Information Spillovers in Experience Goods Competition [*]

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Abstract

Trialling an experience good allows consumers to learn their value for the sampled good and also informs beliefs about their value for similar products. These demand-side information spillovers across products create a relatively well-informed group of potential future consumers for rival firms. When both switching consumers and repeat buyers are profitable, firms face reduced incentives to set a low initial price to attract inexperienced consumers. Switchers and repeat buyers are more likely to be profitable in new product categories that build on major innovations and when firms can price discriminate based on purchasing history. We suggest that competing products and services arising from new innovations often have demand-side information spillovers from any product trial and are, hence, settings where competing firms can make overall profits even when selling products that consumers perceive to be indistinguishable prior to initial trial.

Keywords: Experience goods, Duopoly, Behavior based price discrimination, Product differentiation, Information spillovers.

1 Introduction

A consumer using any smartphone for the first time learns about her value for features of the new technology that are common to all products in the category, like the touchscreen keyboard or the location services that enable mapping apps. A consumer trying an electric car may either marvel or balk at the rapid, silent acceleration and one-pedal driving found in all electric cars. In these and many other cases, sampling one product provides information about that product but also allows consumers to learn about shared features. As a consequence, a consumer who has tried a rival's offering may have very different demand than one who has no familiarity at all with the category. We call this learning a demand-side information spillover and analyze its strategic implications. Our main analysis focuses on the most basic elements of the problem, where duopoly firms sell ex-ante indistinguishable products and managers make dynamic pricing decisions knowing that their consumers are also updating their beliefs about the value of rival products while learning their value for the product they actually sample.

Products and services for which consumers learn their individual value for a firm's offering only through trial are known as experience goods (Nelson, 1970). Firms selling such goods face the challenge of selling to consumers who are unaware of their value for the product. If the firm faces rivals in the new product category, competitive pressures amplify this challenge. We might expect competing firms selling ex-ante indistinguishable products to set low initial prices to gain market share, thereby competing away all future profits. We show, however, that whenever the new products are sufficiently valuable, competing firms can all make positive profits even in a finite horizon model. The key requirement for profitability is that firms are able to sell their product—at a price above marginal cost—to some of the consumers who have previously purchased from a rival firm. Profitable switching consumers allow firms to be profitable overall because it means they compete less intensely early on to gain market share, anticipating future profits from both repeat buyers and switching consumers. That is, the anticipated presence of consumers who have purchased from a rival changes the nature of product market competition.

For there to be any profitable switchers, some of the consumers who had an unsatisfactory experience with the first new product they tried must be, nonetheless, willing to purchase a rival new product. This only happens if consumers expect to find it more valuable to switch than to return to a product that was previously available. When equilibrium prices mean that there are some consumers who switch to rival products, we say the product category is in a "mass market equilibrium". Whereas the previous literature on monopoly pricing refers to a mass market as one where the mean consumer willingness to pay exceeds the monopoly price, our mass market equilibrium definition relates to firms setting prices to attract switching consumers.

There are no profitable switchers in settings where all dissatisfied consumers would rather return to the old technology than try a rival new product. We say these product categories are in a "niche market equilibrium". In these cases, firms make future profits only from the subset of their original buyers who realize a relatively high valuation for the product and repeat buy. Here, each firm therefore faces strong incentives to set a low initial price to maximize early market share, future profits are competed away, and the firms all make zero overall profits.

The existence of a profitable mass market equilibrium depends on whether the value of the innovation in the new product category is sufficiently high and whether firms are able to price discriminate between repeat buyers and switching consumers. These features interact to allow firms to make profits even though the lack of ex-ante perceived differentiation might suggest profits would always be competed away. The magnitude of the profits depends on the extent of demand side spillover between competing products in the new category.

We derive our results in a two-product duopoly model where there are demand-side information spillovers if consumer values for the products in a new category are correlated. If these values have a correlation coefficient close to one, then a consumer with a high (low) value for one product is also likely to have a high (low) value for the other. In our model, we assume consumer values have a bivariate normal distribution and the distribution parameters—including the correlation coefficient—are known by consumers and firms. The correlation parameter, ρ, hence, plays two roles. It represents the degree of perceived differentiation between the two new products and is also a measure of information spillovers from initial product trial. This framework nests Bertrand competition between goods (when $\rho = 1$) and models of experience good pricing when consumers' values are independent (when $\rho = 0$), as in Villas-Boas (2004), establishing a novel connection between these cases. For simplicity, there are no other switching costs, network externalities, or fixed costs in the model.[1]

The results depend on the value of the new product category, which we refer to as the innovation value, because this determines whether there are any switching consumers after initial trial for any given level of demand-side information spillovers. The new product category is an improvement over the existing outside option for the average consumer if the expected value of either new product less marginal cost exceeds the value of the outside option. We denote the innovation value μ, as measured by the mean of the bivariate normal distribution of consumer values, and analyze comparative statics with respect to its value.[2] If the typical

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[1]While these additional features are often present in the technology-enabled new product categories we have in mind, the mechanisms and results laid out in the paper do not rely on their presence, and are mostly robust to extensions that include them. In our setting, switching arises because consumption changes the information structure for consumers with heterogeneous values for the new products.

[2]We interpret the parameter μ as the expected vertical differentiation between the new products and the outside option. The new products are ex-ante homogeneous, but, after trial, they become horizontally differentiated

consumer expects to value the new products above the outside alternative, the new category is called a major innovation, and if the new products will be valued above the outside alternative only by a minority of consumers, it is called a minor innovation.[3] For all major innovations, and some minor innovations, there are switching consumers whenever there are information spillovers from any one consumption experience, that is, whenever $\rho \neq 0$.[4] We show that in the case where $\rho = 0$, there are only switching consumers if the category represents a major innovation. Thus, demand side information spillovers can expand the set of market structures under which competing firms can be profitable.

As firms are now more likely than ever to be able to distinguish between different consumers based on their purchasing history, our baseline model allows firms to set different prices for switching consumers and repeat buyers. In any mass market equilibrium, firms set a lower price for switchers than for repeat buyers to encourage switching. Relative to uniform pricing, the ability to price discriminate based on purchasing history thus expands the range of innovation values for which the profitable mass market equilibrium obtains.

Our main result is summarized in a theorem establishing that in all equilibria where firms make profits, first-period prices are determined by the relative profitability of repeat and switching consumers in the second period. Greater demand-side information spillovers make the mass market equilibrium more likely. We show that even though ex-post product differentiation is also reduced at higher levels of spillovers, because the parameter ρ determines both spillovers and differentiation, greater substitutability does not always lead to lower firm profits. In some cases, an increase in ρ implies that the consumers who switch in a mass market equilibrium have less elastic demand, which generates higher equilibrium prices and profits from switchers and less intense initial competition.

One new product category that offers a motivating example for our model is software development tools, where competing firms sell products that enable developers to write code, compile it, and debug it within the same environment. We argue that such tools are experience goods in that the specific value of any one product to a client organization is hard to fully understand before trying it out. To the extent that many firms compete to offer quite similar tools, however, it is likely that shared features and capabilities mean that any one trial is informative to the client about their value for competing offerings. As an illustration, the software company

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for each consumer to a degree that is measured by ρ. This dynamic nature of product differentiation also appears in Villas-Boas (2006) where consumers' values for competing goods are independent of each other, corresponding to $\rho = 0$ in our setting.

[3]Uninformed consumers purchase a new product even when the expected value is negative if the value of the option of continuing to buy one of the new products once informed is positive.

[4]Chen (1997) presents a model of dynamic pricing in duopoly that also features switching in equilibrium. It arises in that model because firms pay customers to switch, which effectively serves as a form of behavior-based price discrimination.

JetBrains offers a range of tools, including Integrated Development Environments (IDEs), for individual developers or teams. The firm emphasizes the product's easy set up and compatibility with other plug-ins, suggesting switching costs are limited, but the IDE also has features like custom user interfaces and keyboard shortcuts that differentiate it from other alternatives. A potential customer with no prior experience of IDEs would likely have a much less precise idea of their value for these tools and product features than a potential customer currently using a competing product.

Firms in this new product category often price discriminate based on past purchasing history. The results of our model suggest that price discrimination allows firms to be profitable over a wider range of innovation values because it makes the mass market equilibrium with profitable switchers more likely. JetBrains' website shows two offers available to new clients.[5] They offer a 25% discount to customers who can prove they are using a competing commercial product—switching consumers—and the firm also offers 50% off to startups, who are likely making software development tool purchases for the first time as an organization. Hence, a consumer who is brand new to the product category is offered the lowest price, experienced switchers receive an intermediate price, and the highest price is reserved for experienced repeat buyers, appealing only to those who have discovered they have a high value for this particular product.[6]

In general, the extent to which firms currently use consumer information to price discriminate is a much-debated question (Bourreau and De Streel, 2018). The possibility has been discussed in the academic literature since the late 1990s when the power of the internet for information exchange began to emerge (Shapiro et al., 1998; Smith et al., 2001; Bakos, 2001). In particular, behavioral price discrimination has received significant attention from economic theorists (see Fudenberg and Villas-Boas (2006, 2012) for reviews) in a literature that emphasizes the low cost of collecting consumer information online. Articles in several business reviews provide anecdotal evidence of personalized pricing and an illustration of its impact on firm profits. While systematic evidence is more rare, Hannak et al. (2014) find that nine out of the ten e-commerce sites they studied engaged in some form of both steering and price discrimination based on consumer-specific information.[7]

While the literature on dynamic pricing of experience goods in oligopoly has not explicitly considered demand-side information spillovers, Bergemann and Välimäki (1997) study the related case of a new entrant competing with a known incumbent. Their model features a dif-

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[5]Screenshots from the relevant pages of the website are given in Appendix A.

[6]Other firms in this industry offer a similar range of discounts to various consumer groups. Appendix A also shows pricing terms for the WingPython IDE family, which was created specifically for the Python programming language. Their prices also differ for clients switching from competitors (competitor upgrades) and for startups.

[7]Other studies include Hindman (2018) and Mikians et al. (2012).

ferent type of information spillover, in that public beliefs about the common-value component of the new good are updated after any consumer experience.[8] Both firms want to speed up information transmission, and, since only trials of the new product are informative, the incumbent's incentive to compete with the entrant on price is softened. Consumer preferences are also horizontally differentiated, with consumers being distributed uniformly on a line, and both firms prefer maximum ex-post differentiation in this setting. In contrast, in our model, it is within-consumer information spillovers that inform each consumer's private values.[9]

The demand-side information spillovers that enable new product profitability for a wider range of innovation values in this model also differ from both the technology and product market rivalry spillovers created when firms undertake R&D as described in Bloom et al. (2013). Their market rivalry spillovers refer to the business-stealing effect on firm performance of an innovation in a closely competing product. In our case, with imperfect information about consumer values, a rival's new product can expand demand for other similar new products.

We might think that the more valuable the innovation, the more intense the competition between rival firms, each seeking to dominate the new product category that incorporates the new technology. Instead, categories based on large innovations allow the coexistence of profitable firms because, in a valuable category, firms have the ability to pick off profitable consumers who have tried out a rival product and are willing to switch to another new product rather than return to pre-existing options. It is in categories based on less valuable innovations that firms will compete away all future profits to sell to consumers who will only ever try out one new product.

Our analysis shows that demand-side information spillovers allow firms to be profitable over a large range of innovation values. This is because a close competitor educates consumers about their individual values for the new product category as a whole. Managers of firms selling experience goods that build on lower value innovations may therefore find it worthwhile to promote spillovers by highlighting the features that are common across rival products rather than the features that differentiate their own product. Doing so can soften competition in the category as a whole and enable profits even for some new product categories that would otherwise prove unprofitable.

The paper proceeds as follows. Section 2 introduces the primitives of the model. The main

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[8]Moretti (2011) also models market-level social learning about product quality through reviews, and Harel et al. (2021) show that as the number of consumers grows large, the private information transmitted through cross-consumer learning goes to zero.

[9]Fong et al. (2018) study a monopoly model of a single product with observable and experience attributes where the fact that the attributes are complements or substitutes in the consumer's utility function affects the firm's equilibrium choice of the level of each attribute. In our model, the extent to which competing products are ex-post substitutes varies but is assumed to be exogenous.

analysis focuses on the motivating case where $\rho \in (0, 1)$, that is, when consumer values for the new products are positively correlated. Section 3 presents the equilibria of the second-stage sub-game. Section 4 presents the full equilibria and analyzes the range of innovation values for which firms make profits and the range of innovation values for which profits are zero. Section 5 presents the theorem relating firm profits to the ability to attract switching consumers, which generalizes to all $\rho \in [-1, 1]$. This section also describes some implications of the earlier analysis including a numerical example of profits, consumer surplus, and social surplus as a function of innovation value at different levels of information spillovers.[10] Section 6 concludes.

2 Primitives of the Model

There are two firms that each offer one non-durable experience good, A and B, respectively. The marginal cost for both firms is $c \geq 0$. The firms compete by setting prices simultaneously in each of two periods.[11] There exists a unit mass of consumers who each buy one unit of good A or good B or returns to the outside option in each period. Firms and consumers have a common discount factor $\delta \in [0, 1]$.

Valuations: Each consumer's per period value for good $i \in \{A, B\}$ is denoted θ_i, which is scaled relative to the value of the existing alternative that has a normalized value of zero. For simplicity, θ_i is constant across the two periods, but more complicated models could allow consumers to update beliefs about a dynamic process. In the first period, consumers do not know their valuations but know that the joint distribution is bivariate normal $\mathcal{N}(\boldsymbol{\mu}, \boldsymbol{\Sigma})$, where we assume common means for θ_A and θ_B, $\mu_A = \mu_B = \mu$, and a common standard deviation, $\sigma_A = \sigma_B = \sigma > 0$. Symmetry means consumers have ex-ante identical beliefs about the products, which allows us to analyze a case with minimal perceived differentiation at the outset of the game. The extent to which each consumer's valuations for the two products are correlated is given by the parameter $\rho \in [0, 1]$.[12] That is, ρ is the degree of ex-post substitutability between products. $F(\cdot)$ denotes each product's marginal value distribution, and, hence, $F(\cdot)$ is the c.d.f of a univariate normal distribution with mean μ and variance σ. The corresponding p.d.f. is

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[10]The proofs that are not in the main text are provided in Appendix B, which also presents discussion of the uniqueness of equilibria. The equilibria when consumers' preferences are uncorrelated ($\rho = 0$) are presented in Appendix C. Additional appendices extend the two-period duopoly structure to N-firm and T-period settings (Appendix D) and study asymmetric consumer valuations (Appendix E). An online appendix provides some extensions: negatively correlated consumers' preferences ($\rho < 0$), non-experience goods with positively correlated consumer preferences, equilibria where firms are unable to price discriminate based on past purchasing behavior, and derives the price elasticities of interest.

[11]We generalize the analysis to N firms and T periods in Appendix D.

[12]We analyze the $\rho \in [-1, 0)$ case in the online appendix.

denoted $f(\cdot)$.[13]

Learning: After consuming in the first period, a consumer who bought good i learns her θ_i, as in Nelson (1970), and she also updates her expected value for the rival product, that is, her expected θ_{-i}, $E(\theta_{-i}|\theta_i)$, where $-i$ is the rival product, based on her knowledge of μ, σ, and ρ:

$$E(\theta_{-i}|\theta_i) = \mu_{-i} + \rho\frac{\sigma_{-i}}{\sigma_i}(\theta_i - \mu_i) = \rho\theta_i + (1-\rho)\mu.$$

The parameter ρ therefore also measures the information spillover from consumption between the tried and untried new products by the end of the first period. As such, a consumer with a high realization of θ_i updates positively about the expected value of θ_{-i}.

Prices: Firms announce their prices at the beginning of each period simultaneously. The first-period price of firm i is denoted p_i, the second-period price charged to repeat consumers is R_i, and the second-period price charged to switching consumers is S_i.[14] Throughout the main text, we assume that firms can price discriminate between consumers based on their purchasing history and so can set a different R_i and S_i. This choice reflects the fact that firms are, arguably, increasingly able to tailor prices to consumer information, such as past purchases, and appears to be commonplace in our motivating example product category of software development tools.[15],[16] Firms cannot distinguish between switching consumers and those who did not purchase in the first period, so both are offered the same price. We do not allow firms to offer two-period subscriptions in the first period, nor can they commit to future prices.[17]

Consumer payoffs: In each period, each consumer can buy only one unit of either new good or she can choose to take the outside option that she values at zero.[18] A consumer who

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[13]Note that θ_i satisfies the monotone reverse hazard rate (MHR) condition, so that $f(\cdot)/[1 - F(\cdot)]$ is an increasing function, whereas $f(\cdot)/F(\cdot)$ is a decreasing function. The joint distribution is common knowledge to both firms and consumers.

[14]Because we later attach superscripts to each of the endogenous second-period prices to denote the nature of the equilibrium (which we will show varies with μ), we have chosen to denote these prices as R_i and S_i, to repeat and switching buyers respectively, rather than p_{Ri} and p_{Si}, to simplify notation.

[15]In contrast, we find no evidence that firms in this category adjust prices after tailoring product features to consumer experience, as in Hagiu and Wright (2021).

[16]The less general case of uniform prices in the second period of our model is set out in the online appendix.

[17]If both firms offered a two-period subscription at a lump sum price and the cost of return/refund was prohibitively high, then they would effectively be competing in a single-period Bertrand game because goods are ex-ante homogeneous to consumers. If, instead, both firms could commit to second-period prices and price discrimination was not allowed, then firms would charge the marginal cost in both periods and earn zero overall profit.

[18]We interpret the outside option as an "old" tried-and-tested product that remains available to the consumer in each period. For example, in the context of our software tools development example, rather than purchasing an integrated development environment (IDE) from an external firm, a business could create their own continuous integration–continuous development pipeline by stitching together various software components purchased from separate firms.

buys good i in the first period therefore obtains an expected second-period payoff of $u_2(\theta_i) = max\{\theta_i - R_i, \rho\theta_i + (1 - \rho)\mu - S_{-i}, 0\}$ from choosing to buy good i again, switching to good $-i$, or taking the outside option in the second period, respectively.

Cutoff consumer types: To characterize the equilibrium, we define the following cutoff types, given prices, for a first-period consumer of firm i ($i \in \{A, B\}$) who is indifferent between each pair of her three options in period two. Note that there will be market structures where only some of these cutoffs are relevant for equilibrium behavior.

- θ_i^{RS}: the marginal period-two consumer who is indifferent between repeating and switching, that is, between buying good i again and switching to good $-i$. Consumer θ_i^{RS} hence has $\theta_i^{RS} - R_i = \rho\theta_i^{RS} + (1 - \rho)\mu - S_{-i}$. When $\rho \neq 1$ we have

$$\theta_i^{RS} = \mu + \frac{R_i - S_{-i}}{1 - \rho}; \tag{1}$$

- θ_i^{RO}: the consumer who is indifferent between buying good i again and the outside option. Hence, consumer θ_i^{RO} has,

$$\theta_i^{RO} = R_i; \tag{2}$$

- θ_i^{SO}: the consumer who is indifferent between switching to good $-i$ and the outside option. That is, consumer θ_i^{SO} has $\rho\theta_i^{SO} + (1 - \rho)\mu = S_{-i}$, yielding

$$\theta_i^{SO} = \frac{S_{-i} - (1 - \rho)\mu}{\rho}. \tag{3}$$

Note that when $R_i = S_{-i}$, $\theta_i^{RS} = \mu$, so the consumer who is indifferent between repeat buying and switching is the consumer whose realized value is exactly the mean of the value distribution. This implies that exactly half of firm i's consumers, conditional on purchasing in period 1, would switch if the second-period prices were equal. Also, when $\rho > 0$, we have $\lim_{\rho \to 0+} \theta_i^{SO} = +\infty$ if $S_{-i} > \mu$ and $\lim_{\rho \to 0+} \theta_i^{SO} = -\infty$ if $S_{-i} < \mu$. These limits say that when consumers do not learn about the rival, the consumer's decision problem for considering the untried product is based on their ex-ante expected value, μ, relative to the price S_{-i}.

