An extensive body of literature argues for the benefits of planned obsolescence, the strategy of designing products with low durability to induce repeat purchases from the consumers. Yet, some firms avoid planned obsolescence and instead offer products with high durability. In this paper, we offer a demand-side rationale for a high-durability product design strategy: exclusivity-seeking consumer behavior. In the presence of consumers who value exclusivity, we find that firms benefit from designing products with higher durability in conjunction with a high-price, low-volume introduction strategy. A high price jointly exploits the value inherent in a more durable product and lowers the sales volume to achieve the product exclusivity valued by the consumers. This contrasts with the planned obsolescence strategy that capitalizes on the high sales volume achieved by setting a low new product price. Our analysis also unearths insights regarding the effect of exclusivity-seeking behavior on a firm’s demand and pricing. We show that firms’ durability choice may explain the joint increase in price and demand for conspicuous goods. We also find that a positive correlation between consumer valuations and sensitivity to exclusivity may be observed as an endogenous outcome of consumer segmentation due to the firm’s pricing decisions, instead of being an inherent consumer characteristic.

Key words: Durable products; Product obsolescence; Exclusivity-seeking consumers; Demand externalities

History:

1. Introduction and Related Literature

Planned obsolescence is a well-established strategy utilized by firms selling durable products, where they design products of low durability that are characterized by rapidly diminishing consumer value over time. The adoption of planned obsolescence dates back to the early 1900’s, when Dupont reduced the durability of early versions of nylon stockings to induce replacement (Slade 2006). Xerox and Kodak lowered the durability of products such as photocopiers and micrographic equipment by designing their core components to become obsolete faster (Borenstein et al. 1995). Planned obsolescence still remains a popular strategy in practice (The Economist 2009). A large body of academic literature provides support for this practice (see Waldman 2003 for an overview).
Yet, some firms eschew planned obsolescence in favor of a high durability strategy. For example, BMW ensures the high durability of its products with a combination of design choices, free maintenance services and extended warranty for the first four years (BMW 2008), and even promotes this feature using the tagline “holds its value like it holds a corner” (BMW 2012). Similarly, the Swiss watch manufacturer Patek Philippe designs high durability products (Patek Philippe 2012a) and advertises: “You never actually own a Patek Philippe, you merely look after it for the next generation” (Patek Philippe 2012b). We observe that these products are conspicuous in nature, i.e., their ownership and use is public. Prior research in social psychology has established that for such products, consumers may exhibit a desire for exclusivity - the more consumers own a product, the less value each derives from owning it (Lynn 1991, Snyder 1992, Simonson and Nowlis 2000, Tian and Hunter 2001); a “BMW in every driveway” dilutes the value of the car (cf., Bagwell and Bernheim 1996). In this paper, we pose the following question: Does exclusivity-seeking consumer behavior help explain why firms adopt high-durability product design strategies for conspicuous products?

The effect of exclusivity-seeking (or snobbish\(^1\)) consumer behavior on whether the firm prefers high durability vs. planned obsolescence is not straightforward. A key factor is the dependence of the consumers’ utility on the total number of consumers who own a product (i.e., the level of product exclusivity). Consider the impact of planned obsolescence on product exclusivity. Planned obsolescence limits the trade on the secondary market, preventing the product from being traded to lower-valuation consumers, thereby limiting total ownership, and maintaining its exclusivity. This suggests that planned obsolescence should continue to be attractive in the presence of snobs. On the other hand, planned obsolescence leads to a lower new product price and higher new product sales. This may lead to more consumers owning the product, and this drop in exclusivity may hurt the firm’s profits. Overall, therefore, it is not clear whether planned obsolescence is the optimal design choice in the presence of snobbish consumers. We shed light on this question by analyzing a firm’s joint durability and pricing decisions in the presence of snobs. To the best of our knowledge, this is the first work to address durability choice in the context of conspicuous consumption.

A body of literature in operations investigates how a firm’s decisions are influenced by different consumer behavioral traits such as forward-looking or strategic consumers (Su 2007, Cachon and Swinney 2009, Su and Zhang 2009), social comparisons (Roels and Su 2013), hyperbolic discounting (Plambeck and Wang 2013), mental accounting (Erat and Bhaskaran 2012), and procrastination (Wu et al. 2013) (see Netessine and Tang 2009 for an overview). An emerging stream in this literature examines the effect of snobbish consumer behavior on a firm’s production, rationing and

\(^1\) Borrowing from the seminal work of Leibenstein (1950) that dubs exclusivity-seeking consumers as “snobs”, we use the terms “exclusivity-seeking” and “snobbish” interchangeably.
pricing decisions (Tereya˘go˘lu and Veeraraghavan 2012, Arifo˘glu et al. 2012). We contribute to this literature by analyzing a firm’s new product introduction strategy in the presence of snobbish and forward-looking consumers.

An established body of work discusses the benefits of planned obsolescence (see Waldman 2003 and references therein). A fundamental insight of this literature is that when a firm does not control the secondary market\(^2\), it benefits from lowering product durability to reduce the cannibalization of new products by used products. As summarized by Waldman (2003) (p. 138), “The general point is that a durable goods producer with market power wants to lower the quality of the used units.... One way to achieve this is by reducing the physical quality of the product by reducing the durability built into new units.”

Our key contribution is to demonstrate that the presence of snobs results in a striking reversal in the firm’s incentive to practice planned obsolescence. We explain how three different factors jointly determine the firm’s optimal durability choice: the relative utility from owning a used versus a new product, the new product price and the resale value of a used product. We show that the relative impact of changing the durability level on these factors is substantively different in the presence of snobs, leading the firm to choose a high durability strategy. The fundamental mechanism driving this conclusion is robust and holds under a broad range of market and cost conditions. In sum, our analysis uncovers the limitations of planned obsolescence for conspicuous products and offers a rationale for the existence of high durability strategies in practice. We also characterize the firm’s new product introduction strategy in the presence of snobs. In particular, we show that offering higher durability and charging a higher price are complementary levers to respond to consumer snobbishness.

Our results offer a theoretical explanation for the empirical finding that consumers with higher valuations may be more snobbish. For example, Chao and Schor (1998) find a positive correlation between income and conspicuous consumption. Even though we do not assume a correlation between consumer valuations and snobbishness, we find that the consumers who purchase a new product (high valuation consumers) have higher average snobbishness than consumers who purchase a used product (low valuation consumers). Therefore, we show that the empirical observation of a positive correlation between income and conspicuous consumption can be explained by the equilibrium consumer self segmentation due to the firm’s pricing decisions, instead of being an inherent consumer characteristic.

Corneo and Jeanne (1997), Amaldoss and Jain (2005a) and Amaldoss and Jain (2005b) investigate the effect of a firm’s pricing decisions on the aggregate demand in the presence of snobbishness\(^2\) when the firm eliminates the secondary market by leasing, durability provision may be optimal (Bulow 1986, Hendel and Lizzeti 1999b). We focus on the case where the firm has no control over the secondary market.
consumer behavior. These papers focus on non-durable products, and therefore do not consider durability choice. Our results offer an alternative explanation for the unconventional price-demand relationship discussed in the context of conspicuous consumption, namely that price and demand may be observed to jointly increase: Amaldoss and Jain (2005a) show that both snobs and followers (i.e., conformity-seeking consumers) must coexist for price and demand to jointly increase for a non-durable product. We show that this joint increase may take place due to the change in the underlying durability choice of the firm as long as some snobbish consumers are present.

2. The Model

We model the problem as a discrete-time, infinite-horizon\(^3\) game, where the firm and consumers move sequentially in each period. We consider a profit-maximizing monopolist who introduces a durable product in every period. The quality of a new product is fixed and without loss of generality, normalized to one. The product has a maximum useful lifetime of two periods and depreciates with use. Consumers that purchase the product derive utility from two different factors: consumption and exclusivity. Consumers’ valuations are heterogeneous along both these dimensions.

