Online Appendix for

"Demonstrations and Price Competition in New Product Release"

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Management Science

In Appendix A, we provide a more detailed analysis of the game with flexible demonstration design. In Appendix B, we discuss a version of the model in which the innovative firm can use both capacity constraints and product demonstrations as part of their strategy.

Appendix A. Details for analysis 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 ν and $\nu\theta$. When $\nu < \bar{\mu}$, 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 $\nu\theta < \bar{\mu} \leq \nu$, firm β will choose

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

This gives

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

When $\bar{\mu} \leq \nu\theta$, 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*

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

First we rule out the possibility of $\nu < \bar{\mu}$ in equilibrium. When setting prices, it will never be a best response for firm β to choose a price that leads to $\nu < \bar{\mu}$. 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 $\nu > 1$, this is always feasible for firm β, even when $p_\alpha = 0$. This rules out the possibility of an equilibrium in which $\nu < \bar{\mu}$.

Next, we can rule out the possibility of an equilibrium in which $\bar{\mu} \leq \nu\theta$. If we are in this case, then firm α has an incentive to lower its price if doing so results in $\nu\theta < \bar{\mu}$. This is not

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possible only if both $\nu\theta > 1$ and $1 \leq \nu\theta - p_\beta$. For firm β, the profit maximizing p_β such that $\bar{\mu} \leq \nu\theta$ is $p_\beta = \nu\theta + p_\alpha - 1$, which is greater than $\nu\theta - 1$, except when $p_\alpha = 0$. Therefore, the only possibility under which $\bar{\mu} \leq \nu\theta$ involves $p_\alpha = 0$ and $p_\beta = \nu\theta - 1$, in which case $\pi_\beta = \nu\theta - 1$. However, if this is the case, firm β could alternatively set $p_\beta = \nu - 1$ followed by $d = 1$, which gives $\pi_\beta = \nu\theta - \theta$. Since $\nu\theta - \theta > \nu\theta - 1$, it is never a best response to $p_\alpha = 0$ to set $p_\beta = \nu\theta - 1$, 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.

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

Derivatives with respect to the relevant variables are

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

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. $p_\beta = \nu - 1 + p_\alpha$) followed by a fully informative demonstration policy $d = 1$. Such a strategy gives $\pi_\beta = \theta(\nu - 1 + p_\alpha)$. 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 $p_\beta = \nu\theta - 1 + p_\alpha$ followed by $d = 0$, and gives firm β profits $\pi_\beta = \nu\theta - 1 + p_\alpha$. Therefore, firm β's best response to p_α involves

$$p_\beta = \nu - 1 + p_\alpha \quad \text{and} \quad d = 1 \quad \text{when}$$

$$\theta(\nu - 1 + p_\alpha) \geq \nu\theta - 1 + p_\alpha,$$

a condition that always holds.

Thus, firm β's best response to any $p_\alpha < 1$ involves $p_\beta = \nu - 1 + p_\alpha$. 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 $p_\beta = \nu - 1 + p_\alpha$, 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 $p_\beta = \nu - 1$. 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 $p_\beta = \nu - 1$. This gives

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

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 $u_\beta = \theta \nu$. Notice that this is the same expected payoff that β would receive if it set $p_\beta = \nu\theta - 1 + p_\alpha = \nu\theta$, which allows it to capture the entire market. Therefore, there never exists an incentive for β to deviate from any $p_\beta \in [\nu\theta, \nu]$, as each gives $\pi_\beta = \nu\theta$.