Monopoly: In some equilibria, a firm has monopoly power in a share of the market. It is useful for this case to define the monopoly price M in relation to the demand curve where the

firm has a monopoly, $1 - F(\cdot)$. This price satisfies

$$M = \frac{1 - F(M)}{f(M)} + c, \tag{4}$$

and according to the MHR condition, M is uniquely determined.

We denote by $\pi(M) = \int_M^\infty (M - c) dF(x)$ the profit of a monopoly firm from charging price M in a market with demand $1 - F(M)$. $SS(M) = \int_M^\infty (x - c) dF(x)$ is the corresponding social surplus. In the duopoly environment we consider, the demand curve actually faced by each of the firms depends on the nature of equilibrium.

Major and minor innovations: Recall that the average value of the new products relative to the old technology, μ, is exogenously given. We define two types of new product category, based on the magnitude of μ:

- A product category is defined as a *major innovation* if and only if at least half of the consumers value the products in the category at above the marginal cost, so $\mu \geq c$.

- A product category is a *minor innovation* if and only if less than half of the consumers value it at above the marginal cost, so $\mu < c$.

In other words, if consumers were fully aware of their valuations, only consumers with high valuations would prefer a product in a minor innovation new product category to an old-technology product, but a product in a major innovation new product category would be preferred to an old-technology product by most consumers.

Benchmark case where $\rho = 1$: Because ρ plays the dual role of measuring the extent of information spillovers and the degree of substitutability between the new category products, when $\rho = 1$, consumers become fully informed about their valuations for both products after the first period and the valuations are equal. This case becomes standard Bertrand competition in each period. Because each firm has an incentive to reduce price in the second period, the second-period equilibrium price is equal to the marginal cost for both repeat and switching consumers, and firms make zero profit. Since a repeat and a switching customer in the second period both generate zero profits, there is no incentive to reduce first-period price to compete for future customers. Firms, hence, set first-period price equal to the marginal cost in competition for first-period profit. The consumer surplus in such a setting is equal to the social surplus:

$$CS_{\rho=1} = (\mu - c) + \delta \int_c^{+\infty} (x - c) dF(x).$$

A consumer purchases one of the products in the first period if and only if $CS_{\rho=1} \geq 0$.

3 Second-period prices with information spillovers, $\rho \in (0, 1)$

As the first step in describing the sub-game perfect equilibria of the two-stage pricing game, we characterize possible equilibria in the second-period sub-game. We focus on pure-strategy sub-game perfect equilibria throughout. We will prove later, in Section 4, that the market is fully covered in the first period in all sub-game perfect equilibria of the overall game, and so we now proceed by assuming that all consumers have purchased one of the new products in the first period.

Firms' second-period profits consist of profits from repeat consumers and profits from switching customers:

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\underbrace{(R_i - c) \cdot \lambda_i \int_{\max(\theta_i^{RS}, \theta_i^{RO})}^{+\infty} dF(\theta_i)}_{\text{profit from repeat customers}} + \underbrace{\max\left(0, (S_i - c) \cdot \lambda_{-i} \int_{\theta_{-i}^{SO}}^{\theta_{-i}^{RS}} dF(\theta_{-i})\right)}_{\text{profit from switching customers}}, \tag{5}
$$

where λ_i denotes firm i's market share in the first period and, by assumption, for now, $\lambda_i + \lambda_{-i} = 1$. To understand the expression for profit from repeat customers, note that if $\theta_i^{RO} > \theta_i^{RS}$, then consumers with $\theta_i \in (\theta_i^{RS}, \theta_i^{RO})$ will take the outside option rather than switch to the rival product. This illustrates that it is the maximum value of θ_i^{RS} and θ_i^{RO} that determines the cutoff type for characterizing profits in the repeat customer segment.

One key feature of our model is that second-period prices to repeat consumers, R_i, and switching consumers, S_i, are independent of first-period market share λ_i. This is because all consumers make their first-period choice while unaware of their value for each of the products. Hence, in the second period, the distribution of consumer willingness to pay for the purchased good, once fully informed, and for the untried good, while partially informed, is the same as the distribution of willingness to pay in the overall population.[19,20]

There are three possible second-period equilibria for the $\rho \in (0, 1)$ case, which are illustrated in Figure 1, panels a, b, and c. We first describe each of these three equilibria. Then, in Proposition 1, we show that it is the magnitude of μ—the average value of the innovation—that determines which of the three possible equilibria is relevant.

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[19]If, instead of being able to price discriminate on purchase history, firms were restricted to uniform pricing in the second period, first-period market share would affect second-period prices and firms would face potentially different distributions of willingness to pay. In the online appendix, we extend the analysis to uniform pricing, assuming that the firms split the market equally whenever consumers are indifferent in the first period. Because each firm's repeat customers are informed and hence are less price elastic, whereas the opposing firm's customers are less informed and more price elastic, the "average" price elasticity of the consumers lies in between when firms split the market in a symmetric equilibrium (Doganoglu, 2010; Villas-Boas, 2006). However, when firms can identify repeat consumers from past purchasing history and segment the two consumer groups, each firm will choose optimal prices for repeat and switching consumers separately according to each group's price elasticity, and the elasticities are independent of first-period market share.

[20]This property extends to the N-firm setting (given in Appendix D).

In each panel of Figure 1, the x-axis is the consumer's known valuation for the trialed product, θ_i, and the y-axis is consumer surplus given equilibrium prices. In each, the steeper line is the consumer's surplus from purchasing product i again in the second period, $(\theta_i - R_i)$. The consumer's expected surplus from switching to the untried product is $E(\theta_{-i}|\theta_i) - S_{-i} = \rho\theta_i + (1-\rho)\mu - S_{-i}$, and is the flatter—but still positively-sloped—line in each figure. The consumer's expected surplus from switching is positively correlated with θ_i because $\rho \in (0,1)$ in this figure. If there were no information spillovers, i.e. for $\rho = 0$, the consumer's surplus from switching would be constant and independent of θ_i.[21] In each equilibria, consumers are repeat buyers in the second period if their θ_i lies in the range where the steeper line is above the flatter line. The lines intersect exactly once, at the value θ_i^{RS}, where the consumer is indifferent between repeat purchasing and switching.

Figure 1: Second-period equilibria; consumer valuations after learning θ_i.

(a) Niche market equilibrium, where $R_i^n = M$ and $S_{-i}^n \geq c$.

(b) Semi-niche equilibrium, where $R_i^s \in [m, M]$ and $S_{-i}^s = \rho R_i^s + (1-\rho)\mu$

(c) Mass market equilibrium, where R_i^m, S_{-i}^m are given by (7) and (8).
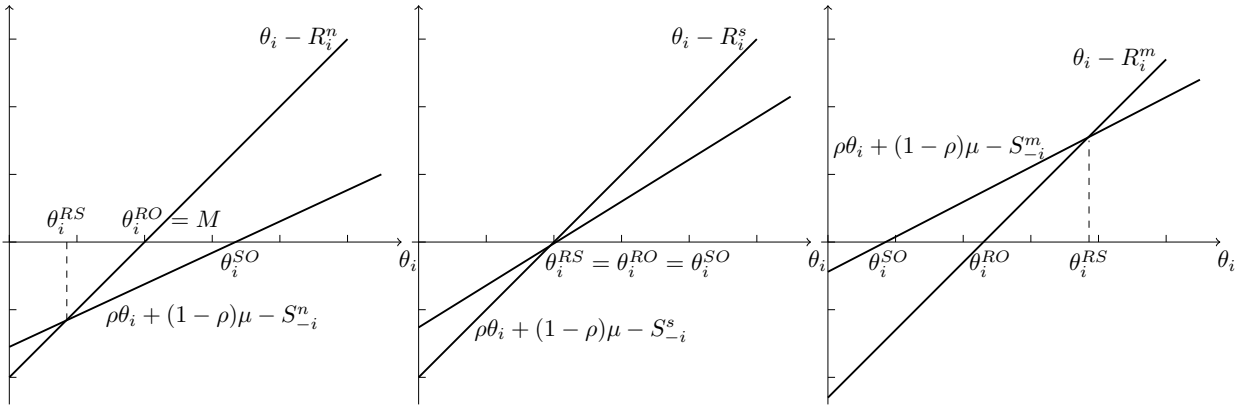
First, when μ is sufficiently small, there exists a "niche market" equilibrium in which the marginal repeat consumer strictly prefers the outside option and the new market is not fully covered in the second period (Figure 1, panel a). That is, while the consumers who had a good experience are repeat consumers of product i, the consumers that have had a bad initial experience choose to leave the new product category rather than switch to the untried product, so $\max(\theta_i^{RS}, \theta_i^{RO}) = \theta_i^{RO}$, there are no switching consumers, and the second maximum in the profit equation (5) takes on the value of zero because $\theta_{-i}^{SO} > \theta_{-i}^{RS}$. Since no consumers switch in equilibrium, each firm makes monopoly flow profits in the second period in its respective share of the market by charging the monopoly price M to repeat consumers.

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[21]The $\rho = 0$ case is set out in Appendix C, which also shows the consumer surplus in each equilibria, analogous to Figure 1, in Figure C.3.

Second, when μ takes on intermediate values, there exists an equilibrium where the marginal repeat consumer is indifferent between consuming again in the new product market and the outside option (Figure 1, panel b). We refer to this equilibrium as the "semi-niche market equilibrium". In this equilibrium, no consumer switches after a bad initial experience—similar to the niche market equilibrium—but a decrease in the price to switching consumers results in some switching.

Third, when μ is sufficiently large, there exists a "mass market" equilibrium in which the marginal repeat consumer strictly prefers to stay in the market rather than to leave the market and take the outside option (Figure 1, panel c). That is, at least some of the consumers who have a less-than-excellent initial experience have a high conditional expectation of their value for the untried product and therefore switch to this product in the second period. The second maximum in the profit equation (5) takes on the value of the non-zero term, as $\theta_{-i}^{RS} > \theta_{-i}^{SO} \geq -\infty$, and the firm makes second-period flow profits from repeat consumers and also from switchers.

The existence, or absence, of switching consumers is the crucial equilibrium feature shaping the nature of competition in this overall game and characterizing the main results. Before describing how switching second-period consumers affect the first-period game, we turn to the equilibrium prices for each of the three equilibria, demonstrate how the magnitude of μ determines which of the three equilibria arises, and derive firm profits in each.

The niche market equilibrium (Figure 1, panel a), where there are no switching consumers, exists if and only if the competitor cannot poach consumers with a price that is weakly greater than the marginal cost c. The necessary and sufficient condition on μ, the exogenously given innovation value, for this equilibrium is given below in Proposition 1 and ensures the competing firm cannot do this. When a niche market equilibrium exists, the first-order approach yields that the optimal second-period price to the repeat customer is exactly the monopoly price.

In the semi-niche market equilibrium (Figure 1, panel b), because the marginal repeat consumer is indifferent between consuming in the new product category and taking the outside option, we can obtain the price to repeat consumers by letting $R_i^m = \theta_i^{RS} = m$.[22] Hence, m satisfies

$$m = \frac{(1-\rho)[1-F(m)]}{f(m)} + c. \tag{6}$$

On the other hand, we can construct the price $\rho m + (1-\rho)\mu$ which ensures that the marginal repeat customer θ_i^{RS} is indifferent between switching and the outside option.[23] There is, in fact,

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[22]The MHR condition ensures m is uniquely determined. We will observe later that $m = M$ when $\rho = 0$ and $m < M$ when $\rho > 0$.

[23]Because switching yields the marginal repeat customer being θ_i^{RS} where $\left[\rho\theta_i^{RS} + (1-\rho)\mu\right] -$

a continuum of semi-niche market equilibria, and the equilibrium we just characterized is the one with the lowest price.

In the mass market equilibrium (Figure 1, panel c), $\max(\theta_i^{RS}, \theta_i^{RO}) = \theta_i^{RS}$, and some consumers switch. We derive the second-period equilibrium prices in this case using equation (5) by the first-order approach to give:

$$R_i^m = \frac{(1-\rho)[1 - F(\theta_i^{RS})]}{f(\theta_i^{RS})} + c, \tag{7}$$

$$S_i^m = \frac{(1-\rho)\left[F(\theta_{-i}^{RS}) - F(\theta_{-i}^{SO})\right]}{f(\theta_{-i}^{RS}) + \frac{1-\rho}{\rho} f(\theta_{-i}^{SO})} + c. \tag{8}$$

By exchanging i and $-i$ in equations (7) and (8), we can solve for the unique prices to repeat and switching consumers, R_i^m and S_{-i}^m.[24] We show the uniqueness of R_i^m and S_i^m in the proof of Proposition 1.

The average value of the new product category relative to the outside option, μ, determines which equilibrium applies:

Proposition 1. *When consumer values are positively correlated, so $\rho \in (0,1)$, and all consumers have purchased one of the goods, in the second period there exists:*

- *a unique niche market equilibrium where firm i charges $R_i^n = M$ to repeat buyers (and any $S_i^n \geq c$) if and only if $\mu \in \left(-\infty, \frac{c - \rho \cdot M}{1-\rho}\right)$;*

- *a continuum of semi-niche market equilibria where firm i charges $R_i^s \in [m, \iota]$ and $S_i^s = \rho R_i^s + (1-\rho)\mu$ if and only if $\mu \in \left(-\infty, \frac{c - \rho \cdot \iota}{1-\rho}\right]$, given any $\iota \in [m, M]$;*

- *a unique mass market equilibrium where firm i charges R_i^m and S_i^m satisfying (7) and (8) if and only if $\mu \in \left(\frac{c - \rho \cdot m}{1-\rho}, \infty\right)$.*

Proposition 1 shows that whenever the average value of the new product category, μ, is sufficiently high relative to the outside option, the mass market equilibrium obtains. This condition differs from the standard definition of a mass market (Bergemann and Välimäki, 2006; Ivanov, 2009), which requires $\mu \geq M$. Our mass market equilibrium emerges for a larger range of innovations. It applies for all major innovations, where $\mu \geq c$, and also for the most valuable minor innovations, because $\frac{c - \rho \cdot m}{1-\rho} \leq c$ is the lowest value of μ sufficient for a mass market in our setting. We continue to refer to this equilibrium as the "mass market equilibrium" because it shares the feature with Bergemann and Välimäki (2006) that the marginal repeat consumer

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$[\rho m + (1-\rho)\mu] = 0.$

[24]Note that $R_i^m \to c$ and $S_i^m \to c$ when $\rho \to 1$. This is consistent with the case where $\rho = 1$, discussed at the end of Section 2.

strictly prefers to stay in the new product category rather than return to the outside option. Figure 2 illustrates the range of μ corresponding to each second-period equilibrium for $\rho \in (0, 1)$.

Figure 2: Relevant range of μ for each second-period equilibrium when $\rho > 0$.
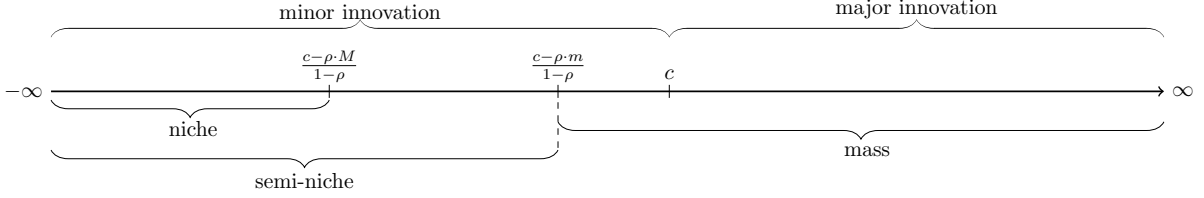
The own- and cross-price elasticities for repeat and switching consumer demand in each of the three equilibria are derived in an online appendix. Prices and market power in both consumer segments vary with ρ and converge when ρ approaches zero ($\lim_{\rho \to 0} R_i^m = \lim_{\rho \to 0} S_i^m = \frac{1}{2f(\mu)} + c$) and when $\rho = 1$. Market power and markups in period 2 are always greater in the niche market equilibrium than in the mass market equilibrium.[25] While it may seem counterintuitive that firms can have less market power when their offering is more attractive, this arises because the rival new product provides more effective competition when the average value of the new product category is greater.

The relative profits from repeat and switching consumers in the mass market equilibrium are important for how the firms in the new product category compete. In particular, their relative magnitude determines the intensity of first-period price competition. The second-period profits from repeat and switching consumers are given, respectively, by:

$$\pi_i^{Rm} = \frac{(1 - \rho)[1 - F(\theta_i^{RS})]^2}{f(\theta_i^{RS})} \tag{9}$$

$$\pi_i^{Sm} = \frac{\rho(1 - \rho)[F(\theta_{-i}^{RS}) - F(\theta_{-i}^{SO})]^2}{\rho f(\theta_{-i}^{RS}) + (1 - \rho)f(\theta_{-i}^{SO})}. \tag{10}$$

Although $R_i^m \geq S_i^m$, which we show in the proof of Proposition 1, the relative magnitudes of the profits from repeat and switching customers in the mass market equilibrium cannot be ordered, and depend on demand-related parameters, including ρ.[26] Note, however, that both profits converge to zero as ρ converges to 1.

Corollary 1. *When $\rho \in (0, 1)$ and all consumers have purchased one of the goods in the first period*

- *firm i's second-period profit in the niche market equilibrium is given by $\lambda_i \pi(M)$;*

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[25]To see why, note that $R_i^m \leq m \leq R_i^s \leq M = R_i^n$, where the first inequality is verified by the proof of Proposition 1.

[26]Section 5 provides numerical examples for the mass market equilibrium with $\rho \in (0, 1)$.

- *firm i's second-period profit in the semi-niche market equilibrium is given by $\lambda_i \pi(R_i^s)$, where $R_i^s \in [m, M]$;*

- *firm i's second-period profit in the mass market equilibrium consists of $\lambda_i \pi_i^{Rm}$ from repeat consumers and $\lambda_{-i} \pi_i^{Sm}$ from switching consumers.*

4   First-period prices with information spillovers, $\rho \in (0, 1)$

We now discuss the sub-game perfect equilibria of the two-stage pricing game. Forward-looking consumers make their first-period choice between the two products in the new product category and the outside option by comparing consumer surplus for $i = A, B$ and zero. Their choices condition on their expectation of being offered one of each of the second-period equilibrium prices for repeat and switching consumers, $R_i^* \in \{R_i^m, R_i^s, R_i^n\}$ and $S_{-i}^* \in \{S_{-i}^m, S_{-i}^s, S_{-i}^n\}$, respectively, depending on whether the second period is a niche, semi-niche, or mass market. The present value of consumer surplus from purchasing product i in the first period is:

$$CS_{\rho > 0} = \underbrace{(\mu - p_i)}_{\text{consumer surplus from trying } i} + \quad \delta \underbrace{\int_{\max\left(\theta_i^{RS}, \theta_i^{RO}\right)}^{\infty} (x - R_i^*) \, dF(x)}_{\text{consumer surplus from sticking with } i}$$

$$+ \quad \delta \underbrace{\max\left(0, \int_{\theta_i^{SO}}^{\theta_i^{RS}} \left[\rho x + (1 - \rho)\mu - S_{-i}^*\right] dF(x)\right)}_{\text{consumer surplus from switching to } -i \text{ or to the outside option}},$$

where $p_i \in \{p_i^m, p_i^s, p_i^n\}$ is the first-period price depending on which second-period equilibria obtains, and δ is the discount factor. Note that the consumer surplus takes into account the option value of experimenting in the first period in order to make a more informed decision in the second period. Anticipating possible adjustments means consumers are willing to purchase at lower or even negative surplus in the first period.

Consumers are ex-ante identical. If the consumer surplus from purchasing good i is greater than from good $-i$, and no less than zero, firm i's first-period market share is $\lambda_i = 1$; if the surplus from purchasing the new goods is non-negative and equal, then $\lambda_i \in [0, 1]$; otherwise, $\lambda_i = 0$. Recall that the second-period prices in each of the three equilibria are independent of λ_i, and the threshold cutoff values for switching and exiting consumers given in Definitions (1) to (3) are also independent of λ_i. However, λ_i affects firm i's second-period profit by determining the quantity of repeat and switching consumers, as shown in equation (5).

