

# A STATE-DEPENDENT MODEL OF HYBRID BEHAVIOR WITH RATIONAL CONSUMERS IN THE ATTRIBUTE SPACE

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*This paper presents a dynamic choice model in the attribute space considering rational consumers. The model presents a stationary consumption pattern that can be inertial, where the consumer only buys one product, or a variety-seeking one, where the consumer shifts among varied products.*

*Under the hybrid utility assumption, the consumer behaves inertially among the unfamiliar brands for several periods, eventually switching to a variety-seeking behavior when the stationary levels are approached. An empirical illustration with myopic agents is run using scanner databases for three different product categories: fabric softener, saltine cracker, and catsup. Non-linear specifications provide the best fit of the data, as hybrid functional forms are found in all the products. The results confirm the gradual trend to seek variety as the level of familiarity with the purchased items increases.*

*Keywords: Choice models, state-dependence, hybrid behavior.*

(JEL C23, D11, D12, D91)

## 1. Introduction

In the last decades, the vast empirical evidence on purchase probabilities being affected by the previously purchased history has fostered relevant lines of research on consumer state-dependence models. However, the observed direction of the effect varies depending on the market characteristics and the product category. In some situations the purchase of an item by a consumer decreases the probability that it

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will be purchased on the next occasion. This pattern is known in the literature as a *variety-seeking* (see McAlister 1982, Givon 1984, Lattin and McAlister 1985, and Kahn, Kalwani and Morrison 1986). On the contrary, the variety-avoiding behavior is present when the choice of an item leads to an increase in the probability of selecting it on a subsequent choice occasion, and the implied pattern is said to be *inertial* (see Kuehn 1962, Morrison 1966, Jeuland 1979, Guadagni and Little 1983, Givon 1984, and Tversky and Kahneman 1991, Hardie, Johnson and Fader 1993, and Fader and Hardie 1996).

Most of the referred models include information on last purchased brand (1st-order brand models) to explain present decisions. However, later research on state dependence adopts two relevant extensions. First, some authors consider additional attributes besides brand to explain purchase decisions. Keane (1997) includes dummy variables to capture preferences on brands, plastic containers and sizes. Kim, Allenby and Rossi (2002) include flavor in the yogurt market and find evidence of simultaneous demand for varied flavors while there is virtually no brand switching between the two leading brands. The second line of extension follows the methodology proposed by McAlister (1982) and Guadagni and Little (1983), and considers a higher order state-dependence level as the utility derived from goods is based on the cumulative levels of attributes. This approach uses exponentially smoothed measures of previous purchases to better capture the past consumption history and proposes utility functions determined by the cumulative levels of the compounding attributes (see Lattin 1987, Fader and Hardie 1996, and Jiménez-Martín and Ladrón-de-Guevara 2007).

Linear specifications for the state-dependence partial utilities do not allow for a behavior where both inertia and variety seeking may co-exist within the individual for the same attribute. However, some empirical evidence consistent with a mixed behavior was originally reported by Wierenga (1974), who observed that consumers tend to fluctuate between repeat purchasing and brand-switching behavior for frequently purchased products. From now on, we refer to this mixture of inertia and variety seeking as *hybrid* behavior. Some theoretical framework in the psychology literature accounts for a hybrid behavior: Berlyne (1963, 1970) proposes that the attractiveness of a stimulus is an inverted-U shaped function of its level of familiarity. According to this theory, an inertial behavior comes into play when the individual is

exposed to a relatively unfamiliar stimulus and there is a tendency to repeat it, increasing the level of familiarity. In fact, the ability to enjoy new attributes is a process that usually requires successive consumption of the same item: It takes time and several trials for a consumer to get used to new musical styles or to develop the ability to appreciate wines. High familiarity, on the other hand, brings the variety-seeking pattern into play, leading to an increasing tendency to look for other stimuli. According to this theory, if repeat purchasing of an item leads to greater familiarity with it, the consumer will switch from an inertial to a variety-seeking pattern once a certain number of repeat purchases are made. This hybrid behavior may be explained assuming inverted-U partial utility functions. Bawa (1990) finds evidence of this concave structure using panel datasets for the facial tissue and paper towel categories at a household level.<sup>1</sup> Jiménez-Martín and Ladrón-de-Guevara (2007) also report relevant segments presenting this hybrid behavior for several product categories.

Noteworthy, contribution in this area has been only empirical, as none of the referred research studies the dynamics and the implied optimal consumption patterns derived from the state-dependence structure assuming rational consumers. Besides, consumer choice models to date have considered myopic agents that do not discount the future utility when taking present decisions. State-dependence assumptions imply that present decisions affect future utilities. This intertemporal interaction between present consumption, attribute accumulation, and future utility requires a dynamic framework to be modeled. Investment is an intertemporal concept and can be defined as the employment of resources in the acquisition of anything from which a future profit is expected. This concept has extensively been used in all sorts of economic models to study both firm and household optimal decisions (e.g. research and development, advertising, household production, economic growth, etc.). As long as future tastes are continuously modified by the stock of attributes accumulated by the past consumption history, a rational agent will plan the consumption pattern across several periods as an attribute-investment process.

<sup>1</sup> Considering the brand as the only valuable attribute, Bawa finds evidence of hybrid behavior using panel datasets at a household level. However, the model assumes that each time a brand switch occurs, the choice process *renews*, so the state-dependence assumption is only valid for the last purchases after the last switch. This assumption seems to be too restrictive for categories where consumers constantly seek variety.

The aim of this article is to provide a general economic framework allowing for the analysis of the consumption dynamics implied by the state-dependence assumptions. All the previous research on consumer choice to date assume myopic agents that do not consider the impact of present decisions on the future utility. In this article we extend the “myopic” framework proposed by authors like McAlister (1982), Lattin (1987), Bawa (1990), Fader et al. (1996), and Jiménez-Martín and Ladrón-de-Guevara (2007), by considering forward-looking rational consumers that discount the future.

In light of the evidence of several state-dependence patterns, we relax the linearity assumption by considering a general utility function. Once the dynamic model is stated, the resulting maximization problem is solved analytically. We determine the first-order conditions and characterize the optimal consumption paths. The model presents a stationary consumption pattern that can be inertial, where the consumer only buys one product, or a variety-seeking one, where the consumer buys several products simultaneously. We run some simulations to determine the transitional optimal consumption plan since an agent tries a new product category, departing from a zero stock level of attributes, until reaching the steady-state equilibrium. Under the inverted-U marginal utility assumption (Bawa 1990 and Jiménez-Martín *et al.* 2007) the consumer behaves inertially among the existing brands for several periods, and eventually, once the stationary stock levels are approached, the consumer may turn to a variety-seeking behavior. Finally, we study how the future discount rate affects the optimal consumption patterns.

