

INFORMATION OVERLOAD WITH ENDOGENOUS PRICING*

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ABSTRACT

One important decision of firms is to select the product line (characteristics and number of products) to offer consumers. This paper explores the effect of the interaction between evaluation costs and pricing on the optimal product line length to offer consumers. Before deciding to buy a product among the products offered, a consumer learns the product line length. Given the product line length, a consumer decides whether to evaluate the products available and their prices. This decision to evaluate depends on the expected consumer surplus after the evaluation being greater than the evaluation costs. When the firm offers few products, the firm may not attract many consumers because of lack of product-fit, and may be forced to offer low prices. When the firm offers many products, all consumers will find a great product-fit, which allows the firm to charge high prices, resulting in lower expected consumer surplus, which may lead consumers not to evaluate the products in the first place. These two forces may then lead to the existence of an interior optimal number of products to offer. The optimal number of products offered is decreasing in the evaluation costs. The paper presents also some results when the firm chooses also the quality of each product, and when the consumer's valuation for the category is positively correlated with how much a consumer cares about product fit.

1. INTRODUCTION

When a firm offers too many alternative products, consumers may feel overwhelmed with so many choices, and end up not purchasing any product.¹ One important issue in such a setting is that firms may act strategically in setting prices and other product characteristics, which are only found out by the consumers after they incur some evaluation costs.

This paper explores this issue of the interaction of the firm decisions on prices and product characteristics to be evaluated by consumers, and the consumer evaluation costs. The main result of the paper is that the evaluation costs of consumers in understanding the pricing and product characteristics decisions of the firms is a force towards a firm offering fewer products. The idea is that by offering fewer products a firm can commit not to extract all possible consumer surplus. After being evaluated, the products have to offer some surplus to the consumers that do not have a good fit with any of the products offered for them to be willing to buy, which means that the consumers that have a good fit will have a significant surplus. Therefore, in expectation, more consumers will be willing to evaluate the products, which will generate in greater demand. If a seller offers too many products, consumers realize that all consumers will find a product that provides a good fit, which means that consumers have to find that product, and the firm will extract the most it can the surplus generated by that good fit. This idea is present in markets where many alternatives are offered and consumers realize that finding the best alternative is important, as that only can generate some significant surplus. Sellers with greater variety may be able to charge more specific (higher) prices, keeping other factors fixed, which may yield lower consumer surplus.² For example, restaurants that offer greater variety may be able to charge higher prices for their specific dishes. Supermarkets that offer a large variety in a certain category may be able to charge higher price for the better product-consumer fit that they provide. In some markets for services, greater service is the ability to better respond to the specific demands of each customer (greater variety of services provided), which can allow the firm to extract more consumer surplus, given the specific needs satisfied.

Consider a situation when consumers are able to observe first the length of the product line (number of products) offered by a firm. For example, this could be the case when a consumer sees the length of shelf space provided in a supermarket or department store for a category, or when a consumer sees the total list of products available in a web page. Then, after observing the number

¹Some evidence on this effect can be seen, for example, in Iyengar and Lepper (2000), Boatwright and Nunes (2001).

²Note, however, that this effect holds when keeping other factors fixed. For example, if there are economics of scope in variety, sellers that offer more variety could have lower costs, which could be a force towards lower prices.

of products available, a consumer has to decide whether or not it is worth to incur evaluation costs to find out how much each product is worth for the consumer. But once the evaluation costs are incurred they are sunk costs, and the consumer only purchases a product if the product offers a positive surplus (excluding the evaluation costs, as they are sunk at the purchase stage). The firm can then benefit from reducing the surplus of the consumers (excluding the evaluation costs) by increasing prices or reducing product quality, if these can only be checked after the products are evaluated. This then gives less incentive for consumers to evaluate the product (as they know that they will have a reduced surplus after evaluation), and the firm ends up with less demand. By offering a smaller number of products the firm can commit that it will offer some significant consumer surplus, as it may still find profitable to attract consumers who do not have such a great fit with any product (which is more likely with a fewer number of products). That is, the interaction between firm pricing and quality decisions, and evaluations costs is a force towards a smaller number of products.

The paper considers first the pricing case, and shows that there is an interior and finite optimal number of products. The optimal number of products is decreasing in the evaluation costs, and converges to infinity when the evaluation costs go to zero. If the evaluations are high enough the market can disappear. In equilibrium, the consumers that evaluate the products are the ones that have a higher general valuation for the category, and some consumers that evaluate the products end up not buying any. The paper then shows that the same results can be obtained when firms make also decisions on the quality of each product, which is only found out after the consumer evaluation, and prices are observed prior to the consumers incurring the evaluation costs. The paper also shows the case when the general consumer valuation for a category is positively correlated with how much a consumer cares about product fit.

Note that effects of the evaluation costs presented here can be seen as information overload (or, more precisely, alternatively overload) effects, as the existence of evaluation costs makes the consumers choose not to buy (and not incur the evaluation costs) when faced with too many alternatives.

