	Group 2	Overall	Prediction
0.4	82.64	81.06	81.85	77.24	66.82	65.13	65.98	23.07
0.6	48.55	57.74	53.14	65.99	76.23	76.55	76.39	124.32

the equilibrium predictions. Earlier, we noted that perhaps followers failed to sufficiently differentiate the quality of their products. Here, we observe a similar pattern of behavior with regard to price.

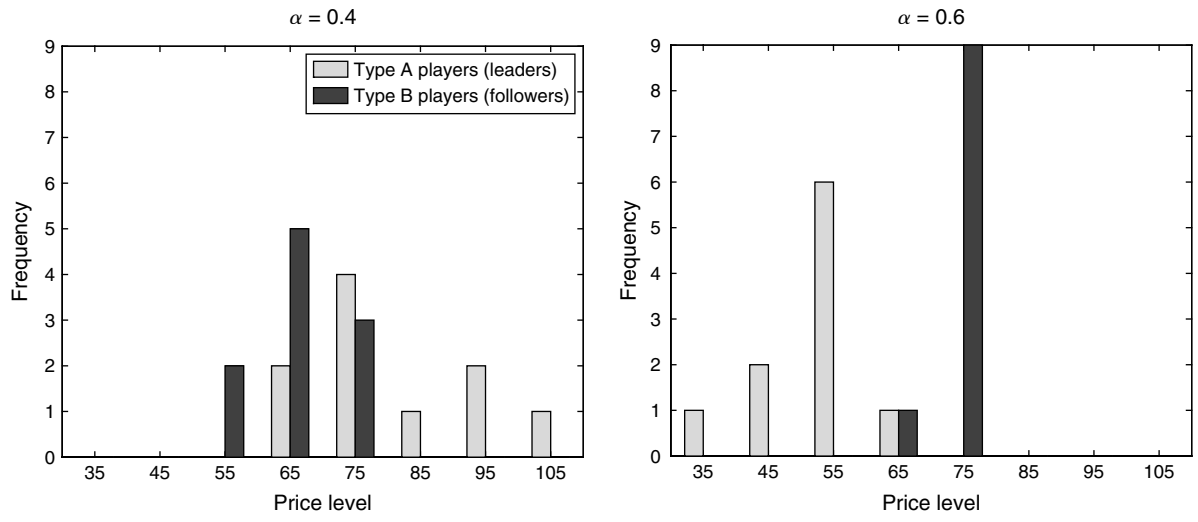
In equilibrium, leaders should charge a higher price than followers if $\alpha = 0.4$. Across the two groups, when α is 0.4, the average price of type A player's product is 81.85, whereas the price of type B player's product is 65.98. Using a repeated-measures analysis, we can reject the null hypothesis that type A and type B players charge the same mean price ($t = 3.36$, $p < 0.002$). According to the equilibrium solution, if $\alpha = 0.6$, the price of a leader's product should be lower than the price of the follower's product. On average, type A player's price is 53.15, whereas type B player's price is 76.39 ($t = 4.92$, $p < 0.001$).

In equilibrium, the leader's price should be 77.24 when $\alpha = 0.4$. Across the two groups, the observed mean price is 81.85, and it is not significantly different from the equilibrium prediction ($t = 0.99$, $p > 0.32$). When α increased to 0.6, the leaders should charge 65.99. In actuality, the leader's price is only 53.14 ($t = 3.84$, $p < 0.001$). Turning our attention to followers, we note that, although they should charge 23.07 when $\alpha = 0.4$, the observed price is 65.98 ($t = 12.83$, $p < 0.001$). Similarly, when $\alpha = 0.6$, the follower's price should be 124.32, but the observed price is 76.39 ($t = 14.3$, $p < 0.001$).

The prices charged by individual participants show substantial variation (see Figure 2). For example, when $\alpha = 0.4$, the average price of individual type A players ranges from 67.90 to 105.28. Likewise, the average price set by individual type B players ranges from 54.31 to 77.45. A nonparametric test confirms that the differences in the individual-level means of type A and type B followers are statistically significant (Kruskal-Wallis test: $\chi^2 = 5.49$, $p < 0.019$). When α increases to 0.6, we notice a similar variation in prices, with the ranges being $36.66 < q_l < 66.11$ and $69.60 < q_f < 79.90$ (Kruskal-Wallis test: $\chi^2 = 14.29$, $p < 0.001$).

3.4.3. Analysis of Profits. In equilibrium, when $\alpha = 0.6$, a leader should earn more profits than a follower even if the leader offers a lower-quality product. On average, when α is 0.6, type A players offer a product of quality 18.58 and earn 87.76. Interestingly, type B players offer a higher-quality product and still earn lower profits ($q_f = 23.50$ and $\pi_f = 64.13$). We reject the null hypothesis that the profits of the type A and type B players are the same ($t = 3.93$, $p < 0.001$). This finding supports the notion that pioneering advantage is related to the order of entry, not product quality. Of course, when the leader also offers a higher-quality product, it becomes difficult to separate the source of competitive advantage. For example, when α is 0.4, type A players offer a

Figure 2 Distribution of Price



higher-quality product ($q_l = 25.01 > q_f = 21.18$) and earn more ($\pi_l = 92.98 > \pi = 62.85$: $t = 5.02$, $p < 0.001$).