After the analysis of the dynamics, we run an empirical illustration for a simplified version of the model with myopic agents to estimate the marginal utility functions for the several compounding attributes. In doing so, we use three well known scanner databases for non-durable indivisible goods: fabric softeners, saltine crackers, and catsup. The datasets have been previously used by several authors: Jain, Vilcassim, and Chintagunta (1994), Roy, Chintagunta, and Haldar (1996), Fader *et al.* (1996), and Jiménez-Martín and Ladrón-de-Guevara (2007). Heterogeneity is introduced in the estimation process by allowing for multiple latent consumption segments. At the attribute level, empirical evidence of hybrid behavior is found for most attributes in all three markets.

The outline of the paper is as follows: In Section 2 the model is introduced, along with a basic discussion of the long-run optimal stationary path, and the main analytical results for the characterization of both inertial and variety-seeking long-run patterns are presented. In Section 3 we analyze the consumption patterns for new categories or new attributes, assuming a utility functional form that allows for a hybrid behavior. In Section 4 the version of the model with indivisible goods and categorical attributes is developed, to account for more realistic choice and consumption processes. In the last part of this section the results from empirical illustrations assuming myopic agents are described. The conclusions are presented in section 5 with some managerial implications of the results and proposals for further developments and extensions of the model.

## 2. The general model

The general model developed in this section describes the optimal consumption path in a dynamic framework. The objective is to model the state-dependence consumption pattern within a frequent-purchase category, in a manner that allows for the different types of behavior described in the literature: pure inertia, pure variety seeking, and hybrid.

Consistent with the characteristics models [see Lancaster (1971)] the approach followed relates the preference for a product to the preference contributions of the attributes derived from its consumption. In line with models like the ones proposed by McAlister (1982) and McAlister and Pessemier (1982), the utility in each consumption period is derived from the attribute inventories accumulated when an item is consumed. The attribute inventory is hypothesized to depreciate continuously, and experiences discrete increments each period an item containing this attribute is consumed. The cumulative stock for the attribute  $j$  in period  $t$ , say  $stkat_j(t)$ , is determined by the following law of motion:

$$stkat_j(t) = inv_j(t) + (1 - \lambda_j)stkat_j(t - 1) \quad [1]$$

where  $inv_j(t)$  is the amount of attribute  $j$  derived from consumption of an item in period  $t$ , and  $\lambda_j$  is the corresponding depreciation rate.

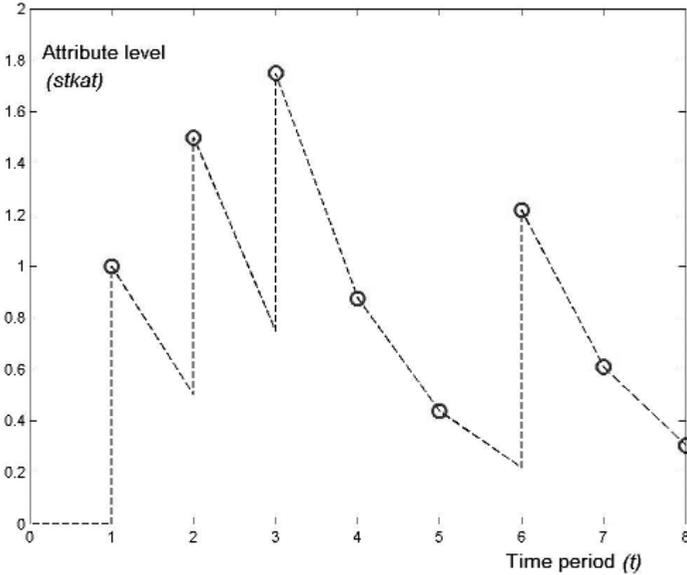
As proposed by Lancaster (1971), when an item is consumed, the contribution to each attribute is assumed to be determined by the following linear consumption technology:

$$inv_j(t) = \sum_{i=1}^I b_{ji}q_i(t) \quad [2]$$

where  $q_i(t)$  is the quantity of good  $i$  consumed at period  $t$  and  $b_{ji}$  is the quantity of the characteristic  $j$  contained in one unit of good  $i$ . Noteworthy, if there were two homogeneous goods (identical proportions of the constituent characteristics) the agent would only consume the efficient one on the basis of cost, showing no demand for the other good. Then, without loss of generality, from now on it will be assumed that all the available goods are differentiated. To illustrate the attribute accumulation process through consumption of goods, let's assume that one unit of attribute  $j=1$  (e.g. caffeine) is contained in good  $i=1$  (e.g. *Coke*), while good  $i=2$  (e.g. *Sprite*) contains no caffeine ( $b_{11} = 1$ ,  $b_{12} = 0$ ). Let's further assume that the caffeine level decreases 50% from period to period ( $\lambda_1 = 0.5$ ). Departing from a zero level of caffeine, Figure 1 shows the implied levels for every period  $t = 1, 2, \dots, 8$ , when an agent consumes *Coke* on periods 1, 2, 3, and 6, and *Sprite* on the remaining periods. Equation [2] determines the contribution of attribute,  $inv_j(t)$ , when good  $i$  is consumed, while the attribute level  $stkat_j(t)$  is determined by the law of motion from equation [1].

FIGURE 1  
Attribute accumulation process for the consumption pattern

$$i = \{1, 1, 1, 2, 2, 1, 2, 2\}, b_{11} = 1, b_{12} = 0, \text{ and } \lambda_1 = 0.5.$$



The consumer is a utility maximizer, responding to a local temporal budget constraint. In line with Thaler (1985), the budgeting process occurs on a periodical basis for each product category. Given the prices and category-specific budget constraint, the consumer evaluates purchases as situations arise. Assuming a previously determined budget for every period, say  $m(t)$ , and a vector of exogenous prices  $p(t)$ , the consumer will face the following restriction:

$$\sum_{i=1}^I p_i(t)q_i(t) \leq m(t) \tag{3}$$

In line with the attribute-based theory, every period  $t$  consumers are assumed to derive utility from the cumulative stock levels of attributes, captured by the  $J$ -dimensional variable  $stkat(t)$ , when consuming a good. The one-period utility,  $u(stkat(t))$ , is assumed to increase monotonically for all the attributes.

