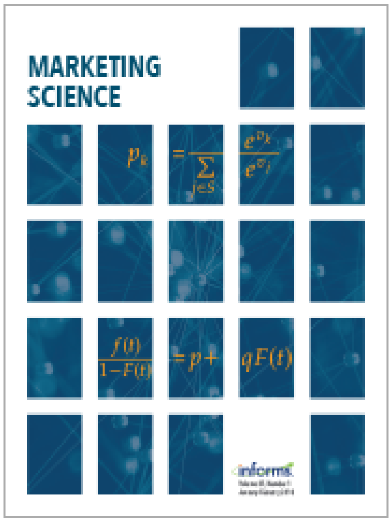

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Consumption Flexibility, Product Configuration, and Market Competition

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When purchase and consumption decisions are separated in time and when future utility is state dependent, consumers may desire to pursue consumption flexibility by purchasing different products together (multiple buying). This paper analyzes the effects of consumption flexibility on competing firms' marketing mix decisions, in a model in which future preference uncertainty exists and consumers differ in their preferred product location on a horizontal attribute. The analysis shows that the nature of price competition in such markets is dependent upon whether consumer multiple buying (and thus primary demand) is endogenously induced. When preference uncertainty is important, the firms are involved in a "flexibility trap" in which primary demand is expanded but profits decrease with the spread of consumer heterogeneity. This counter-intuitive result is caused by the firms being induced to over-cut prices to increase primary demand when consumption flexibility is important. In response to this, the firms may configure their products to alleviate the adverse effect of consumer heterogeneity. For example, if preference uncertainty is important, the firms may choose to minimize differentiation on the horizontal attribute, or extend the current product line, to deal with the "flexibility trap." The implications of allowing for positive salvage value, uncertainty heterogeneity, preference correlation, and state-dependent preference configuration are also investigated.

Key words: consumption flexibility; horizontal differentiation; market expansion; positioning; preference uncertainty; price competition; product line extension
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1. Introduction

1.1. Consumption Flexibility and Consumer Choice

In many differentiated markets, consumer decision making is characterized by two general features. First, the purchase and consumption occasions are not synchronous. Consumers usually buy products or services (called products hereafter) prior to actual consumption. For example, the purchase of appliances, computers or cameras commonly precedes actual use. Most frequently purchased packaged goods are also characterized by the separation in time between a store visit and consumption. Second, the future consumption utility is state dependent (Hauser and Wernerfelt 1990), even for search goods with perfectly known physical attributes or quality. The time lag between purchase and consumption may give rise to uncertainty about future utility, which will be resolved only at the consumption time. The uncertainty could be due to inherent product quality variability (Roberts and Urban 1988), or context-dependent factors such as weather, consumption mood, and so on. For example, on a rainy weekend watching an indoor hockey match is more enjoyable than a football game, although the weather is probably unpredictable at the time of the ticket purchase.

Consumers may therefore desire to maintain consumption flexibility (Kreps 1979, Walsh 1995). When facing state-dependent utility, a consumer can circumvent potential consumption constraints by buying a variety of products together. In doing so, subsequent consumption can be adjusted according to future states. Desired consumption can therefore be guaranteed irrespective of state realizations in future situations. A recent article in *PC World* (McCracken 2004) entitled "The More Operating Systems, the Merrier" describes how the author started "a bi-platform life" with both a PC and a Mac. Noticing that "the vast majority of spyware, virus, and Trojan horse writers design malware exclusive for Windows," the author concludes that "the Mac OS is a less irritating platform than Windows... I'm glad I realized that the Mac remains a viable option—even for a mostly Windows guy like me" (McCracken 2004, p. 21). Consider another example from a personal experience:[1]

> "One problem with the domestic airline: its service was not reliable; there might be a strike or equipment malfunction or unavailable aircraft or some such

[1] I thank an anonymous reviewer for providing this example.

> state uncertainty. Faced with the risk of missing my international connection back to the United States, I would often purchase both an air and a rail ticket to Bombay (now "Mumbai"), knowing that, when there was greater certainty about domestic-airline departure close to my departure date for the United States, I could cancel one (at some cancellation charge) and keep the other."

These examples highlight the role of consumption flexibility in consumer choice: buying competing products simultaneously can be an attractive option when faced with preference uncertainty. The products taken together, a PC and a Mac or an air and a rail ticket, can serve as "insurance" for each other against future unforseen contingencies, thereby enhancing the overall mutual benefits. Similar phenomena are prevalent in many marketplaces. Both professional single-lens reflex (SLR) and amateur point-and-shoot cameras can be found in a photographer's gear set. A single wallet may include multiple credit cards. People may own both cell and fixed-line phones, purchase different cosmetics of similar functionality, or subscribe to different TV channels, magazines, or season tickets. Similarly, people may resort to multiple information services (e.g., multiple doctors, lawyers, accountants, stock experts, databases, consulting companies, etc.) to improve decision making (Sarvary and Parker 1997). It is also empirically demonstrated that multiple variety purchases can be significantly explained by consumption flexibility, even for search goods like yogurt (Guo 2005).[2]

1.2. Research Issues and Summary of Results

Consumption flexibility concerns might have interesting implications for competitive marketing strategies. This paper seeks to investigate the effects of consumption flexibility on firms' decisions in competitive markets. The building block of the model is preference uncertainty, and the objective is to examine the mediating role of consumer multiple buying in the relationship between preference uncertainty, consumption flexibility, and competitive marketing mix decisions.[3]

First, this paper addresses the demand implications of consumers endogenously expanding the purchase option set in response to flexibility considerations. As the considered purchase options grow, the nature of competition between the firms may be changed. For example, when the consumers' decision is about buying a PC or a Mac, a firm's demand expansion is secondary; i.e., the focus is on switching consumers from the rival firm. However, if consumers are deciding between a PC only and both a PC and a Mac, more Macs can be sold without diminishing PC sales (primary demand expansion), and vice versa. The demand region in which the firms ultimately compete is therefore determined by whether consumers choose to purchase the competing products together. In the current context, consumers self-select the optimal option to purchase by gauging their preferences for flexibility against the prices charged. The motivation to seek flexibility can be translated into an actual multiple purchase only if the market prices are not too high. Otherwise, no consumer buys multiple products and the firms compete for secondary demand only. One may therefore want to ask, what is the underlying incentive for the firms to compete in the primary or secondary demand region, and how does that affect their equilibrium pricing decisions and profits?

This paper identifies the conditions under which consumers in equilibrium buy competing products together. It is shown that when the level of (horizontal) consumer heterogeneity is low, the firms find it attractive to expand primary demand by having some consumers buy the competing products together. They may therefore fall into a "flexibility trap" in which equilibrium profits decrease with consumer heterogeneity even as the demand expands, a result that has not been identified in the literature. The intuition has to do with the different roles that consumer heterogeneity plays in different competitive scenarios: mitigating price competition in the secondary demand region while impeding demand expansion when the firms compete for primary demand.

A related issue is how preference uncertainty may influence competing firms' differentiation decisions. An understanding of this impact can shed light on strategic decisions on product design, positioning, advertising, etc. This paper investigates the firms' incentives to increase or decrease horizontal differentiation between competing products. The firms can strategically adjust their product configurations to mitigate the adverse effect of the "flexibility trap." Interestingly, it is found that when the level of consumer heterogeneity is low and hence multiple buying is more likely to occur, the firms have a strong incentive to minimize horizontal product differentiation.

I extend the analysis to investigate the potential use of product line extension as a "de-trapping" strategy. It is shown that the existence of preference uncertainty might broaden the scope of competitive product offerings, making introducing "me-too" products

[2] See Villas-Boas (2004a) on market competition and consumer preference learning of experience goods.

[3] Given the current focus on strategic issues at the market level, this paper goes beyond explaining the multiple purchase behavior of consumers. There are alternative explanations for the multiple-purchase phenomenon, e.g., variety seeking (McAlister 1982) or stockpiling (Bell et al. 2002, Guo and Villas-Boas 2005).

profitable. I also investigate the implications of allowing for consumer heterogeneity in preference uncertainty and the correlation between state-dependent preferences and horizontal differentiation. Finally, the robustness of the minimum differentiation strategy is demonstrated in an extension of the base model in which the firms are allowed to configure their products to deliver either positively or negatively correlated state-dependent utility.

1.3. Related Research

Kreps (1979) formalizes the rationality underlying a set of choice behaviors whereby consumers strategically add more options to the purchased set to increase future consumption flexibility. Walsh (1995) shows that the desire for flexibility can drive consumers to purchase more varieties in a single shopping basket. In the Walsh model, the separation of purchase and consumption is explicitly recognized, and consumers' rational behavior at both stages is analyzed. At the purchase stage, consumers are aware that their future tastes are uncertain, and their choice behavior therefore involves variety purchases. Moreover, it is shown that consumers may optimally select to consume less-preferred products to preserve future flexibility. Another important contribution by Walsh is that he analytically and empirically distinguishes consumption flexibility from variety seeking. Along this line, Hauser and Wernerfelt (1990) show that uncertain consumers desire to evaluate more options to make a choice. There is also some experimental evidence that people do consider future uncertainty in their choice behavior (Simonson 1990). The focus of all these studies is on consumer behavior. The current paper builds on these studies and moves forward to provide insights into the impact of preference uncertainty on competing firms' strategic interactions in terms of pricing, positioning (differentiation), and product line extension.