The present value of consumer surplus from opting not to buy in the first period and purchasing only in the second period is assumed to be $\delta(\mu - S^*)$. That is, firms would treat such

a consumer as a switcher and charge the switching price, in line with the idea that firms would know the consumer was not a repeat buyer because they can observe their own buyers' past histories.

We now show that equilibrium prices in all equilibria mean that consumers purchase a new product in the first period and potentially in the second period, depending on the information they learn from their initial consumption experience.

When the new product category is of low value relative to the outside option, i.e. when μ is small, the relevant second-period equilibrium is either the niche or semi-niche equilibrium, as shown in Proposition 1. In each of these two equilibria, firms make zero profits in the two-stage pricing game. Proposition 2 below shows this result, which is proved in Appendix B.

Proposition 2. *Firms make zero profits in the niche and semi-niche market equilibria, which arises when μ is sufficiently small and $\rho \in (0, 1)$:*

- *if and only if $\mu \in \left[c - \delta \cdot SS(M), \frac{c - \rho \cdot M}{1 - \rho} \right)$, there exists a unique equilibrium in which firm $i = A, B$ makes a profit of zero by charging $p_i^n = c - \delta \pi(M)$ in the first period and charging $R_i^n = M, S_i^n \geq c$ in the second-period niche market equilibrium given by Proposition 1;*

- *if and only if $\mu \in \left[c - \delta \cdot SS(\iota), \frac{c - \rho \cdot \iota}{1 - \rho} \right]$, where $\iota \in [m, M]$, there exists a continuum of equilibria in which firm $i = A, B$ makes a profit of zero by charging $p_i^s = c - \delta \pi(R_i^s)$ in the first period and charging $R_i^s \in [m, \iota], S_i^s = \rho R_i^s + (1 - \rho)\mu$ in the second-period semi-niche market equilibria given by Proposition 1.*

Firms make zero overall profits when μ is sufficiently low to be in the niche or semi-niche equilibrium space because all second-period profits from repeat consumers are competed away via the price set in the first period. No consumers switch in the second period. Expected consumer surplus is non-negative over this range of μ.

We now turn to the mass market equilibrium when $\rho \in (0, 1)$, which Proposition 1 shows applies for values of μ defined as major innovations and also for some minor innovations. Proposition 3 shows that firms make positive profits in the two-stage pricing game when $\rho \in (0, 1)$ whenever the mass market equilibrium applies in the second period.

Proposition 3. *Firms make positive profits when μ is sufficiently large and $\rho \in (0, 1)$:*
If and only if $\mu \geq \mu_L \equiv \max \left(c - \delta(SS^m - 2\pi_i^{Sm}) + \max(0, \delta(\mu - S_i^m)), \frac{c - \rho \cdot m}{1 - \rho} \right)$, there exists a unique equilibrium in which firm $i = A, B$ makes profits of $\delta \pi_i^{Sm} > 0$ by charging $p_i^m = c - \delta \left(\pi_i^{Rm} - \pi_i^{Sm} \right)$ in the first period and charging R_i^m, S_i^m in the second-period mass market equilibrium, where R_i^m, S_i^m, π_i^{Rm}, and π_i^{Sm} are given by (7), (8), (9), and (10), respectively, and

social surplus is:

$$SS^m = \int_{\theta_i^{RS}}^{\infty} (x-c)\,dF(x) + \int_{\theta_i^{SO}}^{\theta_i^{RS}} [\rho x + (1-\rho)\mu - c]\,dF(x). \qquad (11)$$

An outline of the key steps of the proof of Proposition 3 follows and the details can be found in Appendix B.

Suppose the profit from repeat consumers is greater than from switchers. Then, in the first period, firms in the new product category compete by lowering their prices to the point satisfying equation (12) below:

$$\lambda_i(c - p_i^m) = \delta\left(\lambda_i \pi_i^{Rm} - \lambda_i \pi_i^{Sm}\right). \qquad (12)$$

On the left-hand side of equation (12) is firm i's first-period loss from setting a price below marginal cost, given that its rival sets the same price. Since a greater first-period market share increases the firm's second-period profit (because, for now, we assume $\pi_i^{Rm} > \pi_i^{Sm}$), each firm is willing to set the first-period price below marginal cost even if doing so incurs a loss. On the right-hand side of equation (12) is the (discounted) gain in the second period when firm i matches its rival's first-period price and maintains a market share of λ_i rather than charging a higher price and losing market share to the rival. Matching yields firm i a second-period profit of $\lambda_i \pi_i^{Rm} + \lambda_{-i} \pi_i^{Sm}$, whereas charging a higher price yields π_i^{Sm}. The difference is thus $\lambda_i \pi_i^{Rm} - \lambda_i \pi_i^{Sm}$.

When equation (12) holds, the first-period loss from setting price below marginal cost equals the second-period gain from doing so. Neither firm has a profitable deviation from such an equilibrium. If firm i deviates to any price higher than p_i^m, such that it loses all market share in the first period, its first-period profit increases by $\lambda_i(c - p_i^m)$ to zero and, since it has no repeat consumers, its second-period profit decreases by $\lambda_i \pi_i^{Rm} - \lambda_i \pi_i^{Sm}$. Thus, the total change of its profit is zero since, according to equation (12), $\lambda_i(c - p_i^m) - \delta\left(\lambda_i \pi_i^{Rm} - \lambda_i \pi_i^{Sm}\right) = 0$. The same reasoning can be used to rule out any deviation to a price lower than p_i^m, as well as the case where firms make a greater profit from switching than from repeat consumers.

In the equilibrium of the overall game that includes the mass market equilibrium in the

second period, consumer surplus is given by:

$$(\mu - c) + \delta \left[\underbrace{\int_{\theta_i^{RS}}^{\infty} (x - c) \, dF(x) + \int_{\theta_i^{SO}}^{\theta_i^{RS}} [\rho x + (1 - \rho)\mu - c] \, dF(x)}_{SS^m} - 2 \cdot \pi_i^{Sm} \right].$$

The necessary and sufficient condition for μ given in Proposition 3 guaranteeing that firms make profits also guarantees that consumer surplus must be no less than the maximum of zero and the consumer surplus from purchasing only in the second period, that is, $\delta(\mu - S_i^m)$.[27]

In all the equilibria characterized by Propositions 2 and 3, selling only in the second period is weakly dominated for each firm because the equilibrium prices apply to a continuum of equilibria with any market shares such that $\lambda_i + \lambda_{-i} = 1$. The detailed proofs of Propositions 2 and 3 in Appendix B also show that consumers purchase in both periods in equilibrium. Note that the first equilibrium in Proposition 2 and the equilibrium in Proposition 3 are both unique because their corresponding second-period equilibria are unique and there exists no equilibrium in which firms would charge asymmetric prices in the first period.

Propositions 2 and 3 demonstrate our main general finding that firms compete in the first period only for the difference in second-period profits between repeat and switching consumers. When there are no switching consumers because μ is sufficiently small for the niche or semi-niche equilibrium to apply, and, hence, there are no profits from switchers, firms compete away all the profit from repeat consumers by setting prices below marginal cost in the first period. However, when the mass market equilibrium applies in the second period, that is, when μ is sufficiently large, the profits for each consumer group are given in equations (9) and (10), for repeat and switching consumers, respectively. The relative profits determine whether firms compete for repeat or for switching consumers in the first period because they cannot use their first-period price to compete for both groups. If switching consumers are more profitable, first-period prices will be above marginal cost. First-period prices will be below marginal cost if repeat consumers are more profitable.

Figure 3 presents a numerical simulation of prices and profits for a set of model parameters that produces a mass market second-period equilibrium whenever there are information spillovers, that is $\forall \rho \in (0, 1)$. The parameter values c, σ, and μ have been chosen to generate a case where firms compete in the first period for repeat consumers at some values of ρ and for switching consumers at other values of ρ. The left hand panel plots second-period profits from

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[27]We prove Proposition 2 following the same reasoning, that is, by ruling out profitable deviations by the firms, such as selling only in the second period, and profitable deviations by the consumers, such as purchasing only in the second period.

each consumer group. Both groups of consumers are profitable at all values of ρ, but switchers are more profitable at lower values of ρ. The right hand panel plots the first-period price relative to the marginal cost of zero. For the low values of ρ where the profits from switching consumers exceed those from repeat consumers, first-period price exceeds marginal cost.

Figure 3: For lower values of $\rho > 0$, we have $\pi_i^{Rm} < \pi_i^{Sm}$ and hence, $p_i^m > c$, where $\mu = \sigma = 0.5$ and $c = 0$. Note that $R_i^m > S_i^m$ still holds.
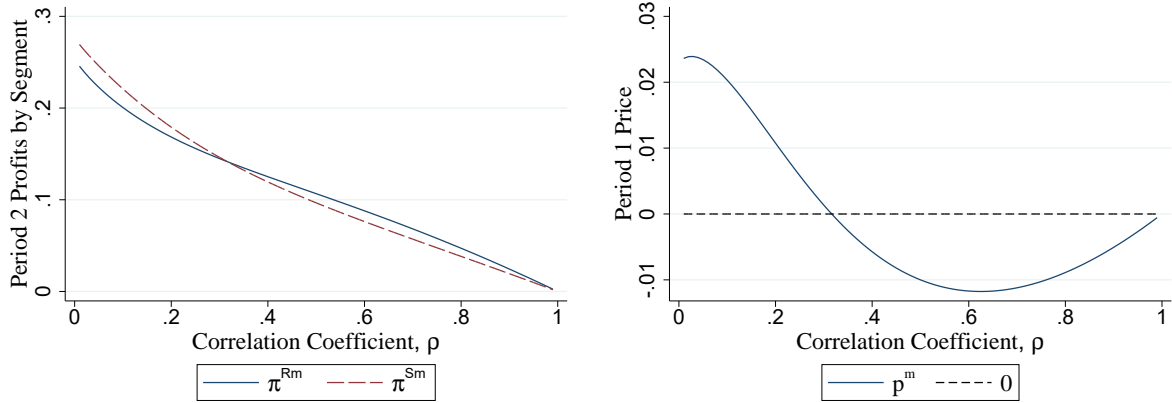
We can see that when repeat and switching consumers are equally profitable in the second period, first-period price is equal to marginal cost. This is because when firms are indifferent between having a consumer purchase from them or from their rival in the second period, they compete in the first period only for first-period profits, and this game resembles a one-period Bertrand game. Whenever repeat consumers are more profitable in the second period, each firm is willing to sell at a loss in the first period to gain repeat consumers. However, the loss in the first period is bounded by the difference in profits from repeat versus switching consumers and is not sufficiently large to offset all the future profit from repeat consumers. Finally, whenever switching consumers are more profitable in the second period, the firm sets a price above marginal cost in the first period so that first-period profits offset the relative loss of repeat consumers in the second period. Therefore in this numerical simulation, at lower values of ρ in $\rho \in (0, 1)$, firms make positive profits in both the first and second periods.

5 The role of information spillovers

5.1 Switching consumers guarantee firm profits.

We now present our main theorem. The analysis so far illustrates that when $\rho \in (0, 1)$, we can put an upper bound on each firm's total discounted profit in the game. The upper bound is the profit a firm would have made with zero market share in the first period and a competitor market share of one. Propositions 2 and 3 provide results that, together, show why a firm can

never do better than this. The propositions demonstrate that firms make zero profit over the two periods if no consumers switch in the second-period equilibrium. In all equilibria where firms make profits, the equilibrium first-period price is low enough that the cost of gaining market share in the first period is equal to the relative profitability of a repeat consumer in the second period compared to a switching consumer. Theorem 1, set out below, shows that this intuition applies in general to any symmetric equilibrium in the game for all $\rho \in [-1, 1]$, regardless of the form of equilibrium in the second period.

Let $\lambda_i \pi^{R*}$ be firm i's second-period profit from repeat consumers and $\lambda_{-i} \pi^{S*}$ be firm i's second-period profit from switching consumers in any symmetric equilibrium.

Theorem 1. *For any $\rho \in [-1, 1]$, firm i's first-period price in any symmetric equilibrium with any market share $\lambda_i \in [0, 1]$ is given by $p^* = c - \delta(\pi^{R*} - \pi^{S*})$ and its profit in the two-stage pricing game is given by $\delta \pi^{S*}$.*

Proof. Since the goods in the new product category are ex-ante homogeneous from the consumers' perspective, consumers purchase the cheaper product in the first period. Suppose $\pi^{R*} > \pi^{S*}$, that is, firm i benefits from increasing first-period market share. Then, both firms compete for first-period market share by lowering the first-period price below c.

If firm i deviates by charging a slightly lower price than p^*, it then gains all the rival firm's market share λ_{-i} and incurs a cost of $\lambda_{-i}(c - p^* + \epsilon)$ in the first period, where $\epsilon > 0$. Since the share λ_{-i} of consumers are now firm i's repeat consumers in the second period, it makes an additional profit from repeat consumers, $\lambda_{-i}\pi^{R*}$, but forgoes the profit that it would have made from switching consumers, $\lambda_{-i}\pi^{S*}$, because there would be no consumers to switch from the rival product in this deviation. In other words, the net benefit in the second period is given by $\lambda_{-i}(\pi^{R*} - \pi^{S*})$. Since $p^* = c - \delta(\pi^{R*} - \pi^{S*})$, and hence, $\lambda_{-i}(c - p^* + \epsilon) = \delta\lambda_{-i}(\pi^{R*} - \pi^{S*}) + \lambda_{-i}\epsilon > \delta\lambda_{-i}(\pi^{R*} - \pi^{S*})$, the cost is greater than the discounted benefit. The deviation is thus not profitable.

If firm i deviates by charging a higher price than p^*, it gives up λ_i market share to the rival firm. Hence, its first-period profit increases by $\lambda_i(c - p^*)$, as it avoids this loss. In the second period, it makes an additional profit from switching consumers, $\lambda_i\pi^{S*}$, but forgoes any profit from repeat consumers, $\lambda_i\pi^{R*}$. Hence, the net *loss* in the second period is given by $\lambda_i(\pi^{R*} - \pi^{S*})$. Since $p^* = c - \delta(\pi^{R*} - \pi^{S*})$, we know that the first-period benefit is equal to the second-period loss. The deviation is thus not profitable.

In fact, the above proof for the case when repeat buyers are more profitable also applies analogously when switching consumers are more profitable than repeat buyers, that is, when $\pi^{R*} \leq \pi^{S*}$. In this case, firms compete for a smaller first-period market share by increasing the

first-period price above c up to a point where the additional profit earned in the first period is balanced by the additional loss in the second period.

The proof so far applies to any $\lambda_i \in [0, 1]$ such that $\lambda_i + \lambda_{-i} = 1$. This means that it is not profitable for a firm to deviate by selling only in the second period while the rival firm sells in both periods ($\lambda_{-i} > 0$). In such a situation, the firm makes a profit of $\delta\pi^{S*}$ which equals the equilibrium profit. Alternatively, when the rival firm sells only in the second period ($\lambda_{-i} = 0$), firm i would make zero profit by deviating to sell only in the second period because then their products are homogeneous to consumers and Bertrand competition drives down their prices to the marginal cost. Therefore, selling only in the second period is weakly dominated by selling in both periods.

To calculate firm i's total profit, substituting for p^* in the profit function gives:

$$\pi_i^* = \lambda_i(p^* - c) + \delta(\lambda_i \pi^{R*} + \lambda_{-i}\pi^{S*}) = \delta\pi^{S*}. \tag{13}$$

Hence, each firm's profit in the *two-stage pricing game* in any symmetric equilibrium is equal to the discounted second-period profit it would have earned if it had zero market share in the first period. Q.E.D.

The proof of Theorem 1 therefore relies on the following simple derivations: If firm i deviated to a lower price, it would capture the rival firm's share λ_{-i}. It then makes an additional profit from this share of (repeat) consumers but has to give up profit from switching consumers whose share is exactly λ_{-i}. The price p^* given in the theorem balances the change in first-period incremental profit with the change in the discounted second-period incremental profit.

Theorem 1 holds for all $\rho \in [-1, 1]$. That is, even without information spillovers ($\rho = 0$), the finding that firms rely on the presence of switching consumers to make positive profits still holds. Given that the majority of the existing literature focuses on experience goods pricing without information spillovers, we contribute to the literature by illustrating the special role played by switchers.

5.2 Beyond two-period duopoly

Appendix D provides some extensions of the model that help develop intuition for the mechanisms giving rise to Theorem 1. Appendix D.1 considers a setting where the number of firms exceeds the number of time periods, focusing on an example where there are $N > 2$ symmetric firms when the number of periods $T = 2$. When $N = 3$, each firm's profit drops to zero because, in the second period, there are two firms competing for switching consumers from the buyers of the third firm's product in the first period. Each switching customer is indifferent between the

two untried products because firms are symmetric, resulting in Bertrand competition between the two untried products. This implies the equilibrium prices charged to switching consumers are equal to the marginal cost and the profits from switching consumers are equal to zero. Consistent with Theorem 1, firms' overall profit is as large as the profits it would make if its only consumers in the second period were switchers, which, when $N = 3$ would be equal to zero. The reason is that firms can only make a profit in the second period from repeat buyers, so they compete intensely for market share in the first period. This drives their first-period prices below marginal cost and the overall profit goes to zero. With N higher than three, the prices are the same as in the $N = 3$ setting and each firm's profit is always equal to zero. That is, the number of competing firms has a strong and discontinuous, negative, impact on firms' prices and profits.[28]

We further extend the model to consider settings where $T \geq N$. Appendix D.3 shows that there always exists a symmetric equilibrium in which all firms make positive profits as long as μ is sufficiently large. Note that our two-firm two-period model is a special case of the $T \geq N$ rather than $T < N$ setting. The analysis in Appendix D.3 shows that the result that firms make profits in the mass market equilibrium extends to a general setting. The intuition is as follows: Consumers can only experience at most one product in each period. When the number of time periods is at least as large as the number of products, we can always find a parameter range (for example, sufficiently high μ) such that, in period $N \leq T$, there is at least one segment of consumers that has tried $N - 1$ products. This leaves the untried product with no competitor, allowing this firm to set a price that will persuade some of this group of consumers to switch, resulting in a positive profit. Despite the fact that consumers account for future learning when making purchasing decisions in each period, and those with a sufficiently high value for one of the products always stick with that product, consumers with lower values switch between products before settling on one.

In the online appendix, we also show that firms always have positive profits in any equilibrium when $\rho < 0$, providing the analysis equivalent to Sections 3 and 4. Firms make positive profits when the niche, semi-niche, or mass market equilibria arise in the second stage when $\rho < 0$ because there are always some consumers who switch in the second period in this setting and Theorem 1 applies.[29]

Further intuition for Theorem 1 can be found in comparisons with the equilibria of games that relax some of the assumptions made in the set up studied here. For example, imagine a

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[28]Appendix D.2 further generalizes the result to any T periods and N firms with $2 \leq T < N$ and shows that firms make zero profit in such a setting.

[29]Appendix C shows that firms make positive profits in the game when $\rho = 0$ when the mass or semi-niche equilibrium arises in the second period because these two equilibria feature switching consumers.

monopoly case where one firm is selling two experience goods with information spillovers from consumption. In this case, the theorem does not apply. A monopolists' total profits typically exceed the profits that it could extract from switching consumers in the second period because first-period prices need only to be low enough to ensure all consumers purchase.

Another comparison example is the duopoly case of non-experience goods, that is, goods where consumers know their valuation for all goods perfectly. Typically, in this case, firms make greater profits than for the experience goods competition case and Theorem 1 does not apply. The intuition is that when consumers know their valuations, goods are more differentiated, which softens competition in the first period. Hence, as long as the firms are not too impatient, such that the first-period profit dominates firms' profit from the whole game, firms make more profit over the two periods. This analysis is shown in the online appendix.

Theorem 1 does, however, generalize to other demand structures such as the binary consumer-type duopoly case, where consumers have either a high or low value for both products that is unknown prior to trial. In Appendix E, we study the impact of asymmetric willingness to pay in a setting where the marginal distributions of consumer valuations are different but the means of willingness to pay are both either sufficiently large, such that a mass market equilibrium exists in each firm's market, or sufficiently small, such that a niche market equilibrium exists in each firm's market. We show that the main result that firms' profitability depends on switchers also extends to this setting. We also generalize Theorem 1 to a uniform pricing setting where firms cannot price discriminate in the online appendix. We provide conditions under which a continuum of symmetric equilibria exists and show that the overall equilibrium profit is no less than the second-period profit a firm could make from switchers if it had zero market share in the first period. The ability to profit from switchers, from a base of zero market share, reduces the incentive to compete aggressively in the first period.