As noted above some experimental work has found that consumers are more likely to purchase and make a choice when confronted with a smaller choice set than when facing a large choice set. This work has argued that consumers may feel overwhelmed or overloaded with too many alternatives or information. This idea goes back to the information overload literature (see, for example, Jacoby, 1977, and the references listed there), and the idea that decision-makers may only be able to process a limited amount of information (e.g., Miller, 1956, Simon, 1955, Shugan, 1980). In this regard, Hauser and Wernerfelt (1990) have argued that consumers may strategically limit their

consideration sets (with search under fixed sampling) in order to reduce evaluation costs. Another important aspect that is not considered here involves the possibility of using attribute information to eliminate alternatives (Payne et al., 1988). Beach and Mitchell (1978) address the issue of decision makers eliminating options on the basis of deviation from their ideal point. Huffman and Kahn (1998) discuss the issue of variety choice creating confusion in preferences (see also, Mick et al., 2004). Kuksov and Villas-Boas (2006) consider search costs in evaluating the fit of each alternative, and show that a strategic supplier of alternatives (spanning the alternatives through the product space) does better by offering a finite number of alternatives than an infinite number, reducing consumer search costs, and leading more consumers to choose an alternative. Some of the issues discussed in that paper can also be seen from the side of the firms through their communication strategies (Villas-Boas, 2004). Van Zandt (2004) considers competition where firms communicate about their products and consumers evaluate a limited and fixed number of alternatives, and finds that there is too much communication in equilibrium, as a firm communicating about its product does not consider the negative externality on consumer information processing affecting the other firms. Kamenica (2006) considers the possibility of the products offered affecting the preferences of consumers, through the ability of finding the more popular products.³ Norwood (2005) considers free-entry price competition among fixed products that are vertically differentiated, one product per firm, under the assumption that only the most popular products are offered, includes an approximation to the consumer sequential evaluation process, and finds that there is excessive entry in equilibrium. Finally, it may also be that a greater number of alternatives may lead the decision-maker to delay choice (and not choose when the choice set is first presented) in order to gather more information on the choice problem (e.g., Dhar and Simonson, 2003). Possibly, this new information could come at a lower cost than the cost of evaluating different alternatives at the present. Note that this explanation could then be seen again as a search costs explanation for no choice when many alternatives are presented.⁴ Note that the objective of this paper is not to argue that the explanation presented here is the most compelling one for the existence of limited product lines.⁵ In relation to the papers above, here we consider the effect of the interaction between the evaluation costs and firm decision-making on variables that affect the consumer surplus (price, quality) on the optimal number of products for a firm to offer. In relation to other explanations for information

³Kamenica considers also endogenous prices with large retail costs uncertainty (unknown to the consumers), such that prices cannot signal product characteristics.

⁴Note also that consumers could potentially prefer smaller choice sets because of self-control problems (see, for example, the discussion in Gul and Pesendorfer 2001, Bénabou and Tirole 2004, Fudenberg and Levine 2005), and regret preferences (see, for example, Loomes and Sugden 1987, Irons and Hepburn 2005, and Sarver 2005).

⁵For example, the existence of fixed costs per product carried can generate a limited product line. Here, the paper presents an additional force towards a smaller number of products offered.

overload, this paper focusses on the explanation based on simple evaluation costs, which is enough to generate information load effects with endogenous pricing.

The results of this paper can be also seen as related to the literature on opportunism of sellers when consumers have to incur sunk evaluation costs before purchase. Lal and Matutes (1994) and Wernerfelt (1994) discuss the possibility of advertised prices as a form to commit the seller not to exploit the consumer sunk costs,⁶ and Wernerfelt discusses also the possibility of returns policies and seller co-location. In relation to that literature this paper considers the possibility of firms choosing a product line, where the length of product line may be more easily observed than prices or product quality. The length of the product line commits the seller to the extent of consumer surplus that is provided. Note also that there may be consumer processing costs for advertised prices, and if prices can be observed without processing or evaluation costs, unobserved quality decisions generate the same problems (see Section 4 below). In addition to that literature, this paper also notes that the product line specification allows ex-ante evaluation costs to generate information/alternative overload effects.

The rest of the paper is organized as follows. The model is presented in the next section. Section 3 presents the main results. Section 4 discusses two extensions: including quality decisions and positive correlation between consumer valuation and importance of product fit. Section 5 concludes.

2. BASE MODEL

Consider a firm, deciding on how many, and which products at what prices to offer to a set of consumers. The products are located on a circle of unit length, and have zero production costs (without loss of generality). Before deciding whether to search, consumers know their general valuation v for the category, and observe the number n of alternatives being offered by the firm. After searching, and incurring the search costs k , the consumers learn the location of all the products offered and their prices, and the location of their ideal product x .⁷ The firm decides the number n of alternatives to offer, the location of each of these alternatives on the circle, and the price of each alternative.

⁶See also Rao and Syam (2001).

⁷Consumers could have also potentially search costs per each additional product being evaluated, but the main messages of the results presented here should also extend to that setting. That set-up would complicate the analysis, while not being central to the market forces presented here. Search costs could also be different across consumers without affecting the main results presented here.

Consumers are heterogeneous on their general valuation v for a product in the category, and on the location of their ideal product x in the circle. If the product consumed is at a distance d of the consumer's ideal product, the consumer incurs a dis-utility td , where t is a parameter measuring the importance of the product fit. The distribution of v and x is assumed independent among consumers. The marginal distribution of x is assumed uniform along the unit circle, and the marginal distribution of v has positive density on the support $[0, \bar{v}]$, with the cumulative distribution function $F(v)$ (density $f(v)$).

The ex-post utility of a consumer with valuation v purchasing a product at price p at distance d of his ideal product is

$$U = v - td - p - k.$$

Prior to incurring the search costs k the consumer does not know d or p , but may be able to infer both the distribution of d from the best product available and the price p from the number of products offered n . After incurring the search costs k a consumer chooses to buy the best product available, which is at distance d , if and only if $v - td - p \geq 0$, as the search costs are sunk at the purchase decision time.

