Selling to Conspicuous Consumers: Pricing, Production and Sourcing Decisions[1]

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Abstract

Consumers often purchase goods that are "hard to find" to conspicuously display their exclusivity and social status. Firms that produce such conspicuously consumed goods such as designer apparel, fashion goods, jewelry, etc., often face challenges in making optimal pricing and production decisions. Such firms are confronted with precipitous tradeoff between high sales volume and high margins, due to the highly uncertain market demand, strategic consumer behavior, and the display of conspicuous consumption. In this paper, we propose a model that addresses pricing and production decisions for a firm, using the rational expectations framework. We show that, in equilibrium, firms may offer high availability of goods despite the presence of conspicuous consumption. We show that scarcity strategies are harder to adopt as demand variability increases, and we provide conditions under which scarcity strategies could be successfully adopted to improve profits. Finally, to *credibly* commit to scarcity strategy, we show that firms can adopt sourcing strategies, such as sourcing from an expensive production location/supplier or using expensive raw materials, that signal deeper investment in unit production costs.
Keywords: Strategic Customer Behavior, Game Theory, Conspicuous Consumption, Pricing, Scarcity, Sourcing.

1. Introduction

Consumers looking to signal their uniqueness and exclusivity, have often expressed themselves by consuming goods prominently to display their status. Firms that design and sell luxury products or innovative gadgets have often desired exclusivity in their looks and design. The prominent display of logos, limited availability, and expensive designs are some ways through which firms have displayed their exclusivity. For instance, the "*Big Pony*" apparel line designed by Ralph Lauren, has more prominent logos that can be displayed conspicuously by the wearer.[2] Many luxury watches with intricate designs, such as *Piaget*, are sold only through limited number of boutique stores and authorized retailers in the United States (*www.piaget.com*). Firms often face decisions on how to make production and pricing decisions when selling such conspicuous goods.

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[2]A comparison between "Classic-Fit Polo" and the more conspicuous "Classic-Fit Big Pony Polo" shirts on *http://www.ralphlauren.com* shows the "Big Pony" designs being sold at higher prices.

We study the decisions of a firm when there is conspicuous consumption, i.e., when some members of the population are motivated by *invidious comparison* (Bagwell and Bernheim 1996). Invidious comparison refers to situations in which a member of a customer class consumes conspicuously to distinguish himself from other members. We examine the cases when some consumers seek, purchase, and consume hard-to-find products to display their distinction from the other consumers in the population. Consistent with the literature (Leibenstein 1950, Amaldoss and Jain 2005a), we term customers that are driven by such invidious comparisons as engaging in *snobbish* behavior.

With increasingly unpredictable market demand conditions, many firms selling to conspicuous consumers face difficult tradeoffs between profits and exclusivity, which puts them in a bind. Some firms adopt the strategy to compete on prices and hope to increase revenues through sales volume. In recent times, retailers such as Nordstrom have attributed their increased revenues to slashed prices and increased inventory availability.[3] On the other hand, other firms have chosen to limit their product availability by creating scarcity (Rigby *et al* 2009), and such shortages for new products have been commonly observed (Gumbel 2007).

In general, a reduction in product availability leads to reduced sales, which may hurt firm profits. Thus, it is still unclear if the firms should use scarcity strategies in selling goods, and if they do so, when those strategies should be implemented. Thus, both from practitioner and research perspectives, it is imperative to understand how firms should make interconnected decisions such as how much of the good to produce, how to price those goods, and when to invest in innovative designs or use an expensive supplier, etc.

In this paper, we analyze a monopolist firm's pricing and production decisions while selling a good to a market with uncertain demand from conspicuous consumers.[4] When the demand in not deterministic, it is difficult to point out if scarcity occurred due to an unexpected high demand (a random realization) or due to decidedly low inventory (a strategic decision). Often, it is difficult to separate the two effects, due to the lack of full information on the production process (unobservability). This is a key focal point of our approach. We show that indeed scarcity strategy could emerge in equilibrium in such markets.

Our model uses the rational expectations framework (Muth 1961, Stokey 1981) to analyze conspicuous consumption. This concept has been used in some recent Marketing and Operations papers (See for instance, Amaldoss and Jain (2005a), Jerath *et al* (2010), Su (2007).).

[3]Nordstrom CEO David Spatz argued for cutting prices of several products to respond effectively to the market. For instance, handmade Anyi Lu designer shoes sold at less than $400, instead of the regular retail price $595 which was accompanied by 69% increase in store inventory (Giacobbe 2009).

[4]Examples of such conspicuous products might include Chrisian Dior watches (Amaldoss and Jain, 2005a), Yves Saint Laurent shoes (Bruner and Hodrick 2005), "Cherry Blossom" Murakami bags (Amaldoss and Jain 2008).

The scheme of our paper is as follows. We first position our contributions with respect to extant literature. In Section 2, we analyze the equilibrium pricing and production decisions of a firm selling to conspicuous consumers in a homogenous market (in §2.1) and a heterogenous market (in §2.2). Using our structural results, we consider strategic "scarcity" decisions in Section 3. In Section 4, we show that our structural insights on scarcity hold under a variety of alternative models and conditions. In Section 5, we discuss how firms can commit to scarcity strategy, either by limiting clearance pricing or sourcing expensively. We conclude and discuss future research in Section 6.

1.1 Our position in the literature

Many new products – gadgets, fashion apparel, and goods (designer brands) – are often treated as vehicles of self-expression through which consumers exhibit their desire for exclusivity or conformity. Economists and Marketing Researchers have long been interested in how consumer decision-making related to a purchase could be dependent on such social factors. Recently, there has also been emergent interest in the operations management literature, on how production decisions are impacted by consumers' decision making behavior (within the rational framework). This paper bridges the marketing and operational decisions of a firm when it sells to consumers involved in conspicuous consumption, and notes how operational decisions in sourcing, salvaging, and production investment can be employed together with marketing strategies such as pricing and scarcity strategies.

Economics Literature: Economists have pointed out how consumption could be beset with positive externalities due to social conformity in the context of restaurant choice (Becker 1991), due to network effects in the context of technology (Katz and Shapiro 1985), due to market frenzies (DeGraba 1995), or due to herd behavior (Bikhchandani et al 1992).

However, the notion of consumers purchasing goods to be *conspicuous* dates back to Veblen (1899) who, in his *"The Theory of the Leisure Class"*, explained how individuals consumed highly conspicuous goods and services in order to advertise their wealth or social status. Leibenstein (1950) emphasized the significance of social factors in consumption, and argued that price by itself might enhance utility. Bagwell and Bernheim (1996) argue that the relationship between price and demand should emerge in equilibrium, and derive conditions for such "Veblen effects" to arise in equilibrium. Corneo and Jeanne (1997) establish that conspicuous consumption might emerge as a tool to signal wealth. While economics literature has focussed on when Veblen effects may emerge in market equilibrium, the pricing and demand management decisions of a firm facing conspicuous consumers have been relatively underexplored.

Marketing Literature: In a series of papers, Amaldoss and Jain (2005a, 2005b) were the first to

model the marketing decisions related to consumer conspicuous consumption behavior. Amaldoss and Jain (2005a) study the pricing decisions of a firm facing *deterministic* price-dependent demand, and show that snobs may exhibit an upwards sloping demand curve only in a heterogenous market. They conduct laboratory experiments that confirm the equilibrium price derived from the model. In Amaldoss and Jain (2005b), the pricing problem related to the model is analyzed for a duopoly. Finally, Amaldoss and Jain (2008) show that the addition of costly features to a product can increase profits in a market with reference group effects. Recent research on shortages of goods as a marketing strategy is also relevant to our paper. Stock and Balachander (2005) provide a signaling strategy to explain product shortages in order to sell 'hot' products in a market with quality uncertainty. Balachander and Stock (2009) provide strategic directions on when to offer "limited products" as a part of the product line.

In contrast, we explore a market with conspicuous consumption and *uncertain* demand. Both pricing and production decisions need to be made before a random demand is realized. In such a market, in the absence of signaling explanations, we show that scarcity strategy could emerge in the market due to the presence of demand uncertainty.

Further, it is difficult to separate if scarcity occurred due to a strategic decision or missed forecasts. Therefore, we offer a signaling explanation for high investment: A firm can credibly commit to scarcity strategy by sourcing or producing its goods in a more expensive production channel, even without reference group effects, due to demand uncertainty. Increased sourcing costs signal an ex ante commitment to exclusivity and low production volumes from the firm. More importantly, we show that such decisions are credible and consistent ex post (i.e., the firm can not overproduce goods after demand realization).

Operations Literature: While operations management literature has a tradition in modeling demand uncertainties, the interest in modeling strategic consumer behavior is recent and gaining increased attention. The operational impact of forward-looking or strategic customers has been considered in variety of contexts such as seasonal goods (Aviv and Pazgal 2008), commitment in supply chain performance (Su and Zhang 2008), triggering early purchases (Liu and van Ryzin 2008), price-match guarantees (Lai *et al* 2009), reservations (Çil and Lariviere 2009) and quick response strategy (Cachon and Swinney 2009). See Netessine and Tang (2009) and papers therein for an excellent overview of strategic consumer behavior literature. There has also been some recent interest in Operations in understanding how inventory shortages (Debo and van Ryzin 2009) or long queues (Veeraraghavan and Debo 2009) may signal quality. However, none of the above papers in this stream of literature consider conspicuous consumption. We believe that our work establishes

how scarcity strategies could emerge in equilibrium in stochastic demand environments. We now detail our contributions to the extant literature (Also, see Table 1).

• We build an analytical framework for a firm making joint operational and marketing decisions (viz. pricing, production quantity and sourcing strategy), when selling to a market with uncertain demand and when consumers exhibit strategic purchasing behavior and/or conspicuous consumption. Our equilibrium results hold under general conditions of demand uncertainty.

• While it has been shown that scarcity can be a strategy to signal quality (Stock and Balachander 2005), it is unclear if scarcity can lead to improved profits when there is no quality uncertainty in the market. Scarcity necessarily implies a reduction in product availability, and therefore a reduction in unit sales. We show that demand uncertainty coupled with conspicuous consumption can indeed lead to market conditions where products are scarce and the firm makes higher profits.

• We show that when selling to markets with conspicuous consumption, due to increased margins, firms may *overproduce* goods compared to its production decision in a market without such conspicuous consumption. Therefore, surprisingly, there may be *fewer* stockouts in a market in which sufficient number of consumers prefer exclusivity. For instance, if the market is composed of snobs, it may be optimal for the firm to overproduce, even more than it would produce in a market in which all strategic consumer behavior is ignored. This finding contrasts with the extant literature, which shows that strategic buying leads to a reduction in production quantities (See Su and Zhang 2008, pp. 64.).

• We show that scarcity strategy is beneficial to the firm when the fraction of consumers engaging in conspicuous consumption ('snobs') is neither too high nor too low. When there are too few snobs in the market, the firm decides to sell to everyone at lower prices. When there are too many snobs in the market, the attractive profit margins trigger the firm to overcommit to large production quantities, to minimize the 'lost sales'. As a result, the product would not be scarce.

