

Demonstrations and Price Competition in New Product Release

Raphael Boleslavsky

Department of Economics, University of Miami, Coral Gables, Florida 33146, r.boleslavsky@miami.edu

Christopher S. Cotton

Department of Economics, Queen's University, Kingston Ontario K7L 3N6, Canada cotton@econ.queensu.ca

Haresh Gurnani

School of Business, Center for Retail Innovation, Wake Forest University, Winston-Salem, North Carolina 27106, gurnanih@wfu.edu

We incorporate product demonstrations into a game theoretic model of price competition. Demonstrations may include product samples, trials, return policies, online review platforms, or any other means by which a firm allows consumers to learn about their value for a new product. In our model, demonstrations help individual consumers to learn whether they prefer an innovative product over an established alternative. The innovative firm controls demonstration informativeness. When the innovative firm commits to demonstration policies and there is flexibility in prices, the firm is best off offering fully informative demonstrations that divide the market and dampen price competition. In contrast, when a firm can adjust its demonstration strategy in response to prices, the firm prefers only partially informative demonstrations, designed to maximize its market share. Such a strategy can generate the monopoly profit for the innovative firm. We contrast the strategic role of demonstrations in our framework with the strategic role of capacity limits in models of judo economics, which also allow firms to divide a market and reduce competition.

Keywords: judo economics; Bertrand competition; marketing strategy; product demonstrations; money-back guarantees; return policies; product reviews

History: Received February 13, 2013; accepted January 6, 2016, by J. Miguel Villas-Boas, marketing. Published online in *Articles in Advance* July 14, 2016.

1. Introduction

When a new product is released, consumers face uncertainty about how well the product will meet their needs. Firms can offer free samples, in-store trials, access to reviews and consumer reports, and other opportunities for consumers to resolve some (or all) of their uncertainty before buying. Return policies and money-back guarantees also enable consumers to learn more about products before fully committing to their purchases.

Allowing consumers to learn about their values for a product is an important part of a firm's marketing strategy. Apple allows consumers hands-on interaction with their products in the curated environment of their stores. Other companies design displays and interactive trials, either for their own stores or for retail chains. For example, Samsung and Microsoft sometimes staff their own "mini stores" inside of retailers such as Best Buy where consumers can try video game consoles, phones, and computers. Similarly, wineries or other food producers visit grocery stores to offer samples of their products. Automakers offer test drives. Software companies offer trial periods.

The informativeness of these opportunities, which we call "demonstrations," can vary: an in-store display at Best Buy may merely display a video of game play footage, or it may allow consumers to play their game of choice on the video game console, affecting the consumer's ability to learn about the console's capabilities. Auto dealers typically choose the route and duration of test drives, which may limit a driver's ability to learn about all aspects of the car's performance. Trial software often offers only a limited set of features. In some other examples, producers of innovative personal hygiene products, household cleaning supplies, exercise equipment, and a variety of other products provide money-back guarantees or extended trial periods, which resolve most or all of a consumer's valuation uncertainty before the purchase decision is final (Heiman et al. 2001). Thus, the degree of information conveyed to consumers before purchase depends on the demonstration design, which is a choice variable for a firm.

Our analysis incorporates a firm's strategic choice of demonstration informativeness into a simple model of price competition between a firm selling an innovative

product for which consumers have uncertain value, and a firm selling an established alternative. Consumers know their values for the established product, but they are uncertain whether the new product meets their needs. If the innovation does meet their needs, then consumers value the innovation more than the established product; if it does not meet their needs, then the innovation is worthless. During a demonstration, consumers privately observe signal realizations, which we refer to as their “impressions” of the innovative product. Consumers with “unfavorable” impressions are confident that the new product does not meet their needs, and they will never purchase it. Those with favorable impressions believe that the new product is more likely to meet their needs, but they may not be completely certain that this is the case. A more informative demonstration offers greater opportunity for consumers to realize that the new product fails to meet their needs: imagine a longer or less restrictive product trial.

Increases in demonstration informativeness affect demand for the innovative product in two ways. First, with a more informative demonstration, fewer consumers for whom the innovation is not appropriate draw favorable impressions. Therefore, a favorable impression conveys “better news” about the new product: it reveals that the innovation is better adapted to the consumer’s needs, increasing the favorable consumer’s willingness to pay and the differentiation between products. Second, demonstrations divide the market into two groups: the group with favorable impressions is interested in the innovation, and the group with unfavorable impressions is not interested. A more informative demonstration increases the probability that a consumer for whom the innovation is not appropriate draws an unfavorable realization, revealing the mismatch between her needs and the product’s attributes. Consequently, with a more informative demonstration, a larger share of the market learns that the innovation is not for them. This increases the established firm’s market share and decreases the share of the market contested by the innovator, which we refer to as the “market division effect.” The product differentiation and market division effects interact with price competition to shape the incentives for strategic demonstration design.

The strategic role of demonstrations depends on the relative flexibility of prices and demonstration policies. When prices are more flexible (which we consider in Section 3), the firms adjust prices in response to the innovative firm’s demonstration policy. This is consistent with settings in which the innovative firms commits to a satisfaction guarantee or return policy, or in which the development of in-store experiences, review platforms, or product trials requires significant time, planning, or effort, making them more difficult to

adjust than prices. In this case, increases in demonstration informativeness decrease the market share contested by the innovative firm (the market division effect). This reduces the established firm’s incentive to defend its market share by setting a low price, thereby dampening subsequent price competition. Simultaneously, the product differentiation effect increases the favorable consumers’ willingness to pay for the innovative product. Together, the dampening of price competition arising from the market division effect and the product differentiation effect imply that the innovating firm’s profit is increasing in demonstration informativeness. Consequently, the innovating firm prefers a maximally informative demonstration, undermining competitive pressure to the greatest possible extent.

When demonstrations are more flexible than prices (which we consider in Section 4), firms first set prices, and then the innovating firm selects its demonstration design. This is consistent with settings where pricing strategies are centralized (made by upper management), and store managers or sales staff have flexibility to adjust demonstration policies (e.g., test drives, displays, or in-store interactions) at the point of sale. It is also consistent with situations in which contracts or reputation concerns lead to sticky prices (e.g., Rotemberg 1982, Blinder 1994). Because prices have already been determined, the innovative firm chooses a demonstration to maximize its market share given these prices: the demonstration is designed to persuade consumers, rather than dampen price competition. In equilibrium, the innovative firm offers the least informative demonstration for which the favorable consumers prefer to buy its product. If the demonstration is less informative, then a favorable impression does not convey enough good news to entice any consumers to purchase the innovation. If the demonstration is more informative, then all favorable consumers buy the innovation, but too many potential customers draw unfavorable impressions, revealing that the product is not for them. By reducing informativeness slightly, the innovating firm reduces the mass of consumers with unfavorable impressions, increasing its market share. Therefore, if the firm selects its demonstration design in response to prices, equilibrium demonstrations convey some, but not all, relevant information to consumers.

