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Demonstrations and Price Competition in New Product Release

Raphael Boleslavsky
University of Miami

Christopher Cotton
Queen's University

Haresh Gurnani
Wake Forest University

Department of Economics
Queen's University
94 University Avenue
Kingston, Ontario, Canada
K7L 3N6

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DEMONSTRATIONS AND PRICE COMPETITION IN NEW PRODUCT RELEASE

RAPHAEL BOLES LAVSKY, CHRISTOPHER COTTON, AND HARESH GURNANI

ABSTRACT. We incorporate product demonstrations into a game theoretic model of firm price competition. Demonstrations may include product samples, trials, return policies, reviews, 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 learn whether they prefer an innovation over an established product. The innovative firm controls demonstration informativeness. When prices can respond to demonstration policies, the firm prefers to provide maximumly informative demonstrations, which optimally segment the market, dampen subsequent price competition, and maximize profits. In contrast, when prices are less flexible, the firm prefers only partially informative demonstrations, designed to maximize its market share at prevailing prices. 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 (e.g. Gelman and Salop 1983), which also allow firms to divide a market and reduce competition.

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Boleslavsky: Department of Economics, University of Miami, Coral Gables, FL 33146, r.boleslavsky@miami.edu.
Cotton: Department of Economics, Queen's University, Kingston, Canada K7L 3N6, cotton@econ.queensu.ca. Gurnani: School of Business, Wake Forest University, Winston-Salem, NC 27106, gurnanilh@wfu.edu . This paper supersedes a previous version circulated as "A Theory of Product Demonstrations." We thank numerous seminar participants, as well as Heski Bar-Isaac, Justin Johnson, Harish Krishnan, Pino Lopomo, Mahesh Nagarajan and Curt Taylor for insightful comments. Cotton is grateful for financial support provided through his position as the Jarislowsky-Deutsch Chair in Economic and Financial Policy at Queen's University.

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, etc. Similarly, wineries or other food producers visit grocery stores to provide tastings 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 gameplay 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 often provide money back guarantees or extended trial periods, which resolve most or all of the consumer's valuation uncertainty before the final purchase decision (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. During a demonstration, consumers privately observe signal realizations, which we refer to as their "impression" of the innovative product. A more informative demonstration offers greater opportunity for a consumer to realize when the new product fails to meet their needs. Imagine a longer or less restrictive product trial. Consumers draw either favorable or unfavorable impressions. Those with unfavorable impressions will never purchase the new product, while those with favorable impressions will purchase the new product if their impression is *favorable enough* given prices.

By selecting a more informative demonstration, the firm affects demand for the innovative product in two ways. First, fewer mismatched consumers draw favorable impressions of the innovation. Therefore, a favorable impression conveys "better news" about the innovative 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, 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 guaranteed market share and reduces the market share that is contested by the innovator. We refer to this effect as *market segmentation*. These two 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. 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 a firm committing to satisfaction guarantees or return policies, or where the development of in-store experiences or product trials requires significant time and planning effort. In this case, demonstrations generate both market segmentation and product differentiation, and increases in demonstration informativeness dampen subsequent price competition, which can increase both firms’ profits. Consequently, the innovating firm selects 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 adjusts its demonstration design. This is consistent with settings in which demonstration experiences are personalized at the point of sale (e.g. test drives), or when firms are unable or unwilling to adjusting prices, with contracts or reputational concerns leading to sticky prices (e.g. Rotemberg 1982, Blinder 1994). In this case, the innovative firm chooses a demonstration to maximize its market share given the prevailing prices—the demonstration is designed to persuade consumers, rather than dampen price competition. In equilibrium, the innovative firm prefers the least informative demonstration for which consumers who draw favorable impressions prefer to buy the innovative product. If the demonstration is less informative, then a favorable impression does not convey enough good news to entice consumers to purchase the innovation, leaving the firm with zero market share. If the demonstration is more informative, then all consumers with favorable realizations purchase the innovation, but 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 segmenting the market ahead of price competition has been explored by Gelman and Salop (1983) using the notion of “Judo Economics.” These authors analyze sequential price competition when the entrant can commit to limit his production capacity.¹ By doing so, the entrant ensures that some fraction of the market will only be able to purchase the incumbent’s product, creating market segmentation. Once the entrant commits to his capacity and price, the incumbent has two possible responses. He can either undercut the entrant, enticing all consumers to buy the incumbent’s product, or he can accommodate the entrant by conceding the