Consumption utility is \(\theta\) for a new product and \(\delta \theta\) for a used product, where \(\theta\) is the per-period consumer valuation for product quality and \(\theta\) is uniformly distributed in \([0, 1]\). Here \(\delta \in [0, 1]\) represents the product durability (Desai and Purohit 1998), where \(\delta = 0\) represents a product that only lasts for one period, whereas \(\delta > 0\) implies that the product lasts for two periods and the depreciation after one period of use is \(1 - \delta\). Thus, we have a vertical differentiation model, where ceteris paribus, every consumer (weakly) prefers a new product over a used product, i.e., \(\delta \theta \leq \theta\) (Desai and Purohit 1998, Desai et al. 2004). This allows us to formally define planned obsolescence as \(\delta^* = 0\), which renders the useful life of the product to be just one period. Without loss of generality, the size of the market is normalized to one. A consumer uses at most one product in a given period.

Utility from exclusivity is given by \(-\lambda Q_e\), where \(Q_e\) is the expectation of the total volume of products in use by consumers in that period, and \(\lambda \geq 0\) represents a consumer’s sensitivity to exclusivity (or “snobbishness”). \(-\lambda Q_e\) decreases in \(Q_e\) and consequently captures exclusivity-seeking behavior, i.e., a consumer experiences a greater disutility from the same product as more consumers own it. Such a linear specification for an externality has been used in the existing literature (Loch

\(^3\)There are three advantages to using an infinite-horizon model: First, at \(t = 0\), it avoids the initial transient time where the supply of used products builds up, which is present in finite-horizon models. Second, using a finite horizon requires specifying artificial terminal conditions, which can skew the results based on the specific terminal condition used (cf., Huang et al. 2001). Third, an infinite planning horizon simplifies the analysis and yields closed-form results for endogenous durability choice, which is not possible in a two-period model. Note that in our model, the time inconsistency effect is not present since we consider a product with finite durability in an infinite-horizon setting (Huang et al. 2001). Nevertheless, our qualitative insights can be shown to hold under a two-period model where time inconsistency is present (see discussion in Appendix §A3.)
and Huberman 1999, Amaldoss and Jain 2005a, Tereya˘ go˘ lu and Veeraraghavan 2012, Arifo˘ glu et al. 2012). This approach of modeling the consumers’ valuation for product exclusivity through a linear negative externality is also consistent with a dating or a matching scenario as in Balachander and Stock (2009), or a status signaling framework as in Diaz-Diaz and Rayo (2009) (see §5 for a detailed discussion). This specification also makes the implicit assumption that consumers are equally sensitive to the presence of new and used products. Our findings are valid even if we relax this assumption (see the discussion in §5 for details).

We model heterogeneity in consumers’ sensitivity to product exclusivity as follows: A fraction \( \beta \in [0,1] \) of the consumers (independent of \( \theta \)) have sensitivity to product exclusivity (or snobbishness) \( \lambda_h > 0 \) and the rest have lower snobbishness, \( 0 \leq \lambda_l \leq \lambda_h \). Consumers with \( \lambda_l = 0 \) are referred to as indifferent consumers.

Putting the two components of consumer utility together, the per-period gross utility of consumer type \( \theta \) of snobbishness \( \lambda \) from using a new product in period \( t \) is given by \( u_n(\theta, Q_t^n) = \theta - \lambda Q_t^n \) and that from a used product in period \( t \) is given by \( u_u(\theta, Q_t^u) = \delta^{-1} \theta - \lambda Q_t^u \). The consumers are forward-looking and form perfect expectations of price and product durability in the future. Finally, the analysis uses a rational expectations framework where each consumer has the same expectation about the volume of products in use \( (Q_e) \) and this expectation is correct in equilibrium.

### 2.1 Sequence of Events and Specification of the Game

The firm first makes the durability decision \( (\delta^t) \), followed by the price of a new product \( (p_t^n) \) in every period. The firm determines the durability of the product through the design process, which involves several actions such as using higher performance components, more durable materials, more reliable interfaces between those components, or better production equipment (Saleh 2008). A product with higher durability requires a higher per-unit cost of production, denoted by \( c(\delta) = c\delta^2 \), where \( c'(\delta) \geq 0 \). This quadratic form has been extensively used in the literature (Mussa and Rosen 1978, Moorthy 1988, Kim and Chhajed 2002, Krishnan and Zhu 2006) and allows to capture a non-linear specification for cost, while still maintaining tractability.

Observing the firm’s pricing and durability decisions, the consumers form rational expectations regarding the total volume of consumers who will own the product, and make their purchasing decisions. The assumption that the consumers form rational expectations after the firm makes its decisions is commonly used in the related literature (Amaldoss and Jain 2005a,b, Balachander and Stock 2009). We assume that the firm can commit to its pricing decision before the consumers make their purchasing decisions, which is also a conventional assumption in the durable goods literature (Desai and Purohit 1998, Hendel and Lizzeri 1999b).

4 Under this assumption, we impose the conditions for the rational expectations equilibrium before solving for the
At the end of every period, consumers who own a product that still has useful life left may choose to sell the used product on the secondary market and purchase a new one. Since there is typically a large number of individual sellers and buyers in the secondary market, we assume that the secondary market is competitive and the resale value of a used product is given by the market-clearing price \( p_t^u \) (cf., Desai and Purohit 1998, Huang et al. 2001). Note that although the firm does not have direct control of the secondary market, it can indirectly influence it through the product durability and the price of the new product.

We restrict our attention to rational expectations, stationary equilibria, where \( p_t^n = p_n \) and \( \delta^t = \delta \). This assumption of restricting attention to stationary equilibria is in line with the existing literature (Hendel and Lizzeri 1999a,b, Debo et al. 2005, Plambeck and Wang 2009). It also allows us to rule out transient effects due to only new products being present in the first period. We also assume that all information regarding the cost structures and preferences are common knowledge, and all players have a common discount factor \( 0 < \rho < 1 \). In order to eliminate the uninteresting cases where the business is never profitable for the firm, we assume \( c(\delta) < 1 + \rho \delta \).  

3. Demand and Pricing Analysis

In order to analyze our model, we solve for the subgame perfect equilibrium of the game by using backward induction. We begin by solving the consumers’ problem and deriving the demand functions in §3.1. In §3.2, we discuss the firm’s pricing strategy for a given product durability. We analyze the firm’s design strategy in §4.

3.1 Demand functions

For a given expectation of the total volume of products in use and the price of the new product, there are at most three undominated consumer strategies (cf. Hendel and Lizzeri 1999a): In decreasing order of the consumer type \( \theta \) that adopts them, always buy a new product and sell the used product on the secondary market, always buy a used product from the secondary market, and do not purchase either product.  

5 If a firm designs a product with durability \( \delta \), the valuation of the highest consumer type \((\theta = 1)\) for this product, \( 1 + \rho \delta \), should be higher than the per-unit cost of producing this product, \( c(\delta) \) for the firm to profitably sell this product.

6 The consumer strategy where a consumer purchases a new product and keeps it in the next period is dominated in infinite-horizon models (cf. for example, Hendel and Lizzeri 1999b), although it is present in two-period models such as in Desai and Purohit (1998) (see Appendix §A1 for details). Our results hold in a two-period model, where such a strategy is not dominated (see Appendix §A3 for details).
The market-clearing price for used products $p_u$ is determined by equating the supply and demand for used products. Aggregating over consumer types that adopt each strategy yields the new product demand $D_n(p_n, \delta; Q_e)$, the used product demand $D_u(p_n, \delta; Q_e)$, and the total volume of products in use $D(p_n, \delta; Q_e) = D_n(p_n, \delta; Q_e) + D_u(p_n, \delta; Q_e)$. For a rational expectations equilibrium, we require that consumer expectations about the volume of products in use are correct in equilibrium, i.e., $D(p_n, \delta; Q_e) = Q_e$. Let $D(p_n, \delta)$ and $D_n(p_n, \delta)$ denote the equilibrium quantities for the total volume of products in use and the new-product demand, respectively. We denote the expression $2(1 - \beta)(\lambda_h - \lambda_l)$ by $\bar{d}$, which can be interpreted as a heterogeneity measure with respect to exclusivity-seeking behavior: The more unbalanced the mix and the larger the difference in snobbishness, the larger the value of $\bar{d}$.