The advantage of dividing the market ahead of price competition has been explored by Gelman and Salop (1983), introducing the notion of “judo economics.” These authors analyze sequential price competition when a market entrant can commit to limit its production capacity. By doing so, the entrant ensures that some fraction of the market will only have access to the incumbent’s product, dividing the market. Once the entrant commits to its capacity and price, the incumbent has two possible responses. The incumbent can

either undercut the entrant, enticing all consumers to buy its product, or it can accommodate the entrant by conceding the portion of the market that the entrant is contesting and extract the monopoly profit from the uncontested fraction. The smaller the entrant's capacity, the higher the incumbent's monopoly profit in the uncontested portion of the market. By limiting its production capacity, the entrant makes accommodation more attractive for the incumbent.

In our model, an unfavorable signal realization reveals that the innovation does not match the consumer's needs. As informativeness increases, consumers who have low values for the innovation are more likely to realize that they are not interested in purchasing it, reducing the innovator's market share (this is the market division effect). Thus, increasing demonstration informativeness affects firms' market shares in the same way that the capacity limits in Gelman and Salop (1983). Therefore, like capacity limits, commitment to a demonstration policy can be used to dampen subsequent price competition. However, unlike capacity limits (which do not affect consumers' valuations), increases in demonstration informativeness increase the expected valuations of favorable consumers through the product differentiation effect. Because of this additional benefit, when the demonstration affects subsequent price competition, the innovating firm selects a demonstration that is maximally informative. When demonstrations are selected after prices are set, the differences between capacity limits and demonstrations are even more pronounced. After prices are set, dividing the market by imposing capacity limits is worthless. In contrast, because of the product differentiation effect, designing a demonstration after prices are set is a powerful tool for innovating firms to expand their market share and increase profit, with significant consequences for the market's equilibrium.¹

¹ To further explore the interaction of capacity limits and demonstration informativeness, the online appendix (available as supplemental material at <http://dx.doi.org/10.1287/mnsc.2016.2449>) analyzes an extension of the game in which the innovating firm can simultaneously use both capacity limits (e.g., Gelman and Salop 1983) and demonstrations as part of its strategy. Because an increase in demonstration informativeness generates both market division and product differentiation effects, while limiting capacity generates only a market division effect, it may seem that increasing informativeness is an unambiguously more desirable strategic instrument. Indeed, when demonstrations are more flexible than prices, the innovating firm never chooses to limit its capacity in equilibrium. When demonstrations are determined before prices, however, the innovating firm may choose to limit capacity in addition to providing demonstrations. This happens because even a fully informative demonstration may not reduce the size of the contested market enough to avoid an aggressive price response from the established firm. In this case (when the innovation is widely appealing but provides low added value) limited capacity and demonstration informativeness are complementary instruments for dampening price competition.

A significant literature considers strategic information provision by a monopolist. Lewis and Sappington (1994), Schlee (1996), and Johnson and Myatt (2006) consider a seller that allows buyers to acquire private information about their value for an item prior to purchase. Villas-Boas (2004) considers the interaction of informative advertising that communicates a product's existence with a monopolist's choice of product line offerings. Gill and SgROI (2012) allow firms to conduct publicly observable product tests. Che (1996) considers the use of customer return policies by a monopolist seller when customers learn about their valuation after purchase. Other papers analyze a monopolist's incentives to signal its private information about product quality through observable actions, such as prices or product warranties. The signaling role of prices is explored by Bagwell and Riordan (1991) and uninformative advertising is explored by Milgrom and Roberts (1986) and Bagwell and Ramey (1988). Moorthy and Srinivasan (1995) and Grossman (1981) consider money-back guarantees and product warranties as signaling instruments. Gardete (2013) considers a cheap talk communication by a firm. In our analysis, valuation uncertainty is only about consumer tastes or needs, and the firm does not have any private information about these attributes. Thus, in our model, information provision does not play a signaling role.

A number of papers consider the interaction of information provision and other aspects of firm competition. Moscarini and Ottaviani (2001) analyze price competition between firms when buyers learn about their value for a product prior to purchase. In contrast to our analysis, the informativeness of product demonstrations is exogenous, while in our model the informativeness of a product demonstration is strategically selected by the innovative firm. Iyer et al. (2005) consider a model of firm competition with targeted advertising (which informs consumers of product existence) and targeted prices, showing that the ability to target advertising to consumers is an important channel to soften price competition. Meurer and Stahl (1994) analyze a related model, in which firms send messages to consumers that perfectly reveal which product the consumer prefers. Unlike our analysis, messages are always perfectly informative, and therefore demonstration informativeness is not a strategic instrument. Kuksov and Lin (2010) also consider information provision by two competitive firms that differ in the quality of their products. In their framework, the high-quality firm has an incentive to provide information resolving uncertainty about product quality, and the low-quality firm may have an incentive to provide information resolving consumer uncertainty about their preferences over quality. The distinguishing feature of our framework is that we allow the innovative firm to not only choose whether to provide demonstrations, but to also choose

how informative to make their demonstrations.² We also consider how the timing of demonstration design (whether it is chosen before or after prices) affects the role of demonstrations in new product release. To our knowledge, this question is novel to the literature.

2. Preliminaries

2.1. Model

We model market competition between two firms: firm α offering an established product and firm β offering an alternative, innovative product for which consumers are uncertain about their valuations. A continuum of consumers exists, normalized to a mass of one. Each consumer shares a common value $v_\alpha = 1$ for firm α 's established product. Consumers and firms are uncertain about each consumer's value for firm β 's product. This value can be either high with $v_\beta = \nu > 1$, or low with $v_\beta = 0$. It is common knowledge that an individual consumer independently draws a high value with probability $\theta \in (0, 1)$. Thus θ represents the fraction of consumers for which product β is a good match. Parameters θ and ν capture different aspects of the innovation's demand: θ is a measure of the product's horizontal quality (or taste), reflecting the size of the market that finds it appealing (e.g., d'Aspremont et al. 1979), and ν is a measure of vertical quality or added value, reflecting the intensity of preference among the consumers who find the innovation appealing (e.g., Shaked and Sutton 1982).