¹An additional difference between our paper and Gelman and Salop (1983) is the model timing. In Gelman and Salop (1983) the entrant first sets his price and capacity, generating a first mover advantage. In our model, the incumbent and entrant set prices simultaneously, so the entrant cannot influence the incumbent’s price by adjusting his own. An extension to the case of sequential price competition can be addressed in our model. Details are available from the authors.

portion of the market that the entrant is contesting, and extracting 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 his 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, a consumer who has low value for the innovation is more likely to realize that they are not interested in purchasing it. In this way, increasing demonstration informativeness segments the market in a similar way that capacity constraints segmented in Gelman and Salop (1983). Like capacity limits, commitment to a demonstration policy can be used to dampen subsequent price competition. However, unlike capacity limits, increases in demonstration informativeness also increase the expected valuation of favorable consumers. Because of this additional benefit, when the demonstration affects subsequent price competition, the innovating firm selects a demonstration that is maximally informative. When selected after prices are set, the differences between capacity limits and demonstrations are even more pronounced. After prices are set, segmenting 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.

To further explore the interaction of capacity limits and demonstration informativeness, Section 5 allows the firm to 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 segmentation and product differentiation, while limiting capacity generates only segmentation, 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 segment the market enough to avoid an aggressive price response from the established firm. In this case (when the innovation is widely appealing but provides low value added) 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 his 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, Soberman and Villas-Boas (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 considers 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 play in a firm's strategy. To our knowledge, this question is novel in 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

²In 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. These models focus on the optimal design of signals, and limit competition to be exclusively through the provision of information.

the *size* of the market that finds it appealing (e.g. d'Aspremont, Gabszewicz and Thisse 1979), and v is a measure of vertical quality or value-added, 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. Because prices are set at the same time, neither firm has a first mover advantage in the pricing stage.

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, her payoff is zero. Consumers have unit demand for the products, and it is only feasible for a consumer to purchase one item.

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. pre-purchase trials, in-store demonstrations and samples, satisfaction guarantees, return periods, reviews).

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 :

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

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,

³Deal 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.

high values of d in the demonstration design represent pre-purchase 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 pre-purchase interactions with less information: an in-store video of gameplay 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, Gerstner and Hagerty 1995).

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:

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

Notice that $\phi(d)$ is decreasing in d (i.e. $\phi'(d) = -(1 - \theta) < 0$). This is the *market segmentation* effect: the more informative the demonstration, the more likely a consumer with a low value will learn this, 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:

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

Notice 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 is specialized to meet their needs. These two effects shape the incentives for price competition and demonstration informativeness, but the role each plays depends on the model timing.

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 would be the case when firms can quickly and easily change their prices (for instance, with online pricing, e.g. Gorodnichenko, Sheremirov and Talavera 2014), or where 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.

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 backwards 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 zero 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 . The consumer's purchase decision is therefore 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. UPFRONT DEMONSTRATION DESIGN

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, developing an in-store experience or product trial may require significant time and planning effort, while cutting or increasing 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

In order to make positive profit, firm β must avoid being priced out of the market. But 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 value-added are sufficiently low, the equilibrium is similar to asymmetric Bertrand competition: the innovating firm sets price a price of zero, 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, $\gamma(1) = v > 1 > \phi(1) = \theta$. Intuitively, because the innovative product’s value added 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 under cut 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

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

⁵If 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 zero 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. But then the innovator too would respond with a marginal price cut.