**Proposition 1.** There exists a unique rational expectations equilibrium for the total volume of products in use, which is characterized as follows:

$$D(p_n, \delta) = \begin{cases} \frac{2(1 - \beta)(1 - p_n + \rho \delta)}{(1 - \beta)(1 + \delta) + \rho \delta (2 - \beta - \delta \beta) + 2(1 - \beta)(\beta \lambda_h(1 + \rho \delta) + \lambda_l (1 - \beta + \rho (1 - \beta \delta)))} & \text{if } 0 \leq \delta \leq \bar{d}, \\
\frac{2(1 - \beta)(1 - p_n + \rho \delta)}{1 + \delta + 2 \rho \delta + 2(1 + \rho \delta)(\beta \lambda_h + (1 - \beta \delta) \lambda_l)} & \text{if } \bar{d} < \delta \leq 1. \end{cases}$$

In equilibrium, both the more and less snobbish consumers buy the used products if and only if $\delta > \bar{d}$. Otherwise, the more snobbish consumers do not purchase a used product.

While both the new and used products are purchased by less snobbish consumers in equilibrium, the above result shows that the more snobbish consumers may refrain from purchasing a used product from the secondary market under sufficient heterogeneity ($\delta < \bar{d}$). The reason for this is as follows: As the fraction of the less snobbish consumers grows ($\beta$ decreases) and they become less snobbish ($\lambda_l$ decreases), more of them purchase a product and therefore, the volume of products in the market increases. A higher total volume increases the negative externality. If this effect is strong enough, i.e., $\bar{d} > \delta$, the net utility of the more snobbish consumers decreases to the point that they abstain from the secondary market (see Figure 1).

### 3.2 Pricing Strategy

We next analyze the firm’s pricing strategy that maximizes its profits for a given durability level $\delta$. Under stationarity, the firm’s problem reduces to

$$\max_{p_n \geq 0} \Pi(p_n, \delta) = (p_n - c(\delta)) D_n(p_n, \delta),$$

where $\Pi(p_n, \delta)$ is the firm’s per-period profit for a given product durability and new-product price. Let $p_n^*(\delta)$ be the optimal price, $\tilde{\Pi}(\delta) = \Pi(p_n^*(\delta), \delta)$ and $\tilde{D}_n(\delta) = D_n(p_n^*(\delta), \delta)$ denote the profit and new-product demand evaluated at this price, respectively.
Figure 1 Equilibrium Segmentation (according to consumer valuation $\theta$) as a function of consumer heterogeneity $\bar{d}$.

More snobbish consumers ($\lambda_h$)  Less snobbish consumers ($\lambda_l$)

Low $\bar{d}$

High $\bar{d}$

Note. In the above figure, $\rho = 0.9$, $\beta = 0.2$, $\lambda_h = 0.45$, $p_n = 0.45$ and $\delta = 0.5$. The segmentation for more snobbish and less snobbish consumers is depicted by the first and second columns, respectively. In the first row, $\lambda_l = 0.3$ where $\delta > \bar{d} = 0.24$, and both more snobbish and less snobbish consumers purchase used products. In the second row, $\lambda_l = 0.1$ where leads to $\delta < \bar{d} = 0.56$, and more snobbish consumers only buy new products.

Proposition 2. For a given product durability, the optimal price for the new product is given by $p_n^*(\delta) = \frac{1 + \rho \delta + c(\delta)}{2}$. $p_n^*(\delta)$ is independent of $\lambda_h$ or $\lambda_l$, and strictly increases in $\delta$.

The firm charges a higher price for a new product with higher durability due to its higher resale value. Interestingly, the optimal price is independent of the consumer snobbishness. Instead, the snobbishness of consumers influences profitability through its impact on demand for the new product, which we focus on next.

Proposition 3. For a given product durability,

i. $\bar{D}_n(\delta)$ weakly decreases in consumer snobbishness $\lambda_h$ and $\lambda_l$.

ii. When $\delta \leq \bar{d}$, $\bar{D}_n(\delta)$ is increasing in $\delta$ if and only if $\rho > c'(\delta)$ and $\lambda_l > \bar{\Lambda}(\beta, \delta, \lambda_h)$.

iii. When $\delta > \bar{d}$, $\bar{D}_n(\delta)$ is increasing in $\delta$ if and only if $\rho > c'(\delta)$ and $\beta \lambda_h + (1 - \beta) \lambda_l > \bar{\Lambda}(\delta)$.

iv. When $\bar{D}_n(\delta)$ decreases in $\delta$, the decrease in the new product demand is lower for higher consumer snobbishness ($d^2\bar{D}_n(\delta)/d\delta d\lambda_h, d^2\bar{D}_n(\delta)/d\delta d\lambda_l \geq 0$).

The demand for the new product decreases as either consumer type becomes more snobbish because the externality faced by them increases, decreasing their net utility from owning a product.$^7$

$^7$ Note that $\bar{D}_n$ is strictly positive even for large values of $\lambda_l$ and $\lambda_h$ and in particular, $\bar{D}_n$ goes asymptotically to zero. This is because for a large $\lambda_h$ and $\lambda_l$, the resulting $Q_e$ is small, which means that the negative externality $\lambda Q_e$ is not sufficiently negative to result in all consumers abstaining from purchasing a new product.
Substituting $\lambda_h = \lambda_l = 0$ in the above result, and referring to Proposition 2, we observe that in the absence of snobbish consumer behavior, the new product demand decreases in durability while the price increases, which is consistent with the existing literature (Waldman 2003). A revealing finding in Proposition 3 is that in the presence of snobbish consumer behavior, the new product price and demand increase in durability, provided consumers are sufficiently forward-looking (sufficiently high $\rho$), and consumers exhibit either high heterogeneity in snobbishness with a minimum requirement on the snobbishness level (ii) or low heterogeneity with a sufficiently high snobbishness level (iii). Even when the demand decreases in durability, its rate of decrease is moderated (iv).

This contrast stems from the combination of three different effects that a more durable product has on a consumer’s net utility from owning a new product as opposed to a used product. First, the drop in the gross utility from owning a used product instead of a new product ($\theta - \delta\theta$) is lower for a more durable product. Second, the firm charges a higher new-product price for a more durable product. Third, the resale value ($p_u$) is higher. The first two effects make purchasing a more durable new product less attractive, while the third makes it more attractive.

In the absence of snobbish consumer behavior, the former effects dominate the latter, and the new product demand decreases in durability. In the presence of snobbish consumer behavior, the magnitude of the first two effects is independent of the consumer snobbishness level. The third effect becomes stronger as the consumer snobbishness increases. A higher resale value ($p_u$) is associated with a lower demand for used products. As a result, a lower total volume of products is in use, reducing the impact of the negative externality, which further increases the resale value. As the consumer snobbishness increases, these reinforcing phenomena are strengthened. Proposition 3 (ii, iii) shows that under certain consumer characteristics, the third effect dominates and results in an increase in the demand in conjunction with a price increase. Amaldoss and Jain (2005a) show that both snobs and followers (i.e., conformity-seeking consumers) must coexist for price and demand to jointly increase for a non-durable product. Our result shows that this effect can be observed for durable products even in the absence of followers, and is attributed to how the price and demand are influenced by the underlying durability choice.

We next focus on the discussion in the literature on conspicuous consumption regarding a correlation between consumer valuations and sensitivity to exclusivity. Chao and Schor (1998) study cosmetic products with different levels of conspicuousness and empirically find that consumers with higher income exhibit greater conspicuous consumption. Pesendorfer (1995) makes an assumption that consumers with higher valuations value conspicuous consumption more than those with lower valuations. In our model, we do not make such an assumption and assume an independence between consumer valuations and snobbishness. Despite this, our next result shows that such an effect may endogenously emerge in equilibrium due to the firm’s pricing decisions. In order to do
so, we compare the average snobbishness of consumers who buy a new product with that for the consumers who buy a used product. We define the average snobbishness as the demand-weighted snobbishness of consumers who buy a given product divided by the total demand for that product.

**Corollary 1.** The average snobbishness of consumers who purchase a new product is higher than the average snobbishness of consumers who purchase a used product.

The above result shows that the consumers who purchase a new product because they have higher valuations, have higher average snobbishness than consumers who purchase a used product because they have lower valuations. Therefore, the empirical observation discussed in the prior literature may be explained by the equilibrium consumer self segmentation due to the firm’s pricing decisions, and not necessarily because higher valuation consumers are inherently more snobbish.