Price competition takes a simple form: the firms simultaneously post prices p_α and p_β for their respective products. Consumers take firms' prices as given when deciding whether to purchase product α , product β , or neither product. When a consumer purchases a product of value V at price p , her payoff is $u = V - p$. If the consumer does not make a purchase, then her payoff is 0. Each consumer has unit demand, and it is only feasible for a consumer to purchase one of the products.

2.1.1. Product Demonstrations and Their Effects.

The innovating firm provides consumers with an opportunity to learn about their values for the innovative product before finalizing their purchase decision. These "demonstrations," encompass a variety of practices that facilitate learning (e.g., prepurchase trials,

in-store demonstrations and samples, satisfaction guarantees, return periods, review platforms, and consumer reports).

Formally, a demonstration is modeled as a binary random variable from which consumers draw either a "favorable" or "unfavorable" realization, corresponding to their "impression" of product β . A consumer who has a high value for product β always draws a favorable impression. A consumer with a low value for product β , draws an unfavorable impression with probability $d \in [0, 1]$ and draws a favorable realization with probability $1 - d$. Variable d therefore represents the demonstration's informativeness. Given d , the distribution of a consumer's posterior expected valuation generated by the demonstration is given by Γ :

$$\Gamma = \begin{cases} 0 & \text{with probability } (1 - \theta)d, \\ \nu \frac{\theta}{1 - (1 - \theta)d} & \text{with probability } 1 - (1 - \theta)d. \end{cases}$$

A consumer with an unfavorable impression is certain that he has a low value for the innovative product. A consumer with a favorable impression, however, is generally left with some uncertainty about whether she has a high or low value.

This class of demonstration is most appropriate for innovative products with a number of possible "deal-breaking" attributes or features. A low-valuation consumer does not like one of the "deal breakers" and is unwilling to purchase the innovation if this critical attribute of the product is encountered.³ Meanwhile, a high-valuation consumer likes the attributes of the product and could never encounter a deal-breaking product attribute. The more consumers interact with the product, and the fewer restrictions placed on their interaction, the more likely a low-valuation consumer encounters a deal-breaking attribute. Hence, if a consumer experiences a demonstration with significant freedom and does not encounter a deal-breaking feature, the consumer rationally infers that he or she is more likely to have a high valuation for the innovation. Thus, high values of d in the demonstration design represent prepurchase interactions with significant information content: long return periods, exhaustive money-back guarantees, or extensive in-store or at-home trials. Conversely, low values of d represent prepurchase interactions with less information; an in-store video of game play footage is less informative about a video game than an in-store trial, which in turn is less informative than an at-home trial over an extended period (Heiman et al. 2001, Heiman and Muller 1996, Davis et al. 1995).

² In this way, our analysis is also related to the emerging literature that considers the strategic design of an informative signal by a "sender" who wishes to influence the actions of a "receiver" who observes the signal's realization. Kamenica and Gentzkow (2011) and Rayo and Segal (2010) consider strategic signal design by a single sender and receiver. Boleslavsky and Cotton (2014, 2015) model signal design in an environment in which two senders try to influence a single receiver.

³ Deal-breaking attributes are often encountered in new product releases. When the iPhone was released, for example, some Blackberry users refused to switch to the iPhone merely because they did not like the experience of its virtual keyboard.

An increase in demonstration informativeness changes the distribution of consumer valuations in two ways. Let $\phi(d)$ denote the portion of consumers with favorable impressions:

$$\phi(d) \equiv \theta + (1 - \theta)(1 - d) = 1 - (1 - \theta)d.$$

Note that $\phi(d)$ is decreasing in d (i.e., $\phi'(d) = -(1 - \theta) < 0$). This is the “market division effect”: as informativeness increases, a consumer with a low value for the innovation is more likely to draw an unfavorable impression during the demonstration, ensuring that she will not buy it. Consequently, when the demonstration divides the market into favorable and unfavorable groups, an increase in informativeness leaves fewer consumers in the favorable group, shrinking the portion of the market that the innovating firm contests. Let $\gamma(d)$ denote the expected valuation of a consumer with a favorable impression:

$$\gamma(d) \equiv \frac{v\theta}{1 - (1 - \theta)d} = \frac{v\theta}{\phi(d)}.$$

Note that $\gamma(d)$ is strictly increasing in demonstration informativeness (i.e., $\gamma'(d) = v\theta(1 - \theta)/\phi(d)^2 > 0$). This is the “product differentiation effect”: as informativeness increases, consumers with favorable impressions are more convinced that the product will satisfy their needs. These two effects shape the incentives for price competition and demonstration informativeness, but the role each plays depends on the model timing.

2.1.2. Timing. We analyze the game with two sequences of moves. First, we consider the possibility that firm β selects demonstration informativeness before prices are established. This corresponds to an environment in which prices are more flexible than demonstrations. This is the case when firms can quickly and easily change their prices (with online pricing, e.g., Gorodnichenko et al. 2014), or when the innovating firm issues a blanket commitment to a return period or money-back guarantee.

Timing I. When price competition follows demonstrations, the game takes place as follows:

(1) *Choice of demonstration policy:* Firm β chooses a demonstration policy $d \in [0, 1]$.

(2) *Price competition:* The two firms simultaneously set prices p_α and p_β .

(3) *Demonstration experience:* Consumers interact with the product receiving a favorable or unfavorable impression. They update their beliefs about their valuations according to Bayes’ rule, accounting for both demonstration informativeness and their realized impression.

(4) *Purchase:* Each consumer decides whether to purchase product α , product β , or neither product.

Second, we consider the possibility that the innovating firm retains flexibility over its choice of d until

after both firms commit to prices. This is the case when firms are reluctant (for reasons that we do not model) to adjust prices too often (e.g., Rotemberg 1982, Blinder 1994), or when prices are set by manufacturers and demonstrations are chosen at the point of sale.

Timing II. When the firm has flexibility to choose a demonstration policy after prices are established, the game takes place as follows: (1) *Price competition.* (2) *Choice of demonstration policy.* (3) *Demonstration experience.* (4) *Purchase.*

It is important to recognize that the only difference between models is the sequencing of price competition and demonstration design. In both models, the demonstration design and pricing stages are identical. We solve for the perfect Bayesian equilibrium of the game by backward induction, starting with the consumers’ purchase decision (which is the same across both timing regimes).