In the described framework, the decisions on present consumption affect the future utilities through the depreciated stock of attributes.

Assuming that the future utility is discounted at a rate  $\delta$ , a rational consumer decides the optimal consumption path by maximizing the discounted flow of utilities derived from the attribute levels reached in every period. Given the initial stock of attributes,  $stkat_0$ , the optimization problem for the consumer consists of choosing the quantities of goods  $q_i$  to be bought at every period  $t$ , subject to the budget restriction (3), to increase the inventory levels of the compounding attributes  $stkat$  according to the socking process determined by equations (1) and (2), in order to maximize the discounted flow of utilities:

$$\max_{\{q_1(t), q_2(t), \dots, q_I(t)\}_{t=1}^{\infty}} \sum_{t=1}^{\infty} (1 - \delta)^t u[stkat(t)] \quad [P]$$

subject to:

$$\begin{aligned} \sum_{i=1}^I p_i(t)q_i(t) &\leq m(t) && \forall t \\ inv_j(t) &= \sum_{i=1}^I b_{ji}q_i(t) && \forall j, \forall t \\ stkat_j(t) &= inv_j(t) + (1 - \lambda_j)stkat_j(t - 1) && \forall j, \forall t \\ stkat_j(0) &= stkat_{j0} && \forall j \end{aligned}$$

### 2.1 The optimal consumption pattern in the attribute space

In order to analyze the dynamics of the model, it is convenient to characterize the optimal solution of the problem stated in the previous section, in the attribute space,  $stkat$ . Every combination of goods  $q(t)$  consumed in period  $t$  contribute to increase the stocks of attributes  $stkat(t)$  from which the utility is derived. Noteworthy, an optimizing consumer will limit his choice to those combinations of goods that constitute the *attribute frontier*, known as the *efficient goods*.

DEFINITION 2.1: For a given budget restriction,  $m(t)$  and a price vector,  $p(t)$ , a good  $i \in I$  is said to be efficient if when the whole budget is allocated to good  $i$ ,  $\{q'(t) \mid q'_i(t) = m(t)/p_i(t), q'_{-i}(t) = 0\}$ , there is no feasible combination  $q''(t)$  of the remaining  $-i$  goods,  $\{q''(t) \mid q''(t) p(t) = m(t), q''_i(t) = 0\}$ , such that  $stkat_j(q''(t)) > stkat_j(q'(t))$  for all  $j \in J$ .

For every feasible combination of goods containing a positive quantity of an inefficient good  $i$ , there is always a feasible allocation of the

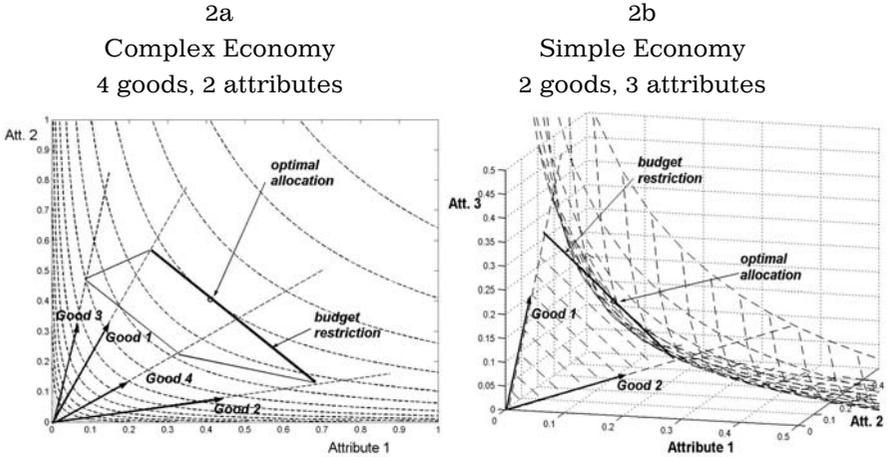
remaining  $-i$  goods allowing for higher levels of attribute. Therefore, positive demand will be limited to the subset of efficient goods.

In the attribute-based framework, the economy may be *simple* or *complex*, depending on the number of available goods compared to the constituent attributes. As defined by Lancaster (1971), in a *complex economy* the number of available products,  $I$ , exceeds the number of attributes,  $J$ . In this case, every attribute vector can be achieved by infinite combinations of goods, but the optimizing consumer will limit his choice to combinations of efficient goods. This gives a one-to-one relationship between the sub-set of  $J$  efficient goods and the  $J$  attributes with zero demand for the remaining  $I - J$  goods. Figure 2a illustrates a complex economy constituted by four available goods, represented as vectors in the 2-dimensional attribute space, where only combinations of the goods 1 and 2 allow for efficient allocations.

On the other side, if the market is characterized by a wide range of characteristics, the opposite case may be presented, with more attributes than available brands ( $J > I$ ). Some products like automobiles are made up of a great amount of constituent features and attributes, in what Lancaster defines as a *simple economy*. The economy is simple in the sense that the number of available items do not allow for acquiring every combination of attributes, so the consumer is limited to the available subset of implied combinations. In a simple economy the consumer will be limited to choose in the subspace of dimension  $I$  generated by the available set of items. The optimization problem can be solved by considering the reduced system of any arbitrarily chosen subset of  $I$  attributes, with the remaining  $J - I$  attributes being implicitly determined. Figure 2b illustrates a simple economy with only two available goods in a three dimensional attribute space. In this case, the consumer maximizes the utility in the two-dimensional subspace determined by combinations of both goods.<sup>2</sup>

<sup>2</sup>See Lancaster (1971) for a detailed analysis of the efficient choice set in the attribute space.