Recently, some researchers examined the "multiple discreteness" issue where consumers may buy multiple units of the same and/or different products during a shopping occasion. Kim et al. (2002) offer an explanation based on "horizontal variety seeking," which is caused by diminishing marginal utility. Hendel (1999) and Dube (2004) present an alternative perspective, where multiple purchases are caused by anticipated preference changes over consumption occasions between shopping trips. These studies can be viewed as offering statistical accounts for variety purchases.[4]

Xie and Shugan (2001) investigate advance selling when consumers' future tastes are uncertain.[5] Unlike their study in which consumers can spot buy when utility uncertainty is resolved, this paper considers the case when purchase and consumption decisions are strictly separated so that spot buying is not possible. This drives consumers to buy competing products together, which is not considered in their model. This paper is also related to the work by Sarvary and Parker (1997), who examine competition in information markets where different pieces of information can be combined to improve decision making. They study consumer heterogeneity in willingness to pay for quality, whereas this paper considers both horizontal and vertical differentiation. Multiple buying always exists in their study, whereas both multiple and single buying can be an equilibrium in the current model. The studies also differ in the mechanism underlying consumers' incentives to purchase multiple products. In addition, product configuration decisions are endogenized in this paper, although information features are exogenous in their study.

The rest of the paper is organized as follows. The next section describes the model, and §3 presents the main analysis and results. The model extensions are presented in §4. The last section concludes the paper and discusses potential directions for future research.

2. The Model

To investigate competing firms' marketing mix decisions with consumer preference uncertainty, consider the following framework. The market is duopolistic with two firms, $i = A, B$, producing at zero marginal costs. Each firm i is endowed with a product denoted by c_i, $i = A, B$. Consumers are composed of expected-utility maximizers in both purchase and consumption decisions. In the purchase stage, consumers purchase product(s) that later can be consumed in each of T consumption periods. Consumption utility is uncertain and cannot be foreseen up front at the purchase time. Let us denote product c's state-dependent utility for consumer x in state s as $U_x(c, s)$.

To characterize $U_x(c, s)$, let us assume that consumers' valuations are affected by two product features. The first feature differentiates the products on a horizontal attribute (Hotelling 1929) and is state independent. For example, the horizontal attribute could capture the ease of use, physical design, or "snobness" of a computer. Formally, firms A and B

[4] Variety purchases could be due to consumption flexibility, variety seeking, and/or group preference heterogeneity. There is empirical evidence that the failure to account for consumption flexibility may lead to misleading estimates on consumer choice behavior (Guo 2005).

[5] Shugan and Xie (2005) study advance selling with competition. Relatedly, the separation of the purchase from consumption raises some interesting issues, e.g., over-selling (Biyalogorsky et al. 1999) and contingent pricing (Biyalogorsky and Gerstner 2004). See also Villas-Boas (2004b) on product line design with consumer confusion.

are positioned on a unit line $[0, 1]$, whose locations are represented by $\underline{l}$ and $\bar{l}$ capturing the distance from the product locations to the end points of the unit line, respectively. That is, product A's location is $\underline{l}$, while product B is located at $1-\bar{l}$. Without loss of generality, I can also restrict the locations to $0 \leq \underline{l} \leq 1-\bar{l} \leq 1$. Consumer type is represented by x capturing a consumer's most preferred product location, which is uniformly distributed on the same line $[0, 1]$. The disutility incurred by consumer x from consuming a product located at $l \in \{\underline{l}, 1-\bar{l}\}$ is given by $(x-l)^2t$, where t is a measure of the degree or spread of consumer heterogeneity.[6] The disutility is incurred not at the purchase time, but only when the product is actually consumed. Therefore, the characterization of consumer heterogeneity here complies with the interpretation of horizontal differentiation.

Second, to capture the uncertainty of consumption utility, let us assume that there are two states of nature for the future world, $\underline{s}$ and $\bar{s}$, with probability ρ and $1-\rho$, respectively. Correspondingly, the products can be classified into two types, namely $\underline{k}$ and $\bar{k}$. All else being equal, the $\underline{k}$-type product has higher state-dependent value in the state $\underline{s}$ than the $\bar{k}$-type product does, while the reverse is true in the state $\bar{s}$.[7] For instance, in a state of no (Windows) virus infection, a PC is preferred over a Mac probably due to the former's higher compatibility with most software and applications, whereas a Mac is definitely preferred if the PC is infected.[8] Similarly, if no strike occurs, people may prefer to take a plane over a train, but the preference is absolutely reversed in the event of an airline strike. Without loss of generality, I assume that the difference in the state-dependent value between the different product types ($\underline{k}$ or $\bar{k}$) is $\nu > 0$ in either state.

This characterization of state-dependent utility offers a parsimonious representation of a general set of purchase scenarios in which consumption flexibility is an important concern. Generally, for consumption flexibility to be achieved from variety purchases, what is necessary is only that a consumer's preference ranking of the products in the assortment is reversible depending upon future contingencies. In other words, a product purchased together with other products can increase the flexibility value of the bundle, *if and only if* it is preferred over other alternatives in at least one (but not all) future state of consumption occasions. To understand this, the following observations are worthwhile. First, preference uncertainty does not necessarily lead to consumption flexibility arising from multiple purchases. For example, suppose product A's and B's state-dependent utility, U_A and U_B, are drawn from $[\underline{U}_A, \bar{U}_A]$ and $[\underline{U}_B, \bar{U}_B]$ respectively, where $\underline{U}_A > \bar{U}_B$. Then, no flexibility can be obtained from buying both products together, since product A is preferred over B in *all* future contingencies. Second, preference uncertainty is not necessarily needed on *all* products for consumption flexibility to arise from multiple purchases. In the above example, suppose product B's utility is certain and $U_B \in [\underline{U}_A, \bar{U}_A]$. Then, product B can be used as a "back-up" and can contribute to increasing flexibility, and so can product A. Therefore, the variability in a PC's (a plane's) utility can allow a Mac (a train) to increase the overall flexibility value, even though a Mac's (a train's) utility tends to be less uncertain.

Overall, the consumers' consumption utility is assumed to be dependent upon the state-dependent value, as well as upon their horizontal locations. We can also characterize a firm's product features as $c_i \in \{c_{kl}\colon k \in \{\underline{k}, \bar{k}\},\ l \in [0, 1]\}$, $i = A, B$. In the base model, the feasible product locations are assumed to be fixed at zero or one, and the products' utility structure along the state-dependent dimension is also assumed to be exogenous, i.e., $c_A = c_{\underline{k}0}$ and $c_B = c_{\bar{k}1}$. In §3.2, I consider the case when the firms are able to position their products along the horizontal line. The base model is also extended in §4.3 when the firms are allowed to configure their product types.

I assume that consumers' valuations over the two dimensions are independent. This implies, for example, that a computer's positioning can be changed along a horizontal attribute (e.g., ease-of-use or "snobness") without influencing its vulnerability to virus attacks. This assumption captures the inherent preference uncertainty that exists in many products (Roberts and Urban 1988), over which firms do not have as much control as over the products' perceptual positioning. Nonetheless, in §4.2 I explore the implications of allowing for both consumer heterogeneity in the state-dependent value and the correlation between the horizontal and state-dependent preferences.[9]

The state-dependent utility, $U_x(c, s)$, for consumer x of product c_{kl} in state $s \in \{\underline{s}, \bar{s}\}$ is then:

$$U_x(c_{\underline{k}l}, \underline{s}) = U_x(c_{\bar{k}l}, \bar{s}) = \mu + \nu - (x-l)^2t,$$
$$U_x(c_{\underline{k}l}, \bar{s}) = U_x(c_{\bar{k}l}, \underline{s}) = \mu - (x-l)^2t,$$

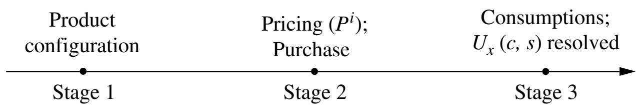
[6] Quadratic disutility is adopted over its linear counterpart to guarantee the existence of pure-strategy equilibrium when endogenizing the firms' location choices (d'Aspremont et al. 1979).

[7] Given the symmetry of the problem, it can be assumed that $\rho \in [0, \frac{1}{2}]$. The case of $\rho \in [\frac{1}{2}, 1]$ is analogous.

[8] This captures the positive correlation for computers between compatibility and vulnerability to virus infection. The case when the firms can choose the state-dependent type (i.e., compatibility or OS) is considered in §4.3.

[9] A noteworthy point is that even though in the base model consumer heterogeneity in the state-dependent value is absent, the heterogeneity on the horizontal dimension allows consumers to differ in their valuation of flexibility, as is illustrated in the next section. This is due to the endogenous nature of the preference for consumption flexibility.

Figure 1 **Timing of the Model**



where μ is the stand-alone value of consuming a product compared to no consumption. Throughout this paper, I assume that μ is large enough such that in equilibrium every consumer buys at least one product. Purchasing the different products together can also be a desirable option if the benefits of preserving consumption flexibility outweigh the associated payments. Note that ν measures the variation in the state-dependent utility, and ρ determines the degree of future uncertainty. The relative flexibility value added by the different k-type products to a purchased assortment is jointly captured by both ν and ρ.

I consider a three-stage game as shown in Figure 1. In the first stage, the firms choose product configurations, which then become common knowledge to the market. In the second stage, the firms simultaneously make price offerings, P^i, $i = A, B$, and consumers make their purchase decisions. The last stage of the game involves T consumption periods, during each of which the utility $U_x(c, s)$ is realized and a consumption decision is made. In evaluating the purchase options, $\Omega = \{\omega\colon \omega \in \{c_A, c_B, \{c_A \& c_B\}\}\}$, consumers take into account what will happen in all future consumption scenarios. Consumers discount future utilities at a rate of $0 \le \zeta \le 1$. Let us also denote $\gamma = (1-\zeta^T)/(1-\zeta) \ge 1$. Given these assumptions, the purchase utility for an option $\omega \in \Omega$ is given by:

$$V_x(\omega) = \gamma \sum_{s \in \{\underline{s}, \bar{s}\}} \rho_s \Big[\max_{c_i \in \omega} U_x(c_i, s)\Big] - \lambda \sum_{c_i \in \omega} P^i, \qquad (1)$$

where $\rho_{\underline{s}} = \rho$, $\rho_{\bar{s}} = 1-\rho$, and λ is the price coefficient that is normalized at $\lambda = \gamma$. This normalization re-scales the valuations for all alternative options (or corresponds to just a change in currency), which therefore does not sacrifice generality. Note also that this normalization is consistent with the literature in which the price coefficient is usually normalized to one. This completes the model specification. A summary of the model notation is presented in Table 1.