2.2. Consumer Purchase Decision

In the final stage of the game, each consumer $i \in [0, 1]$ makes a purchase decision. Before doing so, she observes the demonstration design d and either a favorable or unfavorable impression of the innovative product. Let γ_i denote consumer i ’s expected value for product β after experiencing a demonstration: γ_i is consumer i ’s realization of Γ (equal to 0 if the impression was unfavorable and $\gamma(d)$ if the impression was favorable).

Consumer i ’s expected payoff from purchasing good β is $u_i(\beta) = \gamma_i - p_\beta$, and the consumer’s payoff from purchasing good α is $u_i(\alpha) = 1 - p_\alpha$. If the consumer purchases neither product, the payoff is 0. It is sequentially rational for the consumer to purchase the product that offers the higher expected payoff, provided that this expected payoff is positive. Consumer i therefore purchases product β if

$$\gamma_i - p_\beta \geq 1 - p_\alpha \quad \text{and} \quad \gamma_i - p_\beta \geq 0$$

and purchases product α if

$$\gamma_i - p_\beta < 1 - p_\alpha \quad \text{and} \quad 1 - p_\alpha \geq 0.$$

By setting $p_\alpha > 1$, firm α is guaranteed never to make a sale. These prices are therefore (weakly) dominated by $p_\alpha = 1$. We focus on equilibria in which firm α does not choose a weakly dominated strategy: in equilibrium $p_\alpha \leq 1$. This immediately implies that we can ignore the case in which the consumer purchases neither product, as purchasing α is better than purchasing nothing. Hence, consumer i purchases product β whenever $u_\beta \geq u_\alpha$ and otherwise purchases product α . Therefore, a consumer’s purchase decision is determined by a single threshold for her posterior belief: she purchases firm β ’s product whenever she is sufficiently convinced

that her valuation for the innovation is likely to be high. Let

$$\bar{\gamma}(p_\alpha, p_\beta) \equiv 1 - p_\alpha + p_\beta$$

denote the critical threshold in the posterior belief. Therefore, in equilibrium, a consumer with a favorable impression of product β purchases it if and only if

$$\gamma(d) \geq \bar{\gamma}(p_\alpha, p_\beta).$$

Otherwise the consumer purchases product α . We have assumed that if the consumer is indifferent between products, then the consumer purchases product β . This assumption is without loss of generality, regardless of the model timing.

3. Demonstration Design Before Price Competition

In this section, we solve the model for the case where the innovating firm chooses a demonstration strategy before the firms announce prices. This is consistent with a firm's long-standing commitment to a satisfaction guarantee or return policy, and it is appropriate for settings in which firms can adjust prices more easily than demonstrations. For example, if developing an in-store experience or product trial requires significant time, planning, and effort, then changing a price is simple by comparison.

3.1. Price Competition

In the appendix, we derive the equilibrium strategies in the pricing subgame for any choice of d . Here, we describe the intuition and the results.

To understand the strategic forces underlying the pricing stage, suppose that demonstration informativeness, d , has been set, and consider firm α 's best response to p_β . Two types of strategies can be best responses. (1) Firm α can either target only the share of the market with unfavorable impressions of the innovation by setting $p_\alpha = 1$ and generating profit $1 - \phi(d)$, or (2) it can offer consumers a slightly higher payoff than firm β , capturing the entire market, resulting in profit (arbitrarily close to) $1 - \gamma(d) + p_\beta$.⁴

To make positive profit, firm β must avoid being priced out of the market. However, this is not always possible: sometimes even if firm β prices as aggressively as possible (setting $p_\beta = 0$), firm α still prefers to go for the entire market (setting $p_\alpha = 1 - \gamma(d)$). Comparing α 's profits reveals that this equilibrium exists whenever $\gamma(d) < \phi(d)$. Therefore, whenever demonstration informativeness or added value are sufficiently low, the equilibrium is similar to asymmetric Bertrand competition: the innovating firm sets a price of 0, and

the established firm sets the highest price for which it captures the entire market. This type of equilibrium can arise only when d is sufficiently small: $\gamma(d)$ is increasing in d , while $\phi(d)$ is decreasing; moreover, $\gamma(1) = \nu > 1 > \phi(1) = \theta$. Intuitively, because the innovative product's value exceeds the established product's, with a sufficiently informative demonstration and low price, the innovating firm can always capture some of the market in equilibrium.

When $\gamma(d) > \phi(d)$, there is no pure strategy equilibrium, as one firm would always want to adjust its price in response to the price set by the other firm.⁵ In the mixed strategy equilibrium, the established firm randomizes between its two types of best responses, sometimes setting price $p_\alpha = 1$ to extract the maximum profit from those consumers that have an unfavorable impression of the innovation, and sometimes discounting its price in an attempt to undercut the other firm and capture the entire market, drawing p_α from a continuous distribution supported on $[1 - \phi(d), 1]$. The innovator randomizes over a range of prices that prevents the established firm from always undercutting and capturing the market, choosing p_β from a continuous distribution supported on $[\gamma(d) - \phi(d), \gamma(d)]$ with no mass points. Both firms' mixing densities are explicitly characterized in the appendix.

PROPOSITION 1. *Suppose that the demonstration is determined before prices.*

- When $\gamma(d) < \phi(d)$, the equilibrium of the pricing subgame is $p_\alpha = 1 - \gamma(d)$ and $p_\beta = 0$. Firm α sells to the entire market. Profits are $\pi_\alpha = p_\alpha = 1 - \gamma(d)$ and $\pi_\beta = 0$.
- When $\gamma(d) > \phi(d)$, the equilibrium of the pricing subgame is in mixed strategies. Firm α 's price is drawn from a continuous random variable supported on $[1 - \phi(d), 1]$ and a mass point on 1. Firm β 's price is drawn from a continuous random variable on $[\gamma(d) - \phi(d), \gamma(d)]$ with no mass points. Expected profits are $\pi_\alpha = 1 - \phi(d)$ and $\pi_\beta = \phi(d)(\gamma(d) - \phi(d)) = \nu\theta - (\phi(d))^2$.