5.3   Profits can be increasing in ρ under some conditions.

Having established that firms competing in a new product category make positive profits in any equilibrium with second-period switching consumers, we ask how the extent of information spillovers affects total profits when there are switchers. Recall that ρ plays two roles in the model: it measures how substitutable products are ex-post, that is, the degree of correlation between consumer values for the two products, and it also captures the extent of information spillovers from consumption of either good. This second role of ρ serves to decrease the price elasticity of switching consumers, allowing greater overall profits. This effect can outweigh the downwards pressure on profits from products being closer substitutes. Proposition 4 shows the

sufficient conditions for each firm's profit to be increasing in ρ, conditions that are more likely to be satisfied at low levels of ρ.

Proposition 4. *The equilibrium profit of firm i in the two-stage pricing game, $\delta\pi_i^{Sm}$, is locally increasing in ρ when S_i is greater than μ and the following condition holds:*

$$\underbrace{\theta_{-i}^{RS} - \frac{1 - F(\theta_{-i}^{RS})}{f(\theta_{-i}^{RS})}}_{\textit{virtual valuation at } \theta_{-i}^{RS}} \geq \mu + \underbrace{\left[\frac{1 - F(\theta_{-i}^{RS})}{f(\theta_{-i}^{RS})}\right]'}_{<0} \frac{dS_i^m}{d\rho}. \tag{14}$$

Inequality (14) requires the virtual valuation at θ_{-i}^{RS} to be sufficiently large, where this virtual valuation is the minimum rent a firm can extract from a repeat buyer. In fact, for profits to increase in ρ, the price difference $R_{-i}^m - S_i^m$ must also be sufficiently large. Since our previous analysis suggests that both the prices to repeat and switching customers converge to the marginal cost c as ρ approaches one, the largest difference between these two prices will occur at lower values of ρ. In addition, this condition is more likely to hold when $dS_i^m/d\rho > 0$, which, for the same price convergence reason, will only hold at lower values of ρ.

A numerical example with $c = \sigma = \mu = 0.5$ illustrates the finding in Proposition 4. Comparative statics regarding profits, markups, consumer surplus, and social surplus with respect to ρ are shown in Figure 4. We focus on the mass market equilibrium when $\rho > 0$.

Panel (a) of Figure 4 shows that the profit firms make in the mass market equilibrium, calculated in equation (10), can be a non-monotonic function of ρ. With the chosen values of c, σ, and μ, profits are increasing at low values of $\rho > 0$ and are maximized at around $\rho = 0.6$, consistent with Proposition 4. While the magnitudes depend on the parameter choices, we note that firm profits are twice as high when $\rho = 0.6$ as when $\rho = 0.2$.[30]

Theorem 1 tells us that any differential profit earned from repeat consumers over profit from switching consumers is offset by first-period losses. Therefore, if total profits are increasing over a range of ρ, it must be that profits from switching consumers are increasing over that range. The consequences of the trade off between the two roles played by ρ are summarized in panel (b) of the figure, presenting the difference between price to switching consumers and marginal cost over the price to switching consumers, that is, the Lerner index for this consumer group, $\frac{S_i - c}{S_i}$. Because the markup to repeat consumers, which is monotonically decreasing in ρ, is always offset by lower first-period prices, it is the non-monotonic markup to switching consumers that delivers the non-monotonic overall profit function shown in panel (a).

---

[30]In this example, as $\rho \to 0$, firms make zero profits from switchers because their expected valuation conditional on a switch is μ which equals marginal cost, c.
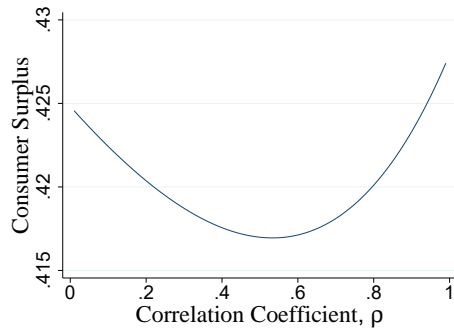
Figure 4: An example with $\mu = c = \sigma = 0.5$ and $\delta = 1$ of profit (π_i^{Sm}), the Lerner index for switching consumers ($\frac{S_i^m - c}{S_i^m}$), consumer surplus, and social surplus as a function of ρ in a mass market equilibrium.
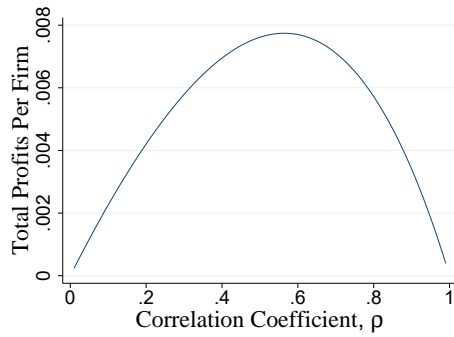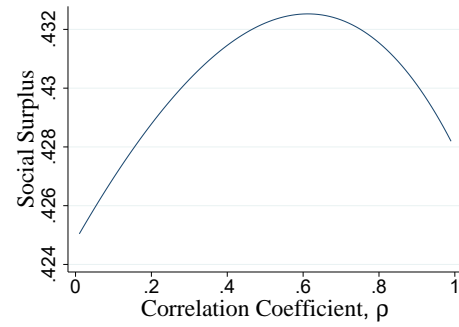

(a) Total profit per firm, π_i^{Sm}
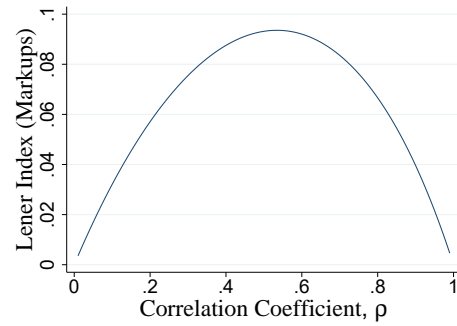
(b) Lerner Index for switchers, $\frac{S_i^m - c}{S_i^m}$

(c) Consumer surplus, $SS^m - 2 \cdot \pi_i^{Sm}$

(d) Social surplus, SS^m

Panel (c) of Figure 4 shows that the consumer surplus over the two periods is U-shaped. Social surplus, given in panel (d) of Figure 4 and calculated in equation (11), has an inverse U shape, similar to firms' profits. We note that the consumer surplus is the difference between the social surplus and twice the profits, because there are two firms, and, thus, that the shape of the profit curve dominates the shape of social surplus curve in this example. The intuition behind the non-monotonic relationship between ρ and consumer surplus lies again in ρ's dual role: greater substitutability increases consumer surplus because it intensifies price competition; but more information spillovers decrease consumer surplus because the demand for the untried product becomes less elastic. In this example, the effect of the information spillovers dominates the effect of substitutability for low values of ρ, whereas the latter dominates for high values of ρ. Hence, consumer surplus has a U shape.

5.4 Information spillovers result in duopoly profits in less-valuable new product markets.

Another insight from our equilibrium analysis is that the presence of positive information spillovers, $\rho \in (0, 1)$, allows firms to make profits over a larger range of new market values, μ, than when $\rho = 0$ (the case presented in Appendix C). The comparative statics with respect to μ are summarized in Figure 5, which extends Figure 2 to reflect the cutoffs for the two-period game, and includes the $\rho = 0$ case above the $\rho \in (0, 1)$ case.

Figure 5 has two parts, and, in each case, μ varies along the horizontal axis holding c constant. The top half of the figure considers the case of $\rho = 0$, and provides the intervals of μ that are necessary and sufficient for the existence of each equilibria, showing also the second-period equilibria for the relevant range. The lower half of the figure does the same for values of $\rho \in (0, 1)$.[31] Note that Proposition 2 gives that both niche and semi-niche market equilibria exist in the interval $[c - \delta \cdot SS(M), \frac{c - \rho \cdot M}{1 - \rho}]$ in the $\rho \in (0, 1)$ case.

Two aspects of Figure 5 merit particular attention. First, relating to the far left hand side of both halves of the figure, when $\mu \in [c - \delta \cdot SS(m), c - \delta \cdot SS(M)]$, there exist some semi-niche market equilibria only if $\rho > 0$, that is, only in the bottom half of the figure. There is no equilibrium in which firms enter the market in the first period and where consumers purchase the goods for this range of μ if $\rho = 0$. Hence, positive information spillovers ensure an equilibrium exists where consumers buy the new products for these minor innovations.

Second, we turn to the most valuable minor innovations, those where $\mu \in [\mu_L, c)$. These innovations are profitable only when there are positive information spillovers. This can be seen

---

[31]Simple calculations show that when $\mu \leq c$ (so that $\mu \leq S_i^m$ due to $S_i^m \geq c$) and $\rho \leq \delta(SS^m - 2\pi_i^{Sm})f(m)/[1 - F(m)]$, then $\mu_L = \frac{c - \rho \cdot m}{1 - \rho}$. This is the case we focus on in Figure 5.

Figure 5: Equilibrium and innovation: on top is the range of innovation μ corresponding to different equilibria for $\rho = 0$ and below for $\rho > 0$ where we focus on the case with $\mu_L = \frac{c - \rho \cdot m}{1 - \rho}$.
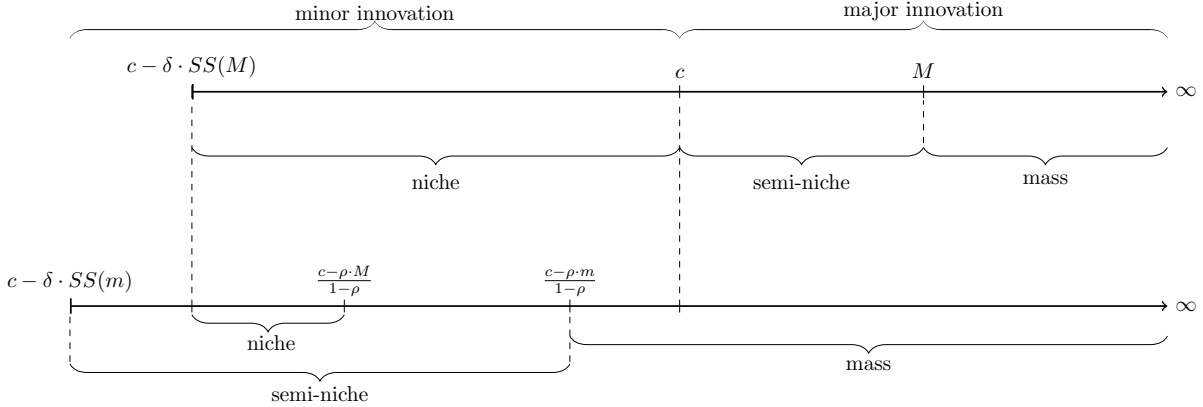
by noting that firms earn positive profits only in the mass market equilibrium when $\rho > 0$ and in the niche and semi-niche market equilibrium when $\rho > 0$. Comparing the top and bottom halves of the figure reveals how the mass market equilibrium when $\rho > 0$ results in an interval of innovation values with a smaller lower bound whenever $\mu_L < c$.

Figure 6 plots firms' profit as a function of μ when the marginal cost is fixed at $c = 0.5$. The solid line is each firm's profit when $\rho > 0$ (in this case ρ is fixed at 0.5) and the dashed line is the profit when $\rho = 0$. Here, minor innovations with $\mu \in [\mu_L, c)$ correspond to $\mu \in [0.2, 0.5]$. When μ is sufficiently high, firms strictly prefer $\rho = 0$. When μ lies below $c = 0.5$, firms make positive profits only if $\rho > 0$, illustrating that firms strictly prefer $\rho > 0$ when the extent of innovation is sufficiently low.

Figure 6: An example with $c = \sigma = \rho = 0.5$. When $\mu - c \le 0$, each firm's profit given $\rho \in (0, 1)$ (solid line) is positive, whereas the profit given $\rho = 0$ (dashed line) is zero.
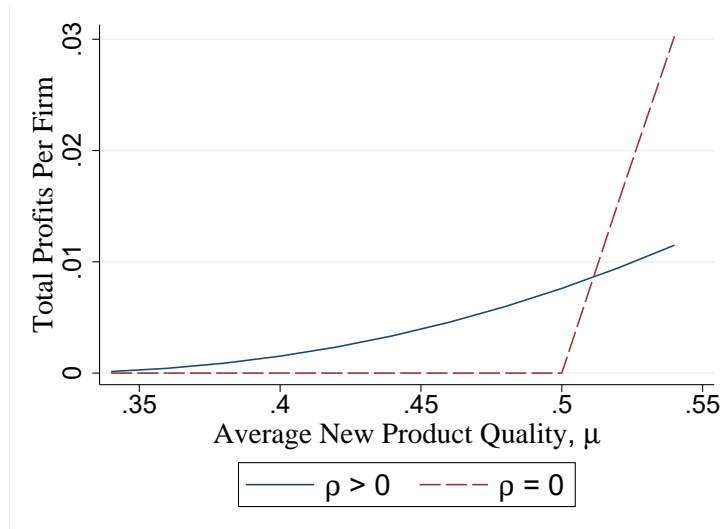
6   Conclusion

This paper analyzes competition in duopoly new product categories where demand has a novel feature: consumption is informative about a consumer's value for other similar goods as well as for the trialled good. This extends the definition of experience goods in Nelson (1970) to include within-consumer information spillovers from consumption. Information spills over when the new products are partial substitutes, that is, when a consumer's values for the two goods are correlated.

Our main finding is that in a mass market equilibrium, defined as a new product category where the value of the new products is sufficiently large that some consumers sample both products in turn, firms' total profits equal the discounted flow profits from switching consumers. Outside the mass market equilibrium, firms make zero profits. Our results show that information spillovers make it more likely that the new product category is in the mass market equilibrium. Learning means that some consumers will want to remain in the market rather than return to their pre-existing alternative, even when their ex-ante expected value for the new products is relatively low. If consumer values were uncorrelated, each firm would be unable to make positive duopoly profits in these situations because consumers would not switch to the untried product, and firms would compete intensely to capture consumers up-front, driving overall profits to zero. Correlated learning can hence expand the set of markets for new goods with non-degenerate or non-monopoly structures.

The mechanism behind these results relies on firms' ability to make profits from repeat buyers and switching consumers. Because firms compete in first-period prices for repeat consumers, anticipating the presence of profitable switchers from among the competitor's initial consumers softens dynamic price competition between the two firms. Price discrimination based on purchasing history, which is increasingly feasible in the new product categories we have in mind, allows firms to extract positive profits from minor innovations that would generate zero profit if price discrimination were not allowed. Switching consumers can even be more profitable than repeat consumers, and the equilibrium first-period price exceeds marginal cost. In these cases, firms have positive profits in both periods.

Our results also show that consumer surplus can be increasing, and firm profit decreasing, in the degree of product differentiation between competing new products for some range of model parameters. This paper, hence, shows that understanding how consumer choices respond to the information spillovers across new products can be important for welfare analysis of different market structures.

For practitioners, our findings imply that firms can be profitable even when selling goods

that appear indistinguishable to inexperienced consumers. In the settings we describe in the model, each firm can free ride on the fact that initial trial of the rival product creates a group of relatively price inelastic consumers willing to switch after their initial experience in the new product category. As a consequence, the competition between firms that actively offer lower prices to rival firms' consumers—as in our motivating example of software development tools— need not actually be as intense as we might think. Anticipated future switching consumers serve to soften initial price competition and allow all firms to make profits when selling similar experience goods.

Appendix

The appendix contains: A. A motivating example; B. Proofs; C. The no information spillovers case, $\rho = 0$; D. N firms and T periods settings; and E, An asymmetric value distribution.

A Software Development Tools, pricing strategies example

Figure A.1 shows two offers available to new customers in screenshots from JetBrain's website. The top half of the figure shows the offer of 25% off to customers who can prove they are using a competing commercial product. The lower half of the figure shows that the firm is offering 50% off to startups who are likely purchasing software development tools for the first time as an organization.

Figure A.1: Promotional offers to new JetBrains customers, October 2022
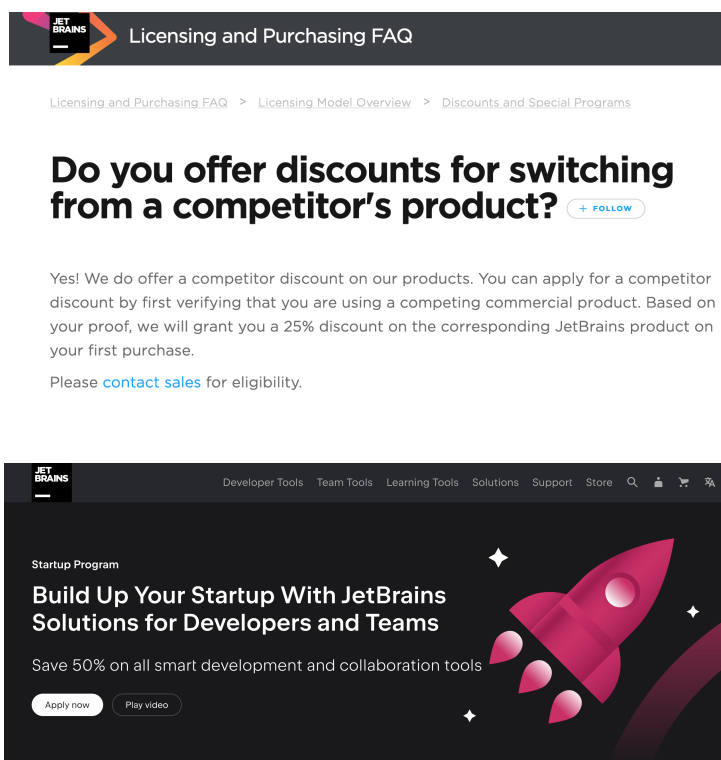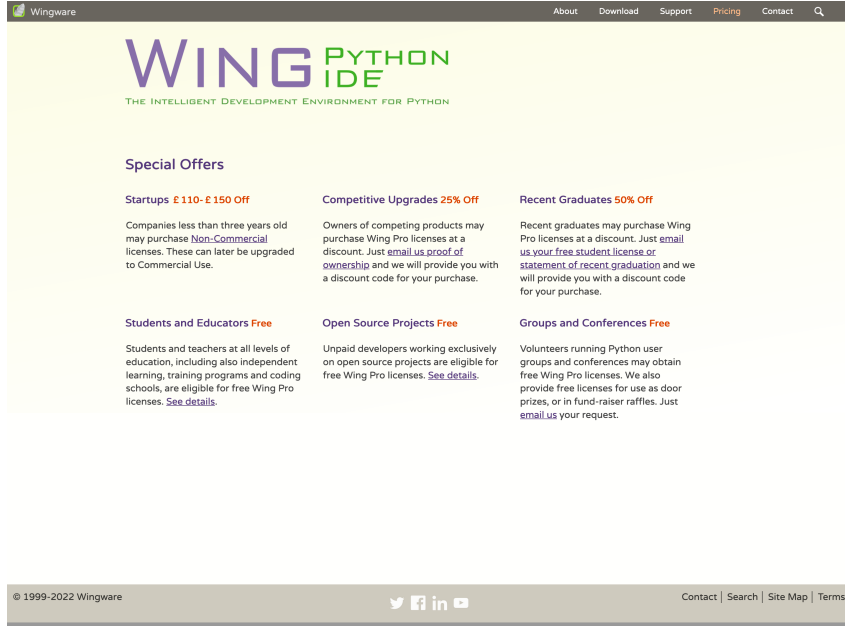

Figure A.2 shows pricing terms for the WingPython IDE family, which was created specifically for the Python programming language. This firm also offers lower prices to consumers switching from competitors (competitor upgrades) and for startups.

Figure A.2: Promotional offers to new WingWare customers, October 2022

B   Proofs

Proof of Proposition 1.

Note that $M > m$. This is true because $(1 - \rho) \in (0, 1)$ and hence, the RHS of equation (6) lies strictly below the RHS of equation (4).