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 $\pi_\beta = \phi(d)(\gamma(d) - \phi(d)) = v\theta - (\phi(d))^2$.*

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 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 market segmentation, 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.*

While 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 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 Lemma 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 non-monotonic 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 benefit from market segmentation and prefer firm β to choose fully informative demonstrations. 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.*

Firm α , like firm β , benefits from the implementation of fully revealing demonstrations.⁶ This is feasible because total surplus is strictly increasing in the match quality of consumers and the products they purchase, and is therefore strictly increasing in demonstration informativeness. When firm β uses a fully informative demonstration, total surplus is higher, and both firms are able to extract higher profits in equilibrium.

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 the design of demonstrations is decentralized, for example endowing car dealers with the ability to choose demonstrations at the point of sale (e.g. test drives). It is also consistent with the firms committing to prices up front, by establishing a policy to not discount its 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 for some cases.

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 segmentation 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 segmentation effect reduces

⁶The 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).

⁷For 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, Hermès Birkin, and Louis Vuitton have similar reputations.

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 with 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 increases segmentation, 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 will 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. $p_\alpha - p_\beta < 1 - v$), then firm α always captures the entire market, regardless of demonstration informativeness.*
- *If prices are sufficiently favorable for firm β (i.e. $1 - v\theta \leq p_\alpha - p_\beta$), then firm β captures the entire market in equilibrium.*

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

- 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,

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

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 segmenting 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 value added 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.

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 inside an interval $p_\beta \in [p_L, p_H] \subset [\nu\theta, \nu]$.
- 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 zero, 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, when $p_\alpha = 1$, the established product offers consumers zero 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

⁹Given that the established product offers zero 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,

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, 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, a portion of the market purchases the innovation even though it 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 with 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 consumers 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.

the probability of generating a favorable impression and the increase in the price exactly offset to generate a constant expected profit.

¹⁰This 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, $\nu\theta$.

5. SIMULTANEOUS USE OF DEMONSTRATIONS AND CAPACITY CONSTRAINTS

Increases in demonstration informativeness generate both product differentiation and market segmentation, and both of these affect price competition in important ways. In a model with sequential pricing, Gelman and Salop (1983) consider an entrant's strategic use of capacity limits (before sequential price setting) for generating market segmentation.¹¹ To further explore the connection between demonstration informativeness and capacity limits, in this section we incorporate capacity constraints into our model in a manner consistent with these authors' analysis.

At the time of product release, firm β can commit to pursue portion λ of the market, and ignore portion $1 - \lambda$ of the market. To achieve this, firm β may observably limit its production capacity, or it could release a product with an easily observed feature that limits its appeal to a portion of the market (releasing a cell phone in limited color options, with a bold style, or with restricted compatibility for example).

Capacity provides a second instrument for segmenting the market: by selecting $\lambda < 1$, the innovating firm limits the size of the contested market, $\phi(d; \lambda)$, where

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

Within the contested portion of the market, demonstrations generate both market segmentation and product differentiation, but the mass of consumers with favorable realizations is no larger than λ , generating a second type segmentation (that is independent of demonstration informativeness). Unlike changes in demonstration informativeness, changes in λ do not affect the expected valuation $\gamma(d)$ of a favorable consumer and, therefore, do not generate product differentiation.

5.1. Upfront demonstration design. Because increasing demonstration informativeness generates both segmentation and differentiation—both of which soften subsequent price competition—while a reduction in capacity generates only segmentation, it may seem that demonstration informativeness dominates capacity as a marketing tool. This intuition is only partially correct, because the market segmentation that can be achieved by increasing informativeness is limited: even with the most informative demonstration, the innovator contests fraction θ of the market. In some cases, the innovator benefits by further segmenting the market, which can be achieved by limiting capacity.

A minor modification of Proposition 1 shows that when demonstrations and capacity constraints are chosen ahead of prices, the innovative firm's expected profits continue to be increasing in d . For sufficiently large d , the firm's profits as a function of d and λ are

$$\pi_\beta(d, \lambda) = (\gamma(d) - \phi(d; \lambda))\phi(d; \lambda) = \lambda\theta v - \lambda^2(\phi(d))^2.$$

Because profits are strictly increasing in d , firm β chooses fully informative demonstrations. Capacity is therefore chosen to maximize $\pi_\beta(1, \lambda) = \lambda\theta v - \lambda^2\theta^2$, and hence, the optimal λ is $\lambda^* = \min\{v/(2\theta), 1\}$.