This model setup captures repeatedly usable products, e.g., computers. Preference uncertainty is present in each of the future consumption occasions. An alternative interpretation is that consumers ex ante know the percentage of times a product will be used in the T periods. One can view the current setup as endogenizing the ex ante expected usage frequency.[10]

Table 1 **Model Notation**

Notation	Explanation
Base model	
i	Firms ($i = A, B$)
x	Consumer type (preferred product location)
l	Product location (product A at $\underline{l}$ and B at $1-\bar{l}$)
t	Spread of consumer heterogeneity
s	States of nature ($\underline{s}$ and $\bar{s}$)
ρ	Probability of the state of nature $\underline{s}$ ($1-\rho$ for state $\bar{s}$)
κ	State-dependent product type ($\underline{\kappa}$ and $\bar{\kappa}$)
ν	Add-on value in a favorable state
μ	Stand-alone value of consumption
c_i	Product of firm $i = A, B$
$c_{\kappa l}$	Product configuration of type κ with location l
$U_x(c, s)$	State-dependent consumption utility for consumer x of product c in state s
P^i	Price of product $i = A, B$
ω	Elements of purchase options ($\omega \in \Omega$)
Ω	Set of purchase options ($\Omega = \{c_A, c_B, \{c_A \& c_B\}\}$)
ζ	Per-period discount factor
γ	Present discounted multiplier ($\gamma = (1-\zeta^T)/(1-\zeta)$)
$V_x(\omega)$	Expected purchase valuation of consumer x for option ω
λ	Price coefficient (normalized to γ)
$\tilde{x}$	Cut-off consumer type between option c_A and c_B
x'	Cut-off consumer type between option c_A and $\{c_A \& c_B\}$
x''	Cut-off consumer type between option c_B and $\{c_A \& c_B\}$
x^i	Demand for product $i = A, B$
Π^i	Profits for product $i = A, B$
f	Salvage value of an unused product
Extensions	
A'	Product line extension by firm A
$P^{A'}$	Price of product A'
$c_{A'}$	Extended product A'
ν_x	Add-on value in a favorable state (ν or 0)
α	Preference correlation coefficient

Under the consumption-flexibility interpretation, consumers' usage from an ex post perspective need not necessarily match the ex ante expectation. This is analogous to the fact that flipping a coin many times does not necessarily result in heads turning up half of the times. The model can also be directly applicable to products that cannot be repeatedly used and have only negligible residual value if not used promptly, i.e., perishables, fashion goods, or information services. In some cases (e.g., air and rail tickets), however, the unconsumed unit could be "salvaged" with some positive value, $f > 0$, through resale, refund, or "forced consumption." The forced-consumption case could capture the situation of, for instance, watching an on-site hockey game along with a football match on the same or close days. Nevertheless, it is shown in the next section that allowing for positive salvage value reinforces the main implications of the paper.

[10] I thank an anonymous reviewer for pointing this out. In this regard, the current setup captures both horizontal and vertical differentiation, where the latter is state-dependent. For example, a consumer may *on average* like a PC (a plane) more than a Mac (a train), although there exist circumstances when the latter is preferred.

3. Analysis and Results

3.1. Basic Case

This section considers the basic case where the firms' product configurations are fixed: $c_A = c_{\underline{k}0}$ and $c_B = c_{\bar{k}1}$. The game is solved through backward induction. I first characterize the consumers' consumption and purchase decisions in the presence of preference uncertainty, followed by deriving the firms' demand functions. The firms' incentive to induce consumers to choose the multiple-buying option, $\{c_A \& c_B\}$, is then investigated. Next, the equilibrium prices and profits are presented. It is established that a "flexibility trap" might exist in which equilibrium profits decrease with consumer heterogeneity if preference uncertainty is significant. I also examine the implications of allowing for positive salvage value for unused products.

3.1.1. Consumers' Decisions. Consider a representative consumption occasion for a consumer of type x who bought a set $\omega_x \in \Omega$ of products in the purchase stage. If ω_x includes only one single product, the consumption decision is trivial and the consumer simply consumes whatever is on hand. When both products are available ($\omega_x = \{c_A \& c_B\}$), in deciding which product to consume, the consumer has to consider the tradeoff between the (realized) state-dependent value and the horizontal disutility. A less-matched product may be selected if it is in its favorable state. Consider first the case of $t \le \nu$, where $\nu - x^2 t \ge -(1-x)^2 t$ and $-x^2 t \le \nu - (1-x)^2 t$ for all $x \in [0, 1]$. This suggests that if ν is large enough, consumption is completely state-driven: a product is consumed if and only if it is in its favorable state. If $t \ge \nu$ instead, consumers who like product A very much ($x \le \frac{1}{2} - \nu/2t$) keep on using it irrespective of the realized state. The case is analogous for those consumers close to product B's location ($x \ge \frac{1}{2} + \nu/2t$). However, consumers who are relatively indifferent between the products ($\frac{1}{2} - \nu/2t \le x \le \frac{1}{2} + \nu/2t$) have their consumption choice determined by the realized state, i.e., they "switch back and forth" between the two products.

In anticipation of future consumption, a consumer's purchase decision is thus influenced by his/her willingness to pay for flexibility, which as the above discussion suggests is dependent upon both the consumer's location x and the relative magnitude of ν to t. Given the prices charged, consumers who value flexibility more will be more likely to put both products into their shopping baskets. Particularly, a direct application of Equation (1) reveals that a consumer of type x prefers purchasing product A over both products A and B if and only if:

$$\gamma(\rho\nu - x^2 t) - \gamma\{\rho \max\{\nu - x^2 t, -(1-x)^2 t\} + (1-\rho)\max\{-x^2 t, \nu - (1-x)^2 t\} - P^B\} \ge 0. \quad (2)$$

It is seen from Equation (2) that the incremental value of buying an additional product B increases with x. So all consumers at $x \le x'$ prefer purchasing product A over buying A and B together, where x' equalizes (2). Similarly, the choice between product B and both A and B involves comparing $V_x(c_B) = \gamma[\mu + (1-\rho)\nu - (1-x)^2 t - P^B]$ and $V_x(\{c_A \& c_B\}) = \gamma\{\mu + \rho \max\{\nu - x^2 t, -(1-x)^2 t\} + (1-\rho)\max\{-x^2 t, \nu - (1-x)^2 t\} - P^A - P^B\}$. This defines x'', where all $x \ge x''$ types prefer to buy product B only over both A and B. Moreover, in deciding which single product to buy, product A is preferred over B if and only if $x \le \tilde{x}$ where:

$$\tilde{x} = \frac{(2\rho - 1)\nu + t + P^B - P^A}{2t}. \quad (3)$$

When $t \le \nu$, the multiple-buying cut-off points, x' and x'', can be simplified:

$$x' = \frac{(1-\rho)(t-\nu) + P^B}{2(1-\rho)t}, \quad (4)$$

$$x'' = \frac{\rho(\nu + t) - P^A}{2\rho t}. \quad (5)$$

Note that for any combination of $\{P^A, P^B\}$ there are only two alternative orderings of $\tilde{x}$, x', and x'' as in (3), (4), and (5). In particular, if it turns out that no consumer buys both products, it must be that $x'' \le \tilde{x} \le x'$. If, on the other hand, some consumers at intermediate locations purchase two products together, we have $x' \le \tilde{x} \le x''$. As the following lemma shows, this characterization of purchase decisions also extends to the case when $t \ge v$.

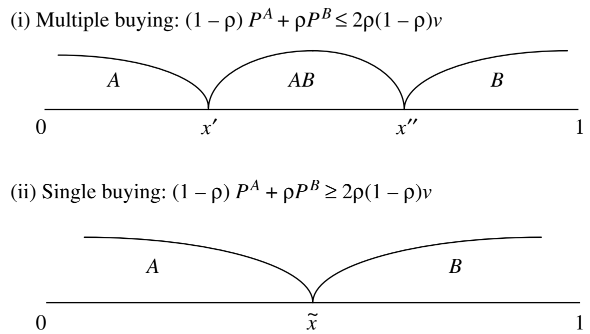
Lemma 1. *$\tilde{x}$, x', and x'' in* (3), (4), (5) *completely characterize the consumers' purchase decisions*:

(i) *If $(1-\rho)P^A + \rho P^B \le 2\rho(1-\rho)\nu$, then $x' \le \tilde{x} \le x''$, where consumers $x \le x'$ buy product A only, $x' \le x \le x''$ buy both products A and B, and $x \ge x''$ buy product B only*;

(ii) *If $(1-\rho)P^A + \rho P^B \ge 2\rho(1-\rho)\nu$, then $x'' \le \tilde{x} \le x'$, where consumers $x \le \tilde{x}$ buy product A, and $x \ge \tilde{x}$ buy product B.*

Lemma 1 highlights the endogeneity of demand expansion when consumers are concerned about consumption flexibility. It illustrates the role of competitive pricing in converting consumers' purchase decisions on an expanded option set to market demand, which can be either primary or secondary. In particular, if the charged prices are relatively low, some consumers who value flexibility more tend to buy both products together. The consumers who purchase multiple products tend to be relatively indifferent between the products in terms of horizontal location. In comparison, those consumers who have a strong preference for a particular product do not feel that the additional payment of buying the other

Figure 2 **Consumer Purchase Decisions and Market Demand**



product is justified by the increased flexibility value. The intuition for this is that those consumers with indifferent location preferences have less to sacrifice from product mismatch in switching back and forth between the different products. In contrast, if the prices remain high, no consumer wants to buy both products together. It is in this case that the multiple-buying option is not endogenously realized as actual purchases.