FIGURE 2  
Illustration of complex and simple economies in the attribute space



In both the simple and the complex economies, the number of efficient goods equals the number of linearly independent attributes, so there is a one-to-one relationship between every possible combination of goods and the implied combination of attributes. The square matrix  $B$  of the reduced system can be inverted and without loss of generality the maximization problem can be expressed in the attribute space. The one-period budget restriction [3] can then be expressed in terms of the level of attributes derived from consumption of the goods purchased:

$$\sum_{j=1}^J p'_j(t) inv_j(t) \leq m(t) \quad \forall t \tag{4}$$

where the price of acquiring one unit of attribute  $j$  at time  $t$ , denoted by  $p'_j(t)$ , is a linear function of the good-price vector  $p(t)$  and the inverse of the technology matrix:

$$p'_j(t) = \sum_{i=1}^I b_{ij}^{-1} p_i(t) \tag{5}$$

To characterize the optimal solution of problem [P], from now on we consider a continuous, strictly increasing, twice differentiable, and concave utility function,  $u(stkat)$ , and a compact and convex set defined

by the constraint equation system [1]-[3]. Under these assumptions, the following first-order conditions characterize the interior solution when nonsatiation of the attributes is also assumed. By using equations [4] and [5], the first-order conditions can be expressed in the attribute space:

$$\sum_{j=1}^J p'_j(t)stkat_j(t) = m(t) + \sum_{j=1}^J p'_j(t)(1 - \lambda_j)stkat_j(t - 1) \quad t = 1, 2, \dots \tag{6}$$

$$\frac{p'_v(t)}{p'_w(t)} = \frac{\sum_{n=0}^{\infty} (1 - \delta)^n (1 - \lambda_v)^n u_v [stkat(t + n)]}{\sum_{n=0}^{\infty} (1 - \delta)^n (1 - \lambda_w)^n u_w [stkat(t + n)]}, \quad \forall v, w \in J \quad t = 1, 2, \dots \tag{7}$$

The first equation is the budget restriction expressed in terms of the attribute inventories  $stkat(t)$  and defines the maximum stocks attainable given the price vector  $p(t)$ , the budget  $m(t)$ , and the depreciated stock-of-attribute vector from the previous period  $stkat(t - 1)$ . This is a first-order difference equation, so at every period, the attribute frontier is a function of the previous-period optimal stocks of attributes. The second equation characterizes interior solutions where strictly positive quantities of all goods are consumed. For interior solutions the price ratio between every two attributes equals the ratio between the discounted flows of future marginal utilities derived from an additional unit of attribute. When interiority is presented the consumer behaves variety-seeking as all the non-durable goods are consumed simultaneously at every period. However, the model may also present non-interior solutions where only one good is consumed along the optimal path. When products are close substitutes the optimal consumption pattern may not be interior, implying an inertial behavior, even under strongly concave preferences.<sup>3</sup>

Assuming that in a frequent-consumption category the agent expects the price vector and the budget to be constant for several periods, the consumption path approaches a stationary pattern. If the price vector

<sup>3</sup>A utility function is said to be strongly concave when the marginal utility approaches infinity as the related attribute goes to 0. As a result, the indifference curves never cross the axes, so a strictly positive level of every attribute is needed to derive utility.

$p(t)$  and the budget  $m(t)$  remain constant, the restriction [6] monotonically converges to a long-run budget restriction, where in every period the consumer faces the same attribute frontier. Once the stationary restriction is reached, the budget for every period is completely used to restore the depreciated levels of attributes. If this is the case, the consumption path has reached a stationary pattern where the purchased quantities and the attribute stocks remain constant period by period. In the long run the consumer splits the budget to restore the depreciated stocks of attributes, maintaining a constant proportion among the different attributes. The set of all the stationary consumption paths attainable with combinations of efficient goods in the long run constitute the long-run frontier in the space of attributes.

As in every standard concave dynamic problem, the steady state governs the transitional dynamics, so any optimal path out of the steady state from any initial conditions is driven by the convergence dynamics towards it. If there is a change in prices or any other variable assumed to be constant, the long-run frontier will shift and the problem will present a new steady state, but the consumption pattern will again be governed by the convergence dynamics, eventually approaching the new steady-state values in the long run. This is the main rationale and motivation to study the stationary consumption path. Let's assume that the exogenous budget  $m(t)$  and the price vector  $p(t)$  remain constant, so a convergence process towards a stationary pattern is presented.

**DEFINITION 2.2:** For a given constant budget restriction,  $m(t)$  and a constant price vector,  $p(t)$ , an *optimal stationary consumption path* is defined as a consumption sequence,  $\{q(t), t = 1, 2, \dots\}$  that solves the optimization problem [P] such that the resulting vector of attribute stocks along the path,  $\{stkat(t), t = 0, 1, 2, \dots\}$  remains fixed over time.

Noteworthy, the optimal stationary consumption path presents the highest utility level from all the attainable stationary consumption paths constituting the long-run attribute frontier. From now on, without loss of generality, our analysis will be limited to the case where consumers derive utility from two different attributes,  $j = 1, 2$ , and two items within a certain category,  $i = 1, 2$ . The following results and conclusions can be extended to a higher-dimension problem. The long-run stationary equilibrium can present a variety-seeking behavioral pat-

tern, where the consumer splits the budget between both goods, or an inertial behavior, where only one good is consumed:

DEFINITIONS 2.3: A *variety-seeking steady-state consumption path* for the optimization problem [P] is a steady-state equilibrium with strictly positive consumption of both goods,  $q_1$  and  $q_2$ . An *inertial steady-state consumption path* is a steady-state equilibrium in which only one of both goods is consumed.

The optimal consumption path characterized by the first order conditions will eventually converge to a steady-state consumption path. Imposing stationarity in the budget restriction [6] and in the first-order condition [7], the following equation system is obtained:

$$m = \lambda_1 p'_1 stkat_1^* + \lambda_2 p'_2 stkat_2^* \tag{8}$$

$$\frac{p'_1}{p'_2} = \frac{[1 - (1 - \delta)(1 - \lambda_2)] u_1(stkat^*)}{[1 - (1 - \delta)(1 - \lambda_1)] u_2(stkat^*)} \tag{9}$$

where

$$p'_j(t) = p_1(t)b_{1j}^{-1} + p_2(t)b_{2j}^{-1} \quad j = 1, 2 \quad \forall t$$