Step 1. A unique niche market equilibrium where firm i charges M to repeat consumers exists if and only if $\mu < \frac{c - \rho M}{1 - \rho}$.

In such an equilibrium, the firm charges the monopoly price to repeat consumers. Hence, there is no profitable deviation in terms of the price to repeat consumers.

For there to be no profitable deviation in prices to switchers, it has to be true that no firm finds it profitable to charge a price no less than marginal cost to attract consumers of the competitor charging the monopoly price. Thus, it has to be true that given firm $-i$ charges M to its repeat consumers, firm i does not find it profitable to charge some $S_i \geq c$ to attract some of firm $-i$'s consumers to switch to product i. This means that the equilibrium exists if and only if the following condition is satisfied $\rho M + (1 - \rho)\mu < c$, i.e. iff $\mu < \frac{c - \rho M}{1 - \rho}$.

Regarding uniqueness, suppose there exists an alternative niche market equilibrium in which both firms charge a price $\tilde{P} \neq M$. According to the definition of niche market equilibrium, there are no switching consumers and firms do not face any competition in their own territory in the second period. This suggests that the optimal second-period price must be M. A contradiction. Thus, there does not exist an alternative niche market equilibrium and the proposition gives the unique niche market equilibrium.

Step 2. A semi-niche market equilibrium where firm i charges R_i^s to repeat consumers and $\rho R_i^s + (1-\rho)\mu$ to switchers, where $R_i^s \in [m, \iota]$ and $\iota \in [m, M]$, exists if and only if $\mu \le \frac{c - \rho\iota}{1 - \rho}$.

The equilibrium is the knife-edge case where the surplus curves of repeat consumers and switching consumers cross at the horizontal axis. To see why, note that

$$\theta_i^{RS} = \mu + \frac{R_i^s - S_{-i}^s}{1 - \rho} = \mu + \frac{R_i^s - [\rho R_i^s + (1-\rho)\mu]}{1-\rho} = R_i^s$$

and thus, $\theta_i^{RS} - R_i^s = \rho\theta_i^{RS} + (1-\rho)\mu - [\rho R_i^s + (1-\rho)\mu] = 0$. This means that $\theta_i^{RS} = \theta_i^{RO} = \theta_i^{SO}$.

To prove that the equilibrium exists for a given $R_i^s \in [m, \iota]$, first suppose firm i deviates to $R_i \ge R_i^s$, then its profit, given firm $-i$'s price $S_{-i}^s = \rho R_i^s + (1-\rho)\mu$, is given by

$$\lambda_i(R_i - c)\int_{\theta_i^{RS}}^{\infty} dF(\theta) = \lambda_i(R_i - c)\int_{\mu + \frac{R_i - S_{-i}^s}{1-\rho}}^{\infty} dF(\theta).$$

Taking the first-order derivative w.r.t R_i, we have:

$$
\lambda_i[1 - F(\theta_i^{RS})]\left[1 - \frac{R_i - c}{1-\rho}\frac{f(\theta_i^{RS})}{1 - F(\theta_i^{RS})}\right]
$$
$$
= \lambda_i\left[1 - F\left(\frac{R_i - \rho R_i^s}{1-\rho}\right)\right]\left[1 - \frac{R_i - c}{1-\rho}\frac{f\left(\frac{R_i - \rho R_i^s}{1-\rho}\right)}{1 - F\left(\frac{R_i - \rho R_i^s}{1-\rho}\right)}\right]. \tag{15}
$$

Since $R_i \ge R_i^s$, then $\theta_i^{RS} = \frac{R_i - \rho R_i^s}{1-\rho} \ge R_i^s$ and thus, we have:

$$
\frac{R_i - c}{1-\rho}\frac{f\left(\frac{R_i - \rho R_i^s}{1-\rho}\right)}{1 - F\left(\frac{R_i - \rho R_i^s}{1-\rho}\right)} \ge \frac{R_i^s - c}{1-\rho}\frac{f(R_i^s)}{1 - F(R_i^s)} \ge \frac{m - c}{1-\rho}\frac{f(m)}{1 - F(m)} \equiv 1,
$$

where the second inequality is due to $R_i^s \ge m$. This implies that the first-order derivative in equation (15) is negative if $R_i > R_i^s$ and firm i does not find it profitable to deviate to a price above R_i^s.

Suppose instead firm i deviates to $R_i < R_i^s$, then the corresponding profit function is given by

$$\lambda_i(R_i - c)\int_{R_i}^{\infty} dF(\theta),$$

which is maximized at $M \ge R_i^s$. Hence, the first-order derivative w.r.t R_i is positive for $R_i < R_i^s \le M$ and it is not a profitable deviation.

Firm $-i$'s profit from switching consumers in this equilibrium is zero, as there is effectively zero measure of consumers who switch. Firm $-i$ does not find it profitable to deviate to a price greater than c if and only if $\rho\theta_i^{RS} + (1-\rho)\mu = \rho R_i^s + (1-\rho)\mu \le c$, i.e., $\mu \le \frac{c - \rho R_i^s}{1-\rho}$. If $\mu \le \frac{c - \rho\iota}{1-\rho}$,

then $\mu \leq \frac{c-\rho R_i^s}{1-\rho}$ holds for any $R_i^s \in [m, \iota]$, hence, firm $-i$ does not wish to deviate. On the other hand, if a semi-niche market equilibrium exists for each $R_i^s \in [m, \iota]$, then it must be true that $\mu \leq \frac{c-\rho\iota}{1-\rho}$ because it implies that $\mu \leq \frac{c-\rho R_i^s}{1-\rho}$ holds for any $R_i^s \in [m, \iota]$.

Step 3. A unique equilibrium, which is a mass market equilibrium, exists if and only if $\mu > \frac{c-\rho m}{1-\rho}$

We start by proving sufficiency, i.e., if $\mu > \frac{c-\rho m}{1-\rho}$ then the mass market equilibrium exists.

First, we show that $R_i^m > S_i^m > c$, assuming that the prices given by equations (7) and (8) are indeed an equilibrium. Since the equilibrium is symmetric, proving $R_i^m > S_i^m$ is equivalent to proving that $R_i^m > S_{-i}^m$. Suppose $R_i^m \leq S_{-i}^m$ instead, then it must be true that $\theta_i^{SO} < \theta_i^{RS} \leq \mu$ and, thus, that S_{-i}^m must satisfy the following inequalities:

$$S_{-i}^m - c = \frac{(1-\rho)[F(\theta_i^{RS}) - F(\theta_i^{SO})]}{f(\theta_i^{RS}) + \frac{1-\rho}{\rho}f(\theta_i^{SO})} < \frac{(1-\rho)[F(\theta_i^{RS}) - F(\theta_i^{SO})]}{f(\theta_i^{RS})} < \frac{(1-\rho)[1 - F(\theta_i^{RS})]}{f(\theta_i^{RS})} = R_i^m - c.$$

The last inequality is due to $1 - F(\theta_i^{RS}) \geq \frac{1}{2} > F(\theta_i^{RS}) - F(\theta_i^{SO})$ because of $\theta_i^{SO} < \theta_i^{RS} \leq \mu$. Hence, there is a contradiction. Given that $R_i^m > S_{-i}^m$, we have $\theta_i^{RS} > \mu$.

Second, we prove that equations (7) and (8) are indeed an equilibrium strategy, given that $\mu \geq \frac{c-\rho m}{1-\rho}$. The following first-order derivative of expression (5) with $\theta^{RS} > \theta^{RO} > \theta^{SO} > -\infty$ w.r.t R_i equals zero when replacing R_i with equation (7):

$$\lambda_i[1 - F(\theta_i^{RS})]\left[1 - \frac{R_i - c}{1-\rho}\frac{f(\theta_i^{RS})}{1 - F(\theta_i^{RS})}\right] = 0 \tag{16}$$

To show that equation (7) is the maximum and not a minimum, recall our assumption on the monotone hazard rate condition and the fact that θ_i^{RS} increases in R_i due to equation (1) and $\rho > 0$. Then, the derivative in equation (16) is positive when $R_i < R_i^m$ and negative when $R_i > R_i^m$. Finally, note that fixing S_{-i}^m, the RHS of equation (7) is a decreasing function of R_i^m, and the LHS is increasing in R_i^m. Hence, there exists a unique R_i^m for each S_{-i}^m.

Similarly, the first-order derivative of expression (5) with $\theta^{RS} > \theta^{RO} > \theta^{SO} > -\infty$ w.r.t S_i

equals zero when replacing S_i with equation (8):

$$\lambda_{-i}[F(\theta_{-i}^{RS}) - F(\theta_{-i}^{SO})] \left[1 - \frac{S_i^m - c}{\rho(1-\rho)} \frac{\rho f(\theta_{-i}^{RS}) + (1-\rho)f(\theta_{-i}^{SO})}{F(\theta_{-i}^{RS}) - F(\theta_{-i}^{SO})}\right]$$

$$= \lambda_{-i}[F(\theta_{-i}^{RS}) - F(\theta_{-i}^{SO})] \left[1 - \frac{S_i^m - c}{\rho(1-\rho)} \underbrace{\frac{\rho \frac{f(\theta_{-i}^{RS})}{1-F(\theta_{-i}^{SO})} + (1-\rho)\frac{f(\theta_{-i}^{SO})}{1-F(\theta_{-i}^{SO})}}{\frac{F(\theta_{-i}^{RS}) - F(\theta_{-i}^{SO})}{1-F(\theta_{-i}^{SO})}}}_{h(S_i^m)}\right]$$

$$= 0.$$

In order for S_{-i}^m given by equation (7) to be the profit maximizer, $h(\cdot)$ has to be an increasing function. We now show that the function $h(\cdot)$ is an increasing function. Suppose $\theta_{-i}^{SO} > \mu$, then $h(\cdot)$ is an increasing function because: (a) θ_{-i}^{SO} is increasing in S_i while θ_{-i}^{RS} is decreasing in S_i, hence, the denominator of $h(\cdot)$ is decreasing in S_i; (b) $\frac{f(\cdot)}{1-F(\cdot)}$ is an increasing function; (c) $\frac{F(\theta_{-i}^{RS}) - F(\theta_{-i}^{SO})}{1-F(\theta_{-i}^{SO})}$ is decreasing in S_i^m, which can be shown by taking first-order derivative w.r.t S_i^m. Hence, $h(\cdot)$ is increasing in S_i.

Suppose instead $\theta_i^{SO} \leq \mu$, then $f'(\theta_{-i}^{SO}) \geq 0$. The first-order derivative w.r.t S_i of $h(S_i)$ is:

$$\frac{dh(S_i)}{dS_i} = \frac{1}{[F(\theta_{-i}^{RS}) - F(\theta_{-i}^{SO})]^2} \left\{ \left[\rho f'(\theta_{-i}^{RS})\frac{d\theta_{-i}^{RS}}{dS_i} + (1-\rho)f'(\theta_{-i}^{SO})\frac{d\theta_{-i}^{SO}}{dS_i}\right] [F(\theta_{-i}^{RS}) - F(\theta_{-i}^{SO})] \right.$$

$$\left. - \left[\rho f(\theta_{-i}^{RS}) + (1-\rho)f(\theta_{-i}^{SO})\right] \left[f(\theta_{-i}^{RS})\frac{d\theta_{-i}^{RS}}{dS_i} - f(\theta_{-i}^{SO})\frac{d\theta_{-i}^{SO}}{dS_i}\right] \right\}$$

$$= \frac{1}{[F(\theta_{-i}^{RS}) - F(\theta_{-i}^{SO})]^2} \left\{ \left[-f'(\theta_{-i}^{RS})\frac{\rho}{1-\rho} + f'(\theta_{-i}^{SO})\frac{1-\rho}{\rho}\right] [F(\theta_{-i}^{RS}) - F(\theta_{-i}^{SO})] \right.$$

$$\left. + \left[\rho f(\theta_{-i}^{RS}) + (1-\rho)f(\theta_{-i}^{SO})\right] \left[f(\theta_{-i}^{RS})\frac{1}{1-\rho} + f(\theta_{-i}^{SO})\frac{1}{\rho}\right] \right\} > 0$$

where $\frac{d\theta_{-i}^{RS}}{dS_i} = -\frac{1}{1-\rho}$ and $\frac{d\theta_{-i}^{SO}}{dS_i} = \frac{1}{\rho}$. The above derivative is positive because $f'(\theta_{-i}^{RS}) < 0$, due to $\theta_{-i}^{RS} > \mu$, and $f'(\theta_{-i}^{SO}) \geq 0$. Thus, again we know that $h(\cdot)$ is an increasing function and S_{-i}^m is the unique maximum of expression (5) given each R_i^m.

Last, we prove that $\theta_i^{RS} - R_i^m > 0$ when $\mu > \frac{c-\rho M}{1-\rho}$, that is, the marginal repeat consumer strictly prefers to stay in the market rather than choosing the outside option. Suppose instead $\theta_i^{RS} - R_i^m \leq 0$, then it must be true that $R_i^m \geq m$. To see why, suppose $m > R_i^m \geq \theta_i^{RS}$. Then

$$m = \frac{(1-\rho)[1-F(m)]}{f(m)} + c < \frac{(1-\rho)[1-F(\theta_i^{RS})]}{f(\theta_i^{RS})} + c = R_i^m$$

where the inequality is due to monotone hazard rate assumption. A contradiction. Thus,

$R_i^m \geq m$. Since $\theta_i^{RS} - R_i^m \leq 0$ implies $\rho\theta_i^{RS} + (1-\rho)\mu \leq S_{-i}^m$, which in turn implies $\theta_i^{SO} \geq \theta_i^{RS}$ according to $S_{-i}^m \equiv \rho\theta_i^{SO} + (1-\rho)\mu$, thus $S_{-i}^m \leq c$ due to equation (8).

Now we show that if $\theta_i^{RS} - R_i^m \leq 0$, then $\rho R_i^m + (1-\rho)\mu \leq c$. Suppose the reverse is true, then $\rho R_i^m + (1-\rho)\mu > c \geq S_{-i}^m$, which implies $[\rho R_i^m + (1-\rho)\mu] - [\rho\theta_i^{SO} + (1-\rho)\mu] = \rho(\theta_i^{RO} - \theta_i^{SO}) > 0$ and hence $\theta_i^{RO} > \theta_i^{SO}$. Thus, we have $\theta_i^{RO} > \theta_i^{SO} \geq \theta_i^{RS}$. When $\theta_i^{RS} = \theta_i^{SO}$, we have $\rho\theta_i^{RS} + (1-\rho)\mu - S_i^m = 0$, which then implies $\theta_i^{RS} - \theta_i^{RO} = \theta_i^{RS} - R_i^m = 0$, which contradicts $\theta_i^{RS} < \theta_i^{RO}$. When $\theta_i^{RS} < \theta_i^{SO}$ and hence $\theta_i^{RS} < \theta_i^{SO} < \theta_i^{RO}$, then we have $\rho = \frac{\theta_i^{RS} - \theta_i^{RO}}{\theta_i^{RS} - \theta_i^{SO}} > 1$, which contradicts $\rho \in (0,1)$. Hence, $\rho R_i^m + (1-\rho)\mu \leq c$.

In sum, if $\theta_i^{RS} - R^m \leq 0$ is true, then $\rho R^m + (1-\rho)\mu \leq c$ which implies $\rho m + (1-\rho)\mu \leq c$, i.e., $\mu \leq \frac{c-\rho m}{1-\rho}$. A contradiction. Therefore, it must be true that $\theta_i^{RS} - R_i^m > 0$.

Now we prove necessity, i.e., if there exists a mass market equilibrium, then $\mu > \frac{c-\rho m}{1-\rho}$. Suppose $m \leq R_i^m$, then according to $\theta_i^{RS} > R_i^m$ in the mass market equilibrium, we have

$$m = \frac{(1-\rho)[1 - F(m)]}{f(m)} + c > \frac{(1-\rho)[1 - F(\theta_i^{RS})]}{f(\theta_i^{RS})} + c = R_i^m.$$

A contradiction. Hence, $m > R_i^m$. Suppose $\mu \leq \frac{c-\rho m}{1-\rho}$, then $\rho R_i^m + (1-\rho)\mu < \rho m + (1-\rho)\mu \leq c$. This, and the fact that in the mass market equilibrium with positive correlation $\theta_i^{RS} > \theta_i^{RO} > \theta_i^{SO}$ holds, imply that $S_i^m \equiv \rho\theta_i^{SO} + (1-\rho)\mu < \rho\theta_i^{RO} + (1-\rho)\mu \equiv \rho R_i^m + (1-\rho)\mu < c < S_i^m$. A contradiction. Hence, it must be true that $\mu > \frac{c-\rho m}{1-\rho}$.

Regarding uniqueness, since the solutions to R_i^m and S_i^m given by equations (7) and (8) are unique, we know that the mass market equilibrium must be the unique mass market equilibrium. No niche and semi-niche market equilibria exist either due to $\mu > \frac{c-\rho m}{1-\rho}$, according to steps 1 and 2 of this proof. Q.E.D.

Proof of Proposition 2.

Recall from Proposition 1 that there are no switchers in either the niche or the semi-niche market equilibrium.

Suppose firm i deviates to a price slightly lower than the p_i^k where $k \in \{n, s\}$ given in the proposition, then it obtains all the market in the first period, i.e., $\lambda_i = 1$. Its second-period profit increases by $\delta\lambda_{-i}\Pi^k$ (where $\Pi^n = \pi(M)$ and $\Pi^s = \pi(R_i^s)$), while its first-period profit decreases by $\lambda_{-i}(c - p_i^k) = \lambda_{-i}\delta\Pi^k$, which is the same as the former profit increment. Hence, any price lower than p_i^k is not a profitable deviation. Alternatively, suppose firm i deviates to a price higher than p_i^k, then it loses all market share in the first period. Given the second-period equilibrium prices, no consumers would switch from the competitor to firm i, hence, firm i's total profit is zero. Thus, raising first-period price above p_i^k is not a profitable deviation.

Note that the proof here applies to any $\lambda_i \in [0, 1]$ such that $\lambda_i + \lambda_{-i} = 1$ and that when both firms sell only in the second period they end up in Bertrand competition with zero profits, which is no greater than their equilibrium profit of zero. Therefore, there is no profitable deviation for either firm in terms of first-period price and whether to sell only in the second period.

Regarding the consumers' choice, we start with the first-period choice given that firms play the niche market equilibrium in the second period, i.e., given $\mu \leq \frac{c - \rho M}{1 - \rho}$. Consumers' surplus given that $\mu \leq \frac{c - \rho M}{1 - \rho}$ is

$$
\begin{aligned}
& (\mu - p_i^n) + \delta \int_M^\infty (x - M) \, dF(x) \\
= \; & (\mu - c) + \delta \pi(M) + \delta \int_M^\infty (x - c) \, dF(x) - \delta \int_M^\infty (M - c) \, dF(x) \\
= \; & (\mu - c) + \delta \underbrace{\int_M^\infty (x - c) \, dF(x)}_{SS(M)}
\end{aligned}
$$

Hence, the above consumer surplus is non-negative if and only if $\mu - c \geq -\delta \cdot SS(M)$. Since purchasing only in the second period yields a payoff of $\mu - S_i^n \leq \frac{c - \rho \cdot M}{1 - \rho} - S_i^n < c - S_i^n \leq 0$, no consumer prefers to do so.

The equilibrium followed by a second-period niche market equilibrium is the unique equilibrium because Proposition 1 shows that the niche market equilibrium is unique and there exists no equilibrium in which firms charge different prices in the first period. Suppose they do. Then, the firm that charges the higher price finds it profitable to deviate to a price lower than the competitor's price.

Next, we turn to the first-period choice of consumers followed by a semi-niche market equilibrium in the second period. Recall from Proposition 1 in the paper, a continuum of semi-niche market equilibria exists if and only if $\mu \leq \frac{c - \rho \iota}{1 - \rho}$ with $\iota \in [m, M]$. There are no switchers in the semi-niche market equilibrium given that $\rho \in (0, 1)$.