3.5. Discussion

In sum, although the observed quality, prices, and profits are in keeping with the qualitative predictions of the equilibrium solution, follower's products are not sufficiently differentiated from those of the leader. What can explain this low level of product differentiation in our experiment? Does the quality choice of the follower constitute a best response to the quality choice of the leader? Can the observed prices be rationalized as the best response to the quality levels chosen by the leader and follower? We attempt to probe these issues by analyzing the quality- and price-response functions of the duopolists. To save space, we only highlight here the key findings of the analysis and relegate the details to Appendix C of the electronic companion. In contrast to the equilibrium best-response function, we find that followers tend to anchor their quality decisions more on the choice of the leader and insufficiently adjust from it. In the price-setting game, even though the observed prices are directionally consistent with the equilibrium predictions, they are different from the point predictions. Here, players tend to be more self-focused in that they pay greater attention to their own quality and insufficient attention to the competitor's quality. Thus, we find traces of common biases in individual decision making, such as anchoring and adjustment bias and egocentric bias, even in a competitive decision-making context.

4. Conclusion

The purpose of this paper was to understand how the size of the low-end market affects the product strategy and in turn the profits of competing firms. Toward this end, we proposed a duopoly model of vertical differentiation in which the market comprises two segments of consumers: a low-end market and a high-end market. We analyzed simultaneous-move as well as sequential-move versions of the model. Our theoretical and empirical analysis helps us to better understand three issues.

1. *How does the size of the low-end market affect a firm's profits*? As low-valuation consumers increase in a market, on average, consumers' willingness to pay decreases. This may lead us to expect firms' profits to decrease as the size of the low-end market increases. Our analysis shows that, if the size of the low-end market is below a threshold, an increase in the size of the low-end market may actually dampen price competition and improve profits, because firms can then strategically choose their quality levels such that their products are more differentiated. This threshold also increases with an increase in the heterogeneity in consumers' valuation of quality or a decrease in the lowest consumer valuation of quality, because both these factors provide greater opportunity for differentiation.

2. *How does the size of the low-end market affect quality leadership in a market*? The conventional view is that the pioneering firm will offer the higher-quality product and earn more profits. Counter to this notion of quality advantage, we show that the Stackelberg leader may offer a lower-quality product and earn more profits. Thus we see support for pioneering advantage, not high-quality advantage. We observe such low-quality leadership only when the size of the low-end market is moderately large.

3. *What is the descriptive validity of our model's predictions*? Because it is difficult to perform a causal test of our model in a field setting, we conducted a laboratory study. In a between-participants experiment, we exogenously varied the size of the low-end market and examined the quality choices and prices of leaders and followers. The experimental results provide support for some of the qualitative predictions of the model. However, we observe departures from the point predictions of the equilibrium solution, and type B players (followers) do not sufficiently differentiate themselves from type A players (leaders). On examining the quality-response function of followers, we find that followers tend to anchor their quality choices more on those of the leader and insufficiently adjust away from the leader's quality. Furthermore, in the price-setting stage, players are more focused on their own product's quality and pay less attention to the competing firm's product quality. Thus, even in competitive decision-making contexts, we can see some trace of anchoring and adjustment bias and egocentric bias. Yet the aggregate behavior is consistent with the qualitative predictions of our model.

4.1. Limitations and Extensions

In developing our model, we made a few simplifying assumptions to gain analytical tractability. These assumptions, however, might raise questions about the generalizability of our results. Our duopoly analysis, for example, may make one wonder whether the results will extend to an oligopoly. Specifically, will the pioneer offer a lower-quality product than the early follower (second mover) and still earn more profits? On analyzing the sequential quality decisions of the three competing firms, we find that the pioneer can offer a lower-quality product and yet earn more profits compared with an early follower. In our original model, we also made the simplifying assumption that each firm offered only one product. However, firms often offer multiple products, and this leads to the next question: What will be the quality order of the multiple products offered by the leader and

the follower? To answer this question, we analyzed a model where the leader and the follower offer two products each. Again, we find support for pioneering advantage, not quality advantage. That is, the pioneer earns more profits despite its highest-quality product being inferior to the follower's highest quality. Next, a common characteristic of emerging markets is that many consumers do not have sufficient purchasing power to buy any of the competing products. On extending our model to consider a partially covered market, we find that in some circumstances, the leader can offer a lower-quality product and yet earn more profits than the follower. Finally, in developing our model, we let α be the size of the low-end market, and we fixed the total market size at 1; thus α could be interpreted as the relative size of the low-end market. Alternatively, one could keep α as the absolute size of the low-end market and use another parameter to represent the absolute size of the high-end market. Our original results hold in this alternative formulation as well. Further details on these model extensions can be seen in Appendix B of the electronic companion.

4.2. Directions for Further Research

In a recent editorial, *Marketing Science* invited marketing researchers to address the implications of the current economic downturn for marketing theory and practice (Bradlow 2009). Our work offers a potential framework for analyzing how reduced consumer income and willingness to pay may affect the strategic behavior of firms. Although we focused our attention on quality choices and prices, future research can investigate how the size of the low-end market influences other elements of a firm's marketing strategy, such as package sizes (e.g., Koenigsberg 2007, Desai et al. 2008) and communication (e.g., Villas-Boas 2004). In addition, a firm's efforts to cater to the low-end market could dilute the equity of its brand in the high-end market (e.g., Amaldoss and Jain 2008). Our original model assumes that firms know with certainty the size of the market segments. It is conceivable that firms might have different levels of uncertainty about the sizes of the different market segments. Further research can explore how the relative uncertainty about the low-end market could temper quality choices. Although our empirical analysis offers some support for the theory, there is a need to search for more corroborating evidence in field data (e.g., Simester et al. 2009).

5. Electronic Companion

An electronic companion to this paper is available as part of the online version that can be found at http://mktsci.pubs.informs.org/.

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