### 4. Product Design Strategy

We now analyze the firm’s optimal product durability $\delta^*$ that maximizes the firm’s profit, i.e., we solve $\max_{0 \leq \delta \leq 1} \Pi(\delta)$. Recall that the firm is said to practice planned obsolescence when it offers a non-durable product, i.e., $\delta^* = 0$. For the rest of our analysis, we assume no discounting, i.e., $\rho = 1$. This simplifies our expressions and helps us to obtain analytical results for the design strategy. Nevertheless, it can be shown that $\rho < 1$ provides similar qualitative insights.

To establish a benchmark and relate to the existing literature on durable goods, we first consider the setting where consumers are not snobbish, i.e., $\lambda_h = \lambda_l = 0$.

**Proposition 4.** If $\lambda_h = \lambda_l = 0$, then the firm practices planned obsolescence ($\delta^* = 0$).

The above proposition shows that in the absence of snobbish behavior, the firm prefers to practice planned obsolescence by making the product non-durable. The reason for this is as follows: As discussed earlier, in the absence of snobbish behavior, the demand for new products decreases with product durability. This negative volume effect on profit is significant enough to dominate the positive price effect from higher durability discussed in Proposition 2. Therefore, the firm prefers to offer a non-durable product. This result is same as that from the literature on durable goods in economics, which discusses that the firm has an incentive to practice planned obsolescence by reducing the product durability to reduce demand cannibalization (cf. Waldman 2003, pg. 138). It is also same as that can be obtained by solving for the profit-maximizing durability in the model of Desai and Purohit (1998).

Next we account for snobbish consumer behavior and show that planned obsolescence may be suboptimal. We begin by analyzing the setting where the firm faces homogeneously snobbish consumers and then generalize to consider heterogeneity in snobbishness.
4.1 Homogeneous Snobishness

Let snobishness be $\lambda_h = \lambda_l = \lambda > 0$. $\Pi(\delta)$ then reduces to $\frac{(1+\delta-c(\delta))^{2}}{4(1+3\delta+4\lambda)}$.

**Proposition 5.** $\delta^{*} > 0$ if and only if $\lambda > L(c)$, where $L(c)$ is increasing in $c$ and $L(0) = 0$.

As presented in Proposition 3 and illustrated in Figure 2a, the firm should not practice planned obsolescence when the consumers’ snobishness is above a threshold, i.e., $\lambda > L(c)$. To understand what drives this result, consider the implications of adopting planned obsolescence in the presence of snobbish consumers: A lower durability exerts a negative pressure on the price that the firm can charge for the new product (due to the lower resale value). The only way this negative price effect can be moderated is through selling a larger volume of products. However, when consumers are snobbish, a volume increase can exert a further negative effect on the price that the firm can charge. The combined effect is that in the presence of snobbish consumers, the firm’s revenue decreases as the durability decreases. In contrast, a higher durability allows the firm to charge a higher price for the product due to a higher resale value, making the product more exclusive, which is valued by the consumers. Therefore, the presence of snobbish consumers has a strong effect on the firm’s durability choice: The firm prefers to offer a durable product. The only factor that can hold it back is the cost of durability. The main implication of this finding is that ignoring the presence of snobbish consumers can lead the firm to incorrectly exercise planned obsolescence.

**Figure 2** Design strategy in the presence of homogenously snobbish consumers ($\lambda_h = \lambda_l = \lambda$).

Note. In panel (a), offering a durable product is optimal in the gray and black regions (defined by $\lambda > L(c)$), with maximum durability $\delta^{*} = 1$ in the black region (where $c < C_{1}(\lambda)$ holds) and $0 < \delta^{*} < 1$ in the gray region. Panel (b) plots the optimal durability as a function of snobishness $\lambda$. The optimal durability increases in $\lambda$ and decreases in $c$.

**Proposition 6.** In equilibrium, the optimal durability $\delta^{*}$ and the new-product price $p^{*}_{n}(\delta^{*})$ are non-decreasing in the consumer snobishness $\lambda$, and the new-product demand $D_{n}(\delta^{*})$ strictly decreases in $\lambda$. 
Proposition 6 and Figure 3 illustrate the firm’s new product introduction strategy in the presence of snobbish consumers. Recall that as consumers become more snobbish, the negative externality increases, which has a negative impact on the firm’s profits. The firm can compensate consumers for the higher negative externality with two different levers: decrease the price of the new product or offer a more durable product. If consumer snobbishness is low enough ($\lambda \leq L(c)$), the firm prefers to not use either of the two levers.\(^8\) As the consumer snobbishness increases beyond $L(c)$, the firm begins to utilize durability as a lever to moderate the negative effect of a higher $\lambda$. Increasing the product durability is costly, but consumers are also willing to pay a higher price for the product (due to a higher resale value). This enables the firm to increase the price to exploit this additional value. In fact, the firm has an additional reason to increase the price: it makes the product more exclusive. If the firm increased its price to only exploit the additional value inherent in a more durable product, one would expect the demand to remain unchanged. However, the new-product demand strictly decreases with increased consumer snobbishness, implying that the firm increases the new product price further to benefit from the value of a more exclusive product. Thus, offering higher durability and charging a higher price are complementary levers to moderate the negative effect of an increase in the consumer snobbishness.

Finally, once the firm reaches maximum durability (which happens at $\lambda = 0.593$ in Figure 3), the only feasible lever to compensate consumers for their higher snobbishness is to decrease the price. However, this would also increase the demand for the new product. Thus, the firm prefers to maintain the new product price at a constant level and allow the demand to decrease as $\lambda$ increases; this behavior is qualitatively the same as where $\lambda \leq L(c)$. The main insight emerging from these results is that the more snobbish the consumers are, the further away from planned obsolescence the firm’s design strategy should be.

\(^8\)Since the firm offers a non-durable product in this region, this result is similar to that one can obtain from the model used in the literature for non-durable products (cf. Amaldoss and Jain 2005a).
4.2 Heterogeneous Snobbishness

We next analyze the firm’s design strategy in the presence of heterogeneously snobbish consumers (i.e., $\lambda_h > \lambda_l \geq 0$). In this case, analytically characterizing $\delta^*$ when $c > 0$ is intractable. However, we can analytically analyze the case where durability is costless ($c = 0$).

**Proposition 7.** If $\lambda_h > \lambda_l \geq 0$ and providing durability is costless ($c = 0$), then $\delta^* = 1$.

The above proposition shows that our earlier result regarding the firm’s design strategy is robust to any degree of heterogeneity in consumer snobbishness: In the presence of homogeneous snobbishness, when durability is costless, the firm chooses $\delta^* = 1$, which is the same as that in the presence of heterogeneity in consumer snobbishness. In addition, we observe consumer self-segmentation in the following manner: The more snobbish consumers do not purchase a used product when $\bar{d} \geq 1$ because $\delta^* < \delta$ always holds. Otherwise, both types of consumers purchase a used product.

Figure 4 demonstrates the robustness of our results regarding the firm’s design choice for the case when durability is costly: The firm chooses planned obsolescence only when the snobbishness of both consumer types is sufficiently low. Otherwise, the firm prefers to offer a durable product. When the consumer snobbishness levels are high, the firm may even choose to offer a perfectly durable product ($\delta^* = 1$). In addition, Figure 4 also depicts the resulting consumer self-segmentation: When the firm chooses $\delta^* > 0$, both consumer types purchase the used products only if the heterogeneity
in their snobbishness is low, i.e., $\lambda_h$ and $\lambda_l$ are not too different. On the other hand, when the heterogeneity is high (large $\lambda_h$ and low $\lambda_l$), the more snobbish consumers do not purchase a used product.

5. Extensions and Discussion of Assumptions

Our model captures snobbish consumer behavior through an exogenous, linear externality, considers only snobbish or indifferent consumers, and assumes that the sensitivity to the exclusivity was the same for new and used products. We now discuss the implications of relaxing these assumptions.

Robustness of the linear negative externality assumption. We can endogenize the externality by accounting for the underlying phenomena that lead to such consumer behavior. For example, we can consider a matching or dating scenario as in Balachander and Stock (2009) (also see Pesendorfer 1995), where a consumer is randomly matched with another consumer and incurs a disutility from being matched with a consumer who owns the same product. The expected disutility of a consumer $\theta$ is given by $\lambda \tilde{p}$, where $\tilde{p}$ is the probability of meeting another consumer who owns the same product. Since $Q_e$ is the total number of consumers who own the product and the total number of consumers in the market is 1 in our model, $p = Q_e/1$, yielding a linear negative externality.