Consumers' surplus given a specific semi-niche market with prices $R_i^s \in [m, \iota]$ and $S_i^s = \rho R_i^s + (1 - \rho)\mu$ and $\mu \leq \frac{c - \rho R_i^s}{1 - \rho}$ is the following:

$$
\begin{aligned}
& (\mu - p_i^s) + \delta \int_{R_i^s}^\infty (x - R_i^s) \, dF(x) \\
= \; & (\mu - c) + \delta \cdot \pi(R_i^s) + \delta \int_{R_i^s}^\infty (x - c) \, dF(x) - \delta \int_{R_i^s}^\infty (R_i^s - c) \, dF(x) \\
= \; & (\mu - c) + \delta \underbrace{\int_{R_i^s}^\infty (x - c) \, dF(x)}_{SS(R_i^s)}.
\end{aligned}
$$

Hence, the above consumers' surplus is non-negative if and only if $\mu - c \geq -\delta \cdot SS(R_i^s)$. Suppose a consumer purchased only in the second period, then her surplus is given by $\mu - S_i^s = \mu - \rho R_i^s - (1-\rho)\mu = \rho(\mu - R_i^s) < \rho(c-m) < 0$. Hence, all consumers purchase one of the products in the first period. Q.E.D.

Proof of Proposition 3.

According to Proposition 1, the second-period equilibrium prices given any λ_i are invariant w.r.t. λ_i. Hence, consumers' expected surplus from the second period is invariant to their purchasing decision in the first period. Thus, consumers purchase the good with the lowest price in the first period.

In the first period, firms compete by choosing a price such that:

$$\lambda_{-i}(c - p_i^m) = \delta \left(\lambda_{-i} \pi_i^{Rm} - \lambda_{-i} \pi_i^{Sm} \right). \tag{17}$$

Suppose the profit from repeat consumers is greater than from switchers, then firms compete by lowering their prices to the point satisfying equation (17). In this way, the first-period loss equals the second-period gain. Neither firm prefers to deviate from such an equilibrium. If firm i deviates to any price higher than p_i^m in the first period, its first-period profit increases by $\lambda_i(c - p_i^m)$ to 0 and its second-period profit decreases by $\lambda_i \pi_i^{Rm} - \lambda_i \pi_i^{Sm}$, thus the total change of its profit is 0 since, according to equation (17), $\lambda_i(c - p_i^m) - \delta \left(\lambda_i \pi_i^{Rm} - \lambda_i \pi_i^{Sm} \right) = 0$. If, instead, firm i deviates to a slightly lower price $p_i^m - \epsilon$ where ϵ is arbitrarily small, then its first-period profit decreases by $\lambda_{-i}(c - p_i^m)$ and its second-period profit increases by $\lambda_{-i} \pi_i^{Rm} - \lambda_{-i} \pi_i^{Sm}$, and the total change of profit is also zero. Any price even lower than $p_i^m - \epsilon$ is strictly dominated. Hence, there is no profitable deviation. Suppose instead that firms make a greater profit from switchers than from repeat consumers, then they would increase their price in the first period up to a point where equation (17) is satisfied. A similar argument that there is no profitable deviation follows.

For consumers, their surplus given the equilibrium prices under the condition $\mu \geq \frac{c - \rho m}{1 - \rho}$ is:

$$
\begin{aligned}
&(\mu - p_i^m) + \delta \left[\int_{\theta_i^{RS}}^{\infty} (x - R_i^m) \, dF(x) + \int_{\theta_i^{SO}}^{\theta_i^{RS}} \left[E(\theta_{-i}|x) - S_{-i}^m \right] dF(x) \right] \\
= \ &(\mu - c) + \delta \left[\int_{\theta_i^{RS}}^{\infty} (x - R_i^m) \, dF(x) + \pi_i^{Rm} - \pi_i^{Sm} + \int_{\theta_i^{SO}}^{\theta_i^{RS}} \left[E(\theta_{-i}|x) - S_{-i}^m \right] dF(x) \right] \\
= \ &(\mu - c) + \delta \left[\underbrace{\int_{\theta_i^{RS}}^{\infty} (x - c) \, dF(x) + \int_{\theta_i^{SO}}^{\theta_i^{RS}} \left[E(\theta_{-i}|x) - c \right] dF(x)}_{SS^m} - 2 \cdot \pi_i^{Sm} \right].
\end{aligned}
$$

In equilibrium, the above consumers' surplus must be no less than the maximum of zero and the consumer surplus from purchasing only in the second period, i.e., $\delta(\mu - S_i^m)$. Hence, the necessary and sufficient condition for the consumer to be willing to follow the equilibrium and purchase one of the products is given by:

$$\mu - c \geq -\delta \cdot \left(SS^m - 2 \cdot \pi_i^{Sm} \right) + \max \left[0, \delta(\mu - S_i^m) \right]$$

where $SS^m = \int_{\theta_i^{RS}}^{\infty} (x - c)\, dF(x) + \int_{\theta_i^{SO}}^{\theta_i^{RS}} [E(\theta_{-i} | x) - c]\, dF(x)$.

The equilibrium is unique because the mass market equilibrium in the second period is unique and there exists no equilibrium in which firms charge asymmetric prices in the first period. Suppose they do and $\pi_i^{Rm} > \pi_i^{Sm}$. Then, the firm who charges lower price finds it profitable to deviate to a slightly higher price that is still below the competitor's price. A similar reasoning follows when $\pi_i^{Rm} \leq \pi_{-i}^{Sm}$. Q.E.D.

Proof of Proposition 4.

Fixing firm $-i$ choosing its equilibrium price R_{-i}^m, we use the envelope theorem to show the relationship between ρ and π_i^{Sm}. Firm i chooses S_i to maximize the profit from switching consumers given the competitor's *equilibrium* price R_{-i}^m, which is a function of ρ. That is, given that the competitor chooses its equilibrium price to repeat customers, i.e., $R_{-i} = R_{-i}^m$ where R_{-i}^m is given by equation (7), firm i chooses S_i to maximize equation (5).

Applying the envelope theorem, the first-order derivative of the equilibrium profit π_i^{Sm} with respect to ρ yields:

$$
\begin{aligned}
\frac{d\pi_i^{Sm}}{d\rho} &= (S_i - c) \left[\frac{d\theta_{-i}^{RS}}{d\rho} f(\theta_{-i}^{RS}) - \frac{d\theta_{-i}^{SO}}{d\rho} f(\theta_{-i}^{SO}) \right] \Bigg|_{S_i = S_i^m} + \underbrace{\frac{\partial \pi_i^{Sm}}{\partial S_i} \Bigg|_{S_i = S_i^m}}_{=0} \frac{dS_i^m}{d\rho} \\
&= (S_i - c) \cdot \left[f(\theta_{-i}^{RS}) \frac{\frac{dR_{-i}^m}{d\rho}(1 - \rho) + R_{-i}^m - S_i}{(1 - \rho)^2} - f(\theta_{-i}^{SO}) \frac{\mu - S_i}{\rho^2} \right] \Bigg|_{S_i = S_i^m}
\end{aligned}
$$

Hence, as long as

$$\frac{dR_{-i}^m}{d\rho}(1 - \rho) + R_{-i}^m - S_i \geq 0$$

i.e.,

$$-\frac{dR_{-i}^m}{d\rho} \leq \frac{R_{-i}^m - S_i}{1 - \rho} \tag{18}$$

and

$$S_i \geq \mu \tag{19}$$

hold when $S_i = S_i^m$, and the equalities do not hold simultaneously, we have $\frac{d\pi_i^{Sm}}{d\rho} > 0$.

We can calculate $\frac{dR_{-i}^m}{d\rho}$ in equation (18) by taking the derivative w.r.t ρ on both sides of equation (7), i.e.,

$$R_{-i}^m = \frac{(1-\rho)\left[1 - F\left(\mu + \frac{R_{-i}^m - S_i^m}{1-\rho}\right)\right]}{f\left(\mu + \frac{R_{-i}^m - S_i^m}{1-\rho}\right)} + c.$$

This yields

$$\frac{dR_{-i}^m}{d\rho} = -\frac{1 - F(\theta_{-i}^{RS})}{f(\theta_{-i}^{RS})} + (1-\rho)\left[\frac{1 - F(\theta_{-i}^{RS})}{f(\theta_{-i}^{RS})}\right]' \frac{\left(\frac{dR_{-i}^m}{d\rho} - \frac{dS_i^m}{d\rho}\right)(1-\rho) + R_{-i}^m - S_i^m}{(1-\rho)^2},$$

where $\theta_{-i}^{RS} = \mu + \frac{R_{-i}^m - S_i^m}{1-\rho}$ and R_{-i}^m and S_i^m are mass market equilibrium prices, which implies

$$\frac{dR_{-i}^m}{d\rho} = \frac{\left[\frac{1 - F(\theta_{-i}^{RS})}{f(\theta_{-i}^{RS})}\right]'\left(\frac{R_{-i}^m - S_i^m}{1-\rho} - \frac{dS_i^m}{d\rho}\right) - \frac{1 - F(\theta_{-i}^{RS})}{f(\theta_{-i}^{RS})}}{1 - \left[\frac{1 - F(\theta_{-i}^{RS})}{f(\theta_{-i}^{RS})}\right]'}$$

Substituting into condition (18) yields

$$\mu + \underbrace{\left[\frac{1 - F(\theta_{-i}^{RS})}{f(\theta_{-i}^{RS})}\right]'}_{<0} \frac{dS_i^m}{d\rho} \leq \underbrace{\theta_{-i}^{RS} - \frac{1 - F(\theta_{-i}^{RS})}{f(\theta_{-i}^{RS})}}_{\text{virtual valuation at } \theta_{-i}^{RS}}. \tag{20}$$

The right hand side of condition (20) is the virtual valuation at θ_{-i}^{RS} and the virtual valuation is increasing due to the normal distribution. The term $\left[\frac{1 - F(\theta_{-i}^{RS})}{f(\theta_{-i}^{RS})}\right]' < 0$ on the left hand side is negative because of the normal distribution's monotonic hazard rate property. Q.E.D.

C No information spillovers, $\rho = 0$

C.1 Second-period equilibria

When $\rho = 0$, there is no correlation between consumers' valuations so consumers who purchased good i in the first period can make no inference about good $-i$ in the second period. Proposition C.1 provides the necessary and sufficient conditions for each of the three equilibria in this case.

Proposition C.1. *Suppose $\rho = 0$ and all consumers have purchased one of the goods. Then, in the second period there exists a unique equilibrium, which is:*

- *a niche market equilibrium where $R_i^n = M$ and $S_i^n \geq c$ if and only if $\mu \leq c$;*

- *a semi-niche market equilibrium where $R_i^s = M$ and $S_i^s = \mu$ if and only if $c \leq \mu \leq M$;*[32]

- *a mass market equilibrium where $R_i^m = S_i^m = \frac{1}{2f(\mu)} + c < M$ if and only if $\mu > M$.*

Proposition C.1 states that the necessary and sufficient condition for a mass market equilibrium to exist is $\mu > M$, which is consistent with the standard definition of "mass market" in the literature (Bergemann and Välimäki, 2006; Ivanov, 2009). We are thus following the literature in naming the equilibrium as such for the $\rho = 0$ case. Note that the new product market is fully covered in this mass market equilibrium—all consumers buy i or $-i$ in the second period.

Prior studies define a "niche market" as existing if and only if $\mu < M$. Yet Proposition C.1 shows that there are two different equilibria for this parameter range. We refer to the equilibrium with no switchers as the niche market because it has the feature that only those consumers who have a high valuation for the products remain in the new market.

Firms' market power among repeat consumers is greater in the semi-niche than in the mass market equilibrium, and greater still in the niche market equilibrium, because $R_i^m < R_i^s = R_i^n$. Firms' market power among switching consumers has the opposite ordering: it is greatest in the mass market equilibrium, then the semi-niche, and then absent in the niche market equilibrium. This is because $S_i^m > S_i^s$ and the niche market equilibrium has no switchers.

We provide here a sketch of the proof for the mass market equilibrium. According to the earlier discussion, the mass market equilibrium with $\rho = 0$, given in Proposition C.1, is characterized by restricting $\theta_i^{RS} > \theta_i^{RO}$ and $\theta_{-i}^{SO} = -\infty$ in the second-period profit, equation (5).[33] First order conditions of equation (5) w.r.t R_i and S_i, respectively, yield

$$R_i^m = \frac{1 - F(\theta_i^{RS})}{f(\theta_i^{RS})} + c \quad \text{and} \quad S_i^m = \frac{F(\theta_{-i}^{RS})}{f(\theta_{-i}^{RS})} + c. \tag{21}$$

By the definition of θ_i^{RS} given in equation (1), we have

$$\theta_i^{RS} = \mu + \frac{1 - 2F(\theta_i^{RS})}{f(\theta_i^{RS})}. \tag{22}$$

In fact, the only θ_i^{RS} that satisfies equation (22) is $\theta_i^{RS} = \mu$, as the LHS of equation (22) increases in θ_i^{RS} and the RHS of equation (22) decreases in θ_i^{RS}. Replacing θ_i^{RS} and θ_{-i}^{RS} with μ in equation (21) gives $R_i^m = S_i^m = \frac{1}{2f(\mu)} + c$.[34]

---

[32] Note that when $\mu = c$, the semi-niche and the niche market equilibrium coincide.
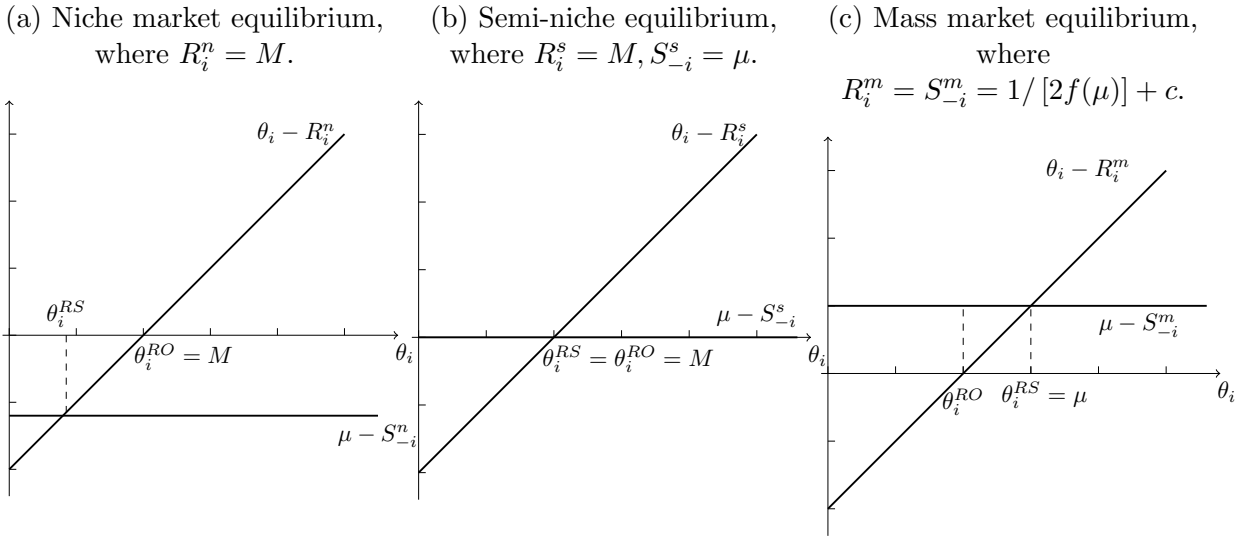
[33] The semi-niche market is characterized by construction.

[34] Observing that the willingness to pay of all switching consumers in the mass market equilibrium is equal to μ, which is greater than M, shows that it is the competition between the two firms that leads to optimal prices to repeat and switching consumers being equal to each other at a level below M.

The online appendix derives the own- and cross-price elasticities for each of the three equilibria. In the mass market case, the own-price elasticities for repeat and switching consumers, respectively, are $E_{R_i^m}^{D_i^R} = -\frac{R_i^m}{R_i^m - c}$ and $E_{S_i^m}^{D_i^S} = -\frac{S_i^m}{S_i^m - c}$. Because $R_i^m = S_i^m$, the firm's market power in each segment is shown by the markup $\frac{R_i^m - c}{R_i^m}$. In the niche market equilibrium, the own-price elasticity for repeat consumers is $E_{R_i^n}^{D_i^R} = -\frac{M}{M - c}$, and there are no switching consumers in equilibrium. The markup for repeat consumers is, hence, $\frac{M-c}{M}$. Because $R_i^m < M$, the market power of each firm in the niche market equilibrium exceeds the market power in the mass market equilibrium.

Figure C.3 illustrates the three equilibria for the $\rho = 0$ case. Panel a is the niche market equilibrium, panel b is the semi-niche market equilibrium, and panel c is the mass market equilibrium. The horizontal line in each figure is the expected value of switching to $-i$ in the second period, $(\mu - S_{-i}^k)$, where $k = n, s, m$ in the niche, semi-niche, and mass market equilibria, respectively.

Figure C.3: Second-period equilibria in $\rho = 0$ case; consumer valuations after learning θ_i.

(a) Niche market equilibrium, where $R_i^n = M$.

(b) Semi-niche equilibrium, where $R_i^s = M, S_{-i}^s = \mu$.

(c) Mass market equilibrium, where $R_i^m = S_{-i}^m = 1/\left[2f(\mu)\right] + c$.

Corollary C.1 describes firm profits in each second-period equilibrium.

Corollary C.1. *Suppose $\rho = 0$ and all consumers have purchased one of the goods. In the second period,*

- *firm i's profit in the niche market equilibrium consists of $\lambda_i \pi(M)$ from repeat consumers and zero profit from switching consumers (of which there are none).*

- *firm i's profit in the semi-niche market equilibrium consists of $\lambda_i \pi(M)$ from repeat consumers and $\lambda_{-i}(\mu - c)F(M)$ from switching consumers;*

- *firm i's profit in the mass market equilibrium consists of $\frac{\lambda_i}{4f(\mu)}$ from repeat customers and $\frac{\lambda_{-i}}{4f(\mu)}$ from switching consumers.*

In fact, the $\rho = 0$ setting is a special case of $\rho \leq 0$, which we analyze in the online appendix. All equilibrium choices in the former can be obtained by setting $\rho = 0$ in the equilibrium choices in the latter.

C.2 Sub-game perfect equilibrium of the two-stage pricing game

The niche market equilibrium applies for all new product markets that are minor innovations, i.e., whenever $\mu < c$, according to Proposition C.1. In these markets, first-period prices are such that firms make no profits.

Proposition C.2 (Zero profit equilibrium). *Suppose $\mu - c < 0$ and $\rho = 0$. If and only if $\mu \in [c - \delta \cdot SS(M), c)$, there exists an equilibrium in which firm $i \in \{A, B\}$ makes zero profit by charging $p_i^n = c - \delta\pi(M)$ in the first period and charging $R_i^n = M, S_i^n \geq c$ in the second-period niche market equilibrium given by Proposition C.1.*

When $(\mu - c)$ is sufficiently low, none of the consumers find it worthwhile to switch even though each firm charges the monopoly price to its repeat purchasers. Firms therefore compete intensely in the first period for market share. They discount the first-period price below marginal cost to the point where they make a loss in the first period that exactly offsets second-period profits and make zero profits overall.[35] The lower bound of innovation value $-\delta \cdot SS(M)$ guarantees that consumer surplus $CS_{\rho \geq 0}$ is non-negative. Note also that since buying only in the second period yields a consumer surplus of $\mu - S_i^n < 0$—assuming firms treat any new consumers as switchers regardless of whether they switch from the old technology or the rival good—all consumers purchase in the first period.

In contrast, firms make positive profits whenever the second-period equilibrium is either the mass market or the semi-niche market equilibria. According to Proposition C.1, one of these equilibria apply when the new product market is sufficiently valuable, that is, it represents a major innovation, with $\mu \geq c$. We characterize the relevant first-period equilibrium and provide necessary and sufficient conditions for its existence in Proposition C.3.

Proposition C.3 (Positive profit equilibria). *When $\mu - c \geq 0$ and $\rho = 0$:*

---

[35]In such an equilibrium, consumers obtain all the social surplus. This is precisely why the existence of the equilibrium requires $\mu \geq c - \delta \cdot SS(M)$. The condition is equivalent to $(\mu - c) + \delta \cdot SS(M) \geq 0$, in which the first term on the LHS is the social surplus from the first period and the second term is discounted social surplus from the second period. Since firms make zero profit in the equilibrium, according to the proposition, consumer surplus equals total social surplus, i.e., the LHS of the condition. The condition thus guarantees consumer surplus is non-negative, which is necessary for the equilibrium to exist.