¹¹We describe the strategic effects of this paper in detail in the Introduction

The innovating firm therefore prefers to commit to a capacity constraint whenever $1 < \nu < 2\theta$, which requires $\theta > 1/2$. When the innovation offers relatively little value added and appeals to a large portion of the market, the innovator prefers to commit to limit capacity, achieving market segmentation beyond what is possible with a demonstration alone.

5.2. Flexible demonstrations. Consider the case where the innovative firm commits to a capacity constraint at the time of product release but retains flexibility over demonstrations until after prices are set. Under (A1), capacity constraints never improve firm β 's payoffs. As we show in the body of the paper, without a capacity constraint the firm is able to use its demonstration policy to maintain monopoly profits. If the firm adopts a capacity constraint $\lambda < 1$, its profits fall to $\pi_\beta = \lambda\nu\theta$. Therefore, in the game with demonstration flexibility, the firm will always prefer $\lambda = 1$.

We summarize these results in the following proposition.

Proposition 4. *(1) Regardless of the model timing, the ability to limit capacity does not change the innovating firm's equilibrium demonstration policy. (2) In the game with demonstration design ahead of pricing, the firm prefers to use both fully informative demonstrations and capacity constraints when its product is widely appealing but offers sufficiently small value added. (3) When releasing a breakthrough or niche product, the firm does not limit capacity.*

6. CONCLUSION

We consider strategic information provision in a model of price competition. Our model of demonstrations may represent product trial, samples, return policies, reviews, 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), while also decreasing the share of consumers with favorable impressions (the market segmentation effect).

Depending on whether the firm's 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 market segmentation, as this minimizes the intensity of price 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 segmentation 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.

Throughout the analysis, we discuss the implications of our results. We show how firms can harness the market segmentation and product differentiation effects of demonstrations to increase industry profits and to give themselves a competitive advantage. The strategic effects of demonstrations depend crucially on the flexibility of prices within the industry. When prices are flexible, demonstrations are used to segment the market and reduce price competition. When prices are sticky, unable to respond to changes in demonstration policies, demonstrations play a persuasion role, as the firm tries to convince as many consumers as possible to purchase its product. Finally, we show that while demonstrations play a similar role to capacity limits in dampening price competition (Gelman and Salop 1983), they may also positively influence the product valuation for some consumers.

MATHEMATICAL APPENDIX

In addition to this appendix, we provide an online appendix providing a more detailed analysis of the flexible demonstrations environment.

I. 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 MSNE 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 .
- 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,

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

This has to equal the equilibrium payoffs $1 - \phi(d)$. Thus, setting 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

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

Notice 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,

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

Notice $F_\alpha(1 - \phi(d)) = 0$ and $F_\alpha(1) = \frac{\phi(d)}{\gamma(d)}$. 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 $p_\alpha = 1$ with weight given by (4).

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

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

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

II. 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

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

when $d^* > 0$. When $1 - p_\alpha \leq v\theta - p_\beta$, 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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ONLINE APPENDIX FOR
 “DEMONSTRATIONS AND PRICE COMPETITION IN NEW PRODUCT RELEASE”

In this appendix, we provide a more detailed analysis of the game with flexible demonstration design. The results in Proposition 2 follow from the analysis in the body and appendix of the main paper. Here, we focus on the equilibrium of the pricing stage of the game.