• Finally, firms that sell to consumers exhibiting conspicuous consumption may resort to expensive sourcing or increased production costs. In such cases, firms deliberately source the good from a more expensive location, or use a costlier supplier, and/or use more expensive raw material components in producing the good.[5] Often inventory commitment is not fully verifiable by consumers. A firm can *credibly* commit to its scarcity strategy, by marketing its sourcing strategy. If products are produced through an expensive process, it is unlikely that the firm can invest in upfront costs

[5]In Operations Literature, sourcing exclusively from a more expensive supplier has been considered an unviable strategy unless the supplier has faster delivery times or better reliability (Tomlin 2006). In those cases, an expensive supply source is sparingly used as an expeditious alternative.

to produce too many units of the good. Therefore, consumers believe that the product is likely to be scarce, which drives up the valuation for snobs in the market.

2. Pricing and Production Decisions

Our model involves a single monopolist firm who has to make two decisions – production quantity, Q, and the price charged per unit, p, – before a random demand, D, is realized in a market composed of non-atomistic customers. The demand is distributed with cumulative distribution function F_D, with density function f_D.[6] The firm incurs a constant marginal cost, c, per unit produced. If the firm produces more than the realized demand, it will be able to salvage the remaining leftover inventory at a lower price, $s(< c)$, at the end of the selling period (i.e., during the salvage period). Let x^+ denotes $max(x, 0)$. The firm's expected profit can be written as, $\Pi_N(Q, p) = \mathbb{E}[p\min(D, Q) + s(Q-D)^+ - cQ]$. We assume that all the customers have the same valuation, v, for the product.[7] In a market without any strategic behavior or conspicuous consumption, the optimal production quantity and price are set as per newsvendor decision (see Cachon and Terwiesch 2008): $p_0 = v, \quad F_D(Q_0) = (p_0-c)/(p_0-s)$. Henceforth, the p_0 and Q_0 shall be referred to as the traditional newsvendor price and quantity.

However, customers are strategic, i.e, the customers recognize that if the product remains unsold it would be available in the salvage market at price s. We term such a customer a *strategic customer* (Su and Zhang 2008). The decision of the strategic customer is to choose whether to buy the product in the selling period, or wait to buy the product later in the salvage period. Since the production quantity remains unobserved, each strategic customer has to form a belief over the expectation of not being able to find the product, i.e., the stockout probability ε_s, during the selling period. Based on these expectations, the customer's expected surplus if she faces an actual regular price p is $U_{strategic} = \max\{v - p, (1 - \varepsilon_s)(v - s)\}$. We apply *rational expectations* (Muth 1961) to solve for the equilibrium price and production quantity chosen by the firm in this environment.

2.1 Modeling Conspicuous Consumption in a Homogenous Market

Customers, in addition to being *strategic (or forward looking)*, may also exhibit conspicuous consumption. As per Leibenstein (1950) and Amaldoss and Jain (2005a), we address these customers

[6] We assume that demand distribution F_D has increasing generalized failure rate (IGFR, Lariviere 2005). This is a mild assumption that fits many distributions including the Normal distribution, the Uniform distribution, the Gamma distribution, and the Weibull distribution. We suppress subscript D and use $F(\cdot)$ to denote $F_D(\cdot)$ when it is unambiguous. Further, let $\overline{F}(\cdot)$ denote $1 - F(\cdot)$.

[7] To eliminate trivial outcomes, we assume that the customer will value a product more than its cost of production, i.e., $v > c$.

as *snobs*. In this section, we begin the analysis with a market composed solely of strategic customers who exhibit conspicuous consumption (The assumption is relaxed in Section 2.2.). Snobs have a higher utility for consuming a product when they figure that other consumers are unable to consume the same product. Suppose a firm produces a good in small quantities. If snobs acquire the product and consume it, they will be seen as the select few members in the market who consume such a scarce good (i.e., their consumption is conspicuously observed), which in turn increases their utility for such products (Brown 2001).

As before, we assume that the actual quantities produced by the firm for the market remain unobservable to the snobs.[8] Thus, belief on product availability is one important factor that snobs can use to exhibit their conspicuous consumption. Based on their beliefs on product availability, they seek out hard-to-find products, and derive a higher utility in their exclusiveness.

A consumer *might* build her belief on availability through two observations: First, she observes that the shelf space dedicated to the product at a retailer is often empty or running low. Second, she deciphers, through information accrual, that many other customers are trying to locate the product, but often facing stockouts. Together, the general non-availability of the product increases her utility for the product, although it might be equally hard for her to get the product. Mathematically, we integrate this snobbishness to her utility function based on the stockout belief ε_s as $U_{snob} = \max\{v + k\varepsilon_s - p, (1-\varepsilon_s)(v-s)\}$, where k represents the *sensitivity to stockouts*.[9] It measures a consumer's responsiveness to the product scarcity.[10] For a snob, the higher the value of k is, the higher the utility she gets from purchasing the product on the observation of a stock-out.[11] There is substantial evidence from literature regarding how stockouts may improve a customer's utility,

[8]Many firms produce exclusive goods to sell to snobs. Sometimes, firms announce the exact quantities (Liverpool FC commemorative phones, Sung 2009). Often being proprietary, inventory and shipment quantities are often not easily verifiable information, because the production process remains unobserved by customers.

[9]We keep the dependency on stockouts linear only for analytical and expository ease. However, as shown in Section 4.3, our results can be expanded to utility functions that have non-linear dependencies on stockout probability.

[10]There is evidence that even snobbish customers wait for a good deal (Rice 2010). Firms such as *bluefly.com*, *Gilt Groupe* (Rice 2010) specialize in salvage markets for luxury goods. In any case, our results hold even if snobs are myopic, and not forward-looking in their purchase behavior (See §4.1).

[11]Comparison with Amaldoss and Jain (2005a): In Amaldoss and Jain (2005a), the utility of the snob is written as $U(z^e, p) = v - p - g(z^e)$ where v is the base valuation, p is the price for the product, and z^e is the quantity produced/sold in equilibrium (which is same as the number of buyers). $g(z)$ is a positive increasing function in the interval $z \in [0,1]$ with $g(0) = 0, g(1) < \infty$.
Note that in our model, the number of buyers is stochastic and distributed over $(0, \infty)$ and there is a production decision Q. In general, the number of buyers is higher or lower than Q. Furthermore, the stockout realization is a discrete variable. Hence, to create a function similar to $g(\cdot)$, we need one variable to connect both demand realization and production decision (Q), i.e., the probability of stockouts, $\Pr[buyers > Q] \simeq \bar{F}(Q) = \varepsilon_s$ (based on rational beliefs). The snobs' utility in the selling period is $v - p + k\Pr[buyers > Q] = v - p - (-k\Pr[buyers > Q])$. Comparing this with $g(\cdot)$, we find that $-k\Pr[buyers > Q]$ is an increasing function in (equilibrium) quantity Q. Nevertheless, our results continue to hold with alternate formulations even if the beliefs were based on fill rate (§4.4), or expected sales (§4.5), or production quantity (§4.6).

or enhance her preference for the product (see Lynn 1991 and references therein).

The firm has to develop beliefs on the customers' reservation price for the product. This belief may be accrued from sales/consumer data from a similar portfolio of products that the firm had made in the past.[12] We denote the firm's (seller's) belief over the reservation price as ε_r. Based on ε_r, it chooses the price optimally, and will produce the corresponding optimal quantity to maximize its profits. A customer's problem is to decide on whether she should buy the product in the selling period, or in the salvage period. She buys in the selling period, if and only if $v + k\varepsilon_s - p \geq (1 - \varepsilon_s)(v - s)$. This leads to the snob's reservation price, $r = \varepsilon_s(k + v - s) + s$.

RE equilibrium requires very little information to be known to the players. In fact, in our case, given every agent's rational expectations, the game between the firm and the consumers decomposes into two separate decision problems. For the consumers: a binary choice problem regarding whether to buy in the selling period or wait (based on stockouts). For the firm: newsvendor profit maximization. Both of these problems have unique solutions. The only information the firm needs is the nature of the decision problem that customers are solving, and vice-versa. Moreover, each decision problem does not require information about the other side of the market (because they are driven by *rational beliefs* that are confirmed in equilibrium). For example, given beliefs ε_s, consumers do not need to know the sellers cost c. Similarly, given beliefs ε_r, the firm does not have to know the consumers valuation v. Therefore, once all players have (rational) beliefs, their optimal actions will settle into the equilibrium outcome. We are now ready to define the rational expectations equilibrium (RE equilibrium) conditions for our model.

Definition 1. *An RE equilibrium* $(p, Q, r, \varepsilon_s, \varepsilon_r)$ *satisfies the following conditions:* (i) $p = \varepsilon_r$, (ii) $Q = argmax_q\ \Pi_N(q, p)$, (iii) $r = \varepsilon_s(k + v - s) + s$, (iv) $\varepsilon_s = \bar{F}_D(Q)$, (v) $\varepsilon_r = r$.

Conditions (i), (ii) and (iii) assert that, under expectations ε_r and ε_s, the firm and all consumers will rationally act to maximize their utilities. Condition (iv) specifies that, in equilibrium, the stockout expectations ε_s must match with the actual probability of not being able to find the product (consistency conditions).

Consider a customer who is indifferent between buying in the first period and waiting to buy in the salvage period. Since she knows that every other customer is also strategic and snobbish, she builds a belief on availability of the product. She rationalizes that other customers who are trying to buy the product face the same stockout probabilities as she does. Since we assume non-atomistic

[12] Often the development process of these beliefs is unspecified. In contrast to evolutive justifications based on the learning offered by the repetitions of game, Guesnerie (1992) offers an eductive approach - forecasting forecasting of others - that also aligns well with the game we study.

decision makers, the mass of remaining customers is D if the realization of the demand is D. Thus, she faces a possibility of stock-out, $P(D \geqslant Q)$, which must be consistent with her belief ε_s, as stated by (iv). Finally, condition (v) requires that the firm correctly predicts the snob's reservation price.

Conditions in Definition 1 can be reduced to conditions in p and Q only: $p = \bar{F}_D(Q)(k+v-s)+s$ and $Q = argmax_q \Pi_N(q,p)$. With the aforementioned conditions, we are ready to describe the RE equilibrium in Proposition 1.

Proposition 1. *In the RE equilibrium all customers can buy immediately, and the firm's price and quantity choices are characterized by:* $p_s^* = s + \sqrt{(k+v-s)(c-s)}$, $\bar{F}_D(Q_s^*) = \sqrt{\frac{c-s}{k+v-s}}$.

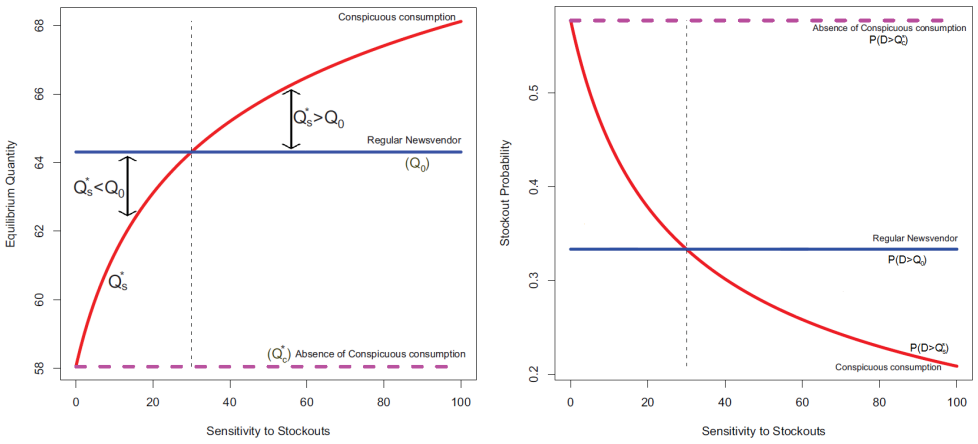
All proofs are deferred to the Appendix. We use p_s^* and Q_s^* to denote the equilibrium price and quantity decision the firm makes, (and subscript s in general), when it chooses to sell the product based on *snobs'* reservation prices. For the purposes of benchmarking, we compare the optimal decision when conspicuous consumption is present in the market to the decisions (p_s^* and Q_s^*) when there is none ($k = 0$).