- *if and only if $\mu > M$, there exists an equilibrium in which firm $i \in \{A, B\}$ makes a profit of $\frac{\delta}{4f(\mu)} > 0$ by charging $p_i^m = c$ in the first period and charging $R_i^m = S_i^m = \frac{1}{2f(\mu)} + c$ in the second-period mass market equilibrium given by Proposition C.1;*

- *if and only if $c \leq \mu \leq M$, there exists an equilibrium in which firm $i \in \{A, B\}$ makes a profit of $\delta(\mu - c)F(M) > 0$ by charging $p_i^s = c - \delta[\pi(M) - (\mu - c)F(M)]$ in the first period and charging $R_i^s = M, S_i^s = \mu$ in the second-period semi-niche market equilibrium given by Proposition C.1.*

In both these cases, the intensity of first-period price competition is determined by the relative profits from selling to switching and repeat customers in the second period. When the equilibrium features the semi-niche equilibrium in the second period, according to Corollary C.1, firms earn greater profits from repeat customers, and therefore set a first-period price that is lower than the marginal cost c but not low enough to offset their total future profits. When the equilibrium features the mass market equilibrium in the second period, firms make exactly the same profit from repeat and switching consumers in the second period, as shown in Corollary C.1. Neither firm is willing to discount the price below marginal cost in the first period to attract customers to earn profit in the future. The first-period resembles Bertrand competition and firms set a first-period price that equals the marginal cost c.

Consumers are willing to purchase one of the products in the first period and potentially the second period rather than only purchase in the second period. The former behavior yields the consumers a surplus no less than $\mu - c$, whereas the latter yields $\delta\left(\mu - \frac{1}{2f(\mu)} - c\right)$, which is strictly less than $\mu - c$.

In the equilibria characterized in Proposition C.2 and Proposition C.3, firms charge the same prices in both periods and consumers are indifferent in the first period. Since neither first-period nor second-period equilibrium prices depend on first-period market share, any market shares satisfying $\lambda_i + \lambda_{-i} = 1$ can hold in equilibrium. It is, however, never an equilibrium for both firms to sell only in the second period because then they face Bertrand competition since uninformed consumers are homogeneous. See details in the proofs of Proposition C.2 and Proposition C.3.

C.3 Proofs for the no information spillovers setting

Proof of Proposition C.1.

We consider each equilibrium in turn:

Step 1: Niche market equilibrium

In the niche market equilibrium, there are no switching consumers. Each firm finds it optimal to charge the monopoly price M to its repeat consumers. Suppose firm $-i$ charges a price $S_{-i} \geq c$ to the consumers of firm i. Then, the type $\theta_i = M$ has a surplus of $\mu - S_{-i} \leq \mu - c$ if she switches to $-i$. Then, a sufficient condition for the existence of the niche market equilibrium is that $\mu \leq c$, as type $\theta_i = M$ and all types with higher valuations must find it unprofitable to switch. Firm $-i$ makes zero profit from i's market in such an equilibrium, and deviating to any price below c is not profitable.

Now we turn to necessity. Suppose the niche market equilibrium exists, then the consumer with $\theta_i = M$ must find it unprofitable to switch to good $-i$, i.e., $\mu - S_{-i} \leq \theta_i - M = 0$ for any $S_{-i} \geq c$, which implies that $\mu \leq c$.

Regarding uniqueness, note that in the niche market equilibrium firms do not face any competition in their own territory. Hence, each firm behaves as a monopoly. Therefore, there does not exist any other niche market equilibrium given that $\mu < c$. No mass or semi-niche market equilibria exist either when $\mu \leq c$, according to steps 2 and 3 of this proof.

Step 2: Semi-niche market equilibrium

Firm i makes monopoly profit in its own market and firm $-i$ makes a profit of $(\mu - c)F(M)$ in firm i's market. Since firm $-i$ charges price μ, any consumers of firm i have a surplus of zero—equal to the value of the outside option—should they switch to firm $-i$. Hence, charging the monopoly price M must be optimal for firm i because its consumers are in effect choosing between purchasing from i or the outside option.

According to the sufficient condition $\mu \geq c$, firm $-i$ makes non-negative profits. Firm $-i$ cannot make greater profits from increasing the price because then no consumers from firm i would switch. Suppose firm $-i$ decreases the price to $S < \mu$, then its profit from consumers from firm i is given by

$$\int_{-\infty}^{\mu + M - S} (S - c) dF(x) = (S - c)F(\mu + M - S).$$

By the first-order derivative w.r.t S:

$$F(\mu + M - S) - (S - c)f(\mu + M - S) = F(\mu + M - S)\left[1 - (S - c)\frac{f(\mu + M - S)}{F(\mu + M - S)}\right],$$

we can find the optimal deviation price S^* given by

$$S^* = \frac{F(\mu + M - S^*)}{f(\mu + M - S^*)} + c. \tag{23}$$

The monotone hazard rate property of the normal distribution guarantees that the above solution is indeed the profit maximizer. Suppose $S^* < \mu$, then

$$S^* > \frac{F(M)}{f(M)} + c \geq \frac{1}{2f(\mu)} + c \geq \mu,$$

where the second and last inequalities are due to the sufficient condition $M \geq \mu$. This contradicts $S^* < \mu$. Thus, any deviation $S < \mu$ must be not more profitable for firm $-i$ than charging $S_i^s = \mu$. Alternatively, any deviation $S > \mu$ will not attract any switchers and hence, is dominated by charging μ.

Now we turn to necessity. Given that the semi-niche equilibrium exists, it must be true that $\mu \geq c$ as otherwise firm $-i$ prefers to deviate to a higher price to avoid a loss. To prove that $\mu \leq M$ is also a necessary condition, suppose $\mu > M$. The fact that $S_i^s = \mu$ in equilibrium implies that $S^* \geq \mu$, where S^* is given by equation (23). Otherwise, firm i would prefer a price lower than μ. But then $S^* \geq \mu$ implies that

$$S^* \leq \frac{F(M)}{f(M)} + c < \frac{1}{2f(\mu)} + c < \mu,$$

which is a contradiction. Thus, $S^* < \mu$ when $\mu > M$, which implies that charging μ is not optimal for firm $-i$. This then contradicts the existence of the equilibrium.

Now we turn to uniqueness. Suppose there exists an alternative semi-niche market equilibrium where firm i charges $\tilde{P}^{sn} \neq M$. Since both switching to firm $-i$ and choosing the outside option yield zero to consumers, firm i's price decision replicates that of a monopoly. Hence, it must hold that $\tilde{P}^{sn} = M$. Neither does there exist any mass or niche market equilibrium when $c \leq \mu \leq M$, according to steps 1 and 3 of this proof.

Step 3: Mass market equilibrium

For the mass market equilibrium, firm i's profit function is given by:

$$(R_i - c) \cdot \lambda_i \int_{\theta_i^{RS}}^{+\infty} dF(\theta_i) + (S_i - c) \cdot \lambda_{-i} \int_{-\infty}^{\theta_{-i}^{RS}} dF(\theta_{-i}).$$

Hence, the prices in the second period must satisfy the following by the first-order approach:

$$R_i^m = \frac{1 - F(\theta_i^{RS})}{f(\theta_i^{RS})} + c \quad \text{and} \quad S_i^m = \frac{F(\theta_{-i}^{RS})}{f(\theta_{-i}^{RS})} + c. \tag{24}$$

Note that there must exist unique solutions of R_i^m and S_i^m because the RHS of the two equations in (24) are decreasing in R_i^m and S_i^m, respectively.

We can find the cutoff types for any λ_i:

$$\theta_i^{RS} - \mu = R_i^m - S_{-i}^m = \frac{1 - 2F(\theta_i^{RS})}{f(\theta_i^{RS})}$$

hence,

$$\theta_i^{RS} = \mu + \frac{1 - 2F(\theta_i^{RS})}{f(\theta_i^{RS})} \tag{25}$$

Suppose $\theta_i^{RS} < \mu$, then $\frac{1-2F(\theta_i^{RS})}{f(\theta_i^{RS})} > 0$ and hence the RHS of equation (25) must be greater than μ, which is a contradiction. Suppose $\theta_i^{RS} > \mu$, then $\frac{1-2F(\theta_i^{RS})}{f(\theta_i^{RS})} < 0$ and hence the RHS of equation (25) must be less than μ. This means that it must be true that $\theta_i^{RS} = \mu$, where $i \in \{A, B\}$. Plugging $\theta^{RS} = \mu$ back into the two equations for R_i^m and S_i^m, respectively, we obtain the mass market equilibrium prices.

The above analysis is valid if and only if the prices indeed form a mass market equilibrium, i.e., $\theta^{RS} - R_i^m = \mu - \frac{1}{2f(\mu)} - c > 0$ is true. Hence, the necessary and sufficient condition for the existence of the above mass market equilibrium is

$$\mu - \frac{1}{2f(\mu)} - c > 0.$$

Given that the function $x - [1 - F(x)]/f(x) - c$ is monotonically increasing and that $M - [1 - F(M)]/f(M) - c = 0$ holds, we have $\mu > M$.

Since the solutions to R_i^m and S_i^m are unique, and according to the first two parts of the proposition, there do not exist any niche or semi-niche market equilibria when $\mu > M$, the mass market equilibrium is the unique equilibrium. Q.E.D.

Proof of Proposition C.2.

According to Proposition C.1, each firm makes monopoly profit from their repeat consumers but no profit from switching consumers as no one switches in the second period if and only if $\mu \leq c$. This suggests firms would compete for first-period market share by lowering the first-period price until the gain in the second period from additional market share balances the loss from capturing firm $-i$'s market share in the first period, i.e.,

$$\underbrace{\lambda_{-i}(c - p_i^n)}_{\text{loss}} = \underbrace{\delta\lambda_{-i}\pi^M}_{\text{gain}}.$$

Neither firm prefers to deviate from such an equilibrium. If firm i deviates to any price higher than p_i^n in the first period, its first-period profit increases by $\lambda_i(c - p_i^n)$ to zero and

its second-period profit decreases by $\lambda_i \pi(M)$, thus the total change of its profit is zero since $\lambda_i(c - p_i^n) - \delta \lambda_i \pi(M) = 0$. If, instead, firm i deviates to a lower price $p_i^n - \epsilon$ where ϵ is arbitrarily small in the first period, then its first-period profit decreases by $\lambda_{-i}(c - p_i^n)$ and its second-period profit increases by $\lambda_{-i} \pi(M)$, and the total change of profit is also 0. Any price even lower than $p_i^n - \epsilon$ is strictly dominated. Hence, there is no profitable deviation for firms.

Note that the above proof applies to any $\lambda_i \in [0, 1]$. This implies that when firm i sells only in the second period while firm $-i$ sells in both periods such that $\lambda_i = 0$, both firms' profit stays unchanged. When firm i sells only in the second period given that firm $-i$ does the same, demand is zero because no consumer would purchase as $\mu - c < 0$. Hence, they also make zero profit. This means that there exists a variety of zero-profit equilibria in which either $\lambda_i + \lambda_{-i} = 1$ when $\max(\lambda_i, \lambda_{-i}) > 0$ or $\max(\lambda_i, \lambda_{-i}) = 0$.

Consumers' surplus is given by

$$
\begin{aligned}
& (\mu - c) + \delta \pi(M) + \delta \int_M^\infty (x - M)\, dF(x) \\
=\ & (\mu - c) + \delta \pi(M) + \delta \int_M^\infty (x - c)\, dF(x) - \delta \int_M^\infty (M - c)\, dF(x) \\
=\ & (\mu - c) + \delta \int_M^\infty (x - c)\, dF(x).
\end{aligned}
$$

Hence, the consumer surplus is only non-negative if and only if the total discounted social surplus over the two periods is non-negative. Since purchasing only in the second period yields a payoff of $\mu - S_i^n < c - S_i^n \leq 0$, all consumers wish to buy in the first period. Q.E.D.

Proof of Proposition C.3.

Note that according to Proposition C.1, all the second-period equilibrium prices are invariant to λ_i. Hence, consumers' expected surplus from the second period is invariant to their purchasing decision in the first period, which implies that they would purchase the good with the lower price in the first period.

We now prove the proposition in two steps.

Step 1. The equilibrium in the second-period sub-game is the mass market equilibrium

In the mass market, each firm makes exactly the same profit from the repeat and the switching customers and thus, its second-period profit does not vary with the first-period market share. Hence, firms compete in the first period as in Bertrand competition by lowering their first-period prices to the marginal cost.

Consumers' discounted surplus over the two periods is given by

$$(\mu - c) + \delta \left[\underbrace{\int_{\theta_i^{RS}}^{\infty} (x - R_i^m) \, dF(x) + \int_{-\infty}^{\theta_i^{RS}} \left[E(\theta_{-i}|x) - S_{-i}^m \right] dF(x)}_{\geq 0} \right] > 0.$$

Consumers must have non-negative surplus in the second period since they are free to leave the market otherwise, hence the terms in the brackets must be non-negative. The above consumer surplus is positive since $\mu \geq M > c$. It is also easy to verify that the above consumer surplus is no less than the surplus from purchasing only in the second period, given by $\delta(\mu - S_i^m) = \delta \left(\mu - \frac{1}{2f(\mu)} - c \right)$. Thus, consumers are willing to purchase one of the products in the first period.

Firms do not wish to sell only in the second period for the following reasons. Given that firm $-i$ sells in both periods, selling only in the second period yields firm i the same profit as given in the Proposition. If firm $-i$ were selling only in the second period, firm i would not find it profitable to sell only in the second period because Bertrand competition would follow and both firms would make zero profit. Therefore, selling only in the second period is weakly dominated for each firm.

Step 2. The equilibrium in the second-period sub-game is the semi-niche market equilibrium

Suppose $\pi(M) = (M - c)[1 - F(M)] \geq (\mu - c)F(M)$, then firms compete for higher market share in the first period by lowering price. Then, through a procedure similar to Step 1 we can prove that the first-period equilibrium price must satisfy $p_i^s = c - \delta \left[\pi(M) - (\mu - c)F(M) \right]$.

For consumers, their surplus is given by

$$(\mu - c) + \delta \left[\pi(M) - (\mu - c)F(M) \right] + \delta \int_M^{\infty} (x - M) \, dF(x) > 0,$$

which is positive since $\mu \geq c$, $\pi(M) \geq (\mu - c)F(M)$, and $\int_M^{\infty} (x - M) \, dF(x) > 0$. Since purchasing only in the second period also yields $\delta(\mu - \mu) = 0$, the fact that the above consumer surplus is positive implies that no consumer wishes to purchase only in the first period. Hence, all consumers are purchase one of the products in the first period.

Suppose instead, $\pi(M) < (\mu - c)F(M)$, i.e., $(M - c)[1 - F(M)] < (\mu - c)F(M)$, then firms may prefer less market share in the first period as they make greater profit from poaching customers from the competitor. Then, they would increase price in the first period up to a point

$$\lambda_i(p_i^s - c) = \delta \lambda_i \left[(\mu - c)F(M) - \pi(M) \right],$$

where the LHS is the profit of firm i by obtaining a market share in the first period and the RHS is the opportunity cost of getting λ_i of first-period market share. Suppose firm i deviates to an even higher price, then it loses the profit $\lambda_i(p_i^s - c)$ in the first period and gains $\delta\lambda_i\left[(\mu - c)F(M) - \pi(M)\right]$ in the second period. The loss and the gain balance each other, which implies that the deviation is not profitable. Alternatively, suppose firm i deviates to a slightly lower price, then it obtains an additional profit of $\lambda_{-i}(p_i^s - c)$ in the first period and loses the profit of $\delta\lambda_{-i}\left[(\mu - c)F(M) - \pi(M)\right]$ in the second period. Again, the two balance each other and the deviation is not profitable. Any price lower than $p_i^s - \epsilon$, where ϵ is sufficiently small, is dominated. Hence, the firm charges exactly the same first-period price as when $\pi(M) \geq (\mu - c)F(M)$.

Note that, as in the proof of Proposition C.2, firms' equilibrium profit is a constant for any $\lambda_i \in [0, 1]$ such that $\lambda_i + \lambda_{-i} = 1$. Furthermore, firms end up in Bertrand competition and make zero profit if both of them sell only in the second period. Therefore, selling only in the second period is weakly dominated.

For consumers, the surplus is given by

$$
\begin{aligned}
&(\mu - c) - \delta((\mu - c)F(M) - \pi(M)) + \delta \int_M^\infty (x - M)\, dF(x) \\
={}& (\mu - c) - \delta((\mu - c)F(M) - \pi(M)) + \delta \int_M^\infty (x - c)\, dF(x) - \delta \int_M^\infty (M - c)\, dF(x) \\
={}& (\mu - c) - \delta(\mu - c)F(M) + \delta \int_M^\infty (x - c)\, dF(x) \\
={}& (\mu - c)\left[1 - \delta F(M)\right] + \delta \int_M^\infty (x - c)\, dF(x) > 0.
\end{aligned}
$$

The above consumer surplus is positive because $\mu \geq c$ and $M > c$. This implies that no consumer wishes to purchase only in the second period. Hence, consumers purchase one of the products in the first period. Q.E.D.

D N firms

In this appendix, we first generalize our two-firm setting to an N-firms setting. Then, we further generalize the model to a $2 \leq T < N$ setting. It will become clear that when the number of firms is strictly greater than the number of periods, each firm's overall profit is driven down to zero by competition. Finally, we show that firms always make a positive profit when the number of periods is no less than the number of firms, that is, when $T \geq N$. In all the extensions, we continue assuming that the marginal distributions of consumers' valuations of the goods are symmetric, and the correlation coefficient between the valuations of any two goods is given by

the same $\rho \in [0, 1]$.

D.1 N-firms, two-period model

Since all of the untried products are valued equally by a consumer after trial of one product, sellers of the untried products must compete in Bertrand competition and set their prices to switchers equal to the marginal cost. That is, $S_i = c$ for all $i \in N$. Despite the fact that consumers with the same first-period trial are heterogeneous due to their varying valuations for the sampled good, each of them strictly prefers the cheapest untried product should they choose to switch. This intensifies competition between the untried products and drives firms' profits from switchers down to zero. That is, $\pi_i^S = 0$ for $i \in N$. In line with Theorem 1, because firms make zero profits from switchers, they compete in the first period for market share. Therefore, the first-period competition drives down all firms' overall profit to zero.

The above discussion implies that firm i's second-period profit in the N-firm setting equals the profit from repeat customers:

$$\underbrace{(R_i - c) \cdot \lambda_i \int_{\max(\theta_i^{RS}, \theta_i^{RO})}^{+\infty} dF(\theta_i)}_{\text{profit from repeat customers}}. \tag{26}$$

Since $S_i = c$, we have

$$\theta_i^{RS} = \mu + \frac{R_i - c}{1 - \rho}. \tag{27}$$

We can then obtain the second-period price to repeat customers by taking the first-order derivative with respect to R_i. In a mass market equilibrium, we have

$$\widehat{R}_i^m = \frac{(1 - \rho) \left[1 - F\left(\mu + \frac{\widehat{R}_i^m - c}{1 - \rho}\right) \right]}{f\left(\mu + \frac{\widehat{R}_i^m - c}{1 - \rho}\right)} + c. \tag{28}$$

Recall that in the $N = 2$ setting we have

$$R_i^m = \frac{(1 - \rho) \left[1 - F\left(\mu + \frac{R_i^m - S_i^m}{1 - \rho}\right) \right]}{f\left(\mu + \frac{R_i^m - S_i^m}{1 - \rho}\right)} + c \tag{29}$$

and that $S_i^m > c$ holds. Hence, it must be true that $\widehat{R}_i^m < R_i^m$ because the right hand side of equation (29) is increasing in S_i^m. This implies that both the prices to repeat and switching customers are lower in the $N = 3$ than in the $N = 2$ setting. When N increases from three,

these prices hold constant.