Figure 2 characterizes graphically the consumers' purchase decisions and the firms' demand under the two alternative price regions as given in Lemma 1. Formally, we can denote the demand for firm i as x^i, $i = A, B$:

$$x^A = \begin{cases} x'' = \dfrac{\rho(\nu+t) - P^A}{2\rho t}, \\ \quad \text{if } (1-\rho)P^A + \rho P^B \le 2\rho(1-\rho)\nu; \\ \tilde{x} = \dfrac{(2\rho-1)\nu + t + P^B - P^A}{2t}, \quad \text{otherwise.} \end{cases}$$

$$x^B = \begin{cases} 1 - x' = \dfrac{(1-\rho)(\nu+t) - P^B}{2(1-\rho)t}, \\ \quad \text{if } (1-\rho)P^A + \rho P^B \le 2\rho(1-\rho)\nu; \\ 1 - \tilde{x} = \dfrac{(1-2\rho)\nu + t + P^A - P^B}{2t}, \quad \text{otherwise.} \end{cases}$$

Lemma 1 also implies that, if the prices are low, an increase in a firm's market sales can be driven by primary demand expansion, and the total market size can be enlarged even with a fixed number of consumers. However, when the prices are high, demand expansion is only secondary in the sense that lowering the price can only switch some consumers away from the competitor while the total market demand is fixed. Then, it is interesting to ask whether and how the marginal consumer's own-price and cross-price sensitivities differ across the two price regions. The following lemma responds to this, which is straightforward from a direct examination of the demand functions.

Lemma 2. *When the market prices are in the multiple-buying region, for both firms, the own-price demand sensitivity is higher and the cross-price sensitivity is lower than in the single-buying region.*

3.1.2. Firms' Pricing Decisions. Let us now investigate the firms' strategic pricing decisions. As we see above, the nature of demand expansion and price sensitivity differs across the two purchase regions. Conventional wisdom might suggest that firms compete less aggressively when demand can be expanded primarily because the firms do not need to compete head-to-head for fixed sales. Following the same logic, one may also conjecture that price competition is more intense and that the firms tend to undercut each other when the market is characterized by the firms competing for secondary demand.

However, this conventional logic captures only local pricing incentives in one of the pricing regions. It remains to be determined into which scenario the firms fall in the first place. Because the boundary of the regions is endogenous, each firm has to decide on both the price region to compete in and on its optimal pricing within that region. A firm might increase or drop its price into an alternative region and thus unilaterally change the nature of competition. The search for the price equilibrium is thus complicated by the discontinuity of the firms' profit functions, $\Pi^i = P^i x^i$, $i = A, B$. To characterize the pricing equilibrium, let us define $t_1 = \nu/3 \le t_2 = ((2+3\sqrt{\rho}-4\rho)/(6-3\sqrt{\rho}))\nu \le t_3 = ((1+3\sqrt{\rho})/(3+\sqrt{\rho}))\nu$.

Proposition 1. *The equilibrium prices and profits in the base model are given by*:

(i) *For* $0 \le t \le t_1$, $P^{A*} = \Pi^{A*} = \rho(\nu - t)$, *and* $P^{B*} = \Pi^{B*} = (1-\rho)(\nu - t)$ *constitute an equilibrium where all consumers buy two products*;

(ii) *For* $t_1 \le t \le t_3$, $P^{A*} = \rho(\nu+t)/2$, $P^{B*} = (1-\rho)(\nu+t)/2$, $\Pi^{A*} = \rho(\nu+t)^2/8t$, *and* $\Pi^{B*} = (1-\rho)(\nu+t)^2/8t$ *constitute an equilibrium where some consumers buy two products*;

(iii) *For* $t \ge t_2$, $P^{A*} = ((2\rho-1)/3)\nu + t$, $P^{B*} = ((1-2\rho)/3)\nu + t$, $\Pi^{A*} = ((2\rho-1)\nu+3t)^2/18t$, *and* $\Pi^{B*} = ((1-2\rho)\nu+3t)^2/18t$ *constitute an equilibrium where no consumer buys two products*.

This proposition characterizes the conditions under which multiple purchasing is observed in equilibrium.[11] When the spread of consumer heterogeneity t is small relative to consumption flexibility, the firms

[11] Note that when $t_2 \le t \le t_3$, one obtains two equilibria; in the other parameter ranges, the equilibrium is unique. For the purpose of simplification, from now on it is assumed that in any subgame including the pricing game, the single-buying equilibrium will be "chosen" when multiple equilibria exist because it leads to higher profits for both firms. None of the qualitative results is affected by this "pareto domination" selection criterion.

find it attractive to drop their prices such that some consumers buy both products together. The incentive to cut prices is supported by the lack of strategic interaction in the multiple-purchase region, and by the homogenization of the products when t is small. Moreover, it can be seen that the larger the preference uncertainty is, the more likely that the multiple-buying equilibrium is observed, since both t_2 and t_3 increase with ρ and ν.

Next, let us look at how preference uncertainty and consumer heterogeneity might influence the firms' equilibrium profits across the different equilibrium regions. To this end, we can take comparative statics of the equilibrium profits:

Proposition 2. *Under the multiple-buying equilibrium* (*i.e.*, $t \le t_2$), $d\Pi^{i*}/d\nu \ge 0$, *and* $d\Pi^{i*}/dt \le 0$. *Under the single-buying equilibrium* (*i.e.*, $t \ge t_2$), $d\Pi^{A*}/d\nu \le 0$, $d\Pi^{B*}/d\nu \ge 0$, *and* $d\Pi^{i*}/dt \ge 0$.

Interestingly, the firms' profits improve with increasing preference variation ν under the equilibrium when consumers are induced to buy multiple products. However, in the equilibrium when the firms compete for secondary demand, only the superior firm B (given the assumption $\rho \le \frac{1}{2}$) benefits from increasing preference uncertainty. The intuition is that in this case, higher preference variability does not increase total market demand but instead magnifies the advantage enjoyed by the superior firm over its inferior counterpart. Another interesting result is that consumer heterogeneity has a qualitatively different impact on equilibrium profits across the two equilibrium regions. To understand this, one can use the envelope theorem:

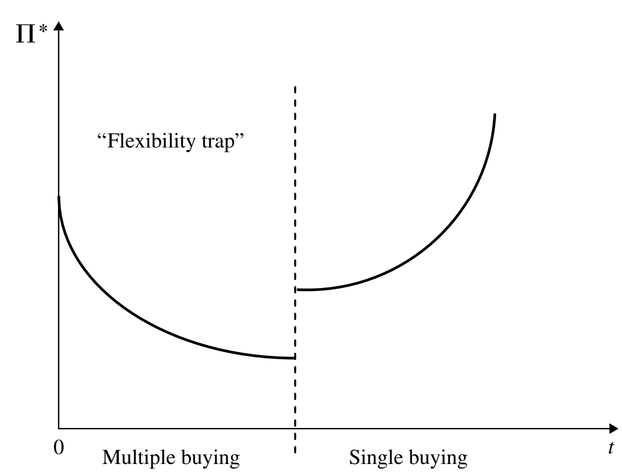
$$\frac{d\Pi^{i*}}{dt} = \frac{\partial \Pi^{i*}}{\partial t} + \frac{\partial \Pi^{i*}}{\partial P^{j*}}\frac{dP^{j*}}{dt}, \quad i = A, B,\ j = B, A.$$

The total effect of t on equilibrium profits can be decomposed into two components. The first term represents the direct effect, which is negative because increasing heterogeneity implies larger disutility from consuming a less-preferred product. The second term captures the (generally positive) strategic impact. As is well known (Tirole 1988), the strategic effect generally dominates the direct one in standard models of horizontal differentiation. Conventional wisdom therefore suggests that increasing consumer heterogeneity benefits equilibrium profits. This is confirmed by Proposition 2 in the case when t is relatively large such that the equilibrium is in the single-purchase region.

However, in the current model, when t is relatively small such that in equilibrium multiple purchases occur, consumer heterogeneity no longer plays the role of differentiating the competing products and thus of mitigating price competition. The strategic effect fades away as a firm's payoff is not influenced by a small change in the rival firm's action. Moreover, in this equilibrium region some consumers purchase their less-preferred product, which they would not otherwise do in the single-buying case. The direct effect is thus more significant. Therefore, as consumer heterogeneity t increases from zero, at first it decreases the equilibrium profits. This results from the firms being unable to resist the temptation to reduce prices when the opportunity of expanding primary demand is sufficiently attractive. Hence, sales increase while equilibrium profits go down, constituting the central result of the paper, which is termed the "flexibility trap." To get out of the trap, t can increase up to the point where the firms in equilibrium compete for secondary demand. It is from then on that the strategic effect (endogenously) comes into play and that larger consumer heterogeneity leads to higher equilibrium profits. Figure 3 illustrates graphically the flexibility trap.