1. The equilibrium price when faced with snobs, p_s^*, turns out to be higher than the equilibrium price choice when faced with just strategic customers, p_c^*. This reaffirms our intuition.

2. Intriguingly, the equilibrium production quantity, when conspicuous consumption is present, Q_s^*, is *higher* than the equilibrium production, Q_c^* (when there is no conspicuous consumption).[13] The firm 'overproduces' due to higher margins (underage costs). Just because consumers exhibit conspicuous consumption does *not* imply that the consequent production quantities would be low. In fact, as customers become more snobbish (i.e., their valuation increases significantly due to stockouts), the equilibrium stockout probability *falls*. This is illustrated in Figure 1(b) where equilibrium stockout probability decreases steadily with sensitivity to stockouts.

3. Note from Figure 1(a), that the production quantity when customers are just strategic is lower than the newsvendor case, i.e., $Q_c^* < Q_0$. However, since $Q_s^* > Q_c^*$, it is unclear whether under conspicuous consumption, the production quantities are lower or higher than the newsvendor quantity. Comparing our equilibrium decisions with the newsvendor decisions, we find that $Q_s^* < Q_0$ and $p_s^* < p_0^*$ when $k < (v-s)(v-c)/(c-s)$ and $Q_s^* \geq Q_0$ otherwise (Proofs deferred to the Appendix). If k is high, the firm produces more than it would in the traditional newsvendor setting. Thus, even though consumers exhibit strategic buying behavior and conspicuous consumption, we find that the firm may not necessarily produce less inventory. The higher margins that can be accrued

[13] Notice that $Q_s^* > Q_c^*$ because $\bar{F}_D(Q_c^*) = \sqrt{\frac{c-s}{v-s}} > \sqrt{\frac{c-s}{k+v-s}} = \bar{F}_D(Q_s^*)$.



(a) (b)

Figure 1: The equilibrium quantities (left panel, a) and stock-out probabilities $P(D > Q)$ (right panel, b) are plotted with respect to the sensitivity to stockouts, k for the three markets: newsvendor, strategic consumers, conspicuous consumers. For illustrative purposes, the demand distribution is $N(\mu = 60, \sigma^2 = 100)$, and the parameters are $v = 20$, $c = 10$, $s = 5$.

from conspicuous consumers, make the firm 'overcommit' to higher production volume, more so than it would if those consumers were not conspicuous consumers. Thus, accounting for marketing behaviors, – such as pricing under conspicuous consumption –, impacts other areas of the firm and leads to distinct operational decisions. We now analyze the heterogenous market which forms the base model for all extensions analyzed in the paper.

2.2 Conspicuous Consumption in a Heterogenous Market (Snobs and Commoners)

The market is composed of *two* different types of customers, whom we term as *snobs* and *commoners* (*cf.* Leibenstein 1950). We use β to denote the fraction of customer population who are snobs. The rest of the population $(1 - \beta)$ is composed of *commoners*. A *commoner* is distinguished from a *snob* in the following sense: A commoner does not exhibit any inclination for conspicuous consumption, but she may still be strategic in her decision-making. Both types of customers (snobs and commoners) are willing to buy the product in the selling period as long as the firm does not charge a price higher than *their own* reservation price. Since there are two possible reservation prices within the market, the firm will have two possible consistent quantity choices, and this will in turn affect the equilibrium availability and beliefs (ε_s).

Thus, there are two possible candidates for the RE equilibrium. The firm charges one of the reservation prices based on the percentage of snobs and produces an optimal quantity that will make the expectations of the customers consistent. Thereafter, the customers observe the price

and decide whether to buy the product in the selling period.

Definition 2. *When the firm charges the snob's (commoner's) reservation price, an RE equilibrium* $(p, Q, r, \varepsilon_s, \varepsilon_r)$ *satisfies the following conditions:* (i) $p = \varepsilon_r$, (ii) $Q = argmax_q\ \Pi_N(q, p)$, (iii) $r = \varepsilon_s(k + v - s) + s$ $(r = \varepsilon_s(v - s) + s)$, (iv) $\varepsilon_s = \bar{F}_{\beta D}(Q)$ $\left(\varepsilon_s = \bar{F}_D(Q)\right)$, (v) $\varepsilon_r = r$.

The conditions imposed in Definition 2 are the same as those imposed in Definition 1 except for the conditions (iii) and (iv). Those conditions relate to the beliefs on the reservation price and product availability. The total mass of the customers who are in the market for the product will vary based on the price charged by the firm, and therefore the beliefs on stockouts and reservation prices will also change.

If the firm prices the product based on its belief on snobs' reservation price, then only snobs are present in the market to purchase the product (since the high price rules out commoners from buying the product). Thus, the random variable D is rescaled from D to βD and stockout probability becomes $P(\beta D \geqslant Q)$ or simply, $\bar{F}_{\beta D}(Q)$. The corresponding equilibrium production quantity is given by Proposition 2(1).

On the other hand, if the firm charges the commoner's reservation price, the mass of the customers in the market remains identical to the initial demand distribution, since the offered price is lower than everyone's reservation price. In this case, a possibility of stock-out stays the same as in Definition 1, $\bar{F}_D(Q)$. This is indicated in Proposition 2(2).

Proposition 2. *1.* ***(Limited Production)*** *In the RE equilibrium under limited production, only snobs can buy, and the firm's price and quantity choices are characterized by* $P(\beta \cdot D > Q_s^*) = \sqrt{\frac{c-s}{k+v-s}}$ *and* $p_s^* = \sqrt{(c-s)(k+v-s)} + s$.

2. ***(Regular Production)*** *In the RE equilibrium, all customers (snobs & commoners) can buy, and the firm's price and quantity decisions are characterized by* $P(D > Q_c) = \sqrt{\frac{c-s}{v-s}}$ *and* $p_c^* = \sqrt{(c-s)(v-s)} + s$.

Depending on the market parameters, the profit-maximizing firm would adopt one of the aforementioned strategies. Since consumers are rational, and can correctly form expectations about firm's strategies, the corresponding RE equilibrium would emerge. We investigate the two candidate strategies to see when limited production or regular production would be preferred by the firm. We use $\Pi_{N,s}^*$ and $\Pi_{N,c}^*$ to denote the firm's optimal profits obtained under the *Limited Production* strategy (selling only to snobs) and *Regular Production* strategy (selling to snobs and commoners) respectively.

Proposition 3. *There exists a unique threshold* β^*[14] *such that for* $\beta \leq \beta^*$ *in the RE equilibrium,* $\Pi^*_{N,s} > \Pi^*_{N,c}$ *the firm adopts Regular Production strategy and all customers can buy. If* $\beta > \beta^*$ *then* $\Pi^*_{N,s} > \Pi^*_{N,c}$*, the firm adopts Limited Production and only snobs can buy.*

If the number of snobs in the market is low (i.e. $\beta \leq \beta^*$), the firm will price the product at the commoner's reservation price, thus making it possible for all consumers to buy it. The additional profits accrued from the higher price premiums can be compensated by selling to a significantly larger market at a lower price. However, if there is a sufficient presence of snobs in the market ($\beta > \beta^*$), the firm adopts the *limited production* strategy, by attempting to sell only to the snobs. On average, the firm can afford to sell to snobs at high prices, even though the volume of sales has been pushed down due to reduced market coverage.

We note that serving only to the snobs might also be perceived as "scarcity" strategy. This is not necessarily true. In this case, the firm's decisions are dictated by two counter-acting factors. First, selling only to snobs means that the average demand in the market is reduced – this means the production quantity will tend to *reduce* on average. However, selling only to snobs increases the *underage cost* or the *product margin*, since the product is now marketed to snobs at more expensive prices. This means that the production quantity will *increase*. Due to the higher underage cost, more units of the product are produced to avoid the opportunity cost of missing those high margin sales (lost sales). These two effects counteract each other. Thus, the resultant production quantity may be higher or lower than the production quantity when the firm sells to everyone in the market.

In fact, we find that if the fraction of snobs in the market is below a certain threshold, the product might be scarce to find compared to the case in which the firm sells the product to all consumer types, i.e., the probability that product is in-stock is lower. This is captured in Proposition 4.

Proposition 4. *There exists a unique fraction of percentage of snobs,* β_Q*, where* $Q^*_s < Q^*_c$ *when* $\beta < \beta_Q$ *and* $Q^*_s > Q^*_c$ *when* $\beta > \beta_Q$*. This threshold level is given by* $\beta_Q = \bar{F}_D^{-1}\left(\sqrt{\frac{c-s}{v-s}}\right) / \bar{F}_D^{-1}\left(\sqrt{\frac{c-s}{k+v-s}}\right)$.

Proposition 4 asserts that the strategy of restricting the sales only to snobs does not always imply the scarcity of the product. In fact, the product might be commonly available even though the firm covers only the snobs in the market. Consequent to Proposition 4, the product is scarce in the market only if (i) the product is limited to snobs (Limited Production), and (ii) the production quantities are lower than the quantities the firm produces when it sells to the whole market (i.e.

[14] $\beta^* = \sqrt{\frac{v-s}{k+v-s}} \cdot \int_0^{\bar{F}_D^{-1}(\sqrt{\frac{c-s}{v-s}})} u f_D(u)\, du \Big/ \int_0^{\bar{F}_D^{-1}(\sqrt{\frac{c-s}{k+v-s}})} u f_D(u)\, du$

$Q_s^* < Q_c^*$). Thus scarcity exists only when $\beta \in (\beta^*, \beta_Q)$. We elaborate this interesting finding on scarcity further in Section 3. In Section 4, we establish the robustness of our result, by showing that this "intermediate" scarcity profile continues to exist under a wide variety of modeling variations.

3. Analysis of Scarcity Strategies

To discuss scarcity strategies in the market, we first define the notion of "scarcity". We define a product to be *scarce* when the total quantity available in the market with conspicuous customers is lower than the optimal quantity that would have been produced for the market (with an identical demand distribution) in which the customers are forward-looking but do not exhibit conspicuous consumption behavior (i.e. $Q_s^* < Q_c^*$).[15]

From Proposition 3, when $\beta \leq \beta^*$, regular production is adopted and Q_c^* units are available in the market. When the fraction of snobs in the population exceeds β^*, the firm switches to selling only to snobs (i.e. Limited Production). As β increases, selling only to snobs continues to remain the optimal selling strategy. However, note that the production volume increases since the mean demand (i.e. the fraction of snobs in the market) is increasing. As a result, if the fraction of snobs in the market is higher than β_Q (from Proposition 4), the total production volume and the availability of products (in-stock probability) are both *higher* than in the case when customers are just strategic. Thus, the in-stock probability for the product is lower (i.e. the product is *scarcer* to find) in the intermediate region between β^* and β_Q. Furthermore, Figure 2 also reveals that the extent of scarcity is the strongest when the fraction of snobs is just higher than β^*.