The differentiability and concavity conditions imposed on the utility function  $u(stkat)$  do not guarantee an interior solution with strictly positive demands for both goods. The second condition [9] is only valid when the demands for both goods are strictly positive. If this is not the case, the consumption pattern is inertial and the consumer only purchases one good. When the technology matrix  $B$  is not diagonal, the long-run frontier determined by equation [8] does not reach the axes. To illustrate this fact lets assume that the attribute  $stkat_1$  is the one intensive in good  $q_1$ , so  $\frac{b_{11}}{b_{21}} > \frac{b_{12}}{b_{22}}$ . It is noticeable that consuming only good  $q_1$  implies producing the minimum proportion of  $stkat_2$ , so the attribute combinations where  $stkat_2 < \frac{b_{21}}{b_{11}} stkat_1$  are not attainable. The same rational is valid for combinations where  $stkat_2 > \frac{b_{22}}{b_{12}} stkat_1$ . The long-run frontier [8] is then limited to the segment  $\left[ \left( \frac{mb_{11}}{p_1 \lambda_1}, \frac{mb_{21}}{p_1 \lambda_2} \right); \left( \frac{mb_{12}}{p_2 \lambda_1}, \frac{mb_{22}}{p_2 \lambda_2} \right) \right]$ . Depending on the preference structure, the optimal stationary consumption path may be interior or lie in one extreme of the segment. The following proposition characterize the three possible long-term equilibria:

PROPOSITION 2.1: Consider the dynamic optimization problem [P], where the utility function  $u(stkat)$  is strictly increasing, twice differentiable, and concave. When the budget  $m(t)$  and the vector price

$p(t)$  remain constant over time, the following three possible situations can be presented:

(a).- If  $\frac{p'_1}{p'_2} \leq \frac{[1-(1-\delta)(1-\lambda_2)]u_1(\frac{mb_{11}}{\lambda_1}, \frac{mb_{21}}{\lambda_2})}{[1-(1-\delta)(1-\lambda_1)]u_2(\frac{mb_{11}}{\lambda_1}, \frac{mb_{21}}{\lambda_2})}$ , the optimal stationary consumption path is an inertial one where only good  $q_1$  is purchased.

(b).- If  $\frac{p'_1}{p'_2} \geq \frac{[1-(1-\delta)(1-\lambda_2)]u_1(\frac{mb_{12}}{\lambda_1}, \frac{mb_{22}}{\lambda_2})}{[1-(1-\delta)(1-\lambda_1)]u_2(\frac{mb_{12}}{\lambda_1}, \frac{mb_{22}}{\lambda_2})}$ , the optimal stationary consumption path is an inertial one where only good  $q_2$  is purchased.

(c).- In all other cases the optimal stationary consumption path is a variety-seeking one where both goods  $q_1$  and  $q_2$  are simultaneously purchased in a fixed proportion.

The examples from Figures 3a, 3b, and 3c illustrate the equilibria presented for each of the three conditions (a), (b), and (c) respectively. These graphical examples illustrate the three possible long-run consumption patterns: the inertial equilibrium consuming only good  $q_1$ , the inertial equilibrium consuming only good  $q_2$ , and the variety-seeking equilibrium. For condition (a), the expression to the right side of the inequality is the marginal rate of substitution MRS evaluated in the lower edge of the long-run frontier (see figure 3a). If this value is higher than the slope of the long-term attribute frontier,  $(RMS(\frac{mb_{11}}{p_1\lambda_1}, \frac{mb_{21}}{p_1\lambda_2}) \geq \frac{p'_1}{p'_2})$ , the consumer is better off in the long run by purchasing only good  $q_1$ . Given the convexity of the indifference curves, when we move to the left side of the frontier we approach lower indifference curves, so any other allocation to the left side of the frontier will imply a utility decrease. The same intuition is valid for condition (b) in the left edge of the long-run frontier, which corresponds to the long-run level of attributes if only  $q_2$  is purchased (see Figure 3b). For case (b), when we move to the right side of the frontier we approach lower indifference curves, so any other allocation to the right side of the frontier will imply a utility decrease. Finally, the concavity assumption for the utility function implies convex indifference curves, so in all other cases the consumer will be better off by purchasing both goods in every period, and the consumption pattern will converge to a variety-seeking steady state (see Figure 3c).

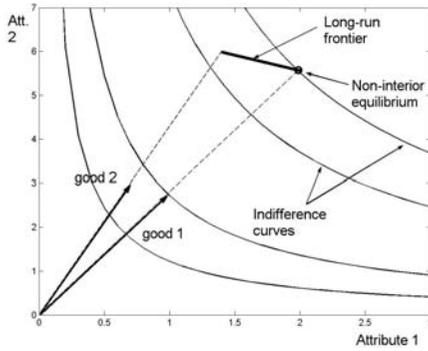
FIGURE 3

Optimal consumption long-run patterns for a logarithmic utility function,  $u(stkat) = \log(stkat)$ .

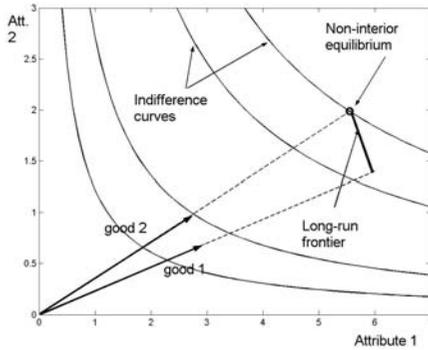
The parameter values are:

$$m = 1, p_1 = p_2 = 1, \lambda_1 = \lambda_2 = 0.5, \text{ and } \delta = 0.2.$$

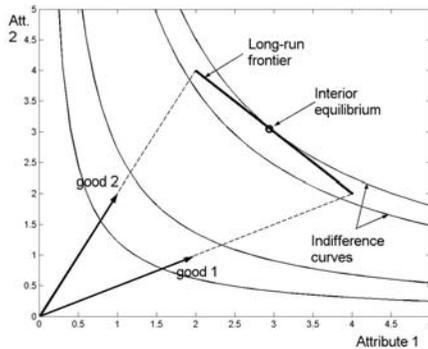
3a. Non-interior equilibrium condition (a)  $B = \begin{vmatrix} 1 & 0.7 \\ 2.8 & 3 \end{vmatrix}$



3b. Non-interior equilibrium condition (b)  $B = \begin{vmatrix} 3 & 2.8 \\ 0.7 & 1 \end{vmatrix}$



3c. Interior equilibrium condition (c)  $B = \begin{vmatrix} 4 & 2 \\ 2 & 4 \end{vmatrix}$



### 3. The transitional consumption

The objective in this section is to determine the optimal consumption patterns under several preference structures out of the steady state (e.g. when the consumer tries a new category or a new attribute is available in an established category). For unfamiliar goods the stock levels for one or some attributes are much lower than the long-run ones, so some simulations must be run out of the steady state to determine the optimal way in which the consumer accumulates the new attributes.