A consumer with valuation v decides to incur the search costs k if the expected surplus expected after search is greater than k . That is, a consumer searches if and only if $E_d[\max\{v - td - p, 0\} | n] \geq k$, where E_d is the expected value operator over the distance d to the best product for that consumer. As the expected value is increasing in v there is going to be a threshold \hat{v} such that a consumer searches if and only if $v \geq \hat{v}$. The firm chooses the prices of the different products (and their location) to maximize profits given that consumers who have searched have $v \geq \hat{v}$. Note that the consumers foresee this behavior by the firm, and therefore, the determination of \hat{v} , the valuation of the consumers indifferent between searching and not searching, takes into account the firm pricing strategy.

Before consumers decide whether or not to search, the firm chooses the number of products to sell, n , such that it maximizes its profit, while foreseeing that the consumers are going to choose whether to search depending on n and the firm's optimal pricing strategy. In order to emphasize again the timing of actions, the firm chooses simultaneously the number of products, and their locations and prices; prior to searching the consumers only observe the number of products; after searching the consumers are also able to observe the product locations and their prices.

3. CONSUMER AND FIRM BEHAVIOR

In this section we consider the consumer behavior whether to search or not to search, and the optimal decision of the firm with respect to prices and the number of products.

3.1. Consumer Behavior

Let us consider the expected surplus of consumers after incurring the search costs. Given the number of products offered n consumers are able to anticipate the equilibrium price charged by each product, and that in equilibrium the products are located equally spaced around the circle.⁸

If the consumer's valuation v is sufficiently greater than the price p , the consumer will always purchase a product. As there are n products, the furthest that a product can be from the ideal product of the consumer is $\frac{1}{2n}$, with an expected distance from the best product of $\frac{1}{4n}$. The expected surplus obtained by the consumer is then $v - p - \frac{t}{4n}$.

On the other hand if the consumer's valuation v is not much greater than the price p , the consumer only buys if the consumer's ideal product is sufficiently close to one of the products. This will occur if $\frac{v-p}{t} < \frac{1}{2n}$. In this case the probability of a consumer purchasing the product after evaluating the product line is $2n\frac{v-p}{t}$ and the expected surplus given that the consumer purchases a product is $v - p - t\frac{v-p}{2t} = \frac{v-p}{2}$. The expected surplus after searching unconditional on the location of the consumer's ideal product is then $\frac{(v-p)^2}{t}n$.

From this, if $\hat{v} > p + \frac{t}{2n}$ we have that the marginal consumer \hat{v} is determined by $\hat{v} - p - \frac{t}{4n} = k$, and all consumers that search buy a product. On the other hand, if $\hat{v} < p + \frac{t}{2n}$ we have that the marginal consumer \hat{v} is determined by $\frac{(\hat{v}-p)^2}{t}n = k$, and some of the consumers that search, after inspecting the products decide not to buy any product. Which case we are in will depend on the firm behavior which we now discuss.

3.2. Firm Pricing Decision and Market Outcome Given the Product Line Length

Consider now the firm's pricing decision. Note that given that consumers have searched the best thing that the firm can do in order to extract the most surplus from the consumers that have searched is to offer equally spaced products at the same price.

⁸As noted below, the equilibrium price is the same across products, and the optimal locations are equally spaced around the circle. Even though the equilibrium price is the same across products, consumers still need to invest resources to check prices, otherwise they could be charged a very high price on one product bought.

Consider first the case in which the optimal price will be such that $\hat{v} < p + \frac{t}{2n}$, such that some consumers after searching choose not to buy any product. In this case the total demand given the price p , the number of products n , and the threshold \hat{v} , $D(p, n, \hat{v})$, is

$$D(p, \hat{v}, n) = \int_{p+\frac{t}{2n}}^{\bar{v}} dF(v) + \int_{\hat{v}}^{p+\frac{t}{2n}} 2n \frac{v-p}{t} dF(v), \quad (1)$$

where the first integral represents the demand of the consumers with a sufficiently high valuation such that they always buy after searching, and the second integral represents the demand of the consumers who only buy after searching if their preferences end up sufficiently close to one of the available products.

Finding the optimal price given the number of products n and the marginal consumer's valuation \hat{v} results from the maximization of the firm's profit $pD(p, n, \hat{v})$ which results in the first order condition

$$1 - F\left(p + \frac{t}{2n}\right) - p \frac{4n}{t} \left[F\left(p + \frac{t}{2n}\right) - F(\hat{v}) \right] + \int_{\hat{v}}^{p+\frac{t}{2n}} \frac{2n}{t} v dF(v) = 0. \quad (2)$$

The equilibrium price p and marginal consumer's valuation \hat{v} is then determined by jointly solving (2) and $\frac{(\hat{v}-p)^2}{t} n = k$. Totally differentiating these two equations with respect to the price p , the marginal consumer valuation \hat{v} , and the number of products offered n one obtains the following result (proof in the Appendix).

PROPOSITION 1: *When the number of products offered, n , increases, the equilibrium price p increases by more than the marginal consumer valuation \hat{v} .*

When the number of products offered increases, consumers that search are able to find products that are a better fit for their preferences, and therefore, if the set of consumers that search remains constant, the firm wants to increase its price. Foreseeing this, consumers become less willing to purchase, i.e., the valuation of the marginal consumer that searches, \hat{v} , is likely to be greater. As the price increases both because of the increase in the number of products and the marginal valuation of the consumers that search, while the marginal valuation increases with the price increase but decreases with the increase in the number of products, the effect on price of an increase in the number of products is greater than the effect on the marginal valuation.