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 $\partial u_\alpha / \partial u_\beta \geq 0$ 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

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

Solving this for p_β gives the requirement

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

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

$$\frac{\theta}{1 - \theta} \leq \nu. \tag{7}$$

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

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

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

$$\theta\nu < p_\beta \leq \nu. \tag{9}$$

It is straightforward to show that $\theta\nu < (1/2)(\theta\nu + \sqrt{(\theta\nu)^2 + 4\theta\nu})$ and to see that $\theta\nu < \nu$. 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" $1 - \nu + p_\beta$, which would result in profits just below $\pi_\alpha = 1 - \nu + p_\beta$. In any pure strategy equilibrium, this must be less than the expected π_α when firm α chooses $p_\alpha = 1$: $\pi_\alpha = 1 - \theta\nu / p_\beta$. The firm has no incentive to deviate to a full market capture price if

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

This inequality is only feasible when

$$\nu > 4\theta. \tag{10}$$

Otherwise, no values of $p_\beta \in (\theta\nu, \nu]$ exist satisfying the expression. Only when (10) is satisfied does there exist a value of p_β sufficiently close to $\nu/2$ 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:

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

The upper bound on range (11) is always less than ν. We can show that $\theta\nu$ is at least as great as the lower bound on range (11) when

$$\frac{1}{1-\theta} \leq \nu \tag{12}$$

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

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

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 ν and θ such the a pure strategy equilibrium exists.

First, if (7) is not satisfied, i.e. if $\nu \leq \theta/(1-\theta)$, 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 $\nu \geq 4\theta$. This implies a more limited range of ν such that $4\theta \leq \nu \leq \theta/(1-\theta)$. It is straightforward to show that $4\theta \leq \theta/(1-\theta)$ if and only if $\theta \geq 3/4$. Furthermore, $\nu > 1$; a requirement that is redundant since $\theta \geq 3/4$ and $\nu > 4\theta$.

Second, if (7) is satisfied but (12) is not satisfied, i.e. if $\theta/(1-\theta) < \nu \leq 1/(1-\theta)$, 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.

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

whenever

$$\nu > \frac{4\theta}{1-\theta^2}. \tag{14}$$

Consider first case where (14) is satisfied. This means $4\theta/(1-\theta^2) < \nu \leq 1/(1-\theta)$. Such a range is feasible only when $4\theta/(1-\theta^2) < \nu \leq 1/(1-\theta)$, 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 $\nu > 1$ is assumed by the model. This means that

$$\begin{array}{ccc} 1 < \nu \leq 1/(1-\theta) & \text{when} & \theta < \sqrt{5}-2 \\ 4\theta/(1-\theta^2) < \nu \leq 1/(1-\theta) & \text{when} & \sqrt{5}-2 \leq \theta < 1/3. \end{array} \tag{15}$$

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

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

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

Next, consider the case where (14) is not satisfied. This means either $\theta/(1-\theta) < \nu \leq 4\theta/(1-\theta^2)$ and $\theta < 1/3$, or $\theta/(1-\theta) < \nu \leq 1/(1-\theta)$ and $\theta \geq 1/3$. For $\theta \leq \sqrt{5}-2$ (approx. 0.236), the required range of ν never exceeds 1, and is therefore infeasible given $\nu > 1$. 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 $\nu > 1$. 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 ν.

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

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

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

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

Third, if (12) is satisfied, i.e. if $\nu > 1/(1-\theta)$, 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 $4\theta \leq \nu \leq \theta/(1-\theta)$, 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 $\nu > 1/(1-\theta)$ 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 $\nu > \max\{4\theta, 1\}$.

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

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

and consumer surplus equals 0.

Appendix B. 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.[12] To further explore the connection between demonstration informativeness and capacity limits, in this section we incorporate capacity constraints into out 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 could 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 dividing 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 division and product differentiation effects, but the mass of consumers with favorable realizations is no larger than λ, generating a second type of partitioning (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.

B.1. **Upfront demonstration design.** Because increasing demonstration informativeness generates both market division and differentiation effects—both of which soften subsequent price competition—while a reduction in capacity generates only a market division effect, it may seem that demonstration informativeness dominates capacity as a marketing tool. This intuition is only partially correct, because the market division effect 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 dividing 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

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

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

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

[12] We describe the strategic effects of this paper in detail in the Introduction

a large portion of the market, the innovator prefers to commit to limit capacity, achieving market division beyond what is possible with a demonstration alone.

B.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 changes 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.*