3.1 Increased Response to stock-outs

We now study the prevalence of scarcity as the snobs' sensitivity to stockouts varies. In Figure 2, we study how scarcity decisions vary with the fraction of snobs in the market, as the sensitivity to stockouts increases (from $k = 10$ in Figure 2(a) to $k = 45$ in Figure 2(b)). We find that when the market is concentrated with snobs, who are highly sensitive to stockouts (high k), the firm might produce more quantity than the regular newsvendor quantity in equilibrium (even though the customers are strategic). Note that these results extend the observations from §2.1 which showed that the equilibrium production may exceed the newsvendor production quantity when the sensitivity to stockouts is high.

[15] Figures in 2 demonstrate that our notion of scarcity is *stricter* than comparing the equilibrium production quantity to the standard newsvendor production quantity.

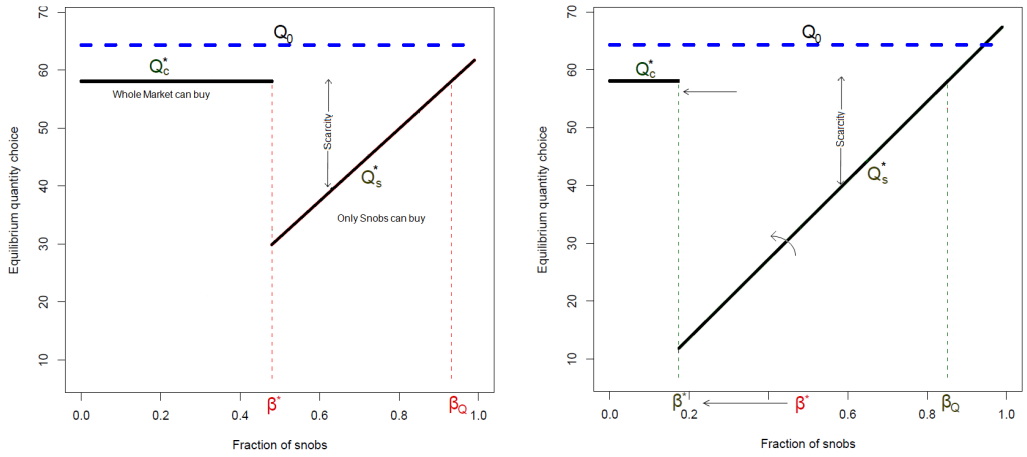


Figure 2: The equilibrium production over different (β). For representative illustration, $v = 20, c = 10, s = 5$, and the demand distribution is $N(\mu = 60, \sigma^2 = 100)$. On the left figure ($k = 10$) and right ($k = 45$). The dotted line above represents the production quantity when customer behavior is entirely ignored. Note that in the region between β^* and β_Q, the optimal production capacity is lower the production quantity when all customers are strategic (Q_c^*). This defines the scarcity region. The difference between Q_c^* and Q_s^*, pointed out in the plot denotes the extent or the *degree* of scarcity in the market. An increase in responsiveness to stockouts k (left figure to right figure) leads to a decrease in β^* and an increase in the slope of Q_s^*.

Furthermore, as the snobs become more sensitive to stockouts, we make two key observations:

1. The threshold β^* decreases with sensitivity to stockouts (k). If scarcity becomes more desirable to snobs, the firm is more likely to offer *limited production*.

2. On the other hand, the optimal equilibrium production quantity under the *limited production* strategy increases more steeply with the fraction of snobs in the market as k increases (i.e. slope of the line under *limited production* strategy increases). If the snobs respond strongly to stockouts, the reservation prices would be even higher, which results in higher price (and an increased underage cost). As a result, the production quantities increase steeply despite the firm adopting a strategy of selling only to snobs. This has the effect of *reducing* the degree of scarcity (fewer stockouts).

Lemma 1. *For higher k, the equilibrium production quantity Q_s^* increases more steeply in β.*

Lemma 1 demonstrates that the optimal production quantity increases faster in β as the sensitivity to stockouts increases. As snobs become more sensitive to stockouts, the firm *increases* its production quantities even further since the margins from the sales to snobs has also increased. Even though snobs are sensitive to stockouts, their willingness to pay more for exclusivity, causes the firm to produce more goods than usual, since the opportunity cost of losing a sale to such a customer is very high. In other words, the firm is averse to losing a high margin sale (on those rare

stockouts), and stocks up on inventory, even though it runs the risk of reduced exclusivity amongst the snobs. Lemma 2 summarizes the behavior of the thresholds with respect to sensitivity of snobs to stockouts.

Lemma 2. *The threshold levels, β^* and β_Q, decrease with increase in sensitivity to stock-out, k.*

Recall that the firm adopts the limited production strategy when the number of snobs in the market is more than β^*. Lemma 2 indicates that the firm would adopt the limited production strategy *more often* as the sensitivity to stockouts increases in the market for the snobbish customers. Conversely, Lemma 2 also states that β_Q decreases in k. The more sensitive the snobs are to stockouts, the more likely the strategy of selling to snobs leads to over-production (i.e. more than the equilibrium quantity produced when the good is available to the whole market). As seen in Lemma 1, the increased opportunity cost drives the firm into producing more goods. In other words, the cost of stockouts are high, when the sensitivity of stockouts for snobs is high. As a result, the firm produces more goods, even though it is limiting its market to a fraction of customers (snobs) in the market. Aided with the results of Lemma 1 and Lemma 2, we can now analyze the region of scarcity.

It is unclear if the scarcity region that exists in the region $\beta \in (\beta^*, \beta_Q)$ expands as snobs become more receptive to stockouts (i.e. as k increases). Proposition 5 provides conditions under which the region of scarcity (i.e. $\beta_Q - \beta^*$) expands as snobs become more sensitive to stockouts.

Proposition 5. *Scarcity region expands if and only if generalized failure rate of the distribution is greater than a threshold, i.e. $g(Q_s^*/\beta) \geq \frac{\beta_Q}{\beta^*} M(Q_s^*/\beta)$ where M is a constant dependent on Q_s^* and β.*

Proposition 5 provides a condition based on demand distribution for the prevalence of stockout strategy. When the snobs are very sensitive to stockouts, the scarcity strategy is often in equilibrium if the distribution of the uncertain demand has a high generalized failure rate (See Lariviere 2005). In the following section 3.2, we focus on how the scarcity region varies with increasing demand variability for a given sensitivity to stockouts parameter.

3.2 Scarcity Strategy: Effect of Uncertainty

In Figure 3, we hold the mean of demand distribution constant and increase its variance. We hold k constant and explore how the scarcity strategy region changes with increasing variability in demand. Figure 3 demonstrates that as the demand uncertainty increases,

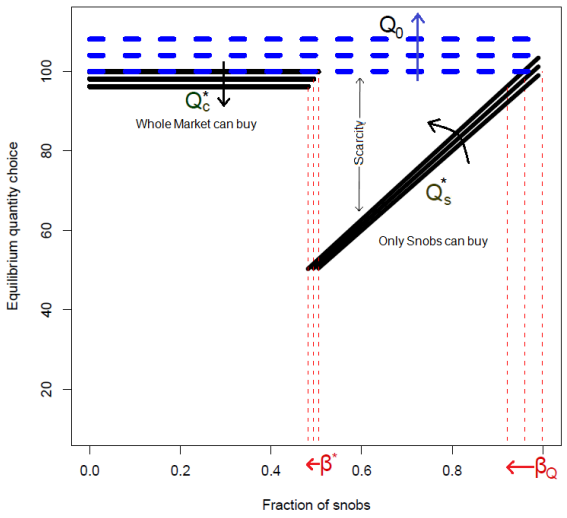


Figure 3: The effect of uncertainty on scarcity strategies: In the figure the variability of demand is increased gradually as the mean demand remains the same. Note that as the variance increases, Q_c^* decreases. Also note that both β^* and β_Q also decrease. The scarcity region is further reduced by the increase of the slope of the line Q_s^*. Parameters are same as in Figure 2(a).

(i) β^* decreases. Applying the result on Proposition 3, the firm is *less* likely to adopt Regular Production strategy as demand uncertainty increases.

(ii) β_Q decreases. Applying the result from Proposition 4, the firm is *more* likely to overproduce, if there are sufficient number of snobs in the market as the demand uncertainty increases.

(iii) $\beta_Q - \beta^*$ decreases. Applying Proposition 5, the market proportion of consumers for which the scarcity strategy is employed decreases. If demand uncertainty increases, the scarcity strategy is less likely.

(iv) Q_c^* decreases (Note that regular newsvendor quantity Q_0 increases). Applying Proposition 2(2), as the demand uncertainty increases, the regular production quantity decreases.

(v) The slope of Q_s^* increases. Applying Proposition 2(1) for the same fraction of consumers in the market, more quantity is produced under the limited production strategy).

(vi) The degree of scarcity (i.e. $Q_c^* - Q_s^*(\beta)$) is reduced. As demand uncertainty increases, applying Proposition 2, the number of stockouts consumers face due to scarcity strategy, is reduced.

In summary, if the demand uncertainty increases, the firm commits to scarcity strategy less often and the degree of scarcity when it so commits is also reduced.

4. Extensions of the Base Model

In the following subsections, we explore variations to the main model. Specifically we consider the following cases: myopic snobs (§4.1), snobs who have low value for abundance (§4.2), non-linear dependency of utilities on stockouts (§4.3), conspicuous consumption beliefs based on fill rate (§4.4), beliefs based on sales (§4.5), beliefs based on production quantity (§4.6), and beliefs based on product prices (§4.7). We show that the main conclusions in Section 2 continue to hold for all the variations. The firm adopts Regular Production strategy when the proportion of snobs in the market (β) is low, and the Limited Production strategy when the fraction of snobs in the market is high. In particular, the scarcity strategy is adopted in the intermediate region of β.

4.1 Myopic Snobs

In this section, we analyze the case when customers exhibit *conspicuous consumption* but they are *not* strategic. Such snobs are willing to pay high prices for scarce products to distinguish themselves from others, and they may buy myopically (Economist 2009). To account for the myopic nature of the snobs, we alter the conditions for the reservation price of snobs (Condition (iii) in Definition 2). Investigating the two candidate strategies for the firms, we find that the threshold similar to that established in Section 2.2 holds, with one exception: the threshold for the limited production strategy when considering myopic snobs is smaller than the threshold when snobs are strategic (i.e. $\beta^*_{myopic} \leq \beta^*$). The firms adopts limited production strategy in more scenarios compared to the case when snobs are strategic. As before, scarcity exists only in the intermediate region of β. Detailed mathematical proofs are deferred to Appendix B1.

4.2 Snobs have a lower value for commonly available products

In Section 2, we assumed that snobs have weakly greater utility for (scarce) goods than commoners. We now extend it to consider the case when snobs have a strictly lower valuation than commoners while the product is widely available to everyone in the market. Let snobs' valuation be $v_s + k\varepsilon_s$ where ε_s is the belief on stockout probability. Further, commoners' valuation is v. We assume $v_s < v$. This would imply that if the stockout probability is lower than or equal to some threshold, the snobs will have a strictly lower utility than the commoners. Therefore, snobs could have a lower utility for widely available products that are consumed in large quantities. In other words, they suffer a disutility due to the lack of exclusivity as in Balachander and Stock (2009). Nevertheless, they still possess snobbishness and enjoy higher utility from scarcer goods.