3.1.3. Positive Salvage Value ($f > 0$)**.** It is important at this point to consider an alternative setup where the products cannot be repeatedly used and an unused product has some residual value, $f > 0$. This represents a broad set of categories, e.g., services. The salvage value could be achieved, for example, through refunds (e.g., air and rail tickets). Under this setup, the single-buying marginal consumer type $\tilde{x}$ remains unchanged (Equation (3)). The multiple-buying cut-off points (Equations (4) and (5)) become $x' = ((1-\rho)(t-\nu) + P^B - f)/(2(1-\rho)t)$ and $x'' = (\rho(\nu+t) - (P^A - f))/2\rho t$, respectively. As a result, the condition identified in Lemma 1 for the occurrence of multiple buying becomes $(1-\rho)P^A + \rho P^B \le 2\rho(1-\rho)\nu + f$. It is then obvious that the qualitative nature of the demand functions is preserved, except that the multiple-buying region is enlarged. This

Figure 3 **The Effect of Consumer Heterogeneity on Equilibrium Profits**



increases the likelihood of observing the multiple-buying region. The main implications of the paper can then be reinforced under this alternative setup. In this regard, the zero-salvage-value assumption, which will be retained in the rest of the paper, is conservative in capturing the effect of consumption flexibility.

3.2. Horizontal Location Choice

As we see in §3.1.2, when the firms are horizontally differentiated, they may fall into the "flexibility trap" in which equilibrium profits decrease with consumer heterogeneity. Then one may ask whether the firms can strategically reduce differentiation in order not to be caught in the trap. To answer this question, let us now investigate the firms' incentive for horizontal differentiation when they can freely choose product locations along the Hotelling line: $0 \le \underline{l} \le 1 - \bar{l} \le 1$.

Differentiation decisions can potentially mitigate the impact of consumer heterogeneity on market interactions. This is because product locations affect not only the consumers' relative product preference on the horizontal attribute, but also the flexibility value of incorporating both products into a basket. As differentiation goes down ($\underline{l}$ or $\bar{l}$ goes up), consumers on average incur less disutility in consuming either product and may therefore be more likely to consider buying both products together. This suggests that the firms can adjust their differentiation strategies to influence subsequent pricing competition. The firms' incentives for horizontal differentiation might be dependent upon whether the following market competition is characterized by primary or secondary demand expansion. To see this, note that, as Proposition 2 demonstrates, whether or not consumer heterogeneity t increases equilibrium profits is determined by whether the equilibrium is in the single- or multiple-buying region. Given the impact of differentiation on effective consumer heterogeneity, one may therefore expect that the firms may desire to decrease market differentiation if the subsequent pricing equilibrium is in the multiple-buying region.

Product locations also determine which equilibrium region in the subsequent pricing game is to be observed. As Proposition 1 shows, the lower the consumer heterogeneity is, the more likely the multiple-buying scenario is in equilibrium. Lowering product differentiation can hence increase the incidence that the firms switch from a single- to a multiple-buying equilibrium. Therefore, to solve for the equilibrium locations, we need to take into account how the firms' incentives for differentiation differ across the multiple- and single-buying regions, as well as which demand region will emerge in the subsequent pricing equilibrium.

Proposition 3. *When the firms can choose product locations on* $[0, 1]$:

(i) *If* $t \le \max\{(4(1+3\sqrt{\rho})/(5+3\sqrt{\rho}))\nu, \min\{\underline{t}^A, \underline{t}^B\}\}$, *a minimal differentiation equilibrium* $(\underline{l}^*, \bar{l}^*) = (\frac{1}{2}, \frac{1}{2})$ *exists, where consumer multiple buying emerges in the subsequent pricing equilibrium,* $P^{A*} = \Pi^{A*} = \rho\nu$, *and* $P^{B*} = \Pi^{B*} = (1-\rho)\nu$;

(ii) *If* $t \ge \max\{((1+3\sqrt{\rho})/(3+\sqrt{\rho}))\nu, \bar{t}^A, \bar{t}^B\}$, *a maximal differentiation equilibrium* $(\underline{l}^*, \bar{l}^*) = (0, 0)$ *exists, where consumer single buying emerges in the subsequent pricing equilibrium,* $P^{A*} = ((2\rho-1)/3)\nu + t$, $P^{B*} = ((1-2\rho)/3)\nu + t$, $\Pi^{A*} = ((2\rho-1)\nu + 3t)^2/18t$, *and* $\Pi^{B*} = ((1-2\rho)\nu + 3t)^2/18t$, *where* $\underline{t}^i$, $\bar{t}^i$, $i = A, B$, *are given in the appendix.*

This proposition summarizes the conditions under which the well-known "maximum differentiation" principle may or may not remain an equilibrium if consumers are faced with future preference uncertainty. The results reflect the well-known tradeoff in differentiation decisions between the strategic concern of inducing more intense price competition and the direct effect of increasing market demand. As the firms become more similar to each other with decreasing differentiation, they will compete more aggressively in price. At the same time, moving to the middle of the horizontal line can also increase a product's overall attractiveness. In standard models of horizontal differentiation with single buying only (e.g., d'Aspremont et al. 1979), the strategic effect dominates the direct demand effect such that maximum horizontal differentiation is sustained in equilibrium. This result is also confirmed in this paper in the case when the subsequent pricing equilibrium involves consumer single buying.

However, firms may be engaged in minimal differentiation if price competition is absent (Tirole 1988, p. 287).[12] In the current model, price competition might be endogenously absent if the firms are involved in the multiple-buying region. It is shown in the appendix that maximal differentiation is a dominated strategy if the induced pricing game involves consumer multiple buying. Moreover, when consumers care more about preference uncertainty than product mismatch, the firms in equilibrium have a strong incentive to minimize product differentiation. Intuitively, when the consumers' preferences for consumption flexibility are sufficiently significant, the firms find it worthwhile to induce primary demand expansion, which relaxes their concern for intense price competition. To cope with the "flexibility trap," the firms hence strategically decrease product differentiation to facilitate consumer multiple buying. In contrast, when preference uncertainty is not sufficiently significant, pursuing primary demand

[12] See Hotelling (1929) for a case in which the absence of price competition is exogenously imposed.

expansion is not profitable. The "maximum differentiation" principle is then recovered as an equilibrium outcome.

4. Extensions

The previous section establishes that, when preference uncertainty is significant, competing firms might be caught in a "flexibility trap" in which equilibrium profits drop and decrease with consumer heterogeneity. In response to this, one strategy that can be employed to evade the trap is through reducing differentiation. It would be interesting to explore alternative strategic instruments that can help the firms escape from the trap. To this end, in this section I investigate the role of product line extension as a trap-avoiding instrument. To further examine the robustness of the minimum differentiation strategy in helping the firms avoid the trap, the base model is also extended to consider consumer uncertainty heterogeneity and the correlation between the horizontal and state-dependent preferences. Finally, I show that the effectiveness of the minimum differentiation strategy is robust to allowing for endogeneity in the state-dependent preference structure.

4.1. Product Line Extension

The base model assumes that each firm is endowed with only one product. In reality, the firms may actually produce a line of products. For instance, Apple offers two portable computer models, PowerBook and iBook, both based on the Mac system. One common rationale for product line extension is to fill up market "holes," whereas firms may also recognize that introducing a similar product to the rival's may reduce market differentiation. Within the current framework, it is interesting to investigate how these concerns can be used strategically to avoid the flexibility trap. To this end, let us modify the base model to address a firm's incentive to extend its current product. In particular, let us consider, without loss of generality, the scenario in which firm A is contemplating whether or not to introduce a new product A' to the market, which has a different state-dependent value (but the same horizontal location) as product B, i.e., $c_{A'} = c_{\underline{\kappa}1}$.[13]

Product A' introduces some new considerations into the firms' strategic interactions. First, firm A is now able to serve the market with more product locations. This allows firm A to sell to more consumers without cutting prices too much. Therefore, product A's price tends to be higher in both the multiple- and single-buying regions than in the base model. This is the main effect of introducing product A'. In addition, introducing product A' has a strategic impact that changes the competitive force faced by firm B. To see this, note that now consumers can achieve consumption flexibility by buying A' and B together, over which they have the same location preference. Therefore, the strategic interaction between products A' and B is driven mainly by consumer preference uncertainty but not by horizontal heterogeneity. Moreover, the co-location of products A' and B limits their prices up to the flexibility value that they each can contribute.[14] It turns out that the overall equilibrium payoff following the introduction of the new product A' depends upon the relative importance of preference uncertainty versus consumer heterogeneity.

Proposition 4. *Firm A's incentive to introduce the new product A' increases with the importance of preference uncertainty relative to consumer heterogeneity. When consumer heterogeneity is sufficiently large, introducing product A' is unprofitable even with zero introduction cost.*

This result highlights the importance of gauging the relative importance of the main and strategic effects in introducing the new product A'. When t is small, the strategic force between products A' and B is driven mainly by preference uncertainty but not by horizontal heterogeneity. The main effect of product line extension then dominates, and firm A's overall equilibrium payoff increases with the new product introduction. However, when t is sufficiently large, the upper limit in pricing A' and B is binding, which in turn has a negative spillover effect on product A. When this strategic impact dominates, firm A is better off not to introduce the new product. This proposition also implies that product line extension can be a substitute for decreasing differentiation in dealing with the flexibility trap. Essentially, introducing the new product A', which is co-located with product B, can save consumer disutility in multiple purchases. The firms hence can cater to the flexibility-seeking demand without cutting prices too much. Therefore, product line extension can be employed as a strategic instrument in coping with the flexibility trap.[15]

4.2. Uncertainty Heterogeneity and Preference Correlation

In this section, I modify the base model to investigate the robustness of the minimum differentiation strategy in assisting the competing firms to get out of the flexibility trap. The first modification captures the notion that consumers could be different in terms

[13] Recall that the current products offered in the market prior to the extension are $\{c_A, c_B\} = \{c_{\underline{\kappa}0}, c_{\bar{\kappa}1}\}$.