From the body of the paper, we know that the equilibrium demonstration design depends on the value of $\bar{\mu} \equiv 1 - p_\alpha + p_\beta$ relative to v and $v\theta$. When $v < \bar{\mu}$, there does not exist a demonstration design such that β captures any of the market, and in equilibrium $\pi_\alpha = p_\alpha$ and $\pi_\beta = 0$. When $v\theta < \bar{\mu} \leq v$, firm β will choose

$$d^* = \frac{1 - p_\alpha + p_\beta - v\theta}{(1 - p_\alpha + p_\beta)(1 - \theta)}.$$

This gives

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

When $\bar{\mu} \leq v\theta$, β chooses $d = 0$, giving $\pi_\alpha = 0$ and $\pi_\beta = p_\beta$.

Lemma 1. *In any pure strategy equilibrium, prices p_α and p_β must be such that*

$$v\theta < \bar{\mu}(p_\alpha, p_\beta) \leq v. \tag{5}$$

First we rule out the possibility of $v < \bar{\mu}$ in equilibrium. When setting prices, it will never be a best response for firm β to choose a price that leads to $v < \bar{\mu}$. Firm β would have an incentive to deviate from doing so to instead choose $p_\beta > 0$ such that one of the two other cases is reached. Because $v > 1$, this is always feasible for firm β , even when $p_\alpha = 0$. This rules out the possibility of an equilibrium in which $v < \bar{\mu}$.

Next, we can rule out the possibility of an equilibrium in which $\bar{\mu} \leq v\theta$. If we are in this case, then firm α has an incentive to lower its price if doing so results in $v\theta < \bar{\mu}$. This is not possible only if both $v\theta > 1$ and $1 \leq v\theta - p_\beta$. For firm β , the profit maximizing p_β such that $\bar{\mu} \leq v\theta$ is $p_\beta = v\theta + p_\alpha - 1$, which is greater than $v\theta - 1$, except when $p_\alpha = 0$. Therefore, the only possibility under which $\bar{\mu} \leq v\theta$ involves $p_\alpha = 0$ and $p_\beta = v\theta - 1$, in which case $\pi_\beta = v\theta - 1$. However, if this is the case, firm β could alternatively set $p_\beta = v - 1$ followed by $d = 1$, which gives $\pi_\beta = v\theta - \theta$. Since $v\theta - \theta > v\theta - 1$, it is never a best response to $p_\alpha = 0$ to set $p_\beta = v\theta - 1$, eliminating this possibility in equilibrium. ■

Lemma 2. *In any pure strategy equilibrium, $p_\alpha = 1$.*

Consider profit of the two firms when (5) is met.

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

Derivatives with respect to the relevant variables are

$$\frac{\partial u_\alpha}{\partial p_\alpha} = 1 - \frac{\theta v(1 + p_\beta)}{(1 - p_\alpha + p_\beta)^2} \quad \text{and} \quad \frac{\partial u_\beta}{\partial p_\beta} = \frac{\theta v(1 - p_\alpha)}{(1 - p_\alpha + p_\beta)^2}.$$

For any $p_\alpha < 1$, $\partial u_\beta / \partial p_\beta > 0$. This means that conditional on (5), firm β 's best response to any $p_\alpha < 1$ involves setting the highest value of p_β such that (5) holds (i.e. $p_\beta = v - 1 + p_\alpha$) followed by a fully informative demonstration policy $d = 1$. Such a strategy gives $\pi_\beta = \theta(v - 1 + p_\alpha)$. This is the best response for β compared to any other p_β if it offers a higher payoff compared to setting a low enough price that β captures the entire market (if such a price is even feasible). This full market capture alternative involves $p_\beta = v\theta - 1 + p_\alpha$ followed by $d = 0$, and gives firm β profits $\pi_\beta = v\theta - 1 + p_\alpha$. Therefore, firm β 's best response to p_α involves

$$p_\beta = v - 1 + p_\alpha \quad \text{and} \quad d = 1 \quad \text{when} \\ \theta(v - 1 + p_\alpha) \geq v\theta - 1 + p_\alpha,$$

a condition that always holds.