Thus, a snob's utility function is ε_s as $U_{snob} = max\{v_s + k\varepsilon_s - p, (1-\varepsilon_s)(v-s)\}$, which changes the reservation price of the snobs to $r = \varepsilon_s \cdot (k + v_s - s) + s$. In light of these modifications, the condition (iii) in Definition 2 is suitably changed.

We can show that the firm adopts Limited production strategy when the fraction of snobs in the market is sufficiently large (i.e., $\beta > \beta^*$). Similarly, we can show that there is a unique threshold β_Q below which we have $Q_s^* < Q_c^*$. We can show that these thresholds β^* and β_Q are both higher than in the base case in Section 2.2. The effect is qualitatively similar to Lemma 2. Thus, as a result of snobs having more disutility from the commonly available products, the firm adopts Limited production strategy *less* often.

One can immediately notice that the scarcity strategies exist in intermediate range (β^*, β_Q). However, to adopt scarcity strategies viably, the firm also needs an increased number of snobs in the market. In addition, the firm has to offer a higher degree of scarcity (i.e. more stockouts) to enable the snobs to overcome their low valuation for commonly available goods. The reader is referred to Appendix B2, for all technical details.

Finally, the decreased valuation of snobs has some interesting effects when the fraction of snobs in the market is low ($\beta < \beta^*$), depending on the sensitivity of snobs to stockouts. When k is sufficiently large, the conclusions remain identical to Proposition 2(2). However, when k is low (i.e. $k < (v - v_s)$), snobs have a much lower valuation than the commoners due to the wide availability of goods.

Proposition 6. ***(Modified Regular Production)*** *In the RE equilibrium, when $k < v - v_s$, only commoners can buy, and the firm's price and quantity decisions are characterized by $P((1-\beta)D > Q_c) = \sqrt{\frac{c-s}{v-s}}$ and $p_c^* = \sqrt{(c-s)(v-s)} + s$. When $k > v - v_s$, Proposition 3(2) holds.*

Proposition 6 points out that given the low fraction of snobs, and their lower valuation, it is optimal for the firm to price the products at commoners' reservation price. Therefore at low β (and low k), snobs do not buy and only commoners buy the product at the sold market price. The result is captured in Proposition 6, which acts as a modified proposition for the regular production case in 3. This result corresponds to the case wherein a product is sold at a low price and in large quantities (which keeps the snobs from buying the product, despite its low price). This result explains the market presence of many non-exclusive brands and low-end retailers who sell inexpensive goods to commoners in large quantities.

4.3 Non-linear utility from stockouts

In Section 2.2, we assumed that the utilities of snobs are linearly dependent on the stockout probability. We now generalize the utility of snobs to *non-linear* dependencies on stockouts probability.

Case A: We consider the utility of snobs in the following functional form: $U_{snob} = \max\{v + k\varepsilon_s^n - p, (1-\varepsilon_s)(v-s)\}$. We find that our conclusions remain unchanged.

There exists a threshold β^* such that if the fraction of snobs is below β^*, the firm uses Regular production strategy. When ($\beta > \beta^*$), the firm adopts Limited production – only snobs can buy, and the firm's equilibrium decisions are characterized by $k\bar{F}_{\beta D}(Q_s^*)^{n+1} + \bar{F}_{\beta D}(Q_s^*)^2(v-s) = c-s$ and $p_s^* = k\bar{F}_{\beta D}(Q_s^*)^n + \bar{F}_{\beta D}(Q_s^*)(v-s) + s$. In the case of regular production ($\beta \leq \beta^*$), all customers (snobs & commoners) can buy. The firm's are characterized by $\bar{F}_D(Q_c) = \sqrt{\frac{c-s}{v-s}}$ and $p_c^* = \sqrt{(c-s).(v-s)} + s$ (same as in Section 2.2).

Again, as in Section 2, the scarcity strategies are employed in the intermediate region when the fraction of snobs $\beta \in (\beta^*, \beta_Q)$. While the structure of the equilibrium remains the same, we find that, due to the non-linearity of the snobs' utility, their valuation for the product is higher, which causes the scarcity strategy to be employed even with a (relatively) lower percentage of snobs in the market. In addition, the degree of scarcity is also lower than it is in the linear case. The detailed analytical expressions for the non-linear case are presented in Appendix B3.

Case B: We also tested another version of non-linearity specified by $U_{snob} = \max\{\frac{v}{(1-\varepsilon_s)^n} - p, (1-\varepsilon_s)(v-s)\}$. Our conclusions are identical to the above conclusions. The firm employs scarcity in the intermediate values of fraction of snobs in the market. Again, the details are presented in the Appendix B3.

4.4 Beliefs based on Fill Rate

In this section, we expanded our definition of conspicuous consumption from stockout probability to one related to fill rate i.e., the fraction of customers who do not find the product ("lost sales") available in equilibrium. The instock probability corresponds to the probability that all demand is fulfilled, whereas fill rate measures the fraction of demand that is fulfilled. Following Cachon and Terwiesch (2008), *fill rate* is $1 - \frac{E[\text{Lost Sales}]}{E[D]}$.

Corresponding to beliefs based on stockout probability, we could respresent the snobs' utility using belief on the *fraction of unfulfilled demand* – ε_{Lost}. Thus, $U_{snob} = \max\{v + k\varepsilon_{Lost} - p, 0\}$ where ε_{Lost} is the fraction of demand lost.

Due to the stochastic nature of the demand, the number of items left unsold from the selling

period may vary. If there are items left over, then the demand in the selling period was lower than the production quantity, and therefore the corresponding fill-rate would equal one. In this case, snobs have no utility from consuming the product in the second period. The assumption aids tractability. However, the property can be generalized and conclusions remain the same (just as in myopic snob case).

The condition for RE equilibrium remains the same as in Definition 2, except for conditions (iii) and (iv) which are now (iii) $r = v + k\varepsilon_{Lost}$, (iv) $\varepsilon_{Lost} = \frac{\int_Q^\infty (u-Q) f_D(u) du}{E[D]}$ respectively.

Even if the snobs' utility depended on (1-fill rate) instead of the stockout probability, we note that our conclusions remain identical. We can show that there exists a threshold β^* proportion of snobs in the market, below which the firm adopts the Regular Production, and above which the firm adopts the Limited Production strategy. It is straightforward to show that the equilibrium decisions when the firm engages in regular production, is identical to the base case. However, when the firm adopts limited production, only snobs can buy due to higher prices; the firm's price and quantity choices are characterized by $\bar{F}_{\beta D}(Q_s^*) = \frac{c-s}{v+k.\frac{\int_{Q_s^*}^\infty (u-Q_s^*) f_{\beta D}(u) du}{E_{\beta D}[D]} - s}$ and $p_s^* = \frac{c-s}{\bar{F}_{\beta D}(Q_s^*)} + s$. We defer all technical details to Appendix B4. If we assume that the demand is distributed as $U(0, N)$, then we obtain the following explicit results for the equilibrium price and quantity under *Limited Production* strategy:

$$p_s^* = (c-s)^{2/3}(k+v-s)^{1/3} + s, \quad Q_s^* = \beta N(1 - \left(\frac{c-s}{k+v-s}\right)^{1/3})$$

Finally, we show that there exists a unique level of percentage of snobs, β_Q, where $Q_s^* \leq Q_c^*$ if $\beta \leq \beta_Q$ and $Q_s^* > Q_c^*$ when $\beta > \beta_Q$. Thus, scarcity strategies are adopted in the intermediate range of $\beta \in (\beta^*, \beta_Q)$. We defer all technical proofs to Appendix B4.

4.5 Beliefs based on Expected Sales

We tested the robustness of our model by considering the dependency of conspicuous consumption on unit sales in which the snobs' utility decreases in expected number of buyers. This is also an extension of the utility model in Amaldoss and Jain (2005), if we ignore the production quantity mismatch. Accordingly, we redefine the utility function based on the belief on expected unit sales, ε_{Sales}. The analysis proceeds as in the previous section. This analysis is tractable for distributions with finite support. When the belief on expected sales is ε_{Sales}, the utility of snobs is, $U_{snob} = max\{v + \frac{k}{\varepsilon_{Sales}} - p, 0\}$. Note that the utility of a snob is decreasing in the quantity of demand that is fulfilled (i.e., the number of buyers).

The condition for RE equilibrium remains the same as in Definition 2, except for conditions for snobs (iii) and (iv) which are now (iii) $r = v + \frac{k}{\varepsilon_{Sales}}$, (iv) $\varepsilon_{Sales} = Q - \int_0^Q F_D(u)du$ respectively.

We note that our conclusions remain unaltered in this case. If the fraction of snobs in the market is below some threshold β^*, the firm adopts Regular Production, and above β^* the Limited Production strategy is adopted. It is straightforward to show that the equilibrium decisions when the firm engages in regular production, is identical to the base case. As in Section §2.2 when β exceeds the threshold β^*, the firm adopts Limited Production strategy, in which its price and quantity are characterized by $\bar{F}_{\beta D}(Q_s^*) = \frac{c-s}{v+\frac{k}{Q_s^* - \beta \int_0^{Q_s^*/\beta} F_D(u)du} - s}$ and $p_s^* = \frac{c-s}{\bar{F}_D\left(\frac{Q_s^*}{\beta}\right)} + s$.

There exists a unique level of percentage of snobs, β_Q, where $Q_s^* < Q_c^*$ if $\beta < \beta_Q$ and $Q_s^* > Q_c^*$ otherwise. This leads to our final conclusion that the firm employs the scarcity strategy in the region (β^*, β_Q). All technical derivations and discussions are provided in Appendix B5.

4.6 Beliefs based on Firm's Production Quantity

In line with our previous settings, we now extend our results to the case in which snobs value the product more when they expect that the firm produces the goods in low quantities. This section matches the results when inventory is (credibly) announced to be limited. Thus, we now represent a snob's utility using his belief about the production quantity, ε_Q: $U_{snob} = max\{v + \frac{k}{\varepsilon_Q} - p, 0\}$. We are ready to define the RE equilibrium conditions:

Definition 3. *When the firm charges the snob's (commoner's) reservation price, an RE equilibrium* $(p, Q, r, \varepsilon_Q, \varepsilon_r)$ *satisfies the following conditions:* (i) $p = \varepsilon_r$, (ii) $Q = argmax_q\ \Pi_N(q, p)$, (iii) $r = v + \frac{k}{\varepsilon_Q}$ $(r = \varepsilon_s(v - s) + s)$, (iv) $\varepsilon_Q = Q$, (v) $\varepsilon_r = r$.

If the fraction of snobs in the market is below some threshold β^*, the firm adopts Regular Production, and above which Limited Production strategy is adopted. The pricing and quantity decisions of the firm under regular production are identical to the base case. As before, when β exceeds the threshold, the firm adopts Limited Production strategy, in which its price and quantity are now characterized by $\bar{F}_{\beta D}(Q_s^*) = \frac{c-s}{v+\frac{k}{Q_s^*} - s}$ and $p_s^* = v + \frac{k}{Q_s^*}$. There exists a unique level of percentage of snobs, β_Q, where $Q_s^* < Q_c^*$ if $\beta < \beta_Q$ and $Q_s^* > Q_c^*$ otherwise. This leads to our final conclusion that the scarcity strategy is exercise in the region (β^*, β_Q). All technical details are provided in Appendix B6.