[14] As the proof shows, this implies that the maximum prices for products A' and B are $\rho\nu$ and $(1-\rho)\nu$, respectively.

[15] An interesting empirical test for this proposition is to look at the correlation between consumer preference uncertainty and the length of product line in differentiated markets.

of preference uncertainty, i.e., the utility variability across future states could differ across consumers. This may imply, in the current framework, that there is consumer heterogeneity in ν. For example, a frequent internet browser might care more about security issues than a game player might. Similarly, people may differ in the perceived disutility of missing a flight. Specifically, let us assume that there are two types of consumers: those who care about uncertainty ($\nu_x = \nu > 0$) and those who are uncertainty neutral ($\nu_x = 0$). Second, to facilitate exposition, let us assume that $\rho = \frac{1}{2}$. The third modification allows consumers' uncertainty concerns to be correlated with their perceived product differentiation on the horizontal attribute. This may imply that the firms' positioning efforts have a "spill-over" effect on the products' utility variability across different future situations:

$$\Pr(\nu_x = \nu) = \alpha|1 - \bar{l} - \underline{l}| + \frac{1-\alpha}{2}, \tag{6}$$

$$\Pr(\nu_x = 0) = -\alpha|1 - \bar{l} - \underline{l}| + \frac{1+\alpha}{2}, \tag{7}$$

where $\alpha \in [0, 1]$ is the correlation coefficient. When α goes to 1, consumer preference uncertainty is perfectly positively influenced by horizontal differentiation. When $\alpha = 0$, the preferences are independent and we obtain a variant of the base model.[16] The following proposition characterizes the firms' equilibrium differentiation decisions under these modifications:

Proposition 5. *Given the heterogeneity in consumer preference uncertainty, $\rho = \frac{1}{2}$, and when preference correlation is sufficiently low, horizontal differentiation is minimized in equilibrium if and only if consumer heterogeneity is intermediate.*

This proposition further illustrates the role of the flexibility trap in the firms' differentiation strategies. To see this, note that compared to the base model, the presence of uncertainty-neutral consumers could decrease equilibrium profits. Under maximum differentiation, equilibrium profits decrease with the number of uncertainty-neutral consumers if the firms are engaged in flexibility-promoting pricing. When differentiation is minimized, the more uncertainty-neutral consumers, the more intense the price competition is. Therefore, the firms' incentive to enhance differentiation increases with the preference correlation (α). Nevertheless, as long as the consumers' horizontal and state-dependent preferences are not sufficiently correlated, minimum differentiation could still be an equilibrium outcome. This would happen when consumer heterogeneity is intermediate such that maximum differentiation would catch the firms at the bottom of the flexibility trap.

4.3. Configuration of the State-Dependent Preference Structure

Until now I have assumed that the state-dependent preference structure is exogenous. In the base model, the products are essentially "differentiated" along the state-dependent dimension, such that all else being equal consumer preference reversals necessarily happen across future states. The reader may wonder to what extent the minimum-differentiation result is influenced by the firms' inability to choose the state of nature their product is suited for. If a firm instead chooses to deliver higher state-dependent value in the same state as its rival does (i.e., positively correlated state-dependent values), then consumer preferences would not be reversed across future contingencies.[17] The flexibility trap could then be prevented even if preference uncertainty still exists.

In this section, I extend the base model such that the firms can configure their products along both the horizontal and state-dependent dimensions. Formally, let us expand the product configuration set faced by the firms in Stage 1 of the game: $c_i \in \{c_{\underline{k}0}, c_{\underline{k}1}, c_{\bar{k}0}, c_{\bar{k}1}\}$, $i = A, B$. The following proposition characterizes this extended product configuration equilibrium:

Proposition 6. *Given the expanded product configuration set, if $t \le 2\rho\nu$, there exist two equilibria where horizontal differentiation is minimized, $\{c_A, c_B\} = \{c_{\underline{k}0}, c_{\bar{k}0}\}$ or $\{c_{\underline{k}1}, c_{\bar{k}1}\}$; if $t \ge 2\rho\nu$, there exists a unique maximal differentiation equilibrium, $\{c_A, c_B\} = \{c_{\bar{k}0}, c_{\bar{k}1}\}$.*

This proposition again demonstrates the role of consumption flexibility in the product configuration decisions. When preference uncertainty is significant, one of the firms gives up the superior product type ($\bar{k}$) to guarantee differentiation on the state-dependent dimension. At the same time, the firms are engaged in minimal differentiation on the horizontal attribute to facilitate consumer multiple buying. When preference uncertainty becomes less important, both firms pursue the superior product type $\bar{k}$ while differentiation is achieved on the horizontal dimension. Interestingly, in all cases the firms never choose to be differentiated on both dimensions. Intuitively, differentiation is more desired on the dimension about which consumers care most.

[16] Note that this is a conservative variant of the base model, since here there is half probability that consumers do not care about preference uncertainty.

[17] Allowing for preference correlation as in the previous section partially deals with this issue by permitting, as a special case, the possibility of keeping the preference ranking fixed across future states.

5. Concluding Remarks

5.1. Summary

This paper investigates the strategic implications of consumption flexibility. It extends the literature on consumer uncertainty by examining the impact of consumption flexibility on competing firms' marketing mix decisions. This paper produces several interesting findings that provide significant managerial insights into competitive interactions in markets characterized by inherent preference uncertainty. First, it demonstrates the relationship between consumers' flexibility concerns and market demand expansion. An endogenous mechanism is illustrated through which competing firms could increase primary demand even in a mature market. It also establishes the equilibrium conditions under which the firms may compete for primary or secondary demand. Specifically, it is shown that the firms in equilibrium compete for primary demand in markets with large preference uncertainty. These insights can benefit managers in diagnosing the sources of sales increases and in understanding the nature of price competition when consumption flexibility is an important issue.

In addition, this paper also explains why the firms' profits may decrease with increasing consumer heterogeneity although market sales are increased, a situation termed the flexibility trap. The strategic rationale underlying this result is closely related to the differential roles of consumer heterogeneity in the different competition scenarios. It is shown that when the firms compete for primary demand, consumer heterogeneity does not alleviate price competition but impedes demand expansion. This equilibrium relationship between consumer heterogeneity, preference uncertainty, market sales and profits can provide an interesting theoretical basis on which managers can check empirical data to improve their understanding of the forces underlying market competition.

Moreover, this paper sheds light on how to improve competitive positioning through effective differentiation strategies. It lays out the conditions under which a firm should follow the well-known "maximum differentiation" principle, or instead pursue a "minimum differentiation" strategy. It concludes that the latter strategy is optimal in markets with significant preference uncertainty. The rationale supporting the results is based on fundamental market characteristics, an approach deviating from the literature in which exogenous restrictions on the firms' pricing behavior are imposed, e.g., collusion (Jehiel 1992, Friedman and Thisse 1993) and price floors (Bhaskar 1997). The advantage of this approach is that managers can easily examine exogenous market conditions to determine their optimal differentiation strategies.

It seems that there has been a transition in the positioning strategy in the PC-Mac interaction. In the early 1990s, the Apple ad campaigns focused on the differences between the Mac and the Windows systems (*Johnson* 1992). However, "today hundreds of ways can be found where a PC and a Mac can get along with each other" (*Blersdorfer* 2004). Does this suggest increasing similarity in computer design based on these two systems, or does it just reflect the firms' endeavors to reduce perceived differentiation despite the systems' inherent differences, or both? The Microsoft 3D-graphics "Longhorn" operating system is making its debut, which is interestingly no longer named "Windows" but "taking cues from Apple" (*Fisco* 2004, p. 27). What is it in the Microsoft managers' mind that initiates this move? With the ever-increasing vulnerability of the Windows system to security attacks, one may expect that among many potential strategic and/or technological issues involved in this initiative, the positioning consideration investigated here could (or ought to) be an important one. The bottom line of the insights gained from this paper is that positioning a product closer to its rival's can be a profitable strategy in markets with significant consumer preference uncertainty.

This paper also extends the analysis to investigate the role of product line extension as a strategic instrument in escaping the flexibility trap. It is demonstrated that product line extension can serve as a substitute to the minimal-differentiation strategy in dealing with the trap. Finally, the main insights of the paper are shown to be retained under several model extensions, i.e., heterogeneity in consumer uncertainty, preference correlation, and endogenous configuration of state-dependent preferences.

5.2. Limitations and Future Research

The proposed model has considered a special type of preference uncertainty with only two future states. As a result, the firms' product configuration decisions along the state-dependent dimension are constrained in the sense that the products' state-dependent values are either perfectly positively or negatively correlated. Future research can relax this restriction and look at more flexible preference uncertainty structure.

In interpreting the flexibility trap, the reader should be reminded that it is intended to capture the equilibrium relationship between profits, horizontal consumer heterogeneity, and preference uncertainty, where equilibrium profits might be unobservable to outsiders. Furthermore, firms might have been aware of the adverse effect of the trap and might have taken preventive strategic actions. As demonstrated in this paper, the set of strategies a firm can adopt to eliminate the effect of the flexibility trap include minimizing differentiation, extending competitive product lines, or delivering the same state-dependent value as the rival firm does. On the flip side, however, the potential existence of the flexibility trap can help us reconcile such market phenomena as minimum differentiation and crowded competitive product lines.

We might seldom observe in reality either maximum or minimum differentiation between competitive offerings. Managers should not arbitrarily constrain themselves only on these two extreme positioning options; there is a continuum of intermediate choices. The reader should be reminded that there could be practical and cost concerns in implementing a particular positioning strategy, besides the strategic considerations investigated in this paper. There are also situations in which "de-differentiation" is not completely feasible, especially when the market boundary is broadly defined (e.g., air and rail as alternative transportation modes). Nevertheless, creative marketing programs (e.g., commercials) can be designed to influence the "perceived" positioning toward the desired direction (e.g., Southwest Airlines is perceived as more substitutable for rental cars than are other airlines).