The analysis of the transitional dynamics plays a crucial role not only for the analysis of the consumption paths when products offering new attributes are launched. Any change in the exogenous variables may shift the long-run values. For instance, a change in the price for a product leads to a new long-run equilibrium. As a result, the consumer will change the consumption path in order to maximize the discounted utility period by period. The transitional dynamics towards the long-run equilibrium capture the consumer response to any change of the market conditions.

In an additively separable specification it is assumed that there are no interactions among the attributes. This assumption is implicit in economic models with Cobb-Douglas and logarithmic preferences. In empirical choice models, the additively separable functional form usually produces good predictions and explains a large part of the total variance in empirical research (Dawes and Corrigan 1974; Green and Srinivasan 1978). An additively separable structure can be extended by including additional terms to test for interaction among attributes. From now on, we assume additive separability among the partial contributions to utility made by each constituting attribute.<sup>4</sup> The utility in period  $t$  can be expressed as follows:

$$u(t) = \sum_{j=1}^J u_j [stkat_j(t)]$$

The utility function assumptions play a central role on the way the consumer behaves when non-familiar attributes are considered in the

<sup>4</sup>According to Johnson, Meyer and Ghose (1989) interactions among attributes are not always statistically significant. They show that adding interaction terms may have a positive effect in the Pearson's validation  $r$  when the attributes are highly correlated in the choice set, but in orthogonal settings decreases validation correlations and appears simply to result in *overmodeling*.

optimal consumption pattern. On one side, convex utility functions present increasing marginal utilities as consumers accumulate levels of attributes. This convexity reinforces its future consumption, leading to an inertial behavior. On the other side, a concave partial utility presents decreasing marginal utilities. As a result, the utility gain from consuming the same good is every time lower, leading to a variety-seeking behavior. For both preference structures, the marginal utilities increase or decrease monotonically, leading to behavioral patterns that do not depend on the cumulative levels of the level of familiarity with the products. However, for a more complex preference structure, as the inverted-U one proposed by Bawa (1990), an increasing marginal utility region is followed by a decreasing marginal utility, leading to a hybrid behavioral pattern. Under this behavior, consumers who behave inertially for new or unfamiliar items may switch to a variety-seeking behavior for a high level of familiarity. These dynamic processes occur out of a stationary pattern, so in this section some simulations are run to determine the transitional consumption patterns departing from zero levels of attributes for several preference structures.

For the simulations run in this section we assume a cubic partial utility function which allows for all the possible behavioral patterns: pure inertia, pure variety seeking and hybrid, as particular cases of the general structure. For expositional purposes we limit the degrees of freedom, setting the following restrictions: the utility function crosses the origin ( $u(0) = 0$ ), the utility range is normalized to the  $(0,1)$  interval, and each attribute presents a saturation point at level  $stkat = 1$ . Imposing these conditions, a cubic formulation for the utility function presents one degree of freedom, depending on the marginal utility at  $stkat = 0$ . The resulting formulation is:

$$u(stkat) = (c - 2)stkat^3 + (3 - 2c)stkat^2 + c stkat \quad [10]$$

where the parameter  $c$  is the marginal utility  $u'(stkat)$  at  $stkat = 0$ . When  $c = 0$  the utility function is convex for  $stkat < \frac{1}{2}$ . Higher values of  $c$  imply a smaller increasing-marginal-utility region. For  $c \geq 1.5$  the marginal utility is downward slopping for all the domain  $stkat > 0$ . The implied partial and marginal utilities, and the resulting indifference curves in a two-attribute space are depicted in Figures 4 and 5 respectively for several values of the parameter  $c$ .

FIGURE 4  
Partial and marginal utility functions for several values of  $c$

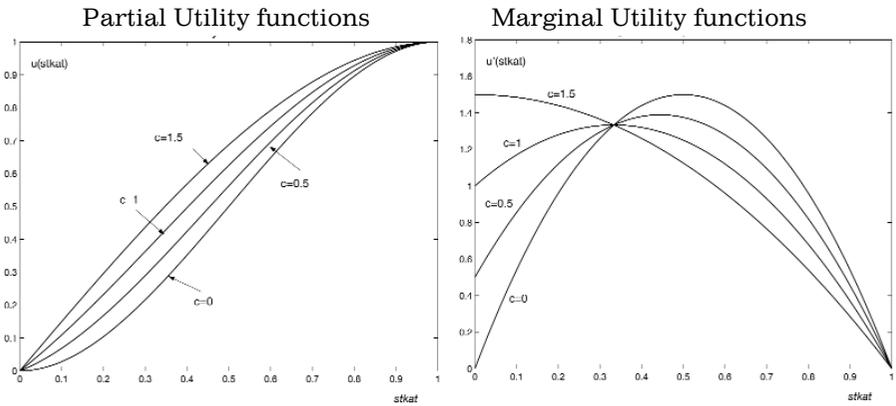
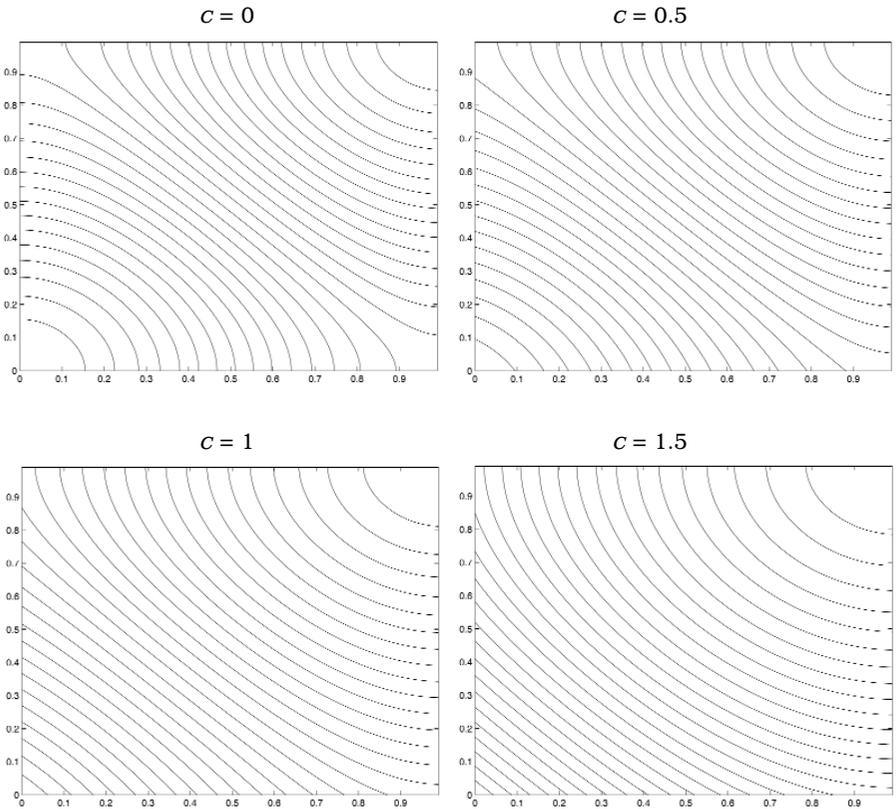