4.7 Price Dependent Stockout Beliefs

It is very likely that consumers make inferences about the stock out probability for a product based on the selling price. For instance, it is quite possible for consumers to expect that less-expensive items are more likely to be produced in large quantities and stay on shelves. On the other hand, even though there are fewer customers in the market for more expensive products, very few of such items are produced. Such price dependent snobbish behavior was proposed by Liebenstein (1950). Note that this assumption does not require the demand to increase in price. (In fact, this belief is consistent with price-dependent demand distributions that are first-order stochastically decreasing in price). In this section, we develop the rational expectations equilibrium for the case when consumers develop their stockout beliefs (and their resultant conspicuous consumption) based on the product price.

Definition 4. *A RE equilibrium* $(p, r_s, r_c, \varepsilon_s(p), \varepsilon_{r_s}, \varepsilon_{r_c})$ *satisfies the following conditions:* $(i) p = argmax_p \Pi(p, Q(p))$, $(ii) r_s = \varepsilon_s(p)(v + k - s) + s$ $(r_c = \varepsilon_s(p)(v - s) + s)$, $(iii) \varepsilon_s(p) = G(p)$, $(iv) \varepsilon_{r_s} = r_s$ $(\varepsilon_{r_c} = r_c)$.

The price dependent stockout beliefs can admit any general price-quantity relationship. In particular, the firm could be solving a newsvendor problem (which would be a specific optimization problem of the firm), in which case, the consistent stock-out beliefs based on the expected reservation prices can be represented as: $G(p) = \{\bar{F}(Q(p))$ if $p \leq \varepsilon_{r_c}$ and $\bar{F}\left(Q(p)/\beta\right)$ if $\varepsilon_{r_c} < p \leq \varepsilon_{r_s}\}$. Now, we are ready to derive the equilibrium price and quantity decisions.

Proposition 7. *If* $\beta \leq \beta^*$, *the firm's price and quantity decisions are characterized by* $p_c^* = \sqrt{(c-s)(v-s)} + s$ *and* $Q_c^* = \bar{F}_D^{-1}(G(p_c^*)) = \bar{F}_D^{-1}(\frac{c-s}{p_c^*-s})$, *and all customers can buy. However, if* $\beta > \beta^*$, *the firm's price and quantity decisions are characterized by* $p_s^* = \sqrt{(c-s)(v+k-s)} + s$ *and* $Q_s^* = \beta \bar{F}_D^{-1}(G(p_s^*)) = \bar{F}_D^{-1}(\frac{c-s}{p_s^*-s})$, *and only snobs can buy.*

Note that the RE equilibrium under this specification is *identical* to the base model. This is because, under REE, the expectations are correctly formed with implicitly assumed price dependencies. Again, we can show the existence of β_Q where the profits from limited production and regular production strategy are equal. Thus, scarcity strategy is found between (β^*, β_Q) (The proofs are deferred to Appendix B7.).

5. Salvage Pricing and Sourcing Decisions

5.1 Endogenous Salvage Pricing

We now extend the results of our base model to quantity based salvage price. In Section 2.2, we had *all* leftover goods salvaged at an exogenous salvage price s, while the equilibrium price in the selling period is dependent on the price. Arguably, in many cases, the salvage value is dependent on the quantity that is left over. (If there are not many items left over, the salvage prices would be expected to be very low). We use a linear salvage price function decreasing in the the proportion of left-over quantity to the product quantity. The salvage price function is $s(L) = s_0 - s_1 \cdot L$ where $L = \frac{(Q-D)^+}{Q}$ and D is the realized demand. In light of endogenous salvage pricing, the firm's expected profit can be written as,

$$\Pi_N(q,p) \quad = \quad (p-c)q - (p-s_0)\int_0^q (q-u)dF_D(u) - \frac{s_1}{q}\int_0^q (q-u)^2 dF_D(u).$$

Consumers will base their decisions and the firm makes its choice, not only based on the stock-out probability, but also based on the probability that the goods will be available on the salvage market. We represent this belief by $\varepsilon_{salvage}$. We are ready to define the RE equilibrium conditions:

Definition 5. *A RE equilibrium $(p, Q, r, \varepsilon_s, \varepsilon_r)$ satisfies the following conditions: (i) $p = \varepsilon_r$, (ii) $Q = argmax_q\ \Pi_N(q,p)$, (iii) $r = \varepsilon_s(k + v - \varepsilon_{salvage}) + \varepsilon_{salvage}$, (iv) $\varepsilon_s = \bar{F}_D(Q)$, (v) $\varepsilon_{salvage} = E[s_0 - s_1\frac{(Q-D)^+}{Q}]$, (vi) $\varepsilon_r = r$.*

Note how the reservation price of the snobs is dependent on both ε_s and $\varepsilon_{salvage}$. The snobs have a higher utility for the product that is more likely to be stocked out and less likely to be salvaged. Our main insights continue to hold.

Proposition 8. *1. **(Limited Production)** If $\beta > \beta^*$, in the RE equilibrium, only the snobs can buy, and the firm's price and quantity decisions are characterized by*

$$p_s^* = \bar{F}_D(Q_s^*/\beta)\left(k + v - s_0 + s_1 \int_0^{Q_s^*/\beta} \frac{(Q_s^* - \beta u)}{Q_s^*} dF_D(u)\right) + s_0 - s_1 \int_0^{Q_s^*/\beta} \frac{(Q_s^* - \beta u)}{Q_s^*} dF_D(u) \qquad (1)$$

$$\frac{s_1}{Q_s^{*2}} \int_0^{\frac{Q_s^*}{\beta}} \beta^2 u^2 dF_D(u) + \bar{F}_D(\frac{Q_s^*}{\beta})\left(\bar{F}_D(\frac{Q_s^*}{\beta})(v + k - s_0) + s_1 - s_1 F_D(\frac{Q_s^*}{\beta}) \int_0^{\frac{Q_s^*}{\beta}} \frac{(Q_s^* - \beta u)}{Q_s^*} dF_D(u)\right) = c - (s_0 - s_1) \qquad (2)$$

*2. **(Regular Production)** If $\beta \leq \beta^*$, in the RE equilibrium, all customers (snobs & common-*

ers) can buy, and the firm's price and quantity decisions are characterized by

$$p_c^* = \bar{F}_D(Q_c^*)\left(v - s_0 + s_1 \int_0^{Q_c^*} \frac{(Q_c^* - u)}{Q_c^*} dF_D(u)\right) + s_0 - s_1 \int_0^{Q_c^*} \frac{(Q_c^* - u)}{Q_c^*} dF_D(u) \tag{3}$$

$$\frac{s_1}{Q_c^{*2}} \int_0^{Q_c^*} u^2 dF_D(u) + \bar{F}_D(Q_c^*)\left(\bar{F}_D(Q_c^*)(v - s_0) + s_1 - s_1 F_D(Q_c^*) \int_0^{Q_c^*} \frac{(Q_c^* - u)}{Q_c^*} dF_D(u)\right) = c - (s_0 - s_1) \tag{4}$$

Note from Proposition 8, that there exists a threshold β^* above which there is limited production in the market, and there is an increased stockout probability (i.e. $Q_s^* < Q_c^*$). However, we can also show that there exists another unique threshold, β_Q, where $Q_s^* \leq Q_c^*$ when $\beta < \beta_Q$ and $Q_s^* > Q_c^*$ when $\beta > \beta_Q$. Thus, scarcity occurs in the intermediate region of the fraction of snobs in the market. We note that with added salvage flexibility, the firm increases the extent and degree of stockouts. The technical details and proofs are deferred to Appendix C1.

5.2 Clearance Pricing Model

In this section, we explore the optimal price and quantity decisions of the firm using a clearance pricing model (based on the model introduced by Cachon and Kok (2007)) that consists of two periods. In Period 1, $(1 - \beta)$ commoners and β fraction of snobs (who exhibit conspicuous consumption) make their strategic decision of whether to buy or not. In period 2, since all the products offered are *left-overs* from period 1, all consumers in the market have a low utility for the product. Consumers buy the product at the clearance price offered by the firm if they receive a net positive utility.

To keep the multi-period model tractable, we use an inverse linear price function for the clearance price offered based on s_2 items that the firm salvages in the second period. Let the price function be $p_2(s_2) = p_a - p_b s_2$ for period 2 demand without loss of generality. Let $R_2(s_2) = s_2(p_a - p_b s_2)$ be the unconstrained revenue function in period 2, which is concave in s_2.

In period 1, the firm has to make two decisions - production quantity, Q, and the price charged per unit, p_1, - before a random demand, D, (distributed with c.d.f $F_D(\cdot)$) is realized. In period 2, the firm has to make only one decision - how much of the remaining units from period 1 to sell, $s_2(D)$, - to maximize the period 2 revenue. In line with the extant models, the cost of production is higher than the maximum possible unit revenue that a firm can obtain in period 2, i.e., $c > p_a \geq p_b$. The firm's expected profit can be written as, $\Pi(Q, p_1, s_2(D)) = E[p_1 \min\{Q, D\} - cQ + p_2(s_2(D))s_2(D)]$.

The belief on product availability in period 1 and belief on period 2 price for every possible

realization of D, are two factors that snobs use to make their conspicuous consumption decision. Based on their beliefs on product availability in period 1 and on period 2 price, they seek out hard-to-find products and derive a higher utility in their exclusiveness. For snobs, the utility based on the stockout belief is ε_s as $v + k\varepsilon_s - p_1$, where k represents the sensitivity to stockouts. A consumer develops stockout belief for period 1, beliefs for period 2 price for every possible realization of the demand, D, and the number of units produced in period 1, q.

We denote the firm's belief over the customers' reservation price in period 2 as $\varepsilon_{r_2}(q, D)$. The price in period 2 is a direct mapping to the number of units sold in period 2 through the clearance-price function. To increase a snob's utility for the product, the expected period 2 price needs to be high (and the number of items sold in clearance needs to be low). We represent the customer's overall utility as $U_{snob}(q) = max\{v + k\varepsilon_s - p_1, E[(1 - \varepsilon_s)(v - \varepsilon_{r_2}(q, D))]\}$ when the firm chooses to produce q number of units in period 1.

Similarly, the firm develops beliefs over the customers' reservation price for the product in period 1. We denote the firm's belief over the reservation price as ε_{r_1}. Based on ε_{r_1}, the firm chooses the price optimally, and will produce the optimal quantity to maximize its profits. Every snob decides whether she should buy the product in the first period or not. She buys in the first period, if and only if $v + k\varepsilon_s - p_1 \geq E[(1 - \varepsilon_s)(v - p_2(s_2, D))]$. This condition then leads to snobs' reservation price, $r_1 = \varepsilon_s(v + k - E[p_2(s_2, D)]) + E[p_2(s_2, D)]$. The commoners make their decisions in the same manner.

Thus, there are two possible candidates for the RE equilibrium. The firm charges one of the reservation prices based on the percentage of snobs and produces an optimal quantity consistent with consumer expectations. After the realization of the demand and sales in period 1, the firm chooses the number of remaining units to sell, and sets the period 2 clearance price through the clearance-price function. To achieve this, the firm has to solve a constrained optimization problem, where the sales quantity is bounded above by the quantity of items left over from the first period. Condition (iii) below discusses this optimization; If the firm sold goods at the commoners' reservation price and the demand in first period was D, the optimal sales quantity in the second period is $s_2^*(q, D) = \arg\max_{s_2}\{s_2 p_2(s_2) | s_2 \leq (q - D)^+\}$. To this end, the firm has to develop beliefs over the customers' reservation price in period 2 for every possible realization of the demand from period 1 before making the decision on how much to sell in period 2. Since every player in the market in period 1 has the same information set, the firm anticipates customers' reservation price in period 2 as $\varepsilon_{r_2}(q, D)$. Based on this reservation price and the quantity left over unsold from period 1, the firm chooses the optimal sales quantity in period 2. We can now describe the REE conditions.