From a theoretical point of view, a firm's differentiation strategy might be influenced by other industrial or institutional considerations, e.g., network externalities (Sun et al. 2004) and standard competition. Expanding primary demand through leveraging consumers' flexibility concerns is only one aspect of the competitive positioning consideration. There exists potential for future studies to gauge the relative importance of these alternative strategic incentives.

Another interesting direction for future research is to investigate the bundling and product line design issues under consumer preference uncertainty. Finally, it would be fruitful to investigate the dynamic effects of consumption flexibility and its interaction with other consumer choice issues, e.g., learning and stockpiling.

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Appendix

Proof of Lemma 1. If $t \le \nu$, then x' and x'' are obtained as in (4) and (5), respectively. It is straightforward to check that $x' \le \tilde{x} \le x''$ if and only if $(1-\rho)P^A + \rho P^B \le 2\rho(1-\rho)\nu$, for any $P^i \ge 0$, $i = A, B$. Then, part (i) of the lemma follows immediately. Part (ii) is also similar.

Now consider the case when $t \ge \nu$. If $x \le (t-\nu)/2t$, then (2) holds for all $P^B \ge 0$. When $(t-\nu)/2t \le x \le (t+\nu)/2t$, (2) is obtained if and only if $x \le x'$. For $x \ge (t+\nu)/2t$, (2) leads to $x \le x_1 = ((2\rho-1)\nu + t + P^B)/2t$. Similarly, $V_x(c_B) \ge V_x(\{c_A \& c_B\})$ if and only if one of the following conditions is satisfied: (1) $x \le (t-\nu)/2t$ and $x \ge x_2 = ((2\rho-1)\nu + t - P^A)/2t$; (2) $(t-\nu)/2t \le x \le (t+\nu)/2t$ and $x \ge x''$; or (3) $x \ge (t+\nu)/2t$.

Note first that if $P^B \le 2(1-\rho)\nu$, then $(t-\nu)/2t \le x' \le (t+\nu)/2t$ and $x_1 \le (t+\nu)/2t$, which in turn leads to $V_x(c_A) \ge V_x(\{c_A \& c_B\})$ if and only if $x \le x'$. If instead $P^B \ge 2(1-\rho)\nu$, then $x' \ge (t+\nu)/2t$ and $x_1 \ge (t+\nu)/2t$. So $V_x(c_A) \ge V_x(\{c_A \& c_B\})$ if and only if $x \le x_1$. Similarly, if $P^A \le 2\rho\nu$, then $V_x(c_B) \ge V_x(\{c_A \& c_B\})$ if and only if $x \ge x''$; if $P^A \ge 2\rho\nu$, then $V_x(c_B) \ge V_x(\{c_A \& c_B\})$ if and only if $x \ge x_2$. One obtains part (i) immediately because $(1-\rho)P^A + \rho P^B \le 2\rho(1-\rho)\nu$ implies that $P^B \le 2(1-\rho)\nu$ and $P^A \le 2\rho\nu$.

To see that part (ii) also holds, note that $(1-\rho)P^A + \rho P^B \ge 2\rho(1-\rho)\nu$ leads to $x_2 \le \tilde{x} \le x_1$. Then, $\max\{x_2, x''\} \le \tilde{x} \le \min\{x_1, x'\}$. Part (ii) then follows. Q.E.D.

Proof of Proposition 1. Let us first look at the region $(1-\rho)P^A + \rho P^B \le 2\rho(1-\rho)\nu$. Firm A maximizes $\Pi^A = P^A[(\rho(\nu+t) - P^A)/2\rho t]$. Similarly, firm B solves for $\mathrm{Max}_{P^B} \Pi^B = P^B[((1-\rho)(\nu+t) - P^B)/(2(1-\rho)t)]$. The first-order conditions give rise to $\underline{P}^A(P^B) = \rho(\nu+t)/2$ and $\underline{P}^B(P^A) = (1-\rho)(\nu+t)/2$, respectively. Then the (local) best response functions are given by:[18]

$$\underline{P}^A(P^B) = \frac{\rho(\nu+t)}{2}, \quad \text{if } 0 \le P^B \le \frac{(1-\rho)(3\nu-t)}{2} \text{ and } t \le 3\nu;$$

$$\underline{P}^B(P^A) = \frac{(1-\rho)(\nu+t)}{2}, \quad \text{if } 0 \le P^A \le \frac{\rho(3\nu-t)}{2} \text{ and } t \le 3\nu.$$

Note that in this case the response functions are flat. Following the same procedure, one can obtain the (local) best response functions in the region $(1-\rho)P^A + \rho P^B \ge 2\rho(1-\rho)\nu$:

$$\bar{P}^A(P^B) = \frac{(2\rho-1)\nu + t + P^B}{2}, \quad \text{if } P^B \ge \frac{(1-\rho)((2\rho+1)\nu - t)}{1+\rho} \text{ or } t \ge (2\rho+1)\nu;$$

$$\bar{P}^B(P^A) = \frac{(1-2\rho)\nu + t + P^A}{2}, \quad \text{if } P^A \ge \frac{\rho((3-2\rho)\nu - t)}{2-\rho} \text{ or } t \ge (3-2\rho)\nu.$$

One can see that these response functions are continuous within each region but discontinuous across regions. Moreover, both $\underline{P}^A(\cdot)$ and $\bar{P}^A(\cdot)$ could be defined on $(1-\rho)((2\rho+1)\nu - t)/(1+\rho) \le P^B \le (1-\rho)(3\nu-t)/2$, and $\underline{P}^B(\cdot)$ and $\bar{P}^B(\cdot)$ on $\rho((3-2\rho)\nu - t)/(2-\rho) \le P^A \le \rho(3\nu-t)/2$. So, over these overlapping price ranges, a firm may want to increase or drop its price such that it can compete in one price region over the other. To determine the deviating points, let us plug these response functions into the corresponding profit functions to get the local optimal payoff that one firm can obtain if it stays in a particular region. In the region $(1-\rho)P^A + \rho P^B \le$

[18] The boundary conditions ensure that the prices remain in the multiple-buying region.

$2\rho(1-\rho)\nu$, a firm's profits are independent of the rival firm's price: $\underline{\Pi}^A(P^B)=\rho(\nu+t)^2/8t$ and $\underline{\Pi}^B(P^A)=(1-\rho)(\nu+t)^2/8t$. In the region $(1-\rho)P^A+\rho P^B\geq 2\rho(1-\rho)\nu$, these are given by $\overline{\Pi}^A(P^B)=((2\rho-1)\nu+t+P^B)^2/8t$ and $\overline{\Pi}^B(P^A)=((1-2\rho)\nu+t+P^A)^2/8t$. Note that $\overline{\Pi}^i(P^j)$ increases in P^j. Also, $\overline{\Pi}^A(\cdot)\geq\underline{\Pi}^A(\cdot)$ if and only if $P^B\geq(1+\sqrt{\rho}-2\rho)\nu-(1-\sqrt{\rho})t$. Similarly, $\overline{\Pi}^B(\cdot)\geq\underline{\Pi}^B(\cdot)$ if and only if $P^A\geq(2\rho-1+\sqrt{1-\rho})\nu-(1-\sqrt{1-\rho})t$. As a result, the global best response functions for the firms are given by:

$$P^A(\cdot)=\begin{cases}\dfrac{\rho(\nu+t)}{2}, & 0\leq P^B\leq(1+\sqrt{\rho}-2\rho)\nu-(1-\sqrt{\rho})t;\\[2mm] \dfrac{(2\rho-1)\nu+t+P^B}{2}, & \text{otherwise;}\end{cases}$$

$$P^B(\cdot)=\begin{cases}\dfrac{(1-\rho)(\nu+t)}{2}, & \\ \qquad 0\leq P^A\leq(2\rho-1+\sqrt{1-\rho})\nu-(1-\sqrt{1-\rho})t; & \\[2mm] \dfrac{(1-2\rho)\nu+t+P^A}{2}, & \text{otherwise.}\end{cases}$$

Then, an equilibrium exists within the multiple-buying region if and only if $(1-\rho)(\nu+t)\leq 2((1+\sqrt{\rho}-2\rho)\nu-(1-\sqrt{\rho})t)$ and $\rho(\nu+t)\leq 2((2\rho-1+\sqrt{1-\rho})\nu-(1-\sqrt{1-\rho})t)$.[19] This then leads to part (ii) of the proposition. Similarly, part (iii) holds under the conditions given in the proposition where the global best response functions cross each other in the single-buying region. Q.E.D.

Proof of Proposition 3. To prove the proposition, I first solve for the equilibrium multiple- and single-buying profits conditional on given locations $\underline{l}$ and $\bar{l}$. Several results are then derived investigating the firms' (local) incentives for horizontal differentiation in anticipation of competing in the multiple- or single-buying regions. Finally, the equilibrium conditions are identified under which the firms are engaged in minimal or maximal differentiation.