Consider now the case in which the optimal price will be such that $\hat{v} > p + \frac{t}{2n}$, such that all consumers after searching choose to buy a product. In this case, the optimal price is the one that makes the marginal consumers at the mid-point between two products to be just indifferent between

buying and not buying a product, $p = \hat{v} - \frac{t}{2n}$. Consumers with $v > \hat{v} - \frac{t}{4n} + k$ choose to search. As the marginal consumer searching has valuation \hat{v} this condition only holds if $k < \frac{t}{4n}$. But this is the condition such that the equilibrium where some consumers that search end up not buying holds, $p + \frac{t}{2n} > \hat{v} = p + \sqrt{\frac{kt}{n}}$. That is, the case in which all consumers that search end up buying a product is never an equilibrium. If $k > \frac{t}{4n}$, the equilibrium is for no consumer to search as they know that once they search the price they face will be so high that their ex-ante surplus would be negative. In other words, if the firms chooses a number of products n that is too high, then no consumer will search and no consumer will buy.

In order to illustrate the results above for the case $k < \frac{t}{4n}$ consider the example where v is distributed uniformly in $[0, \bar{v}]$. In that case (2) becomes $\bar{v} - p - \frac{t}{2n} - \frac{n}{t}(\frac{t}{2n} - \sqrt{\frac{kt}{n}})(2p - \frac{t}{2n} - \sqrt{\frac{kt}{n}}) = 0$, generating an equilibrium price

$$p = \frac{1}{2} \frac{\bar{v} - \frac{t}{4n} - k}{1 - \sqrt{\frac{nk}{t}}}.$$

It is straightforward to check that the equilibrium price is increasing in n , and that it increases faster than the equilibrium \hat{v} . Figure 1 shows how \hat{v} and the price p vary with the number of products for $\bar{v} = 4, t = 2$, and $k = .08$. Note that for this example if $n \geq 7$, then $k > \frac{t}{4n}$ and no consumer chooses to search.

Using the proof of Proposition 1,⁹ one can also see that when the search costs k increase, fixing the number of products n , the equilibrium price p and valuation of the marginal consumer \hat{v} decrease. As the search costs increase, the price would have to decrease in order to attract the same number of consumers to search, which makes more consumer being willing to search (lower \hat{v}).

3.3. Optimal Number of Products

Let us now consider the optimal decision by the firm on the number of products to offer. We already noted that if the number of products offered is too high, such that $k > \frac{t}{4n}$, then no consumer searches and the firm ends up with no demand. The question now is what is the optimal number of products offered n .

Denoting $p(n)$ as the equilibrium price per product given that n products are offered, and \hat{v} the

⁹The slope $\frac{d\hat{v}}{dp}$ of the condition $\hat{v} = p + \sqrt{\frac{kt}{n}}$ is steeper than the same slope for (2) at the equilibrium.

equilibrium valuation of the marginal consumers searching, we can write the problem of the firm as

$$\max_n p(n)D(p(n), \hat{v}(n), n) \quad (3)$$

where $D(p(n), \hat{v}(n), n)$ is directly obtained from (1). By the envelope theorem, the derivative with respect to n of (3) only needs to take into account the direct effect of n on profits, and the effect of n through the equilibrium \hat{v} . The first order condition determining n is then

$$p(n) \frac{\partial D}{\partial n} + p(n) \frac{\partial D}{\partial \hat{v}} \frac{d\hat{v}}{dn} = 0. \quad (4)$$

It is immediate to see that $\frac{\partial D}{\partial n} > 0$. That is, keeping prices and the valuation of the marginal consumers fixed, an increase in the number of products increases demand. Furthermore, $\frac{\partial D}{\partial \hat{v}} < 0$, keeping prices and the number of products fixed, and increase in the valuation of the marginal consumers reduces demand. Then, from (4), we can obtain that close to the optimum $\frac{d\hat{v}}{dn} > 0$, as the number of products offered increases the number of consumers that search falls. By Proposition 1, we also then know that, close to the optimum, as the number of products offered increases, the equilibrium price also increases.

PROPOSITION 2: *Close to the optimum, as the number of products offered increases, then both the valuation of the marginal consumers searching and the equilibrium price increases.*

This result illustrates the effect of strategic pricing on the optimal decision of the firms, and on the decision of consumers not to search – the information overload effect. That is, close to the optimum, as the numbers of products increases, fewer consumers choose to search (and ultimately do not purchase the product), as the high prices that they fear to pay after searching, may not allow them to recoup the search costs incurred in finding out about the product attributes.

It is illustrative to investigate what happens when the search costs k go to zero. In that case, for a fixed n , we have \hat{v} converging to the price p , and $\frac{\partial D}{\partial \hat{v}}$ converging to zero, which from (4) implies that the optimal number of products offered converges to infinity. The condition on the equilibrium price (2) converges then to $1 - F(p) - pf(p) = 0$, which is the typical condition for monopoly pricing under no search costs. Figure 2 illustrates the optimal number of products n as a function of the search costs k when v is distributed uniformly on $[0, 4]$ and $t = 2$. In general, one can obtain the result that, for some region of the search costs, when search costs increase the optimal number of products decreases. The intuition is that when the search costs increase, the firm has to offer a greater surplus for consumers to be willing to search, and it can achieve that by reducing the number of products offered, as a lower number of products generates lower prices.