Definition 6. *When the firm charges the snob's (commoner's) reservation price, an RE-equilibrium* $(p_1, p_2^*(q,D), Q, r_1, r_2(q,D), \varepsilon_s, \varepsilon_{r_1}, \varepsilon_{r_2}(q,D))$ *satisfies the following conditions:*

$(i) p_1 = \varepsilon_{r_1}$ *and* $p_2^*(q,D) = \varepsilon_{r_2}(q,D)$,

$(ii) Q = \arg\max_q \{E[p_1 \min\{q, \beta D\} - cq + p_2^*(q,D) s_2^*(q,D)]\}$ $\left(Q = \arg\max_q \{E[p_1 \min\{q, D\} - cq + p_2^*(q,D) s_2^*(q,D)]\}\right)$,

$(iii) s_2^*(q,D) = \arg\max_{s_2} \{s_2 p_2(s_2) | s_2 \le (q - \beta D)^+\}$ $\left(s_2^*(q,D) = \arg\max_{s_2} \{s_2 p_2(s_2) | s_2 \le (q - D)^+\}\right)$,

$(iv) r_1 = \varepsilon_s (v + k - E[\varepsilon_{r_2}(Q,D)]) + E[\varepsilon_{r_2}(Q,D)], (r_1 = \varepsilon_s (v + E[\varepsilon_{r_2}(Q,D)]) + E[\varepsilon_{r_2}(Q,D)])$

$r_2(q,D) = p_2(s_2^*(q,D))$ $(r_2(q,D) = p_2(s_2^*(q,D)))$

$(v) \varepsilon_s = \bar{F}_{\beta D}(Q)$ $\left(\varepsilon_s = \bar{F}_D(Q)\right)$,

$(vi) \varepsilon_{r_1} = r_1$; $\varepsilon_{r_2}(q,D) = r_2(q,D)$

Conditions (i), (ii), (iii) and (iv) assert that under the expectations ε_{r_1}, $\varepsilon_{r_2}(q,D)$ and ε_s, the firm and all consumers will rationally act to maximize their utilities. Condition (v) specifies that, in equilibrium, the stockout probability belief ε_s must match with the actual probability of not being able to find the product. Finally, condition (vi) requires that the firm correctly predicts customers' reservation price in period 1 and period 2. The conditions imposed in Definition 6 relate to the production decision in period 1, remaining units to sell decision in period 2, and beliefs on the reservation price and product availability.

Depending on the market parameters, the profit-maximizing firm would adopt one of the aforementioned strategies. Since consumers are rational, and can correctly form expectations about the firm's strategies, the corresponding RE equilibrium would emerge.

When there is a sufficient presence of snobs in the market, the firm prices the product based on its belief of snobs' reservation price in period 1, and thus, the random variable D is scaled down to βD and stockout probability becomes $\bar{F}_{\beta D}(Q)$. The corresponding equilibrium production quantity in period 1 is given by Proposition 9(1). On the other hand, if the fraction of snobs in the market is low, the firm charges the commoner's reservation price. In this case, the stock-out probability stays the same at $\bar{F}_D(Q)$. This is indicated in Proposition 9(2).

Proposition 9. *1.* ***Limited Production*** *When $\beta > \beta^*$, in the RE equilibrium, only snobs can buy, and the firm's price and quantity choices are characterized by*

$$s_{2,s}^*(q,D) = \begin{cases} \frac{p_a}{2p_b} & \text{if } \frac{p_a}{2p_b} \le (q - \beta D)^+, \\ (q - \beta D)^+ & \text{if } \frac{p_a}{2p_b} > (q - \beta D)^+. \end{cases}$$

$$p_{2,s}^*(q,D) = \begin{cases} \frac{p_a}{2} & \text{if } \frac{p_a}{2p_b} \le (q - \beta D)^+, \\ p_a - p_b (q - \beta D)^+ & \text{if } \frac{p_a}{2p_b} > (q - \beta D)^+. \end{cases}$$

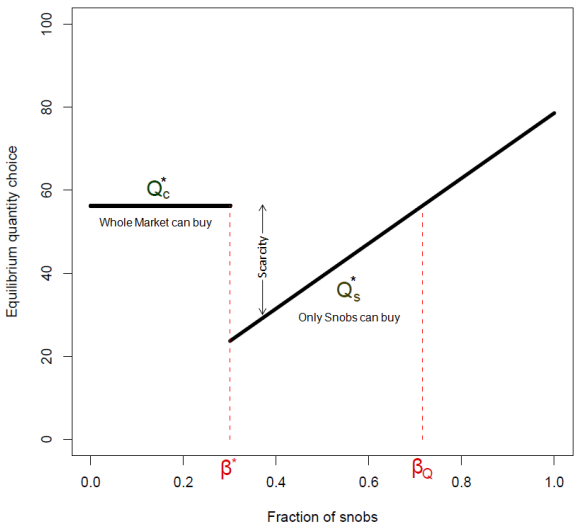


Figure 4: Clearance Pricing: The equilibrium production for different (β) under the clearance pricing model. For representative illustration, $v = 350, c = 120, p_a = 30, p_b = 10, k = 70$ and the demand distribution is $U[0, 100]$. Note that in the region between β^* and β_Q, the optimal production capacity $(Q_s^* < Q_c^*)$. This defines the scarcity region. The difference $Q_c^* - Q_s^*(\beta)$ denotes the *degree* of scarcity in the market.

$$p_{1,s}^* = \int_0^{\frac{Q_s^*}{\beta}} \left(\bar{F}_D(\frac{Q_s^*}{\beta}) \left(v + k - p_2^*(Q_s^*, u)\right) + p_2^*(Q_s^*, u) \right) dF_D(u)$$

$$\bar{F}_D\left(\frac{Q_s^*}{\beta}\right) F_D\left(\frac{Q_s^*}{\beta}\right) ((v + k - p_a)\bar{F}_D(\frac{Q_s^*}{\beta}) + p_a) - \bar{F}_D(\frac{Q_s^*}{\beta}).F_D(\frac{Q_s^*}{\beta}).F_D\left(\frac{Q_s^* - \frac{p_a}{2p_b}}{\beta}\right)\frac{p_a}{2}$$
$$- (\bar{F}_D(\frac{Q_s^*}{\beta})F_D(\frac{Q_s^*}{\beta}) + 2)p_b \int_{\frac{Q_s^* - \frac{p_a}{2p_b}}{\beta}}^{\frac{Q_s^*}{\beta}} (Q_s^* - \beta u) dF_D(u) - c + p_a.\left(F_D(\frac{Q_s^*}{\beta}) - F_D\left(\frac{Q_s^* - \frac{p_a}{2p_b}}{\beta}\right)\right) = 0$$

2. ***Regular Production*** *When $\beta \leq \beta^*$, in the RE equilibrium, all customers (snobs & commoners) can buy, and the firm's price and quantity choices are characterized by*

$$s_{2,c}^*(q, D) = \begin{cases} \frac{p_a}{2p_b} & \text{if } \frac{p_a}{2p_b} \leq (q - D)^+, \\ (q - D)^+ & \text{if } \frac{p_a}{2p_b} > (q - D)^+. \end{cases}$$

$$p_{2,c}^*(q, D) = \begin{cases} \frac{p_a}{2} & \text{if } \frac{p_a}{2p_b} \leq (q - D)^+, \\ p_a - p_b(q - D)^+ & \text{if } \frac{p_a}{2p_b} > (q - D)^+. \end{cases}$$

$$p_{1,c}^* = \int_0^{Q_c^*} \left(\bar{F}_D(Q_c^*)\left(v - p_2^*(Q_c^*, u)\right) + p_2^*(Q_c^*, u)\right) dF_D(u)$$

$$\bar{F}(Q_c^*)F(Q_c^*)((v-p_a)\bar{F}(Q_c^*)+p_a)-\bar{F}(Q_c^*)F(Q_c^*)F\left(Q_c^*-\frac{p_a}{2p_b}\right)\frac{p_a}{2}$$
$$-(\bar{F}_D(Q_c^*)F_D(Q_c^*)+2)p_b\int_{Q_c^*-\frac{p_a}{2p_b}}^{Q_c^*}(Q_c^*-u)dF_D(u)-c+p_a\left(F_D(Q_c^*)-F_D\left(Q_c^*-\frac{p_a}{2p_b}\right)\right)=0$$

Using the results, we can calculate the profits accrued from both the strategies under rational expectations equilibrium. Although the above expressions are implicit, the equilibrium values can be calculated using numerical computations. In our clearance pricing model, we find that when the firm adopts the scarcity strategy, the clearance prices are lower than corresponding clearance price when there is no scarcity. We also establish that scarcity strategies, again as before, are applied in the intermediate value of β, as supported by a representative numerical example in Figure 4.

5.3 Commitment to Scarcity: Signaling through Sourcing Investments

While it is true that scarcity strategies can be adopted by firms to generate more revenues, when the market conditions are favorable, it is far from certain that such shortage information is credible, especially since the production decisions are often unobservable. For instance, firms can often stock their shelves as the demand evolves, and it is clear that overall availability is higher, even though more stockouts are observed on store visits. Amaldoss and Jain (2008) correctly observe that "limited edition strategy is constrained by the firms' ability to credibly convince consumers that it will not sell a higher quantity ... (since it is ex post profitable to do so)". In this section, we study how firms may signal their exclusivity by strengthening their commitment to scarcity strategies credibly. We show that in equilibrium, the firms *may* end up with lower production volume (depending on the market structure) due to higher upfront investments in sourcing costs. In our model, the firm does not have any additional utility to produce more goods after the demand is realized, since the reservation price for the remaining consumers is reduced to salvage value s (i.e., overage cost is incurred on additional units).

In particular, we look at the sourcing strategies of the firm and examine how the supply-side decisions can be employed as signaling devices to indicate possible shortages to the market. Such strategies are not uncommon in the market. Nearly all European luxury-goods companies still produce their goods in Europe, despite the much-higher production costs in Europe (Bruner and Hodrick 2005). Also, many luxury apparel firms advertise their products to be handmade[16] or

[16]For instance, Louis Vuitton offers its *Monogram Multicolore Marilyn OR* with 33 colors all handcrafted on to the white leather canvas. Louis Vuitton uses a special hand painting or stamping process depending on the type of the product.

Italian leather[17] signaling higher value to the customer. In addition, many firms that produce conspicuous products, such as Timbuk2,[18] prominently advertise their expensive sourcing decisions in order to sell the goods at a higher premium. We argue that in some cases such information may not be, in itself, intrinsically valuable to snobs (i.e., snobs may have no additional utility in handmade bags or shoes made of imported Italian leather). However, such information may be processed by snobs as being indicative of the firm's cost-commitment to the product.