Although some of the effects in our pricing stage are reminiscent of Gelman and Salop (1983), the simultaneous price setting in our model introduces crucial differences. When the innovator prices first (as in Gelman and Salop 1983), it anticipates the established firm's response, and it can always select a price for which $p_\alpha = 1$ is a best response, generating a pure

⁵ If the innovator prices aggressively ($p_\beta < \gamma(d) - \phi(d)$), then the established firm prefers to focus on the portion of the market that dislikes the innovation, setting a price of $p_\alpha = 1$. If it does so, then the established product offers 0 payoff to consumers, and there is therefore no reason for the innovator to price aggressively (it would set price $p_\beta = \gamma(d)$ instead). Meanwhile, if the innovator sets a relatively high price ($p_\beta > \gamma(d) - \phi(d)$), then the established firm would have an incentive to marginally undercut, capturing the entire market. However, then the innovator too would respond with a marginal price cut.

⁴ To capture the entire market, firm α must set a price for which $1 - p_\alpha > \gamma(d) - p_\beta$ or, equivalently, $p_\alpha < 1 - \gamma(d) + p_\beta$.

strategy equilibrium. If the established firm cannot observe the innovator's price, then both firms must act unpredictably to avoid exploitation.

3.2. Demonstration Informativeness

An increase in demonstration informativeness generates product differentiation and decreases the size of the contested market share, both of which dampen subsequent price competition. Indeed, as demonstration informativeness increases, in equilibrium both firms are more likely to set higher prices.

COROLLARY 1. *When demonstrations are established before prices, an increase in d generates a first-order stochastic dominance shift toward higher prices in each firm's equilibrium mixed strategy.*

Although the share of the market that has a favorable view of the innovation (β 's maximum market share) decreases with demonstration informativeness, the loss of market share is offset by an increase in the price. Interestingly, the price effect dominates.

COROLLARY 2. *When demonstrations are established before prices, firm β 's profit is weakly increasing in informativeness and strictly increasing when informativeness passes a threshold. In equilibrium, firm β chooses a fully informative demonstration.*

This result is driven by the product differentiation effect of informative demonstrations, which allows the innovator to set higher prices for the group of favorable consumers, offsetting the lost market share from the larger group of consumers who view the product negatively.

To highlight the importance of the product differentiation effect in generating a profit function that increases with informativeness, we briefly consider a benchmark version of our model in which the product differentiation effect is artificially turned off. Specifically, suppose that the willingness of favorable consumers to pay is fixed at γ^* rather than increasing in d . The characterization of the pricing equilibrium in Proposition 1 also applies here, with γ^* replacing $\gamma(d)$. Hence, when $\phi(d) < \gamma^*$, firm β 's expected profit in the benchmark is $\pi_\beta^* = \phi(d)(\gamma^* - \phi(d))$. If $\gamma^* < 2$, then this function is nonmonotonic in d for $d \in [0, 1]$, and indeed, when $\gamma^* < 2\theta$, it is decreasing over this domain. Therefore, the product differentiation effect is an essential component in these results.

When prices respond to demonstrations, an interesting alignment of interest arises between the competing firms: both firms' profits are highest when firm β chooses a fully informative demonstration. To see this alignment, note that whenever $\gamma(d) > \phi(d)$, firm α 's equilibrium profit $(1 - \phi(d))$ is also increasing in demonstration informativeness. Therefore, for values of d such that $\gamma(d) > \phi(d)$ (which always exist), the established

firm prefers $d = 1$, generating profit $1 - \theta$. However, when $\gamma(d) < \phi(d)$, firm α 's profit, $1 - \gamma(d)$, is decreasing in demonstration informativeness. Hence, for values of d such that $\gamma(d) < \phi(d)$, the established firm prefers $d = 0$, generating profit $1 - \nu\theta$. Because $\nu > 1$, comparing these profits reveals the following corollary.

COROLLARY 3. *When demonstrations are established before prices, firm α 's profit is highest when firm β chooses a fully informative demonstration.*

Because the market division effect dampens competition to the greatest possible extent and increases the prices that both firms charge in equilibrium, firm α also generates the highest profit that it can when firm β selects a fully revealing demonstration.⁶

4. Flexibility in Demonstration Design

In this section, we consider the case where firm β has the flexibility to adjust its demonstration policy after prices are observed. This is consistent with settings in which retail managers, sales staff, or dealers have the ability to adjust demonstrations to maximize sales. It is also consistent with the firms committing to prices up front, by establishing a policy to not discount items at the point of sale.⁷ There is ample evidence that prices tend to be sticky, with firms reluctant to change their prices too often (e.g., Rotemberg 1982, Blinder 1994), suggesting that this timing is often reasonable.

4.1. Demonstration Informativeness

When demonstration informativeness is chosen after prices, its strategic role is significantly different. Here, the demonstration responds to the prevailing market prices and it cannot be used to soften price competition, because prices have already been set. Instead, the innovating firm adjusts the informativeness of its demonstration in order to maximize its market share: the demonstration is designed to persuade consumers to buy the innovation, not to dampen competition.

In the previous section, both the market division and product differentiation effects reduce competitive pressure and increase profits. In this section, in contrast, the product differentiation effect increases the innovating firm's profit, but the market division

⁶ The established firm prefers to select a fully informative demonstration and accommodate the innovator, rather than to select a less informative demonstration, which reduces consumer value for product β , but also leads to more fierce price competition. This is reminiscent of the "puppy dog ploy" described by Fudenberg and Tirole (1984).

⁷ For example, Canada Goose never discounts its jackets and does not allow any authorized retailer to do so either. Similarly, Apple and other electronics manufacturers rarely or never discount their current generation of productions. Luxury clothing and accessory makers such as UGG, Hermés Birkin, and Louis Vuitton have similar reputations.

effect reduces it. With these effects working against each other, the optimal demonstration is no longer fully informative, but rather maintains some consumer uncertainty about their values.

To explore this difference in more detail, suppose that with an uninformative demonstration, the innovation offers consumers a higher expected payoff than the established product. In this case, increasing informativeness only reduces β 's market share, because doing so increases the mass of consumers with unfavorable impressions and no interest in product β . In this case, an uninformative demonstration is optimal.⁸ However, if the innovation offers a smaller expected payoff than the established product, when the demonstration is uninformative, then increasing informativeness can be beneficial by generating product differentiation. Indeed, increasing informativeness increases the valuation of consumers with favorable impressions, and firm β prefers demonstration that is informative enough to convince those with favorable impressions to buy its product. However, increasing informativeness also causes market division, which reduces the fraction of favorable consumers and the firm's market share. Therefore, when demonstrations follow prices, the firm prefers an intermediate level of demonstration, maximizing the share of consumers willing to buy its product at the given prices.