FIGURE 5  
Indifference curves in a two-attribute space for several values of  $c$



We now run some simulations to determine the optimal consumption path since the consumer tries a new product category. For expositional convenience and without loss of generality, the two products considered in the previous analysis are not multiattribute, so the technology matrix considered in the examples is diagonal. Lets suppose the consumer chooses between two soft drinks: the first one containing coffee, and the second one containing orange juice. The two compounding attributes are caffeine and vitamins. The first drink contains one unit of caffeine, but no vitamins, while the second drink contains one unit of vitamin but no caffeine. In this example the technology matrix considered is diagonal. However, we could alternatively run simulations for a market with two products, each one containing different proportions of both attributes.

The law of motion for the state variables  $\{stkat_1(t), stkat_2(t)\}$  is derived by following a standard numerical technique: departing from the steady-state neighborhood, we move backward through the first-order-condition dynamic system [6]-[7]. Noteworthy, for some periods far away from the steady state the positivity restrictions in the demands for both goods may be binding even for a convex-indifference-curve region, implying a zero purchase level for one product. If this is the case, condition [7] does not hold and the corner solution is determined by the budget constraint [6].

The shape of the partial utility function  $u(stkat)$  conditions the variety-seeking or inertial pattern along the transition, depending on the convexity-concavity of the indifference curves. In all the following examples the long-run equilibrium is a variety-seeking one, as the interiority condition (c) from Proposition 2.1 holds, so eventually the consumer will end up buying simultaneously both goods. However, the path departs from a zero level of attribute inventories, so the transitional dynamics illustrates the optimal consumption pattern while the consumer gets used to both attributes.

FIGURE 6  
Optimal consumption paths in the attribute space, departing from a zero level of attributes, and the following parameter values:

$$m = 0.15, p_1 = 0.99, p_2 = 1, \lambda_1 = \lambda_2 = 0.1, \delta = 0.1, B = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}.$$

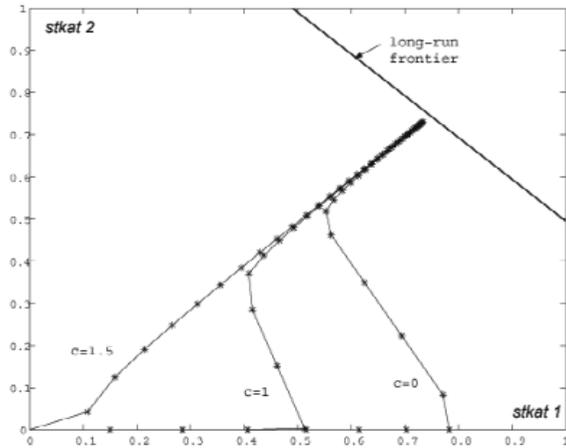
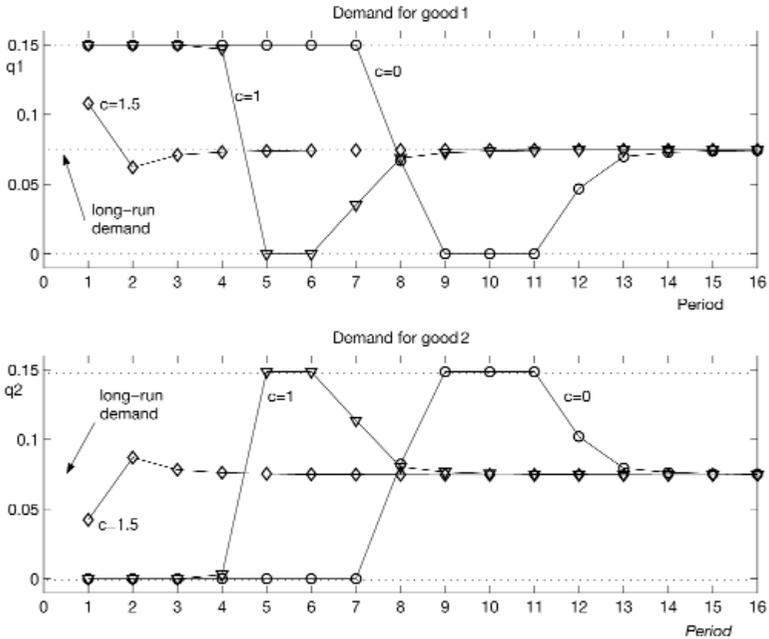


FIGURE 7  
Demands for goods, departing from a zero level of attributes, and the following parameter values:

$$m = 0.15, p_1 = 0.99, p_2 = 1, \lambda_1 = \lambda_2 = 0.1, \delta = 0.1, B = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}.$$



The optimal consumption paths in the attribute space and the implied demands are depicted in Figures 6 and 7 respectively for several utility functions. When  $c = 1.5$  the marginal utility function is decreasing in all the domain  $[0, 1]$ , so every additional unit consumed reduces the next-period marginal utility, discouraging its consumption. Along the whole transition path the consumer splits the budget between both goods and balances both attributes, so the proportion between them gradually approaches the long-run value. As a result, the consumer seeks variety not only in the long run, but also during the first consumptions.

When the utility function is hybrid ( $c < 1.5$ ) the pattern is completely different, as the agent maximizes the utility by consuming only one product and cumulating only one attribute for several periods. Its accumulation fosters its further acquisition while the marginal utility is sloping upward and the indifference curves are concave (see Figures 4 and 5). As a result, the consumer behaves inertially by consuming only one good. Switching to the other product will not occur until the discounted marginal utility of acquiring an additional unit is lower than the marginal utility of consuming the first unit of the unknown product. From then on, the consumer will behave inertially with the second attribute, and so on, until the long-run variety-seeking equilibrium is approached.