Thus, firm β 's best response to any $p_\alpha < 1$ involves $p_\beta = v - 1 + p_\alpha$. Such a choice of p_β by firm β gives firm α a strict incentive to deviate to a marginally lower price. If firm α sets its price just marginally below the p_α in $p_\beta = v - 1 + p_\alpha$, then there exists no demonstration policy that firm β can provide in the second stage which will entice even those consumers with high value for firm β 's product to buy it. A marginal decrease in firm α 's price allows it to capture the entire market. The only time such a deviation is not possible for firm α is when $p_\alpha = 0$. Therefore, there exists no p_α, p_β combination such that $0 < p_\alpha < 1$ and p_α and p_β are best responses to each other. This rules out the existence of pure strategy equilibrium in which $0 < p_\alpha < 1$.

Next, we rule out the possibility that $p_\alpha = 0$. If this is the case, then firm β 's best response involves $p_\beta = v - 1$. This is because we already established that when $p_\alpha < 1$, firm β prefers to offer fully informative trials and set a price that fully extracts the surplus of those with high value for its product. Given β 's best response strategy, firm α could earn higher profits by increasing its price. To see this, evaluate $\partial u_\alpha / \partial p_\alpha$ at $p_\beta = v - 1$. This gives

$$\frac{\partial u_\alpha}{\partial p_\alpha} = 1 - \frac{\theta v^2}{(v - p_\alpha)^2},$$

which is strictly positive at $p_\alpha = 0$. This rules out the possibility of a pure strategy equilibrium in which $p_\alpha = 0$.

The only remaining possibility involves pure strategy equilibria in which $p_\alpha = 1$. ■

Firm β has no incentive to deviate. When $p_\alpha = 1$, $\partial u_\beta / \partial p_\beta = 0$ for all values of p_β . This means that β is indifferent between any p_β such that (5) holds. Each value gives $u_\beta = \theta v$. Notice that this is the same expected payoff that β would receive if it set $p_\beta = v\theta - 1 + p_\alpha = v\theta$, which allows it to capture the entire market. Therefore, there never exists an incentive for β to deviate from any $p_\beta \in [v\theta, v]$, as each gives $\pi_\beta = v\theta$.

Range of p_β for which firm α has no incentive to deviate. There must also not exist an incentive for firm α to deviate to a lower value of p_α . This requires that: (1) firm α doesn't prefer a marginally

lower p_α , which requires $\partial u_\alpha / \partial p_\alpha \geq 0$ when evaluated at $p_\alpha = 1$; and (2) firm α doesn't prefer a deviation to a low enough price that it captures the entire market.

It is the case that $\partial u_\alpha / \partial p_\alpha \geq 0$ when $p_\alpha = 1$ when

$$1 - \frac{\theta v(1 + p_\beta)}{p_\beta^2} \geq 0.$$

Solving this for p_β gives the requirement

$$\frac{1}{2}(\theta v - \sqrt{(\theta v)^2 + 4\theta v}) \leq p_\beta \leq \frac{1}{2}(\theta v + \sqrt{(\theta v)^2 + 4\theta v}). \quad (6)$$

We have already established that in any pure strategy equilibrium, p_β must satisfy $\theta v < p_\beta \leq v$. The lower bound in (6) is lower than θv . Value v is at least as great as the upper bound in (6) when

$$\frac{\theta}{1 - \theta} \leq v. \quad (7)$$

Therefore, when (7) is satisfied, p_β must satisfy

$$\theta v < p_\beta \leq \frac{1}{2}(\theta v + \sqrt{(\theta v)^2 + 4\theta v}), \quad (8)$$

and for lower v such that (7) is not satisfied, p_β must satisfy

$$\theta v < p_\beta \leq v. \quad (9)$$

It is straightforward to show that $\theta v < (1/2)(\theta v + \sqrt{(\theta v)^2 + 4\theta v})$ and to see that $\theta v < v$. Therefore, a range of p_β which satisfies (8) and (9) always exist.