Let us first solve for the pricing equilibrium. Comparing the three purchase options yields the following cut-off points:

$$x_0=\frac{(2\rho-1)\nu+((1-\bar{l})^2-\underline{l}^2)t+P^B-P^A}{2(1-\underline{l}-\bar{l})t},$$
$$\underline{x}=\frac{(1-\rho)(((1-\bar{l})^2-\underline{l}^2)t-\nu)+P^B}{2(1-\rho)(1-\underline{l}-\bar{l})t}\quad\text{and}$$
$$\bar{x}=\frac{\rho(\nu+((1-\bar{l})^2-\underline{l}^2)t)-P^A}{2\rho(1-\underline{l}-\bar{l})t},$$

where $\underline{x}\leq x_0\leq\bar{x}$ if and only if $(1-\rho)P^A+\rho P^B\leq 2\rho(1-\rho)\nu$. Following the same procedures as in Proposition 1, one can establish the following multiple-buying equilibrium: if $0\leq t\leq\check{t}$, $P^{A*}=\Pi^{A*}=\rho(\nu-((1-\underline{l})^2-\bar{l}^2)t)$, and $P^{B*}=\Pi^{B*}=(1-\rho)(\nu-((1-\bar{l})^2-\underline{l}^2)t)$; if $\check{t}\leq t\leq\hat{t}$,

$$P^{A*}=\frac{\rho(\nu+((1-\bar{l})^2-\underline{l}^2)t)}{2},$$
$$P^{B*}=\frac{(1-\rho)(\nu+((1-\underline{l})^2-\bar{l}^2)t)}{2},$$

$$\Pi^{A*}=\frac{\rho(\nu+((1-\bar{l})^2-\underline{l}^2)t)^2}{8(1-\underline{l}-\bar{l})t},\quad\text{and}$$
$$\Pi^{B*}=\frac{(1-\rho)(\nu+((1-\underline{l})^2-\bar{l}^2)t)^2}{8(1-\underline{l}-\bar{l})t},$$

where

$$\check{t}=\frac{1}{(1-\underline{l}-\bar{l})(3-\underline{l}+\bar{l})}\nu\quad\text{and}$$
$$\hat{t}=\frac{1+3\sqrt{\rho}}{(1-\underline{l}-\bar{l})(3+\underline{l}-\bar{l}+(1-\underline{l}+\bar{l})\sqrt{\rho})}\nu.$$

Similarly, the equilibrium single-buying profits are given by

$$\Pi^{A*}=\frac{((2\rho-1)\nu+(1-\underline{l}-\bar{l})(3+\underline{l}-\bar{l})t)^2}{18(1-\underline{l}-\bar{l})t}\quad\text{and}$$
$$\Pi^{B*}=\frac{((1-2\rho)\nu+(1-\underline{l}-\bar{l})(3-\underline{l}+\bar{l})t)^2}{18(1-\underline{l}-\bar{l})t}.$$

Result 1. Maximal product differentiation is a dominated strategy if the induced pricing game involves consumer multiple buying. Consider firm A for example. Using the envelope theorem, we have

$$\frac{d\Pi^{A*}(\underline{l},\bar{l})}{d\underline{l}}=\frac{\partial\Pi^{A*}(\underline{l},\bar{l})}{\partial\underline{l}}+\frac{\partial\Pi^{A*}}{\partial P^{B*}}\frac{dP^{B*}}{d\underline{l}}=\frac{\partial\Pi^{A*}(\underline{l},\bar{l})}{\partial\underline{l}},$$

where the second equality is obtained from the fact that

$$\bar{x}=\frac{\rho(\nu+((1-\bar{l})^2-\underline{l}^2)t)-P^A}{2\rho(1-\underline{l}-\bar{l})t}$$

does not have P^B in it. When $0\leq t\leq\check{t}$, $\bar{x}^*=1$. Therefore, $P^{A*}=\Pi^{A*}=\rho(\nu-((1-\underline{l})^2-\bar{l}^2)t)$, which is increasing in $\underline{l}$ and $\bar{l}$. If $t\geq\check{t}$,

$$\bar{x}^*=\frac{\rho(\nu+((1-\bar{l})^2-\underline{l}^2)t)-P^{A*}(\underline{l},\bar{l})}{2\rho(1-\underline{l}-\bar{l})t}.$$

Therefore,

$$\begin{aligned}\frac{\partial\Pi^{A*}(\underline{l},\bar{l})}{\partial\underline{l}}&=P^{A*}(\underline{l},\bar{l})\frac{\partial\bar{x}(\underline{l},\bar{l})}{\partial\underline{l}}\\&=P^{A*}(\underline{l},\bar{l})\frac{\rho(\nu+(1-\underline{l}-\bar{l})^2t)-P^{A*}(\underline{l},\bar{l})}{2\rho(1-\underline{l}-\bar{l})^2t}.\end{aligned}$$

Plugging in $P^{A*}=\rho(\nu+((1-\bar{l})^2-\underline{l}^2)t)/2$ yields

$$\operatorname{sign}\left\{\frac{\partial\Pi^{A*}(\underline{l},\bar{l})}{\partial\underline{l}}\right\}=\operatorname{sign}\{\nu+(1-\underline{l}-\bar{l})(1-3\underline{l}-\bar{l})t\},$$

which, when evaluated at $\underline{l}=0$, is positive for all $\bar{l}\in(0,1)$.

Result 2. If $t\leq 8\nu$, minimum differentiation ($\underline{l}=\bar{l}=\frac{1}{2}$) is a market outcome if it leads to an equilibrium pricing game with consumer multiple buying. Note first that there are two cases for the multiple-buying pricing game. If $t\leq\check{t}$, all consumers buy both products and $\{\Pi^A,\Pi^B\}=\{\rho(\nu-((1-\underline{l})^2-\bar{l}^2)t),(1-\rho)(\nu-((1-\bar{l})^2-\underline{l}^2)t)\}$, which is maximized at $(\underline{l},\bar{l})=(\frac{1}{2},\frac{1}{2})$. Note also that at $(\underline{l},\bar{l})=(\frac{1}{2},\frac{1}{2})$, it is always true that $t\leq\check{t}$. Minimum differentiation is indeed an

[19] That in equilibrium both x'' and x' must be within $[0,1]$ implies that $P^A\geq\rho(\nu-t)$ and $P^B\geq(1-\rho)(\nu-t)$. When $t\leq\nu/3$, these constraints are binding. Part (i) of Proposition 1 then follows.

optimal strategy in this case. If $t \geq \check{t}$ instead, only some consumers make multiple purchases. Let us then differentiate

$$\Pi^A = \frac{\rho(\nu + ((1-\bar{l})^2 - \underline{l}^2)t)^2}{8(1-\underline{l}-\bar{l})t} \quad \text{and}$$

$$\Pi^B = \frac{(1-\rho)(\nu + ((1-\underline{l})^2 - \bar{l}^2)t)^2}{8(1-\underline{l}-\bar{l})t}$$

with respect to $\underline{l}$ and $\bar{l}$, respectively. It can be seen that the first-order conditions are positive if $t \leq 8\nu$.

Result 3. Nonmaximal differentiation can never be a market outcome if the subsequent pricing game involves consumer single buying. Differentiating the equilibrium single-buying profits

$$\Pi^A = \frac{((2\rho-1)\nu + (1-\underline{l}-\bar{l})(3+\underline{l}-\bar{l})t)^2}{18(1-\underline{l}-\bar{l})t} \quad \text{and}$$

$$\Pi^B = \frac{((1-2\rho)\nu + (1-\underline{l}-\bar{l})(3-\underline{l}+\bar{l})t)^2}{18(1-\underline{l}-\bar{l})t}$$

with respect to $\underline{l}$ and $\bar{l}$, respectively, one finds that the first-order conditions have the same sign as $-((2\rho-1)\nu + (1-\underline{l}-\bar{l})(3+\underline{l}-\bar{l})t)$ and $-((1-2\rho)\nu + (1-\underline{l}-\bar{l})(3-\underline{l}+\bar{l})t)$ respectively, which are negative if $t \geq \hat{t}$. The result follows.

Let us then look at minimal differentiation. $(\underline{l}, \bar{l}) = (\frac{1}{2}, \frac{1}{2})$ is an equilibrium location choice if no firm wants to deviate. Note first that, given $t \leq 8\nu$, a deviation leading to multiple buying is always dominated and the only possible deviation is to 0. Moreover, if $t \leq (4(1+3\sqrt{\rho})/(5+3\sqrt{\rho}))\nu$, no single-buying equilibrium can be sustained through deviating to 0. If $t \geq (4(1+3\sqrt{\rho})/(5+3\sqrt{\rho}))\nu$, firm A wants to deviate if and only if the equilibrium profits with location $(0, \frac{1}{2})$ are greater than that with $(\frac{1}{2}, \frac{1}{2})$, i.e., $((2\rho-1)\nu + \frac{5}{4}t)^2/9t \geq \rho\nu$. The left side of the inequality is increasing in t. Let $\underline{t}^A$ solve $((2\rho-1)\nu + \frac{5}{4}t)^2/9t = \rho\nu$.[20] Minimal differentiation is an equilibrium only if $t \leq \underline{t}^A$. Similarly, for firm B not to deviate from minimal differentiation, we must have $t \leq \underline{t}^B$, where $((1-2\rho)\nu + \frac{5}{4}\underline{t}^B)^2/9t = (1-\rho)\nu$.

Similarly, for no firm to deviate from the maximal differentiation locations, we must have

$$t \geq \frac{1+3\sqrt{\rho}}{3+\sqrt{\rho}}\nu, \quad \frac{((2\rho-1)\nu+3t)^2}{18t} \geq \rho\nu \quad \text{and}$$

$$\frac{((1-2\rho)\nu+3t)^2}{18t} \geq (1-\rho)\nu.$$

Let $\bar{t}^A$ and $\bar{t}^B$ solve the latter two equations, respectively. The second part of the proposition on equilibrium locations then follows.

Given the equilibrium locations, the subsequent equilibrium prices and profits in both the minimal- and maximal-differentiation cases can be readily obtained as given in the proposition. Q.E.D.

[20] There are two solutions for the quadratic equation. Only the larger one is meaningful. This is also the case for $\underline{t}^B$, $\bar{t}^A$, and $\bar{t}^B$.

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