It is also interesting to note that if firms were able to observe prices before incurring search costs, then the optimal number of products to offer would be infinity, as given price demand increases in the number of products offered.¹⁰ However, as noted in the next section, if consumers can observe price but are unable to observe product quality prior to incurring the search costs, then the optimal number of products would continue to be finite, as a larger number of products would allow a firm to extract too much consumer surplus by offering lower product quality.

4. EXTENSIONS

In this section we consider two extensions of the base model above, and provide further discussion. The extensions considered are for the case when the consumers incur search costs to inspect the product qualities but not prices, and for the case when consumers with a greater valuation for the product care also more about which product they end up buying.

4.1. Costly Quality Evaluation

In some markets one may argue that it may be less costly for consumers to find out about prices than about the product characteristics. In such markets the results above still hold if the firm has also to decide on a quality dimension for each product, which is costly to evaluate.

To see this consider a variation of the model above where a firm in addition to choosing the number of products offered, their positioning on the horizontal dimension, and their prices, also chooses a quality dimension for each product offered. The ex-post utility of a consumer with valuation v purchasing a product with quality q at price p at distance d of his ideal product is

$$U = v + q - td - p - k.$$

Prior to incurring the search costs k the consumer knows p and v and does not know d or q , but may be able to infer both the distribution of the distance d from the best product available and q from the number of products offered n and the prices charged p . After incurring the search costs k , a consumer learns the positioning and quality level of all the products, and chooses to buy the best product available, which is at distance d , if and only if $v + q - td - p \geq 0$, as the search costs are sunk at the purchase decision time.

¹⁰If search costs are incurred per product evaluated then the optimal number of products to offer would still be finite if prices are observed prior to consumers incurring the search costs. The endogenous pricing effects discussed here would still be present if search costs are incurred per product evaluated.

The unit cost of production of a product with quality q is $c(q)$, with $c'(0) = 0$, $c'(q) > 0$, and $c''(q) \geq 0$ for all $q > 0$, generating a margin per unit sold of $p - c(q)$.

Given the number of products offered n and the prices charged p consumers decide whether or not to search and incur the search costs k , foreseeing the quality levels that firm has chosen for the products. We restrict the presentation to the case in which all products are offered at the same price and quality.¹¹ As above, denote the valuation of the marginal consumers deciding to incur the search costs as \hat{v} .

As considered above, if the consumer's valuation $v + q$ is not much greater than the price p , the consumer only buys after searching if the consumer's ideal product is sufficiently close to one of the products. This will occur if $\frac{v+q-p}{t} < \frac{1}{2n}$. In this case the probability of a consumer purchasing the product after evaluating the product line is $2n \frac{v+q-p}{t}$ and the expected surplus given that the consumer purchases a product is $v + q - p - t \frac{v+q-p}{2t} = \frac{v+q-p}{2}$. The expected surplus after searching unconditional on the location of the consumer's ideal product is then $\frac{(v+q-p)^2}{t} n$. The marginal consumer \hat{v} is determined by $\frac{(\hat{v}+q-p)^2}{t} n = k$, with some of the consumers that search, after inspecting the products, deciding not to buy any product.

The first order condition with respect to quality is

$$1 - F\left(p - q + \frac{t}{2n}\right) - \left(p - q + \frac{p - c(q)}{c'(q)}\right) \frac{2n}{t} \left[F\left(p - q + \frac{t}{2n}\right) - F(\hat{v})\right] + \int_{\hat{v}}^{p - q + \frac{t}{2n}} \frac{2n}{t} v dF(v) = 0. \quad (5)$$

The equilibrium quality q and marginal consumer's valuation \hat{v} is then determined by solving (5) and $\frac{(\hat{v}+q-p)^2}{t} n = k$. Note that the solution to this problem is similar to the pricing problem considered in the previous section, and, therefore, under some conditions one is able to obtain the same results, now with respect to the quality decision. In particular, when the number of products offered increases, consumers that search may be able to find products that are a better fit for their preferences, and, therefore, if the set of consumers that search remains constant, the firm wants to decrease the quality offered to save production costs. Foreseeing this, consumers become less willing to purchase, the valuation of the marginal consumer that searches, \hat{v} , may increase. As before, one can obtain examples, that if the number of products offered is too large, no consumer chooses to search in fear of the possible very low quality offered. If too few products are offered, the firm has further incentives to provide quality as it gets more of the consumers who search. Additionally, if the firm charges a greater price it will have incentives to offer more quality.

¹¹The quality product characteristic was included in the utility function as an additive term in order not to have price discrimination effects. If the quality product characteristic interacts with the consumer valuation v then firms may choose to offer different qualities and prices for price discrimination purposes.

Given the equilibrium quality q and marginal consumer's valuation \hat{v} , as a function of the number of products offered and price, $q(n, p)$ and $\hat{v}(n, p)$, and given the equilibrium demand

$$D(q, \hat{v}, p, n) = 1 - F\left(p - q + \frac{t}{2n}\right) + \int_{\hat{v}}^{p - q + \frac{t}{2n}} 2n \frac{v + q - p}{t} dF(v),$$

one can set up the problem of the firm to obtain its optimal price and number of products offered as

$$\max_{n, p} (p - c(q(n, p))) D(q(n, p), \hat{v}(n, p), p, n). \quad (6)$$

Along the lines of the analysis for Proposition 2 one can then show that close to the optimum, an increase in the number of the products offered leads to a reduction in demand through an increase in the valuation of the marginal consumer willing to search.