Alternatively, we can also consider a status-signaling framework as in Diaz-Diaz and Rayo (2009), where a consumer $\theta$'s utility from exclusivity is given by $\lambda S$, where $S$ represents that consumer’s status, which is given by the posterior conditional expectation of his vertical type given that he owns the product. In our model, the consumer’s vertical type $\theta$ is uniformly distributed between 0 and 1, and the consumers’ expectation of the total number of consumers who own a product is denoted by $Q_e$, yielding a posterior uniform distribution on $[1 - Q_e, 1]$. Under this setting, $\lambda S = \lambda(1 + (1 - Q_e))/2 = \lambda/2 - \lambda Q_e/2$, which exhibits a linear utility loss in volume, similar to our analysis. Under this specification, our main result that the presence of snobbish consumers results in a high durability strategy still holds.

Conformity-seeking Consumers (The Follower Effect). In some settings, some consumers may enjoy a higher utility if they own a product that is also owned by a larger number of consumers. This might arise from network externalities due to synergies from the use of the same product or technology (for products like software and telecommunication products; cf. Katz and Shapiro 1994, Shapiro and Varian 1999, Loch and Huberman 1999, Parker and Van Alstyne 2005) or from a greater availability of complementary products (cf. Bhaskaran and Gilbert 2005). Such an externality may also arise from intrinsic behavioral traits like the desire for conformity, known as the “follower effect” (for products such as books, toys, and garments; Leibenstein 1950, Becker 1991, Hung and Plott 2001, Amaldoss and Jain 2005a). We can extend our analysis to consider
the impact of followers on a firm’s design choice by considering a consumer population composed of both snobs and followers (i.e., $\lambda_h > 0$ and $\lambda_l < 0$). Our structural and qualitative results hold as long as $\lambda_l$ is not too negative. If $\lambda_l$ is sufficiently negative, there can be multiple equilibria (cf. Amaldoss and Jain 2005a). We can also consider a consumer population composed of only followers, i.e., $\lambda_l < \lambda_h < 0$. In such a setting, our results are similar to that for $\lambda_h = \lambda_l = 0$, i.e., it is always optimal to practice planned obsolescence.

**Differential in the sensitivity to the exclusivity of new and used products.** In our analysis, we assume that the consumers are equally sensitive to the presence of other consumers who own the new product versus those who own a used product. We can extend our model to relax this assumption: Consider the setting where the sensitivity of a consumer to the used and new products is different and denoted by $\lambda_u$ and $\lambda_n$, respectively. The externality is then given by $\lambda_u D_u + \lambda_n D_n$, where $D_u$ and $D_n$ are the consumers’ expectations of the total volume of used and new products in use. Under stationarity, we have that $D_u = D_n = Q_e/2$. Thus, the externality is given by $Q_e (\lambda_u + \lambda_n)/2$, which can be rewritten as $\lambda Q_e$, where $\lambda = (\lambda_n + \lambda_u)/2$. It is straightforward to then see that all our structural and qualitative insights hold in this setting.

6. Conclusions

Articles in the academic literature and the business press have long argued for the benefits of a planned obsolescence strategy that induces consumers to make repeat purchases (Bulow 1986, Waldman 1996, Desai and Purohit 1998, Hendel and Lizzeri 1999b, Waldman 2003, The Economist 2009). While there are firms pursuing such planned obsolescence strategies in practice (Slade 2006), others take the opposite approach and emphasize the highly durable nature of their designs. We posit that the conspicuous nature of some product categories, where consumers value product exclusivity, may explain this dichotomy. To the best of our knowledge, this paper is the first to account for exclusivity-seeking behavior as an explanatory factor in firms’ durable product strategies. Our results carry significant managerial implications along two dimensions:

*Implications for design.* We outline conditions that render a high-durability design strategy more profitable than the planned obsolescence strategy. As in the prior literature, we find that a firm should design products of low durability in the absence of exclusivity-seeking behavior. This explains the planned obsolescence strategy adopted by firms like Kodak or Xerox for products such as copiers or printers that are bought by consumers primarily based on their functionality and not exclusivity. However, for conspicuous products, the high-volume, low-price new product introduction strategy associated with planned obsolescence imposes an indirect cost because the consumer desire for exclusivity results in a utility loss due to the high volume. In a broad range of settings, designing a more durable product allows for a high-price, low-volume introduction strategy that
maintains exclusivity and benefits the firm. This result provides theoretical support for some high durability strategies observed in practice (BMW 2008, NYT 2008, 2010).

Implications for demand and pricing. We offer a mechanism that explains the unconventional price-demand relationship that the price and demand increase jointly in the context of conspicuous consumption (cf. Amaldoss and Jain 2005a). We show that this is driven by the underlying durability choice made by firms. In other words, rather than treating this relationship as a property of certain product categories, we find that such ex-post observations may be attributed to the combined effect of the underlying durability choice and the exclusivity-seeking consumer characteristic. In particular, when consumers exhibit a high enough snobbishness on average or they are highly heterogeneous with respect to this characteristic, price and demand jointly increase in product durability. In the absence of exclusivity-seeking behavior, this effect does not exist; demand decreases in durability. This discussion highlights the importance of accounting for the different dimensions of consumer valuation and product durability in understanding the demand implications of pricing strategies.

We find that even if the consumer valuation and snobbishness are independent, one may observe that consumers who buy a new product have higher average snobbishness than those that buy a used product. This suggests that an observed positive correlation between consumer valuations and snobbishness may emerge due to consumer segmentation arising from the firm’s pricing decisions, instead of higher valuation consumers being inherently more snobbish, as some studies have assumed (Pesendorfer 1995). As such, our finding sends a cautionary message about making inferences about consumer characteristics based on observed purchasing patterns.

Finally, our results advocate a need for greater alignment between product design choices and consumer behavior to increase the effectiveness of the product development process. They also reinforce the importance of focusing managerial attention on consumers earlier in the design process and using empathic design approaches to identify such latent behavioral traits (Leonard-Barton and Rayport 1997, Thomke and Von Hippel 2002, Business Week 2004).

We conclude with a discussion of directions for future research. In this paper, we focused on the setting where a monopolist firm sold products directly to end consumers. However, some durable goods may be sold through a retailer (Bhaskaran and Gilbert 2009, 2013). A promising direction for future research is to consider the effect of snobs on the firm’s durability choice in such a decentralized setting, or in the presence of competition between manufacturers (Desai and Purohit 1999). Another interesting direction for future research is to analyze a firm’s new product introduction strategies in the presence of reference groups, i.e., where consumers experience a higher negative externality not only due to more consumers buying the same product, but also
based on the identity of the consumers buying the product (Pesendorfer 1995, Amaldoss and Jain 2008).

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**Appendix**

**A1. Derivation of demand functions**

We only need to consider two-period strategies because a product lasts only for two periods. Therefore, there are nine potential strategies: BNBN, BNBU, BUBN, BNX, XBN, BUX, XBU, BUBU, XX. Note that in our model, holding onto a used product is equivalent to selling the used product and buying it back. Therefore, under stationarity, the per-period net utility from purchasing a new product (BN) is \( \theta - p_n + \rho p_u \), that from purchasing a used product (U) is \( \delta \theta - p_u \), and from remaining inactive (X) is 0. The net utility from any of these actions is independent of the action in the previous period. Therefore, any strategy where a consumer chooses an action different than its action in the previous period is dominated. For example, a strategy where the consumer purchases a new product and continues to hold onto it for the next period is dominated (cf. Hendel and Lizzeri 1999a, p. 1099-1100 for an intuitive explanation for this). This leaves only three potentially undominated strategies: BNBN (always buy a new product), BUBU (always buy a used product), and XX (never purchase a product). The net present values for these strategies are given by

\[
\tilde{\Theta}_1(\lambda_x) = \frac{\theta - \lambda_x Q_e - p_n + \rho p_u}{1 - \rho},
\]

for consumers playing BNBN, \( \frac{\delta \theta - p_u - \lambda_x Q_e}{1 - \rho} \) for consumers playing BUBU, and 0 for consumers playing XX.