At the same time that these conditions hold, firm α must not prefer to deviate from $p_\alpha = 1$ to a sufficiently low price that it captures the entire market. It could capture the entire market by setting p_α "just below" $1 - v + p_\beta$, which would result in profits just below $\pi_\alpha = 1 - v + p_\beta$. In any pure strategy equilibrium, this must be less than the expected π_α when firm α chooses $p_\alpha = 1$: $\pi_\alpha = 1 - \theta v / p_\beta$. The firm has no incentive to deviate to a full market capture price if

$$1 - v + p_\beta \leq 1 - \frac{\theta v}{p_\beta}.$$

This inequality is only feasible when

$$v > 4\theta. \quad (10)$$

Otherwise, no values of $p_\beta \in (\theta v, v]$ exist satisfying the expression. Only when (10) is satisfied does there exist a value of p_β sufficiently close to $v/2$ such that firm α 's best response does not involve setting a low enough p_α to capture the entire market. Firm α has no incentive to deviate to a value of p_α which captures the entire market as long as:

$$\frac{1}{2}(v - \sqrt{v^2 - 4\theta v}) \leq p_\beta \leq \frac{1}{2}(v + \sqrt{v^2 - 4\theta v}). \quad (11)$$

The upper bound on range (11) is always less than v . We can show that θv is at least as great as the lower bound on range (11) when

$$\frac{1}{1 - \theta} \leq v \quad (12)$$

This means that when (12) is satisfied, a pure strategy equilibrium requires p_β such that

$$\theta v \leq p_\beta \leq \frac{1}{2}(v + \sqrt{v^2 - 4\theta v}). \quad (13)$$

When (12) is not satisfied, the necessary range of p_β is given by (11).

Parameter ranges under which pure strategy equilibria exist. One can combine the above conditions on the parameters to determine the ranges of v and θ such that a pure strategy equilibrium exists.

First, if (7) is not satisfied, i.e. if $v \leq \theta/(1 - \theta)$, then (12) is also not satisfied, and a pure strategy equilibrium requires p_β satisfy both (9) and (11). In this case, (9) is redundant. Leaving only (11) as a restriction on p_β .

This entire case is only feasible when (10) is also satisfied, i.e. when $v \geq 4\theta$. This implies a more limited range of v such that $4\theta \leq v \leq \theta/(1 - \theta)$. It is straightforward to show that $4\theta \leq \theta/(1 - \theta)$ if and only if $\theta \geq 3/4$. Furthermore, $v > 1$; a requirement that is redundant since $\theta \geq 3/4$ and $v > 4\theta$.

Second, if (7) is satisfied but (12) is not satisfied, i.e. if $\theta/(1 - \theta) < v \leq 1/(1 - \theta)$, then a pure strategy equilibrium requires p_β which satisfied both (8) and (11). This presents multiple possibilities, depending on which upper bound is more restrictive.

$$\frac{1}{2}(\theta v + \sqrt{(\theta v)^2 + 4\theta v}) < \frac{1}{2}(v + \sqrt{v^2 - 4\theta v})$$

whenever

$$v > \frac{4\theta}{1 - \theta^2}. \quad (14)$$

Consider first case where (14) is satisfied. This means $4\theta/(1 - \theta^2) < v \leq 1/(1 - \theta)$. Such a range is feasible only when $4\theta/(1 - \theta^2) < v \leq 1/(1 - \theta)$, which is feasible only when $\theta < 1/3$. Furthermore, $4\theta/(1 - \theta^2) > 1$ when $\theta > \sqrt{5} - 2$. For lower values of θ , the lower bound is 1 rather than $4\theta/(1 - \theta^2)$ since $v > 1$ is assumed by the model. This means that

$$\begin{aligned} 1 < v \leq 1/(1 - \theta) & \quad \text{when} \quad \theta < \sqrt{5} - 2 \\ 4\theta/(1 - \theta^2) < v \leq 1/(1 - \theta) & \quad \text{when} \quad \sqrt{5} - 2 \leq \theta < 1/3. \end{aligned} \quad (15)$$

Whenever one of these conditions is satisfied, there exists a pure strategy equilibrium whenever p_β is such that

$$\frac{1}{2}(v - \sqrt{v^2 - 4\theta v}) < p_\beta \leq \frac{1}{2}(\theta v + \sqrt{(\theta v)^2 + 4\theta v}). \quad (16)$$

Notice that (14) makes (10) redundant, meaning that in this case, $4\theta \leq v$ is always satisfied.