Now we turn to the first period. Denote by $\lambda_i \pi^{R*}$ firm i's second-period profit from repeat consumers. Theorem D.1 shows that as the number of products increases from two to three, there is a sudden drop of profit, following the discussion at the beginning of this section.

Theorem D.1. *For any $\rho \in [-1, 1]$ and $N > 2$, firm i's first-period price in any symmetric equilibrium with any market share $\lambda_i \in [0, 1]$ is given by $p^* = c - \delta \pi^{R*}$ and its profit in the two-stage pricing game is zero.*

Proof. Since the products are still ex-ante homogeneous from the consumers' perspective, consumers purchase the lowest-priced product in the first period. Firm i benefits from increasing first-period market share because it can only make a profit from repeat customers in the second period. Then, all firms compete for first-period market share by lowering the first-period price below c until the overall profit equals zero. This part of the proof follows from the proof of Theorem 1 by letting $\pi^{S*} = 0$. In addition, there is no firm that wishes to deviate to sell only in the second period because there are always $N - 2 \geq 1$ competitors for every switcher and such competition drives the profit down to zero. Q.E.D.

Theorem D.1 illustrates that whenever there are more than two firms, and only two periods, all firms' profits are driven down to zero. The intuition behind this result is the same as in the two-firm case: In two-period price competition, the profit of each firm only depends on the profit from switching customers. Thus, firms make zero profit if the profit from switchers is zero, as in the current $N > 2$ setting, or if there is no consumer switching in equilibrium, as in the niche and semi-niche market equilibrium in the $N = 2$ setting.

When N increases from two to three, the second-period price to repeat consumers decreases from R_i^m to $\widehat{R}_i^m$ and the price to switchers drops from S_i^m to the marginal cost c. The difference in the first-period price between the $N = 2$ and $N = 3$ settings is ambiguous and depends on the relative magnitude of profits from repeat consumers in the two settings as well as the profit from switching consumers in the former setting.

D.2 N-firms T-periods model with $T < N$

The previous subsection has illustrated that with more than two firms, each firm's profit in the two-period game is always zero. We now extend this result to a multiple period model with the restriction that the number of firms is strictly greater than the number of periods. To do so, we consider a $T = 3, N = 4$ model to illustrate the main trade-off that firms face in choosing their prices.

Denote by π_i^{kl} the third-period profit of firm $i \in N \equiv \{1, 2, 3, 4\}$ from the segment of consumers that has experienced product $k \in \{1, 2, 3, 4\}$ in the first period and product $l \in \{0, 1, 2, 3, 4\}$ in the second period. Note that $l = 0$ refers to the segment of consumers that chooses the outside option in the second period. Denote by π_i^k the second-period profit of firm i from the segment of consumers who experienced product $k \in \{1, 2, 3, 4\}$.

Lemma D.1. *The third-period profits from all segments of consumers are non-negative in any equilibrium.*

Proof. Suppose $\pi_i^{kl} < 0$ for some k, l, and i. Then, firm i has a profitable deviation to not sell in the third period. Q.E.D.

Lemma D.2. *If $k, l \neq i$, then the third-period profit satisfies $\pi_i^{kl} = 0$ in any equilibrium.*

Proof. The segment of consumers with $k, l \neq i$ has never experienced product i and, hence, firm i has to compete against another firm j with $j \neq k, l$. Since this segment finds products i and j indifferent, firm i and j compete in a Bertrand competition and the equilibrium prices equal to the marginal cost. Thus, $\pi_i^{kl} = 0$ when $i \neq k, l$. Q.E.D.

Lemma D.2 implies that if $\pi_i^{kl} > 0$, then it must be true that at least one of k and l equals i. In other words, if a firm can make a profit in the third period, it must be made from segments of consumers who have experienced its product in previous periods. This feature of third-period profits shapes the competitive behavior in the second period.

Lemma D.3. *In any equilibrium, firm i's second-period profit satisfies $\pi_i^k = -\delta\pi_i^{ki} \leq 0$ if $k \neq i$ and satisfies $\pi_i^k > 0$ if $k = i$ instead.*

Proof. Without loss of generality, let us consider firm 1's second-period profit from customers switching from firm 2. Firm 1 competes for this segment of customers against firm 3 and 4. Each consumer weighs $\theta_2 - R_2$ plus an expected utility from learning in the future against $E(\theta_1|\theta_2) - S_1$, $E(\theta_3|\theta_2) - S_3$, or $E(\theta_4|\theta_2) - S_4$, plus another expected utility from learning, where R_2 is firm 2's price to repeat customers, S_1, S_3, S_4 are firm $1, 3, 4$'s prices to customers who switch from product 2. Note that $E(\theta_1|\theta_2) = E(\theta_3|\theta_2) = E(\theta_4|\theta_2)$ because the products are ex-ante homogeneous and that the expected utility from learning in the future must be the same after purchasing product $1, 3,$ or 4 due to products being ex-ante symmetric. Since firms $1, 3,$ and 4 make a non-negative third-period profit from the segment that purchases product 2 in the first period and their product in the second period, each of them has an incentive to lower the switching price to attract as many of firm 2's customers as possible. In equilibrium, their switching prices must equal to $S^* = c - \delta\pi_i^{ki}$, with $i = 1, 3, 4$. To show that S^* is indeed

the equilibrium price, suppose firm 1 deviates by charging a higher price while firm 3 and 4 charge S^*. Then, firm 1 suffers a loss because it can not attract any of firm 2's customers and has to forgo a profit of π_1^{21} in the third period. Suppose instead firm i deviates to a slightly lower price $S^* - \epsilon$, then it attracts all firm 2's switching customers and yields a profit of π_1^{21} from this segment in the third period. The sum of its second- and third-period profits is given by $S^* - \epsilon - c + \delta \pi_1^{21} = -\epsilon < 0$. This is worse than sticking to S^*, which yields a zero sum of profits.

The profit π_i^i is firm i's profit from repeat customers in the second period. The profit is strictly positive because these customers have sufficiently high θ_i and product i is differentiated from other alternatives. Q.E.D.

Lemma D.2 illustrates that firms charge a lower-than-marginal-cost price to switching customers, and the third-period profit from the segment of consumers is competed away due to the second-period loss. In the second period, firm i competes for customers switching from j with the other two firms not only to maximize the profit in the second period, but also to induce customers to experience its product, such that it can make a profit $\pi_i^{ki} \geq 0$ in the third period. Our proof of Theorem D.1 illustrates that the former force drives firm i's price to switching customers down to the marginal cost and the corresponding profit to zero. The latter force drives the price further down to somewhere below the marginal cost and incurs a loss in the second period.

Now, we turn to the first period. Denote by $\lambda_1, \lambda_2, \lambda_3, \lambda_4$ the first-period market shares of the firms, respectively, and note that $\sum_{i=1}^{4} \lambda_i = 1$. Then, in the first period, firm 1's overall profit is given by

$$
\begin{aligned}
&\lambda_1(p_1 - c) + \delta \sum_{k=1}^{4} \lambda_k \pi_1^k + \delta^2 \left(\lambda_1 \sum_{l=0}^{4} \pi_1^{1l} + \sum_{k=2}^{4} \lambda_k \pi_1^{k1} \right) \qquad (30) \\
=\ &\lambda_1(p_1 - c) + \delta \left[\lambda_1 \pi_1^1 + \lambda_2 \pi_1^2 + \lambda_3 \pi_1^3 + \lambda_4 \pi_1^4 \right] \\
&+ \delta^2 \left[\lambda_1(\pi_1^{10} + \pi_1^{11} + \pi_1^{12} + \pi_1^{13} + \pi_1^{14}) + \lambda_2 \pi_1^{21} + \lambda_3 \pi_1^{31} + \lambda_4 \pi_1^{41} \right] \\
=\ &\lambda_1(p_1 - c) + \delta \left[\lambda_1 \pi_1^1 - \lambda_2 \delta \pi_1^{21} - \lambda_3 \delta \pi_1^{31} - \lambda_4 \delta \pi_1^{41} \right] \\
&+ \delta^2 \left[\lambda_1(\pi_1^{10} + \pi_1^{11} + \pi_1^{12} + \pi_1^{13} + \pi_1^{14}) + \lambda_2 \pi_1^{21} + \lambda_3 \pi_1^{31} + \lambda_4 \pi_1^{41} \right] \\
=\ &\lambda_1(p_1 - c) + \delta \lambda_1 \underbrace{\left[\pi_1^1 + \delta(\pi_1^{10} + \pi_1^{11} + \pi_1^{12} + \pi_1^{13} + \pi_1^{14}) \right]}_{\Pi_1} \qquad (31)
\end{aligned}
$$

In deriving the profit function in equation (31), the initial formula for firm 1's profit utilizes Lemma D.2, the first equality utilizes Lemma D.3. The Π_1 in equation (31) is the sum of firm 1's profits after the first period from consumers who experienced product 1 in the first period.

Then, our logic in proving Theorem 1 indicates that there exists a symmetric equilibrium in the first period in which firms make zero profit.

Theorem D.2. *There exists a symmetric equilibrium in the $T = 3, N = 4$ setting in which firm i's ($i = 1, 2, 3, 4$) first-period price equals $p^* = c - \delta\Pi_1$, where Π_1 is defined in (31) and satisfies $\Pi_1 \geq 0$, and its overall profit in the three-period pricing game is zero.*

Proof. Since the products are ex-ante homogeneous from the consumers' perspective, they all purchase the cheapest product in the first period. Suppose firm i deviates to a higher price, then it has zero market share in the first period, i.e., $\lambda_1 = 0$. Then, by equation (31) we know that firm i's profit is still zero. Suppose firm i deviates to a slightly lower price $p^* - \epsilon$, then it will gain the entire market in the first period, i.e., $\lambda_1 = 1$. The resulting profit is $p^* - \epsilon - c + \delta\Pi_1 = -\epsilon < 0$, which is lower than the equilibrium profit. Q.E.D.

Firms make zero overall profit in the three-period four-firm setting because firms compete for customers who have not experienced their product in each period in order to secure a profit in later periods. After experiencing product i, consumers consider it differentiated from other tried or untried products, resulting in a positive profit of firm i in later periods. Thus, firms have incentives to compete for inexperienced consumers in each period.

In general, firms make zero profit in any $2 \leq T < N$ setting. The result relies on the same intuition as in the $T = 3, N = 4$ setting. Firms can only make a positive profit from two categories of consumer segments: Those who have experienced their products in the first period, and those who have experience in later periods.

In period T, firm i can only make a positive profit from segments of consumers who have previously experienced its product. Segments who have never tried product i view it as identical to the other M (with $M \geq T - 1 \geq 2$) products, and, hence, firm i cannot make a profit from these segments.

In period $T-1$, firm i competes against other firms for consumers who have never experienced the products from these competing firms, anticipating positive profits from a portion of these consumers in the next period. Such competition drives down the price to these consumers and the sum of profits in this and next period is zero.

Regarding those who have tried firm i's product before, firm i is able to set a price such that some of them purchase product i and make a positive profit. But then, anticipating such a positive profit, firm i must compete intensely for switchers in a previous period. Such competition, again, drives down the price and the sum of profits to zero.

The segment of consumers that hasn't been discussed is loyal customers of firm i, who always purchase from firm i in every period. Since firm i makes a positive profit from this segment

in every period, it must compete in the first period for a greater market share. Since all firms are symmetric, such competition drives down the sum of first-period profit and future profits to zero.

D.3 N-firms T-periods model with $T \geq N \geq 2$

In this subsection, we show that firms' equilibrium profit is positive in a mass market equilibrium whenever the number of periods is at least as large as the number of firms. The $T = 2, N = 2$ setting in the main text is a special case of the $T \geq N$ setting.

Theorem D.3. *Suppose $T \geq N \geq 2$. Then, for some $\underline{\mu}$, there exists a symmetric equilibrium in which each firm makes a positive overall profit if $\mu \geq \underline{\mu}$.*

Proof. Suppose in a symmetric equilibrium, there is a period $t > 1$ in which no firm makes a sale. Then, firm i can deviate by selling to the segment of consumers who experienced its product before period t and make a monopoly profit in that segment. Suppose no firm sells in period $t = 1$, then all firms' second-period profit is $\frac{p^* - c}{N}$. Firm i must find it profitable to deviate to selling in period one. This is because doing so allows firm i to make a profit of $p^* - c$ in the first period, which is greater than what it can make in the second period in equilibrium. In addition, all consumers will experience product i making the product differentiated from other products. In sum, all firms sell in every period in any symmetric equilibrium.

Now, suppose in a symmetric equilibrium, all firms make zero profit for any μ. Then, firm i has the following profitable deviation as long as μ is sufficiently large: instead of selling in each period, firm i can deviate to only sell in period $t = N \leq T$. Since the firms are ex-ante symmetric and the correlation coefficient between any two products is a constant, ρ, there is a positive mass of consumers who switch to an untried product in each period if μ is sufficiently large. In period $t = N$, they have experienced all products except product i. Some of them will switch to product i in this period, and firm i will make a positive profit. This is a contradiction to all firms making zero profit in the equilibrium. Q.E.D.

The number of products that a consumer has experienced before the start of period t is lower than t. This means that at period $t = N$, there are consumers who have experienced $N - 1$ products and who will be willing to switch to the only remaining untried product, as long as the unconditional expectation of valuation μ is sufficiently high. Selling the last untried product to these consumers yields the seller a positive profit because there is no competitor for this segment of switching customers. This profit is not competed away for future profits because starting from period $t = N + 1$, all products are differentiated for this segment of consumers and they settle on one of them, resulting in a positive profit to the corresponding seller.

D.4 Consumer experimentation

Consumers experiment in our main model and in the above model extensions. In the two-firm, two-period model, consumers' first-period purchase decisions are made to maximize total discounted expected utility, anticipating learning from the experience in the first period and adjusting their purchasing decision in the second period. This is reflected in the utility function given at the beginning of Section 4.

When there are more than two periods, the second-period purchasing decision is no longer guided by the comparison between $\theta_i - R_i$ and $E(\theta_{-i}|\theta_i) - S_i$. Each term must be adjusted for expected gains from learning in the future. Hence, consumers can benefit from experimenting with the products, i.e., the incentives to switch to an untried product can be stronger when there are more periods. These adjustments anticipating future learning do not change consumers' decisions qualitatively. While experimentation affects the range of types of consumers that choose to repeat or switch and equilibrium prices, a positive mass of consumers purchases repeatedly and another positive mass switches to other products, as long as the unconditional expectation of valuation μ is sufficiently high.

However, increasing the number of periods does not guarantee that consumers switch more often because the experimentation incentives are affected by firms' endogenous choice of prices. In periods after the second period, firms choose optimal prices given truncated distributions because a positive mass of consumers has left the new product category and another, positive, mass of consumers has experienced both goods and are charged a different price. Thus, the equilibrium prices are different from those in the two-period setting. There is no clear ranking of the prices in the two settings. Hence, the value of the marginal consumer in each period in the multiple-period model can be either higher or lower than in the two-period setting. When the number of periods is relatively low, there exist some consumers who do not experience both goods because their value for good A is sufficiently large that it is never worthwhile to experiment with the other good. When the number of periods becomes sufficiently large, potentially all consumers experiment with both products and settle on the one with the higher value.

E Asymmetric value distribution

While the assumption of a symmetric distribution of willingness to pay in our model is common in the literature, we discuss the implications of an asymmetric value distribution in this section. We focus on the case where the marginal distributions of willingness to pay for both products have either a sufficiently large mean, such that both firms' second-period markets have the

mass-market equilibrium, or a sufficiently small mean, such that both have the niche-market equilibrium.

Consider the former case. The cutoff types of consumers are different from those given in equations (1) and (3) in the symmetric distribution setting. Since the conditional expectation is now given by $E(\theta_{-i}|\theta_i) = \mu_{-i} + \rho\frac{\sigma_{-i}}{\sigma_i}(\theta_i - \mu_i)$, we can find the cutoff type θ_i^{RS} by setting $\theta_i^{RS} - R_i = \mu_{-i} + \rho\frac{\sigma_{-i}}{\sigma_i}(\theta_i^{RS} - \mu_i) - S_{-i}$, hence,

$$\theta_i^{RS} = \mu_i + \frac{R_i - S_{-i}}{1 - \rho\frac{\sigma_{-i}}{\sigma_i}} + \frac{\mu_{-i} - \mu_i}{1 - \rho\frac{\sigma_{-i}}{\sigma_i}}.$$

Similarly, by setting $\mu_{-i} + \rho\frac{\sigma_{-i}}{\sigma_i}(\theta_i^{SO} - \mu_i) - S_{-i} = 0$, we have

$$\theta_i^{SO} = \frac{S_{-i} - (1 - \rho\frac{\sigma_{-i}}{\sigma_i})\mu_{-i}}{\rho\frac{\sigma_{-i}}{\sigma_i}} + (\mu_i - \mu_{-i}).$$

In the second-period profit function (5), we replace the cutoff types with those above and denote the cumulative distribution function of θ_{-i} by $G(\cdot)$ (and the corresponding probability density function by $g(\cdot)$) while continuing to denote the distribution of θ_i by $F(\cdot)$. Since we now focus on the mass market equilibrium, let us assume that $\max(\theta_i^{RS}, \theta_i^{RO}) = \theta_i^{RS}$ and $\theta_i^{RS} > \theta_i^{SO}$ for $i = A, B$. Then, we can find the equilibrium prices by taking first-order derivatives w.r.t R_i and S_i, respectively. The prices are of the forms given in equations (7) and (8) in the symmetric setting in the main text:

$$
\begin{aligned}
R_i^m &= \frac{(1 - \rho\frac{\sigma_{-i}}{\sigma_i})[1 - F(\theta_i^{RS})]}{f(\theta_i^{RS})} + c, \\
S_i^m &= \frac{(1 - \rho\frac{\sigma_{-i}}{\sigma_i})\left[G(\theta_{-i}^{RS}) - G(\theta_{-i}^{SO})\right]}{g(\theta_{-i}^{RS}) + \frac{1 - \rho\frac{\sigma_{-i}}{\sigma_i}}{\rho\frac{\sigma_{-i}}{\sigma_i}}g(\theta_{-i}^{SO})} + c.
\end{aligned}
$$

It then follows that the mass market equilibrium prices continue to be independent of the first-period market share λ_i even when the value distributions are asymmetric.

Denote firm i's second-period profit from repeat consumers by π_i^R and the profit from switching consumers by π_i^S. Suppose $\pi_A^R - \pi_A^S \geq \pi_B^R - \pi_B^S > 0$ and consumers' second-period surpluses are the same across products. Then, firms compete for greater market share in the first period, and thus, the first-period price must be $c - \delta(\pi_B^R - \pi_B^S)$. This is the case because firm B would stop reducing price at this point to avoid an overall loss in the game. In such an equilibrium, firm B makes zero profit while firm A makes a positive profit of

$$\lambda_A\left[c - \delta(\pi_B^R - \pi_B^S) - c\right] + \delta\left(\lambda_A\pi_A^R + \lambda_B\pi_A^S\right) = \delta\lambda_A\left(\pi_A^R - \pi_B^R\right) + \delta\left(\lambda_A\pi_B^S + \lambda_B\pi_A^S\right).$$

Note that when the marginal distributions are similar, in that the difference between the means and between the variances are sufficiently small, the term $(\pi_A^R - \pi_B^R)$ is sufficiently close to zero, whereas the term $(\lambda_A \pi_B^S + \lambda_B \pi_A^S)$ is sufficiently close to π_A^S, consistent with Theorem 1.

The case of the second-period niche market equilibrium is similar. Since firms make the monopoly profit in the niche market equilibrium, second-period prices are independent of first-period market share. Denote firm i's monopoly profit by π_i^M.[36] Suppose $\pi_A^M \geq \pi_B^M$. Then, following a similar logic, the first-period price is given by $c - \delta \pi_B^M$. Firm B makes zero profit, whereas firm A's profit is

$$\lambda_A (c - \delta \pi_B^M - c) + \delta \lambda_A \pi_A^M = \delta \lambda_A (\pi_A^M - \pi_B^M).$$

When the difference in the marginal distributions is sufficiently small, this profit is sufficiently close to zero, consistent with Theorem 1.

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[36] π_i^M is equivalent to $\pi(M)$ when the distributions of willingess to pay are symmetric.

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