It is straightforward to see from the net present values that consumers who play BNBN will have higher \( \theta \) than those who play BUBU, who have higher \( \theta \) than those who play XX. Let the marginal consumer who is indifferent between BNBN and BUBU, BUBU and XX, be denoted by \( \Theta_1(\lambda_x) \) and \( \Theta_2(\lambda_x) \), respectively. Consumers in \( \theta \in (\Theta_1(\lambda_x), 1] \) will always buy new products (BNBN), consumers in \( \theta \in (\Theta_2(\lambda_x), \Theta_1(\lambda_x)] \) buy used products from the secondary market in every period (BUBU) and consumers in \( \theta \in (0, \Theta_2(\lambda_x)] \) never purchase a product (XX). Using the derived net present value functions, \( \Theta_1(\lambda_x) \) and \( \Theta_2(\lambda_x) \) can be found by solving

\[
\tilde{\Theta}_1(\lambda_x) - \frac{\lambda_x Q_e - p_n + \rho p_u}{1 - \rho} = 0,
\]

and

\[
\frac{\delta \Theta_1(\lambda_x) - p_n (1 + \rho)}{1 - \rho} = 0.
\]

Note that if \( \Theta_2(\lambda_x) \geq \Theta_1(\lambda_x) \), then BUBU is dominated, leaving only BNBN and XX as the undominated strategies. Under this situation, the marginal consumer who is indifferent between BNBN and XX can be found by solving

\[
\tilde{\Theta}_1(\lambda_x) - \frac{\lambda_x Q_e - p_n + \rho p_u}{1 - \rho} = 0,
\]

and is given by \( \tilde{\Theta}_1(\lambda_x) = p_n - \rho p_u + \lambda_x Q_e \).
A2. Proofs

Proof of Proposition 1. \( \Theta_1 \) is independent of \( \lambda_x \), and \( \Theta_2 \) & \( \tilde{\Theta}_1(\lambda_x) \) is increasing in \( \lambda_x \). Let \( D_n \) denote the demand for new products and \( D^*_u \) denote the demand for used products, where \( x \in \{l, h\} \). Then \( D^*_u = \max(\beta(\Theta_1 - \Theta_2(\lambda_x)), 0) \), and \( D^*_u = \max((1 - \beta)(\Theta_1 - \Theta_2(\lambda_x)), 0) \). Since \( \Theta_2(\lambda_x) \) is increasing in \( \lambda_x \), we have that if \( D^*_u \) > 0, then \( D^*_u \) always holds. Therefore, we can have three different cases: a. \( D^*_u, D^*_l > 0 \) (or \( \Theta_2(\lambda_x) \leq \Theta_2(\lambda_x) < \Theta_1 \)), b. \( D^*_l > 0 \) and \( D^*_u = 0 \) (or \( \Theta_2(\lambda_x) < \Theta_1 \leq \Theta_2(\lambda_x) \)), and c. \( D^*_u = D^*_u = 0 \) (or \( \Theta_1 \leq \Theta_2(\lambda_x) < \Theta_2(\lambda_x) \)).

First, consider the setting where \( D^*_u, D^*_l > 0 \), i.e., there is demand for used products from both the more snobbish and the less snobbish consumers. The aggregate volume of products in use is then given by \( D(p_n, \delta; Q_e) = 1 - \Theta_1 + (1 - \beta)(\Theta_1 - \Theta_2(\lambda_x)) + \beta(\Theta_1 - \Theta_2(\lambda_x)) \). The market-clearing price under this setting can be found by solving \( D_n = D^*_u + D^*_l \), and is given by \( p_u = \frac{\delta(1 - 2p_n + \delta - Q_e(1 - \delta)(\lambda_x + (1 - \delta)\lambda_x))}{1 + \rho + 2\rho^2} \) in \( D^*_u \), we get that \( D^*_u > 0 \) if and only if \( \delta \leq Q_e(1 - \delta)(\lambda_x + (1 - \delta)\lambda_x) \). Similarly, substituting the value of \( p_u = \frac{\delta(1 - 2p_n + \delta - Q_e(1 - \delta)(\lambda_x + (1 - \delta)\lambda_x))}{1 + \rho + 2\rho^2} \), and \( D^*_l > 0 \) under this condition. Suddenly, substituting the value of \( p_u = \frac{\delta(1 - 2p_n + \delta - Q_e(1 - \delta)(\lambda_x + (1 - \delta)\lambda_x))}{1 + \rho + 2\rho^2} \), where \( Q_e < Q_y \). Therefore, we can characterize \( D(p_n, \delta; Q_e) \) as follows: If \( 0 \leq Q_e < Q_x \), then \( D^*_u, D^*_l > 0 \) (there is demand for used products from both consumer types) and \( D(p_n, \delta; Q_e) = \frac{2(1 - p_n + \rho \delta - Q_e(1 + \rho)(\lambda_x + (1 + \delta)\lambda_x))}{1 + \rho + 2\rho^2} \). If \( Q_x < Q_e < Q_y \), then \( D^*_u > 0 \) and \( D^*_l > 0 \) (only less snobbish consumers purchase the used products), and \( D(p_n, \delta; Q_e) = \frac{2(1 - p_n + \rho \delta - Q_e(1 + \rho)(\lambda_x + (1 + \delta)\lambda_x))}{1 + \rho + 2\rho^2} \). Finally, if \( Q_y < Q_e \), then \( D^*_u = D^*_l = 0 \) (there is no demand for used products) and \( D(p_n, \delta; Q_e) = 1 - p_n - Q_e(\lambda_x + (1 - \delta)\lambda_x) \).

Let \( \sigma(Q_e) = D(p_n, \delta; Q_e) - Q_e \). \( \sigma(Q_e) \) is non-increasing in \( Q_e \), \( \sigma(0) > 0 \) and \( \sigma(Q_y) < 0 \). Therefore, there exists a unique rational expectations equilibrium which is given by the value of \( Q_e \) between 0 and \( Q_y \) such that \( \sigma(Q_e) = 0 \) (or \( D(p_n, \delta; Q_e) = Q_e \)). The condition for whether this value of \( Q_e \) is smaller than \( Q_x \) is \( \sigma(Q_x) < 0 \), which is given by \( \delta \geq 2(1 - \beta)(\lambda_x - \lambda_l) \). Therefore, we can characterize the rational expectations equilibrium as follows:

\[
D(p_n, \delta; Q_e) = \begin{cases} 
\frac{2(1 - \beta)(1 - p_n + \rho \delta)}{1 + \rho + 2\rho^2} & \text{if } 0 \leq \delta \leq \tilde{d} = 2(1 - \beta)(\lambda_x - \lambda_l), \\
\frac{2(1 - \beta)(1 + \rho \delta - Q_e(1 + \rho)(\lambda_x + (1 + \delta)\lambda_x))}{1 + \rho + 2\rho^2} & \text{if } \tilde{d} < \delta \leq 1.
\end{cases}
\]

At the rational expectations equilibrium, the new-product demand is given by \( D_n(p_n, \delta) = D(p_n, \delta)/2 \) and is strictly positive (i.e., \( \Theta_1 < 1 \) or \( \tilde{\Theta}_1 < 1 \)), which implies that both consumer types ...
purchase the new product. However, note that when $\delta < \tilde{d}$, we have that $Q_x < Q_e = D(p_n, \delta) < Q_y$, which implies that used products are purchased only by the less snobbish consumers ($D_u^b = 0$).