Formally, for given product prices p_α and p_β , firm β 's optimal choice of d solves

$$\max_{d \in [0, 1]} \phi(d) \quad \text{s.t.} \quad \gamma(d) - p_\beta \geq 1 - p_\alpha.$$

Firm β chooses d to maximize the mass of consumers who receive a favorable impression of its product, subject to the constraint that the demonstration is sufficiently informative that consumers with a favorable impression prefer the innovation. As demonstrations become more informative, a larger portion of consumers have unfavorable impressions of the product as they realize that the product does not meet their needs. This decreases firm β 's market share at the given price. Therefore, firm β prefers as low of d as possible while meeting the constraint. The expected value of product β , given a favorable impression, is increasing in d . Thus, firm β prefers the minimum d such that $\gamma(d) - p_\beta \geq 1 - p_\alpha$.

When firm β 's price advantage is sufficiently large, consumers will purchase its product even if $d = 0$. In that case, it provides uninformative (or no) demonstrations and captures the entire market. When neither firm has a sufficiently large price advantage, firm β implements a partially informative demonstration. In this case, its demonstration is no more informative

than needed to persuade consumers with favorable impressions to purchase its product. Consequently, the consumers that purchase product β are indifferent between the two products.

PROPOSITION 2. *When demonstrations respond to prices, the innovative firm uses demonstrations to maximize its market share given prices. When feasible, it prefers the least informative demonstration policy such that favorable consumers (weakly) prefer the innovative product.*

- *If prices are sufficiently favorable for firm α (i.e., $p_\alpha - p_\beta < 1 - \nu$), then firm α always captures the entire market, regardless of demonstration informativeness.*
- *If prices are sufficiently favorable for firm β (i.e., $1 - \nu\theta \leq p_\alpha - p_\beta$), then firm β captures the entire market in equilibrium.*
- *For intermediate levels of price differences (i.e., $1 - \nu \leq p_\alpha - p_\beta < 1 - \nu\theta$), firm β chooses a partially informative demonstration with $d \in (0, 1)$, firm α sells to consumers who receive an unfavorable impression of product β , and firm β sells to consumers who receive a favorable impression. Therefore,*

$$\pi_\alpha = \left(1 - \frac{\nu\theta}{1 - p_\alpha + p_\beta}\right)p_\alpha \quad \text{and} \quad \pi_\beta = \frac{\nu\theta}{1 - p_\alpha + p_\beta}p_\beta.$$

The expression for the equilibrium d^* is given in Equation (4) in the appendix. When chosen prior to price competition, demonstrations play a strategic role of dividing the market and minimizing competition between the firms when setting prices. When chosen after price competition, demonstrations persuade consumers to purchase product β . Clearly, the product differentiation effect is essential for demonstrations to have any value for the innovating firm after prices are set; instruments that only generate market segmentation (like capacity limits) are not beneficial after prices are set.

4.2. Price Competition

When choosing prices, the firms anticipate how their choices influence the subsequent design of demonstrations and its impact on their market share. When deriving equilibrium pricing strategies, we focus on the case where

$$\nu > 4\theta. \tag{A1}$$

This assumption can be viewed in one of two ways: (1) The product is a "breakthrough," offering a large added value over the existing product (ν is big). (2) The product is a niche product, appealing to a relatively small portion of the market (θ is low). The assumption is mainly for tractability, allowing us to characterize the equilibrium in closed form. The detailed analysis in the online appendix establishes that (A1) is necessary and sufficient for the existence of a pure strategy equilibrium in the pricing game, characterized in the following proposition.

⁸ With an uninformative demonstration, all impressions are favorable, i.e., $\phi(0) = 1$.

PROPOSITION 3. *When demonstrations respond to prices:*

- A pure strategy equilibrium of the pricing stage exists if and only if (A1).
- In any pure strategy equilibrium, firm α sets $p_\alpha = 1$, and firm β selects any price $p_\beta \in [p_L, p_H] \subset [\theta\nu, \nu]$.
- On the equilibrium path, the innovative firm chooses a partially informative demonstration, those with favorable impressions purchase the innovation, and those with unfavorable impressions purchase the established product.
- Firm β expects the monopoly profit $\pi_\beta = \nu\theta$, consumer surplus is 0, and the established firm's profit is smaller than the monopoly profit in the uncontested fraction of the market, $\pi_\alpha < 1 - \theta$.

To understand the structure of this equilibrium, note that when $p_\alpha = 1$, firm β is indifferent between all prices inside $[\nu\theta, \nu]$, which deliver the innovating firm the monopoly profit $\nu\theta$ (see Proposition 2). Intuitively we see that when $p_\alpha = 1$, the established product offers consumers 0 payoff, and it is therefore not really competing with the innovator.⁹ Thus, if some p_β inside this interval could be found for which $p_\alpha = 1$ is a best response, then these would constitute an equilibrium of the pricing stage. Firm α considers two types of deviations from $p_\alpha = 1$: large price cuts to capture the entire market (independent of firm β 's subsequent demonstration strategy), or a smaller price cut that incentivizes β to select a more informative signal. As we argue in the online appendix, precluding these deviations imposes bounds on feasible prices p_β (the set of prices satisfying these conditions is nonempty when (A1) is satisfied). The calculations are technical, but the effects that generate the bounds are intuitive. When p_β is low, firm β 's profit per unit sold is low, and the firm has an incentive to increase its price, forfeiting some market share, but increasing overall profit. When p_β is too high, firm α does not need to drop its price much from $p_\alpha = 1$ to capture the entire market and will choose to do so. Therefore, an intermediate value of p_β is needed for $p_\alpha = 1$ to be a best response and for firm β not to prefer a price increase.

When demonstrations are more flexible than prices, the innovating firm selects a partially revealing demonstration designed to persuade the maximum number of consumers to purchase its product. This has significant normative implications. First, the equilibrium demonstration leaves consumers (nearly) indifferent between purchasing either product, and the firms extract all surplus as profits: the entire consumer surplus in the

market is extracted by the firms despite competition. Second, the expected total surplus in the market is determined by the match between the consumers and the products. Because demonstrations are only partially revealing, some consumers purchase the innovation although they would be better off purchasing the established alternative, generating inefficient matches in equilibrium. As such, total surplus would be higher under a system of fully informative demonstrations.