Consider a firm that makes a sourcing or production decision for a conspicuous good before the decisions are made on price and production quantity. The sourcing decision will distinguish the product from the functionally equivalent product sourced elsewhere. For simplicity, we assume that there are two possible production methods. The cheaper sourcing method has a marginal cost c_L, and the more expensive method involves c_H, i.e., $c_H > c_L$. The more expensive source might involve a combination of factors that increase the marginal cost of production: – an in-sourced supplier whose assembling wages are higher, or the utilization of more expensive raw materials, or the employment of a more-intricate and less-efficient production process.

We consider the decision of the firm and consumers in a multi-period game. In the first period, the firm makes its sourcing decisions. In the second period, firm and consumers play their strategies: pricing and quantity decisions are made by the firm before demand is known, and the consumers make their purchase decisions. This is followed by the period in which left over goods are salvaged. We derive the RE equilibrium through backward induction. In the second period, given the sourcing decision, the subgame proceeds exactly as analyzed in the previous sections (except that c_L or c_H replaces c). Since there are two possible production methods with different marginal costs in each subgame, the firm decides the profit maximizing strategy given the sourcing decision. Then, in the first period, the firm compares the profits obtained from each sourcing decision, and will choose the alternative that maximizes its profit.

Following Proposition 3, for each source there exists a unique fraction of percentage of snobs in the market above which the firm always chooses limited production, i.e. the firm chooses limited production when $\beta \geq \beta^*_{c_L}$ when the sourcing cost is c_L, and when $\beta \geq \beta^*_{c_H}$ with the sourcing cost is c_H. Proposition 10 shows that this unique threshold level is decreasing with the marginal cost of supply.

Proposition 10. *The threshold level for limited production decreases with the marginal cost c of*

[17] "[. . .] companies also wanted (as did most consumers) the "Made in Italy" and "Made in France" labels" (Bruner and Hodrick 2005).

[18] Timbuk2 bags sold at higher premiums are handmade and customized in a (more-expensive) facility in San Francisco, rather than being sourced from a cheaper overseas supplier (Cachon *et al* 2007).

the supply source. Therefore $\beta^*_{c_H} < \beta^*_{c_L}$.

Since, the threshold ($\beta^*_{c_H}$) under the more expensive supply is lower than the threshold level ($\beta^*_{c_L}$) under the cheaper supply, we note that limited production is more prevalent when the supplier is expensive. This yields three possible positions for the fraction of snobs within the population: (i) $\beta < \beta^*_{c_H} < \beta^*_{c_L}$ (Low Intensity). The firm prefers to use *regular production* when using either source. (ii) $\beta^*_{c_H} < \beta < \beta^*_{c_L}$ (Medium Intensity). The firm prefers to use *limited production* for the expensive source, and the *regular production* strategy for the cheaper source. (iii) $\beta^*_{c_H} < \beta^*_{c_L} < \beta$ (High Intensity). The firm prefers to use *limited production* for both sources.

From Figure 2, we know that scarcity occurs when the production is limited to serve only the snobs in the market. We focus our attention on the most interesting case (Case (iii)), when the firm adopts *limited production* with either source. The other cases offer the same qualitative conclusions, and are omitted for the sake of brevity.

To analyze the sourcing decisions, we study the profits of the firm as a function of the expensive source cost c_H (holding the cost of the cheaper source c_L constant). We show that this profit function is unimodal and attains the global maximum at $c_H = c^* \in [s, v]$ (the unique global minimum is at v). Further, at $c_H = c_{equal}$, the profit using expensive supply matches the profit using the low cost source.[19] This property of the profit function helps us to provide equilibrium results for a general demand distribution and product costs in Proposition 11. We present the equilibrium result for the High Intensity region, when the firm prefers to adopt *limited production* for either of the two supply sources, but the results for low-intensity and medium-intensity are qualitatively similar. Proposition 11 provides conditions under which an expensive option is chosen by the firm. The specific sourcing decisions are indicated in Figure 5.

Proposition 11. *The subgame perfect equilibrium of the game when* $\beta > \beta^*_{c_L} (> \beta^*_{c_H})$ *depends on the following conditions.*

1. *If* $c_L \geq c^*$*, then the firm chooses the cheaper source, sells only to snobs by setting price* p^*_s *and produces* Q^*_s*. [Region D].*

2. *If* $c_H \leq c^*$*, (thus* $c_L \leq c^*$*), the firm chooses the more expensive source, and sells only to snobs by setting* p^*_s *and produces* Q^*_s*. [Region A]*

3. *If* $c_L < c^* < c_H < c_{equal}$*, the firm chooses the more expensive source, sets* p^*_s *and produces* Q^*_s*. [Region B].*

[19] See Appendix C3 for technical details (Proof of Proposition 11).

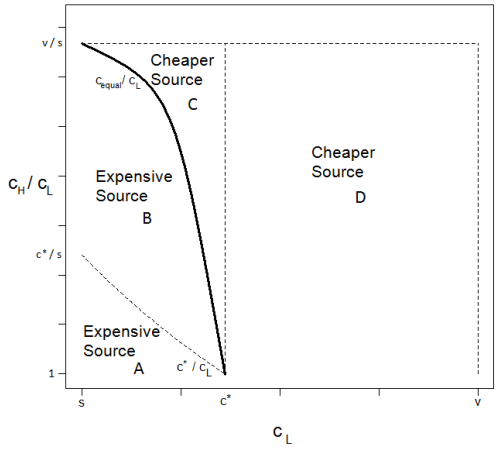


Figure 5: Equilibrium decisions of the firm regarding which source to use based on the given variable cost of the sources. For illustrative purposes $v = 20$, $s = 5$. Note that the expensive supply source is chosen when the low-cost source is cheap. The sourcing choice is employed as a signal for commitment to scarcity strategy.

4. *If $c_L < c^* < c_{equal} < c_H$ the firm chooses the cheaper source, sets p_s^* and produces Q_s^*. [Region C].*

Figure 5 reveals that a more expensive source may be chosen to signal scarcity in the market. The firm decides to use the more expensive source, (i) when the low-cost source is cheap (i.e. c_L is low), and (ii) when the expensive source is (comparatively) not too costly (i.e. $c_h/c_L < c_{equal}/c_L$). The latter point is intuitive. We focus on the intriguing first condition (Condition (i)). It is interesting to note that the firm avoids sourcing from the cheaper source when the source is at its cheapest cost. In other words, a sufficiently cost-efficient production process or supply source will be unused in equilibrium. This is because using a *really* low-cost supplier is perceived by the market as a signal that the firm is committing to a high volume of production (low-exclusivity) in equilibrium.

Thus, contrary to the notions of cost-reduction with sourcing and production, there might be market scenarios where a firm obtains higher profits by choosing the more expensive source. This result mirrors the higher marginal cost result of Amaldoss and Jain (2008), which shows, using reference group effects, that increased marginal costs can improve the profits of a firm. In their paper, increased costs make the product less attractive to followers, thus leaders (to differentiate themselves) adopt the product at a *lower* price (at a high volume of sales). Our explanations are based on demand uncertainty. Given that the firm has to make a "bet" on optimal quantity in an

uncertain demand market, the firm with the higher sourcing costs produces less goods, because the marginal cost of unsold goods $(c-s)$ is high. This low inventory in turn increases the valuation for snobs, and hence, the equilibrium price. Thus, in equilibrium, the firm with higher costs produces fewer quantities sold at a higher price. Also note that the *limited production* strategy and an expensive supplier need *not* be employed concurrently in our model.

Thus investment in development, sourcing, and production with higher marginal cost signals a firm's commitment to producing exclusive goods. Consumers can rationalize that given the uncertain demand environment, the firm's increased investment and production costs can only be recouped by producing a few exclusive items and selling each of those items at a high margin. Therefore, the snobs derive a higher utility because of the exclusivity of the product, and expensive sourcing acts as a signal of ex-ante commitment to exclusivity. Even if the product produced using the cheaper source is indistinguishable in terms of performance quality, a firm selling conspicuous goods may prefer to use an expensive source to produce those goods as a commitment to scarcity.

6. Conclusions

This paper attempts to fill in the gap as to how a firm combines marketing decisions such as pricing and scarcity strategy with operational decisions such as production and sourcing. In particular, we model the role that stockouts play in the decisions of a firm. Su and Zhang (2009) show how the cost of customers of not being able to find the product might force firms to provide availability guarantees to allay scarcity fears. Our paper takes a different approach. Just as scarcity may be a signal of product quality (Stock and Balachander 2005), we show how scarcity may, in markets with uncertain demand, also be used to influence demand and consumer valuations, especially when some consumers' decisions are affected by the desire for exclusivity.

We show through an analytical model that the existence of conspicuous consumption, by itself, does not guarantee scarcity and low production volumes. In fact, if there are sufficient number of snobs in the market, the firm may be driven by high margins to produce more goods (because the cost of losing a sale is high). We provide an explanation for why some firms may limit their production before introducing the product to the market, and others do not, even in an uncertain market where demand remains unobserved. Unlike extant results, our results on limited production are ex-post consistent, i.e. the commitment the firm can make to limited quantities is *credible*, and the firm cannot produce and sell more items after purchasing occurs. Using the *limited production* results, we consider when and how firms should adopt the scarcity strategy, and how it is dependent

on market parameters and demand uncertainty.

We find that the scarcity strategy by itself is worthwhile to apply when the fraction of snobs in the market is neither too high nor too low. For a market with a low percentage of snobs, it is not worth excluding the commoners by charging the snob's reservation price because the number of snobs is not enough to overcome the revenues accrued from additional sales. When the fraction of snobs in the market is too high, the firm is influenced by the margins/underage costs to overproduce. We provide an analytical identification of the interval of the percentage of snobs where scarcity is a more profitable strategy. This scarcity region decreases as the demand becomes more variable, thus making it harder for a firm to commit to scarcity strategy under uncertain demand. We show our results remain robust under modeling variations.

We explore how firms adopt more expensive sourcing decisions, incurring higher up-front costs to produce a functionally equivalent good in order to signal scarcity. We find that when a sequential decision is made related to sourcing, and then price and production quantity, the firm may prefer to invest in a more-expensive source when selling to conspicuous consumers. The higher-cost investment in turn helps the firm in distinguishing its product in terms of exclusivity, even though the consumer utility of the product itself remains unaltered. Intriguingly, we find that the choice of a more expensive sourcing may or may not be employed in conjunction with scarcity strategies.

Finally, our model is not without its limitations. In reality, the firms and consumers could make product decisions periodically over multiple periods. In such a dynamic model, *learning* about stockouts may play a role in how snobs and commoners make their future decisions.

Some future directions include empirically testing our analytical findings using secondary data from natural or laboratory experiments. We hope that our detailed analytical conclusions for the uncertain demand market can provide interesting hypotheses for empirical research. Manksi (2004) points out revealed preferences alone is insufficient to draw conclusions, and researchers need to measure consumer expectations while those choices are being made. He points out the paucity of empirical research on expectations formation from various factors. In our context, a careful empirical research would have to differentiate between consumer choice and expectations when consumers buy an expensive product based on conspicuous consumption, herding effects, network effects, or learning/quality effects. This differentiation might be quite involved (Manski 1993). We believe that a careful empirical analysis of the relationship between consumer characteristics and the impact of stockouts on their buying behavior (*cf* Anderson *et al* 2006), or an experimental approach (*cf* Amaldoss and Jain 2010) would help us understand how exclusive goods are sold and bought in a market with conspicuous consumption.

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Appendix:

Technical appendix to the paper is available by electronic email and is also downloadable from the authors' web page.