**Proof of Proposition 2.** For a given $\delta$, $\Pi(p_n, \delta) = (p_n - c(\delta)) D_n(p_n, \delta)$ is strictly concave in $p_n$ for both forms of $D_n$ (i.e., whether $\delta < \tilde{d}$ or $\delta > \tilde{d}$). Solving the first-order condition with respect to $p_n$, we obtain $p_n^*(\delta) = \frac{1 + \rho \delta + c(\delta)}{2}$ for both forms of $D_n$. $p_n^*(\delta)$ is independent of $\lambda_h$ and $\lambda_l$, and increasing in $\delta$. $\square$

**Proof of Proposition 3.** Let $\tilde{\Pi}(\delta) = \Pi(p_n^*(\delta), \delta)$ and $\tilde{D}_n(\delta) = D_n(p_n^*(\delta), \delta)$. $\tilde{D}_n(\delta)$ is given by $\frac{(1 - \beta)(1 + \rho \delta - c(\delta))}{2(1 - \beta)(1 + \rho \delta + \rho^2(2 - \beta - \delta) + 2(1 - \beta)(\beta \lambda_h + \lambda_l(1 - \beta + \rho(1 - \beta))))}$ for $0 \leq \delta \leq \tilde{d}$ and $\frac{1 + \rho \delta - c(\delta)}{2(1 + \rho)(\beta \lambda_h + (1 - \beta) \lambda_l)}$ otherwise. It is straightforward to see that $\tilde{D}_n(\delta)$ is weakly decreasing in $\lambda_h$ and $\lambda_l$. The rest of the proposition is straightforward to prove by differentiating $\tilde{D}_n(\delta)$ with respect to $\delta$ and imposing the required conditions. Closed-form expressions for the thresholds in the statement of the proposition are given by $\tilde{\Lambda}(\beta, \delta, \lambda_h) = \frac{2(\beta - \beta \delta - 2(\beta - c(\delta)) + c(\delta)(1 - \beta)(1 + \beta \lambda_h + c(\delta)(3 - 2(\beta + 2(1 - \beta) \lambda_h))}{2(1 - \beta)(\beta(1 - \beta) - c(\delta)(1 + \beta - \delta))}$ and $\tilde{\Lambda}(\beta, \delta, \lambda_l) = \frac{(1 + \rho)(1 + \beta \delta - c(\delta))}{2(1 + \rho)(\rho - c(\delta))}$. $\square$

**Proof of Corollary 1.** The average snobbishness of consumers who buy a new product is given by $\Omega_n = \frac{\lambda_h D_n^b + \lambda_l D_n^l}{D_n^b + D_n^l}$, and that for the consumers who buy a used product is given by $\Omega_u = \frac{\lambda_h D_u^b + \lambda_l D_u^l}{D_u^b + D_u^l}$. When $\delta < \tilde{d}$, $\Omega_n = \lambda_h(1 - \beta - \beta \delta) + \beta \lambda_h(1 + \delta) + 2\beta(1 - \beta)(\lambda_h - \lambda_l)^2$ and $\Omega_u = \lambda_l$. Otherwise, $\Omega_n = \beta \lambda_h + (1 - \beta) \lambda_l$ and $\Omega_u = \lambda_l + (\beta \lambda_h - \lambda_l)(3 + 2(1 - \beta)(\lambda_h - \lambda_l))$. It is straightforward to show that for all $\delta \in [0, 1]$, $\beta \in (0, 1)$ and $\lambda_l < \lambda_h$, $\Omega_n > \Omega_u$. $\square$

**Proof of Proposition 4.** Let $\lambda_l = 0$ and $\rho = 1$. $\tilde{\Pi}(\delta)$ is then given by $\frac{1 + \delta - c(\delta)}{4(1 + 3\delta)^2}$. $\tilde{\Pi}(0) - \tilde{\Pi}(\delta) = \frac{\delta(1 - \delta) + c(\delta)(2c(\delta) + 2\delta)}{4(1 + 3\delta)^2}$ is strictly positive for all $\delta \in (0, 1]$ and $c(\delta) < 1 + \delta$. Therefore, $\delta^* = 0$. $\square$

**Proof of Proposition 5.** The firm’s profit evaluated at $\rho = 1$ is given by $\tilde{\Pi}(\delta) = \frac{(1 + \delta - c(\delta))^2}{4(1 + 3\delta)^2}$. The firm’s problem is to maximize $\tilde{\Pi}(\delta)$ by choosing $\delta \in [0, 1]$. By solving the first-order condition for the unconstrained problem, $\tilde{\Pi}'(\delta) = 0$, we get four roots given by $r_1 = \frac{1 - \sqrt{1 + 4c}}{2c}$, $r_2 = \frac{1 + \sqrt{1 + 4c}}{2c}$, $r_3 = \frac{-3 - 4c(1 + 4\lambda) - \sqrt{9 + 4c(-15 + 48\lambda + 4c(1 + 4\lambda)^2)}}{18c}$ and $r_4 = \frac{3 - 4c(1 + 4\lambda) + \sqrt{9 + 4c(-15 + 48\lambda + 4c(1 + 4\lambda)^2)}}{18c}$. It is straightforward to show that $r_1 < 0$ and $r_2 > 1$ for $c \in [0, 1 + \delta]$ and $r_3$ is a local minimizer because $\tilde{\Pi}''(r_3) > 0$. Thus, we have only three candidate solutions for $\delta^*$: 0, $r_1$ and 1.

We will characterize $\delta^*$ in the $\lambda$-$c$ space. We begin by finding the condition when $\tilde{\Pi}(1) > \tilde{\Pi}(0)$. Let $x_1(c, \lambda) = \tilde{\Pi}(0) - \tilde{\Pi}(1)$. $dx_1(c, \lambda)/dc = \frac{2c}{1 + 4\lambda} > 0$. Thus, $x_1(0, \lambda) = -3\lambda/(2 + 10\lambda + 8\lambda^2) < 0$ and $x_1(1, \lambda) = 3/(8 + 40\lambda + 32\lambda^2) > 0$. Thus, there is a unique indifference curve defined by $c = C_2(\lambda) \equiv 2 - \frac{2(1 + \lambda)}{\sqrt{1 + 4\lambda}}$ where $\tilde{\Pi}(0) = \tilde{\Pi}(1)$; $\tilde{\Pi}(1) > \tilde{\Pi}(0)$ only if $c < C_2(\lambda)$ and $\tilde{\Pi}(1) \leq \tilde{\Pi}(0)$ otherwise. The condition $c < C_2(\lambda)$ can be rewritten as $\lambda > l_1(c) \equiv \frac{c(c - 4 - c)}{4(3 - c)(1 - c)}$. We are now going to divide the $\lambda$-$c$ space in three different collectively exhaustive and mutually exclusive regions: $c < C_1(\lambda) \equiv \frac{2 + 8\lambda}{13 + 16\lambda}$, $C_1(\lambda) \leq c \leq 1/2$ and $1/2 < c$. The reason for choosing these regions is as follows: If $c < C_1(\lambda)$ and $r_4$ is real-valued, $r_4 \geq 1$ and can be ruled out. Moreover, $\lim_{\lambda \to \infty} C_1(\lambda) = 1/2$. In each of these regions,
we will determine $\delta^*$ from the three candidate solutions (0, $r_4$ and 1) by comparing $\tilde{\Pi}(0)$, $\tilde{\Pi}(r_4)$ and $\tilde{\Pi}(1)$.

First, if $c < C_1(\lambda)$, then $r_4 \geq 1$ and is ruled out. We only need to compare 0 and 1. We know that $\tilde{\Pi}(1) > \tilde{\Pi}(0)$, i.e., $\delta^* = 1$ if $\lambda > l_1(c)$ (or $c < C_2(\lambda)$) and $\delta^* = 0$ otherwise.

Second, if $C_1(\lambda) \leq c \leq 1/2$, then we can show that $\tilde{\Pi}(0) > \tilde{\Pi}(1)$. Thus, we only need to compare $r_4$ and 0. However, $r_4 > 0$ if and only if $\lambda > \frac{-6 - 4c + 3\sqrt{c}D}{4c}$, then $r_4$ is ruled out and $\delta^* = 0$. If $\lambda > \frac{-6 - 4c + 3\sqrt{c}D}{4c}$, then $\tilde{\Pi}(r_4) > \tilde{\Pi}(0)$ only if $\lambda > l_2(c) = \frac{\sqrt{1 + 18c + 108c^2 + 216c^3 - 3 - 29c - 16c^2}}{8c(1 + 8c)}$, where $l_2(c) > \frac{3c^2 - 8 - 4 - 4c}{3c^2 - 8c - 4 + 4c^2}$. Thus, if $C_1(\lambda) \leq c \leq 1/2$, then $\delta^* = 0$ for $\lambda < l_2(c)$ and $\delta^* = r_4$ otherwise.

Finally, consider $1/2 < c$: If $\lambda < 1/8$, then $r_4$ is not real valued and is ruled out. We only need to compare 0 and 1. We can show that $1/8 < l_1(c)$, which implies $\lambda < l_1(c)$. Thus, $\tilde{\Pi}(0) > \tilde{\Pi}(1)$ for $\lambda < 1/8$, i.e., $\delta^* = 0$. If $1/8 \leq \lambda$, then we can show that $\tilde{\Pi}(r_4) > \tilde{\Pi}(0)$ and $\tilde{\Pi}(r_4) > \tilde{\Pi}(1)$, i.e., $\delta^* = r_4$. Thus, if $1/2 < c$, then $\delta^* = 0$ for $\lambda < 1/8$ and $\delta^* = r_4$ otherwise.