That the innovator is able to obtain the monopoly profit has interesting implications for innovation policy, the goal of which is to ensure that innovators receive enough compensation for their innovations that they allocate sufficient resources toward developing new products. A major concern is that innovations are protected from imitators, a concern that we do not address. However, another important issue is that the value of developing an innovation may be diluted by competition from inferior products.¹⁰ In our analysis, when the innovating firm has developed a breakthrough (so that (A1) holds) and it can design product demonstrations in response to prices, this concern does not arise. The innovating firm captures the monopoly profit, despite the presence of an inferior established alternative, and therefore, its incentives to innovate are not reduced by competition from the inferior product.

Finally, the analysis suggests that a firm may be better off retaining flexibility in its demonstration policy, adjusting its consumer information strategy to account for price differences between the products. This highlights a way in which firms in innovative industries may benefit from a reputation for not changing prices. It also suggests that consumer surplus and total surplus may be higher in industries where prices are less sticky, which (as we showed in Section 3) leads firms to adopt more informative demonstrations.

5. Conclusion

We consider strategic information provision in a model of price competition. Our model of demonstrations may represent product trials, samples, return policies, review platforms, or any other means by which firms give consumers exposure to products before the consumers commit to purchase decision. A firm releases an innovative product, which may benefit only some consumers. By providing demonstrations, the firm gives consumers an opportunity to better learn about their own value for the innovation. More information simultaneously increases the expected valuation of those who receive favorable impressions of the new product (the product differentiation effect),

⁹ Given that the established product offers 0 expected payoff, the innovator can achieve the monopoly profit by charging any price $p_\beta \in [\nu\theta, \nu]$ and choosing demonstration informativeness such that $\gamma(d) = p_\beta$. In expectation, the probability of generating a favorable impression and the increase in the price exactly offset each other to generate a constant expected profit.

¹⁰ This effect arises when demonstrations are determined before prices, for example, where the innovator's equilibrium payoff is $\nu\theta - \theta^2$, which is less than the ex ante social surplus generated by the innovation, $\nu\theta$.

while also decreasing the share of consumers with favorable impressions (the market division effect).

Depending on whether its demonstration policy is chosen before or after prices are set, the innovating firm either designs its demonstration policy to reduce subsequent price competition or to persuade consumers to purchase its product given the prevailing prices. When prices respond to the demonstration policy, the firm prefers to make its demonstrations as informative as possible, generating the greatest amount of product differentiation and reducing the contested portion of the market as much as possible, minimizing the intensity of competition in the pricing stage. In contrast, when the firm adjusts its demonstration policy in response to prices, the product differentiation effect can increase demand for the innovation, while the market division effect reduces it. Consequently, the innovating firm prefers only a partially informative demonstration, designed to maximize its market share. In this case, the ability to offer demonstrations can lead to the innovating firm collecting the monopoly profit.

This result implies that an innovating firm may benefit from the ability to adjust its demonstration strategy in response to market prices. If feasible, a firm may prefer to commit to prices, while allowing retailers or sales agents to choose in-store demonstrations, samples, or test drives to maximize sales, once prices are set. This suggests that the returns to innovation may be higher in industries in which manufacturers control prices, or prices are otherwise sticky and slow to change (e.g., Rotemberg 1982, Blinder 1994). Such strategies are generally consistent with automobile manufacturers giving dealers relatively little flexibility in adjusting prices, and a lot of flexibility in the design of test drives and showroom experiences (e.g., Cato 2014), and Apple, which is known for adjusting its prices on its iPhone, iPad, and Mac computers very infrequently (often only once per year), and which establishes its own stores where it controls many details of the consumer shopping experience (e.g., Kane and Sherr 2011).

In settings with a higher degree of price flexibility, an innovative firm is better off providing more-informative demonstrations. Although demonstrations may lead some consumers to realize a new product is not for them, this potential loss in market share is offset by an increase in the willingness to pay off those with favorable impressions, and by a decrease in the incentives that competitors have to cut their prices in response to the entry of the new product. In such settings, firms should help potential customers to learn as much as possible about their values. Where feasible, this may involve offering generous return policies, satisfaction guarantees, or unrestricted product trials. It may also involve providing professional reviewers with samples,

or establishing online review platforms to help potential consumers learn from the experiences of others. This is broadly consistent with the behavior of Amazon.com, for example: online prices are easily adjusted, and the company has established a generous return policy and extensive review system to help consumers learn about new products (e.g., Lecher 2015).

Supplemental Material

Supplemental material to this paper is available at <http://dx.doi.org/10.1287/mnsc.2016.2449>.

Acknowledgments

The paper greatly benefited from valuable comments made by department editor J. Miguel Villas-Boas, the associate editor, and two anonymous referees, as well as Heski Bar-Isaac, Justin Johnson, Harish Krishnan, Pino Lopomo, Mahesh Nagarajan, and Curt Taylor. C. S. Cotton is grateful for financial support provided through his position as the Jarislowsky-Deutsch Chair in Economic and Financial Policy at Queen's University. H. Gurnani's research is partially supported by the Benson-Pruitt endowed professor position at Wake Forest University. The research started while he was Leslie O. Barnes Professor at the University of Miami.

Mathematical Appendix

In addition to this appendix, an online appendix provides a more detailed analysis of the flexible-demonstrations environment and considers a version of the model in which the firm can simultaneously use demonstrations and capacity constraints in an effort to limit competition.

A.1. Upfront Demonstration Design

Derivation of equilibrium of the pricing subgame. When choosing prices following the choice of d , firm α 's best response to p_β is either $p_\alpha = 1$, which earns profits $\pi_\alpha = 1 - \phi(d)$, or $p_\alpha = 1 - \gamma(d) + p_\beta$ (or "just under" this value when $\gamma(d) > 1$), which results in α capturing the entire market and earning $\pi_\alpha = 1 - \gamma(d) + p_\beta$. The problem is similar to asymmetric Bertrand price competition, except that when p_β is low enough, firm α prefers to avoid competition all together, set $p_\alpha = 1$, and focus on its role as a monopolist provider to those with unfavorable impressions of the innovative product.

Case 1. Suppose $\gamma(d) \leq \phi(d)$. Then the equilibrium involves firm α setting $p_\alpha = 1 - \gamma(d)$, and firm β setting $p_\beta = 0$. Firm α captures the entire market, earning $\pi_\alpha = 1 - \gamma(d)$. Given that $\gamma(d) \leq \phi(d)$, this payoff is at least as large as the firm's profit from setting $p_\alpha = 1$ and earning $1 - \phi(d)$.