4.2. Positive Correlation Between Consumer Valuation and Importance of Product Fit

In some markets consumers that value the product category more may also be the ones that value more having a product closer to their horizontal specifications preferences. Consider then a variation of the model in previous section in which the dis-utility of having a product at distance d interacts with the general valuation for the product category v , and is now vtd , with the ex-post utility of a consumer with valuation v purchasing a product at price p at distance d of his ideal product being now

$$U = v - vtd - p - k.$$

If the consumer's valuation v is sufficiently greater than the price p , the consumer will always purchase a product. As there are n products, the furthest that a product can be from the ideal product of the consumer is $\frac{1}{2n}$, with an expected distance from the best product of $\frac{1}{4n}$. The expected surplus obtained by the consumer is then $v(1 - \frac{t}{4n}) - p$.

On the other hand if the consumer's valuation v is not much greater than the price p , the consumer only buys if the consumer's ideal product is sufficiently close to one of the products. This will occur if $\frac{v-p}{vt} < \frac{1}{2n}$. In this case the probability of a consumer purchasing the product after evaluating the product line is $2n \frac{v-p}{vt}$ and the expected surplus given that the consumer purchases a product is $v - p - vt \frac{v-p}{2vt} = \frac{v-p}{2}$. The expected surplus after searching unconditional on the location of the consumer's ideal product is then $\frac{(v-p)^2}{vt} n$.

From this, if $\hat{v} > p/(1 - \frac{t}{2n})$ we have that the marginal consumer \hat{v} is determined by $\hat{v}(1 - \frac{t}{4n}) - p = k$, and all consumers that search buy a product. On the other hand, if $\hat{v} < p/(1 - \frac{t}{2n})$ we have that

the marginal consumer \hat{v} is determined by $\frac{(\hat{v}-p)^2}{vt}n = k$, and some of the consumers that search, after inspecting the products decide not to buy any product.

Consider the case in which the optimal price will be such that $\hat{v} < p/(1 - \frac{t}{2n})$, such that some consumers after searching choose not to buy any product. Similarly to the analysis above, in this case the total demand given the price p , the number of products n , and the threshold \hat{v} , $D(p, n, \hat{v})$, is

$$D(p, \hat{v}, n) = \int_{p/(1-\frac{t}{2n})}^{\bar{v}} dF(v) + \int_{\hat{v}}^{p/(1-\frac{t}{2n})} 2n \frac{v-p}{vt} dF(v). \quad (7)$$

Finding the optimal price given the number of products n and the marginal consumer's valuation \hat{v} results from the maximization of the firm's profit $pD(p, n, \hat{v})$ which results in the first order condition

$$1 - F(p/(1 - \frac{t}{2n})) - p \frac{4n}{t} \int_{\hat{v}}^{p/(1-\frac{t}{2n})} \frac{1}{v} dF(v) + \frac{2n}{t} [F(p/(1 - \frac{t}{2n})) - F(\hat{v})] = 0. \quad (8)$$

The equilibrium price p and marginal consumer's valuation \hat{v} is then determined by jointly solving (8) and $\frac{(\hat{v}-p)^2}{vt}n = k$. One can then obtain, along the lines of the analysis in Section 3.2 (see Appendix), that the optimal number of products is finite, that some consumers that search end up not buying any product, and that, close to the optimum, an increase in the number of products leads to a reduction of the number of consumers that search (increase of \hat{v}), and to an increase in the equilibrium price.

5. CONCLUDING REMARKS

This paper investigates the role of product evaluation costs on consumer behavior and firm strategies when prices are endogenous and the firm chooses the product length. The paper shows that if consumers have to invest resources to learn about the prices charged, then we have an information overload effect in the sense that a greater number of products offered leads to fewer consumers being willing to choose. This effect results from the consumers being aware that more products will lead the firm to charge higher prices, as the products fit the consumer preferences better. This effect also then generates the effect that the optimal number of products is finite even though there is no cost per product offered. In sum, the paper shows that with product evaluation costs, endogenous pricing leads to fewer products being offered.

The paper also discusses how the results extend to the case in which product quality is also a choice variable by the firms, and to the case when the consumers that value more the product category are also the ones that care more about product fit. The paper considers the monopoly case. It would be interesting to investigate what happens when there is competition. Another interesting issue to investigate would be the implications on price discrimination and vertical differentiation of product evaluation costs. The analysis above considers only horizontal differentiation, but similar model features may lead themselves to study vertical product differentiation.

APPENDIX

PROOF OF PROPOSITION 1: Note first that (2) implies that $\int_{\hat{v}}^{p+\frac{t}{2n}} (2p-v) dF(v) > 0$, which implies $2p > \hat{v}$. Differentiating (2) with respect to \hat{v} one obtains $x \equiv \frac{2n}{t} f(\hat{v})(2p - \hat{v})$ which is positive as $2p > \hat{v}$. Adding x to the derivative of (2) with respect to p one obtains

$$y \equiv -f\left(p + \frac{t}{2n}\right) - \frac{4n}{t} \left[F\left(p + \frac{t}{2n}\right) - F(\hat{v}) \right] + \frac{2n}{t} f(\hat{v})(2p - \hat{v}) - \frac{2n}{t} f\left(p + \frac{t}{2n}\right) \left(p - \frac{t}{2n} \right).$$

Note that for $p = 0$ the condition $\hat{v} = p + \sqrt{\frac{kt}{n}}$ yields a \hat{v} that is greater than the \hat{v} obtained from (2), as $\frac{t}{2n} > \sqrt{\frac{kt}{n}}$, given that in equilibrium we need to have $p + \frac{t}{2n} > \hat{v}$. That implies that the slope $\frac{d\hat{v}}{dp}$ of the condition $\hat{v} = p + \sqrt{\frac{kt}{n}}$ is steeper than the same slope for (2) at the equilibrium, which implies $y < 0$.