Next, consider the case where (14) is not satisfied. This means either $\theta/(1 - \theta) < v \leq 4\theta/(1 - \theta^2)$ and $\theta < 1/3$, or $\theta/(1 - \theta) < v \leq 1/(1 - \theta)$ and $\theta \geq 1/3$. For $\theta \leq \sqrt{5} - 2$ (approx. 0.236), the required range of v never exceeds 1, and is therefore infeasible given $v > 1$. Condition (10) must also be satisfied. One can show that $4\theta \geq \theta/(1 - \theta)$ when $\theta \leq 3/4$, and $4\theta < 1/(1 - \theta)$ and $4\theta < 4\theta/(1 - \theta^2)$ are always satisfied.

Because product β provides some consumers a higher value than product α , it also must be the case that $v > 1$. One can show that $\theta/(1 - \theta) \geq 1$ iff $\theta > 1/2$, and $4\theta \geq 1$ iff $\theta > 1/4$. For lower values of θ , the lower bounds should be 1 rather than $\theta/(1 - \theta)$ or 4θ . Similarly, $4\theta/(1 - \theta^2) > 1$

when $\theta > \sqrt{5} - 2$. For lower θ , the upper bound in the case where $\theta \leq 1/3$ is below the minimum possible v .

Therefore, the relevant range of v when (7) is satisfied but (12) and (14) are not satisfied is

$$\begin{aligned}
 1 < v \leq \frac{4\theta}{1-\theta^2} & \quad \text{when} \quad \sqrt{5} - 2 < \theta \leq \frac{1}{4} \\
 4\theta < v \leq \frac{4\theta}{1-\theta^2} & \quad \text{when} \quad \frac{1}{4} < \theta \leq \frac{1}{3} \\
 4\theta < v \leq \frac{1}{1-\theta} & \quad \text{when} \quad \frac{1}{3} < \theta \leq \frac{3}{4} \\
 \frac{\theta}{1-\theta} < v \leq \frac{1}{1-\theta} & \quad \text{when} \quad \theta > \frac{3}{4}.
 \end{aligned} \tag{17}$$

In any of these parameter cases, a pure strategy equilibrium requires p_β such that

$$\frac{1}{2}(v - \sqrt{v^2 - 4\theta v}) < p_\beta \leq \frac{1}{2}(v + \sqrt{v^2 - 4\theta v}). \tag{18}$$

Third, if (12) is satisfied, i.e. if $v > 1/(1 - \theta)$, then both (7) and (10) are also satisfied. This means that p_β must satisfy both (8) and (13). Combined, this again requires (16).

In summary,

- (1) Whenever $3/4 \leq \theta$ and $4\theta \leq v \leq \theta/(1 - \theta)$, there exists a continuum of pure strategy equilibria in which $p_\alpha = 1$ and p_β is any value satisfying (11).
- (2) Whenever any combination of conditions in (15), or whenever $v > 1/(1 - \theta)$ for any value of θ , there exists a pure strategy equilibrium in which $p_\alpha = 1$ and p_β is any value satisfying (16).
- (3) Whenever any combination of conditions in (17), there exists a continuum of pure strategy equilibrium in which $p_\alpha = 1$ and p_β is any value satisfying (18).

In aggregate, these conditions imply that a pure strategy equilibrium exists if and only if $v > \max\{4\theta, 1\}$.

In each of these equilibria, demonstration informativeness is given by (4) evaluated at $p_\alpha = 1$. That is,

$$d^* \Big|_{p_\alpha=1} = \frac{p_\beta - v\theta}{p_\beta(1 - \theta)} = \frac{1}{1 - \theta} - \frac{\theta}{1 - \theta} \frac{v}{p_\beta},$$

and consumer surplus equals 0.