Putting all three cases from above together: $\delta^* = 0$ if and only if $\lambda \leq L(c)$, where $L(c)$ is defined as follows:

$$L(c) = \begin{cases} l_1(c) & \text{if } c < C_1(\lambda), \\ l_2(c) & \text{if } C_1(\lambda) \leq c \leq 1/2, \\ 1/8 & \text{if } c < 1/2. \end{cases}$$

If $\lambda > L(c)$, then $\delta^* > 0$. If $c < C_1(\lambda)$ also holds, then $\delta^* = 1$, otherwise $\delta^* = r_4$. □

**Proof of Proposition 6.** From Proposition 5, $\delta^* = 0$ for $\lambda \leq L(c)$, $\delta^* = r_4$ for $\lambda > L(c)$ and $c > C_1(\lambda)$ (where $C_1(\lambda)$ increases in $\lambda$) and $\delta^* = 1$ otherwise. Since $r_4$ increases in $\lambda$, $\delta^*$ is non-decreasing in $\lambda$. It is straightforward to see that $p_1^c(\delta)$ is increasing in $\delta$ (since $c(\delta)$ increases in $\delta$). Thus, $p_1^c(\delta^*)$ is non-decreasing in $\lambda$. When $\delta^* = 0$, $\tilde{D}_n(0) = 1/(2 + 8\lambda)$, which strictly decreases in $\lambda$. When $\delta^* \in (0, 1)$, it is straightforward to show that $dD_n(\delta^*)/d\lambda < 0$. Finally, when $\delta^* = 1$, $\tilde{D}_n(1) = \frac{1 - c}{8 + 2\lambda}$, which strictly decreases in $\lambda$. Thus, $\tilde{D}_n(\delta^*)$ strictly decreases in $\lambda$. □

**Proof of Proposition 7.** When $\lambda_h > \lambda_i > 0$, the firm’s design problem is given by $\max_{0 \leq \delta \leq 1} \Pi(\delta)$, where

$$\tilde{\Pi}(\delta) = \begin{cases} \Pi_h(\delta) & \text{if } 0 \leq \delta \leq \tilde{d}, \\ \Pi_b(\delta) & \text{if } \tilde{d} < \delta \leq 1. \end{cases}$$

Let $c(\delta) = 0$ and $\rho = 1$. $\Pi_h(\delta)$ and $\Pi_b(\delta)$ are both convex in $\delta$ and $\tilde{\Pi}(\delta)$ is continuous at $\delta = \tilde{d}$. $\tilde{\Pi}(0) - \tilde{\Pi}(1) = \frac{-(\beta \lambda_h + \lambda_i(3 - \beta))}{4(1 + 2\beta \lambda_h + 4\lambda_i - 2\beta \lambda_i)(1 + \beta \lambda_h + \lambda_i(1 - \beta))}$, which is negative for all $\beta \in [0, 1]$ and $\lambda_h > \lambda_i \geq 0$. Therefore, $\tilde{\Pi}(0) < \tilde{\Pi}(1)$, i.e., $\delta^* = 1$. □

A3. The role of time inconsistency

We can consider a two-period model similar to the one in Desai and Purohit (1998), where time inconsistency is present. We generalize their model to incorporate the exclusivity-seeking behavior.
and cost of durability as in our main model (details about this are available on request). In such a two-period model, the firm offers new products in the first period. However, in the second period, consumers who purchased a new product earlier, can choose to sell the used product on the secondary market. Therefore, while only new products are available in the first period, both new and used products may be available in the second period. It can be shown that there can be at most four consumer strategies in the two-period model: a consumer can buy a new product in both periods (by selling the old product on the secondary market in the second period), a consumer can buy a new product in the first period and hold onto it in the second period, a consumer can choose to not purchase a new product in the first period and buy a used product from the secondary market in the second period (if available).

While the optimal pricing decisions can be found analytically, finding the optimal durability is analytically intractable. However, it can be found by numerical optimization (details available on request) and is depicted in Panel B of Figure 5. By comparing the panels in Figure 5, it can be seen that our results also hold in the presence of time inconsistency: The firm may prefer to not practice planned obsolescence in the presence of snobbish consumers, and the firm’s optimal design strategy is similar under the infinite-horizon and two-period models.

**Figure 5** Comparison of the optimal design strategy with $\lambda_b = \lambda_i = \lambda$ under an infinite-horizon model (panel A) and a two-period model (panel B)

A4. Alternative model where the firm cannot commit to its pricing decision.

In our main analysis, we assumed that the firm can commit to its pricing decision, and therefore imposed the conditions for rational expectations equilibrium before solving for the firm’s optimal price. We now consider an alternate formulation, where the firm cannot commit to its pricing
decision. We will show that even under such a formulation, our main result that the firm may prefer to offer a higher durability product and avoid planned obsolescence remains unchanged. For brevity, we focus on the homogeneous case to demonstrate this (i.e., $\lambda_h = \lambda_l = \lambda$). The above change in assumption does not change that there are three undominated consumer strategies and the marginal consumers also remain the same. The market-clearing price can be found by equating $1 - \Theta_1(\lambda) = \Theta_1(\lambda) - \Theta_2(\lambda)$ and is given by $p_u = \frac{\delta (-1 + \rho - \lambda Q_e(1 - \delta))}{1 + \delta + 2\rho \delta}$. The demand for new products is given by $D_n(p_n|Q_e, \delta) = 1 - \Theta_1(\lambda) = \frac{1 + \rho \delta - p_n - \lambda Q_e(1 + \rho)}{1 + \delta + 2\rho \delta}$. The firm’s pricing problem is then given by $\max p_n(p_n - c(\delta))D_n(p_n|Q_e, \delta)$ subject to the condition for rational expectations, i.e., $Q_e = D(p_n|Q_e, \delta) = 1 - \Theta_2(\lambda)$, as a constraint, which evaluated at the marketing clearing price is given by $Q_e = \frac{2(1 - p_n + \rho \delta - \lambda Q_e(1 + \rho))}{1 + \delta + 2\rho \delta}$. Note that under this formulation, the firm’s problem is a function of $Q_e$, and the condition for rational expectations is solved along with the first-order conditions for the firm’s problem to optimize $p_n$.

Solving for the firm’s optimal price, we get $p^*_n(\delta) = \frac{1 + \delta(1 + \rho - 3\delta + 2\delta p + \lambda(1 + \rho))}{2(1 + \delta + 2\rho \delta + \lambda(1 + \rho))}$ and $D_n(\delta) = Q_e/2 = \frac{1 - \delta(1 + \rho - 3\delta + 2\delta p + \lambda(1 + \rho))}{2(1 + \delta + 2\rho \delta + \lambda(1 + \rho))}$. The firm’s profit optimized at these values is given by $\Pi(\delta) = \frac{(1 + \delta + 2\rho \delta)(1 - \delta(1 + \rho - 3\delta + 2\delta p + \lambda(1 + \rho)))}{4(1 + \delta + 2\rho \delta + \lambda(1 + \rho))^2}$. We now solve for $\delta^*$. For brevity, we will restrict our attention to the special case where durability is costless to provide ($c = 0$) and as in our main analysis for the firm’s design strategy, we will assume $\rho = 1$. First, if $\lambda = 0$, there is no difference in the firm’s profit under the two formulations, i.e., even under this formulation if $\lambda = 0$, then $\delta^* = 0$. Therefore, to find $\delta^*$, we focus on the case where $\lambda > 0$. While the profit is not strictly convex in $\delta$, there are no local maximizers between 0 and 1. This implies that there are only two potential solutions: $\delta^* = 0$ or $\delta^* = 1$. $\Pi(0) - \Pi(1) = -\frac{2\lambda(1 + 5\lambda)}{4(2 + \lambda)^3} < 0$ for $\lambda > 0$. Therefore, $\delta^* = 1$ for $\lambda > 0$. This implies that our result that the firm may prefer to avoid planned obsolescence and offer products with high durability is robust to our assumption that the consumers form their expectations after the firm has committed to the new-product price. □

References


9 See Katz and Shapiro (1985), who also compare two such formulations in the context of positive effects to examine the robustness of their results.


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