Totally differentiating the condition $\hat{v} = p + \sqrt{\frac{kt}{n}}$ and (2) with respect to \hat{v}, p , and n , one obtains $\frac{d\hat{v}}{dn} = \frac{z-a(y-x)}{y}$ and $\frac{dp}{dn} = \frac{z-ax}{y}$ where $a = \frac{1}{2} \frac{kt}{n^2} \left(\frac{kt}{n}\right)^{1/2}$ and z is minus the derivative of (2) with respect to n . One can then obtain $\frac{dp}{dn} - \frac{d\hat{v}}{dn} = \frac{a(y-2x)}{y} > 0$. QED

ANALYSIS OF THE CASE OF POSITIVE CORRELATION BETWEEN CONSUMER VALUATION AND IMPORTANCE OF PRODUCT FIT: Note first that both (8) and

$$n(\hat{v} - p)^2 - \hat{v}tk = 0 \tag{i}$$

represent a positive relationship between \hat{v} and p . Note also that (8) and $\hat{v}(1 - \frac{t}{2n}) = p$ yields $\hat{v} = \bar{v}$, while (i) and $\hat{v}(1 - \frac{t}{2n}) = p$ yields $\hat{v} < \bar{v}$ if n is not too large. Then, at the equilibrium (\hat{v}, p) , the slope $\frac{d\hat{v}}{dp}$ is steeper for (8) than for (i). Denoting the left hand side of (8) and (i) as A and B , respectively, we have $\frac{\partial A}{\partial \hat{v}} > 0$, $\frac{\partial A}{\partial p} < 0$, $\frac{\partial B}{\partial \hat{v}} > 0$, $\frac{\partial B}{\partial p} < 0$, and $\frac{\partial A}{\partial \hat{v}} \frac{\partial A}{\partial p} - \frac{\partial A}{\partial p} \frac{\partial B}{\partial \hat{v}} > 0$. By arguments similar to the ones in the proof of Proposition 2, one also obtains $\frac{d\hat{v}}{dn} > 0$, which implies $\frac{\partial A}{\partial p} (\hat{v} - p)^2 - \frac{\partial A}{\partial n} \frac{\partial A}{\partial p} > 0$. Then, using the fact that the slope $\frac{d\hat{v}}{dp}$ is steeper for (8) than for (i), one obtains $\frac{dp}{dn} > \frac{d\hat{v}}{dn}$ close to the optimum. Finally, note that for any $\hat{v} < \bar{v}$ the optimal price obtained from (8) is greater than $\hat{v}(1 - \frac{t}{2n})$, which implies that some consumers who search end up not purchasing any product.

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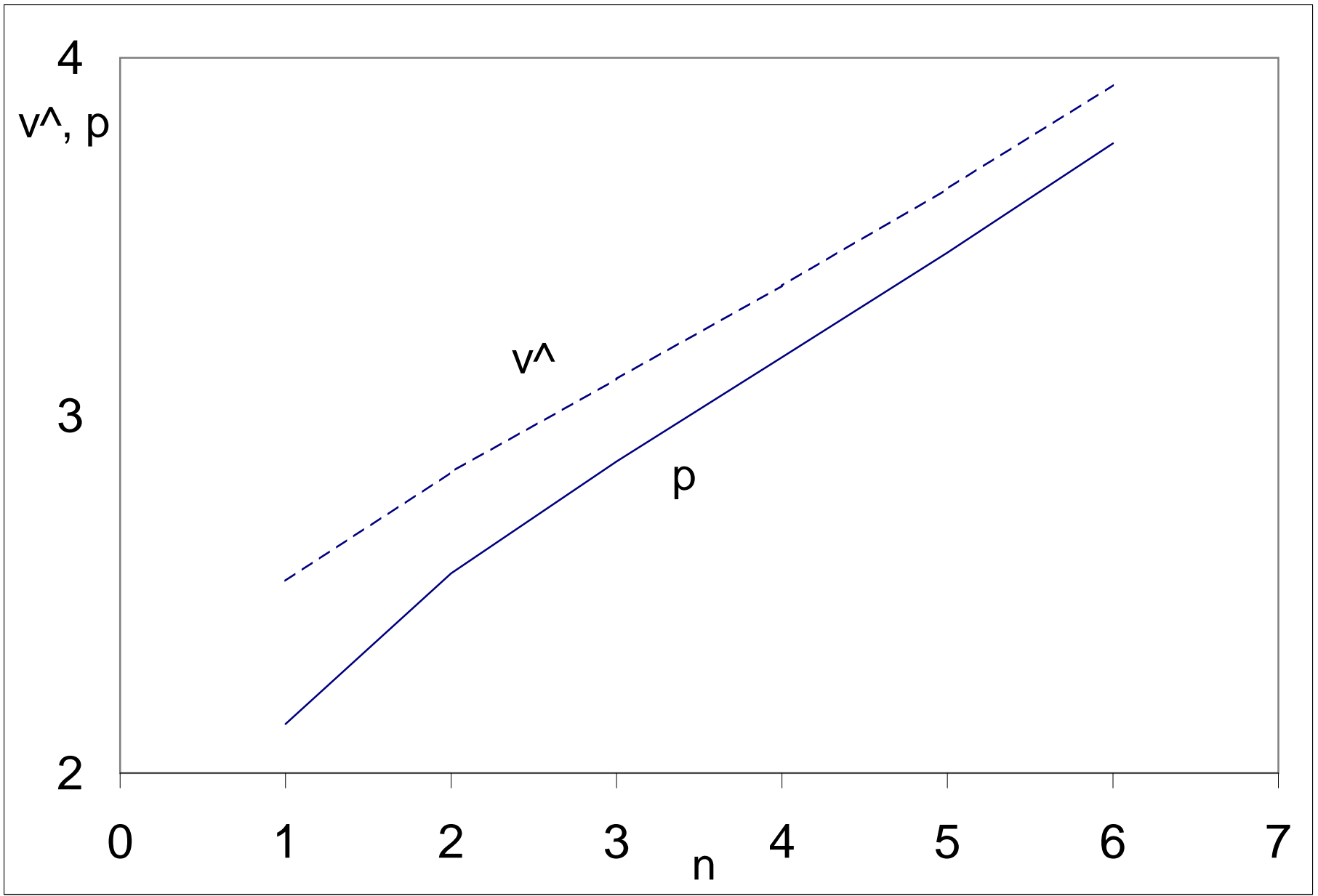