Case 2. Suppose $\gamma(d) > \phi(d)$. In this case, there is no pure strategy equilibrium. Consider the possibility of a mixed strategy Nash equilibrium in which

- firm α mixes using a smooth continuous distribution over a continuum $(p_\alpha^{\min}, 1)$ according to F_α and a mass point on $p_\alpha = 1$ with weight ω_α ; and
- firm β mixes using a smooth continuous distribution over a continuum $[p_\beta^{\min}, \gamma(d))$ according to F_β .

When firm α sets $p_\alpha = 1$, doing so results in $\pi_\alpha = 1 - \phi(d)$. Thus, any other strategy played with positive probability by the mixed strategy must also give $\pi_\alpha = 1 - \phi(d)$. The minimum p_α that returns such a profit is $p_\alpha = 1 - \phi(d)$, and

only when setting such a price leads to a market share of 1 for firm α . This implies a lower bound for β 's mixing distribution, since $1 - p_\alpha = 1 - (1 - \phi(d)) = \phi(d)$ must be higher than $\gamma(d) - p_\beta$ for all p_β . Thus, $p_\beta > \gamma(d) - \phi(d)$. (This could be negative, a possibility we rule out later.)

This implies that $p_\alpha^{\min} = 1 - \phi(d)$ and $p_\beta^{\min} = \gamma(d) - \phi(d)$.

In turn, this implies that firm β can achieve a profit of $\pi_\beta = (\gamma(d) - \phi(d))\phi(d)$ from setting a price at this lower bound, and thus the profits from other prices in the mixing distribution must equal this amount.

Firm α must be indifferent between all $p_\alpha \in (1 - \phi(d), 1]$. An arbitrary p_α in this range results in α capturing the entire market if $1 - p_\alpha > \gamma(d) - p_\beta$, which is true if $p_\beta > \gamma(d) - 1 + p_\alpha$. Thus,

$$\begin{aligned} \pi_\alpha(p_\alpha) &= F_\beta(\gamma(d) - 1 + p_\alpha)(1 - \phi(d))p_\alpha \\ &\quad + (1 - F_\beta(\gamma(d) - 1 + p_\alpha))p_\alpha \\ &= p_\alpha - F_\beta(\gamma(d) - 1 + p_\alpha)\phi(d)p_\alpha. \end{aligned}$$

This has to equal the equilibrium payoffs $1 - \phi(d)$. Thus, setting the above expression equal to $1 - \phi(d)$ and solving for $F_\beta(\gamma(d) - 1 + p_\alpha)$ gives

$$F_\beta(\gamma(d) - 1 + p_\alpha) = \frac{p_\alpha - (1 - \phi(d))}{\phi(d)p_\alpha},$$

which implies a distribution of p_β such that

$$F_\beta(p_\beta) = \frac{p_\beta - (\gamma(d) - \phi(d))}{\phi(d)(p_\beta - (\gamma(d) - 1))}. \quad (1)$$

Note that if $p_\beta = \gamma(d) - \phi(d)$ then $F_\beta(\gamma(d) - \phi(d)) = 0$, and if $p_\beta = \gamma(d)$ then $F_\beta(\gamma(d)) = 1$.

Similarly, firm β must be indifferent between all $p_\beta \in [\gamma(d) - \phi(d), \gamma(d)]$. An arbitrary p_β in this range results in

$$\pi_\beta(p_\beta) = (1 - F_\alpha(1 - \gamma(d) + p_\beta))\phi(d)p_\beta,$$

which must equal payoffs $(\gamma(d) - \phi(d))\phi(d)$. Setting the expression for $\pi_\beta(p_\beta)$ equal to $(\gamma(d) - \phi(d))\phi(d)$ and solving the implied equality for $F_\alpha(1 - \gamma(d) + p_\beta)$ gives

$$F_\alpha(1 - \gamma(d) + p_\beta) = 1 - \frac{\gamma(d) - \phi(d)}{p_\beta}.$$

Thus,

$$F_\alpha(p_\alpha) = \frac{p_\alpha - (1 - \phi(d))}{\gamma(d) - 1 + p_\alpha}. \quad (2)$$

Note that $F_\alpha(1 - \phi(d)) = 0$ and $F_\alpha(1) = \phi(d)/\gamma(d)$. Thus, the mass on $p_\alpha = 1$ equals $\omega_\alpha = 1 - F_\alpha(1)$ or

$$\omega_\alpha = \frac{\gamma(d) - \phi(d)}{\gamma(d)}. \quad (3)$$

In equilibrium of the pricing subgame, firm β mixes over all $p_\beta \in [\gamma(d) - \phi(d), \gamma(d)]$ according to distribution (2). Firm α mixes over all $p_\alpha \in (1 - \phi(d), 1]$ according to distribution (3), with mass point on $p_\alpha = 1$ given by (3).

Optimal demonstration policy. It is always feasible for firm β to set a demonstration strategy $d \in [0, 1]$ such that $\gamma(d) > \phi(d)$. Given that $\gamma(d) \leq \phi(d)$ results in $\pi_\beta = 0$ and $\gamma(d) > \phi(d)$ results in $\pi_\beta > 0$, firm β always prefers such a d .

The optimal d such that $\gamma(d) > \phi(d)$ maximizes

$$\pi_\beta = (\gamma(d) - \phi(d))\phi(d) = \theta\nu - (1 - d(1 - \theta))^2,$$

which is strictly increasing in $d \in [0, 1]$. Thus, fully informative demonstrations are optimal for firm β .

A.2. Flexible Demonstrations

Firm β chooses a demonstration that is just informative enough that those with favorable realizations buy its product. Doing so maximizes the number of consumers with sufficiently favorable impressions to purchase the product. Then, firm β 's best response demonstration to prices p_α and p_β is

$$d^* = \frac{1 - p_\alpha + p_\beta - \nu\theta}{(1 - p_\alpha + p_\beta)(1 - \theta)}, \quad (4)$$

when $d^* > 0$. When $1 - p_\alpha \leq \nu\theta - p_\beta$, it follows that $d^* \leq 0$, and the preferred demonstration involves $d = 0$. When $d^* > 1$, there does not exist a feasible demonstration policy that leads to firm β selling to any share of the market.

Detailed derivation of the upfront pricing strategies, as well as the necessary and sufficient conditions for the existence of pure strategy equilibria, are included in the online appendix.

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