Figure 1: Evolution of the equilibrium valuation $v^$ of the marginal consumers and of the price p as a function of the number of products n , for v uniformly distributed on $[0,4]$, $t=2$, and $k=.08$.

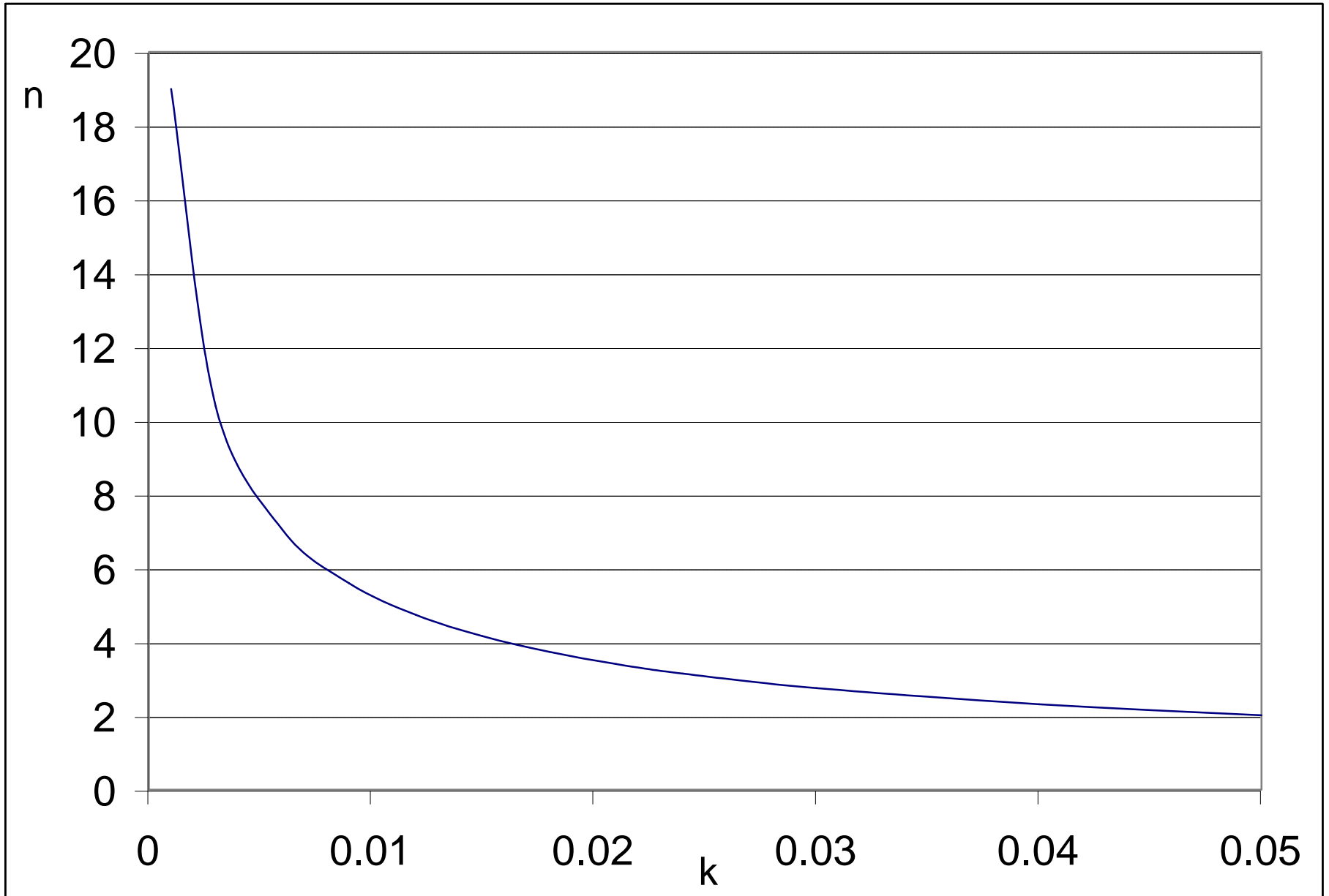


Figure 2: The optimal number of products n as a function of the search costs k , for v uniformly distributed on $[0,4]$ and $t=2$.