As said before, the technology matrix used in the simulations is diagonal, so the products in the analysis are not multiattribute. However, when multiattribute products are considered, the consumer is more likely to choose inertial transitional patterns, as products become substitutes in the attribute space. The more similar the proportions of attributes, the closer substitute products are; and the more likely to happen non-interior conditions (a) or (b) of Proposition 2.1. If both products are close substitutes, and the long-term conditions (a) or (b) hold (Figures 3a and 3b), the consumer would behave inertial in the long run, and the hybrid pattern from Figures 6 and 7 would not be present. However, when the long-run interiority condition (c) of Proposition 2.1 holds for multiattribute products, the consumption dynamics shown in Figures 6 and 7 (former Figures 4 and 5 in the previous version) are similar, so the consumer ends up seeking variety in the long run.

#### 4. Indivisible goods and categorical attributes

Divisibility of goods and continuous attributes are standard assumptions in most microeconomic models, as the implied demand functions can be best understood if all goods and services are assumed to be fully divisible in the attribute space.<sup>5</sup> However, the empirical models on consumer choice assume that agents choose among a discrete set of alternative goods compounded of categorical attributes. When consumers decide on the optimal purchase, only few goods like gasoline or electricity can be bought in any quantity desired. For the rest of the goods the consumer is restricted to purchase among a limited set of available products and presentations, so in this section we formulate and analyze the discrete-choice version of the model. We further assume categorical attributes, as most of the compounding attributes of consumers' goods present a categorical nature (e.g. flavor, size, brand, etc.). Indivisibility of goods and categorical attributes are standard assumptions in empirical research on consumer choice. These statements bring reality to both the purchase and consumption processes and are of special interest for understanding the individual demand for most frequent-consumption categories.

Each categorical attribute  $j$  (e.g. flavor), is characterized by a set of  $K_j$  categories (e.g. 1=strawberry, 2=lemon, 3=vanilla, ...,  $K_j$ =chocolate). If we assume that consumer preferences for a product like a yogurt depend exclusively on flavor, it would be required a  $K_j$  dimensional space (one dimension for each flavor) to define the state of a consumer, based on previous consumption. Therefore, for each attribute  $j$  we define the state-dependence variable,  $stkat_j$ , which is a vector of length equal to the  $K_j$  categories, that accounts for the cumulative stock of every category of attribute. The element  $stkat_{jk}$  is the cumulative stock level of category  $k$  for attribute  $j$ . The corresponding consumption technology for good  $x_i$  is captured by a binary vector  $b_{ji}$  of length equal to the  $K_j$  categories of attribute  $j$ . The element of this vector  $b_{jik}$  corresponding to the category  $k$  included in the item  $i$  is equal to 1 and the remaining elements equal 0. In our example, the vector  $b_{ji}$  corresponding to the attribute  $j$  (flavor) for a lemon yogurt ( $k=2$ ) would be  $(0,1,0,0,\dots,0)$ .

In the discrete version of the problem, every period the agent is restricted to choose among a limited set of alternatives to be consumed. Consistent with the choice models with indivisible goods, at every pe-

<sup>5</sup>See Lancaster (1971) for a detailed exposition and analysis of the attribute-based microeconomic models.

riod  $t$  the agent derives utility from consuming any of the  $I$  available indivisible goods,  $x_1, x_2, \dots, x_I \in X$ , for a given category. Let's further assume that the consumer can afford any of the consumption alternatives for the category-specific budget,  $p_{x_i}(t) \leq m(t) \forall t, \forall x_i \in X$ . Economic models usually assume that consumers facing a discrete-choice process choose the alternative providing the highest surplus. For doing so, prices of items are commonly placed in an additively separable utility function. As a result, a consumer with valuation  $v_{x_i}$  who purchases the item  $x_i$  at price  $p_{x_i}$  receives utility  $v_{x_i} - p_{x_i}$ . (see Maskin and Riley 1984, Farrell 1986, and Milgrom and Roberts 1986 among others). The same additive separability for prices is also assumed for conjoint analysis (or trade-off analysis), an attribute-based technique widely used in marketing for product and concept evaluation (see Green and Srinivasan 1978 and Mandansky 1980 for a good expository description of the technique). For this version of the model with indivisible goods we also assume a separable price-dependent utility function. As in the previous sections, we also assume that the utility function is additively separable in the attribute space, being determined by the cumulative levels of each of the  $K_j$  categories of each attribute  $j$ . In every period  $t$  the agent derives utility from the stock level of each category of attribute  $stkat_{jk}$ :

$$u_{x_i}(t) = \sum_{j=1}^J \sum_{k=1}^{K_j} u_{jk} [stkat_{jk}(t)] - p_{x_i}(t)$$

where the stock of category  $k$  of attribute  $j$  derived from consumption of good  $x_i$  is determined by the law of motion:

$$stkat_{jk}(t) = b_{jik} + (1 - \lambda_j)stkat_{jk}(t - 1) \quad \forall i, \forall j, \forall k, \forall t \quad [11]$$

By plugging equation [11] into the summation, the partial utility derived from consumption of good  $x_i$  at time  $t$  can be expressed as a function of the depreciated level of attribute categories  $(1 - \lambda_j)stkat_j(t - 1)$  plus the additional units of attributes, provided by product  $x_i$ :

$$u_{x_i}(t) = \sum_{j=1}^J \sum_{k=1}^{K_j} u_{jk} [(1 - \lambda_j)stkat_{jk}(t - 1) + b_{jik}] - p_{x_i}(t)$$

The partial utility functions can be approximated by a first-order Taylor expansion from the depreciated levels of attribute categories from previous period,  $(1 - \lambda_j)stkat_{jk}(t - 1)$ :

$$u_{x_i}(t) \simeq \sum_{j=1}^J \sum_{k=1}^{K_j} u_{jk} [(1 - \lambda_j) stkat_{jk}(t - 1)] + \sum_{j=1}^J b_{ji} u'_{jk} [stkat_j(t)] - p_{x_i}(t)$$

The first summation in the previous equation is common for every alternative good and represents the baseline utility derived from the depreciated levels of attribute categories. The second summation represents the additional utility derived from the attributes contained in good  $x_i$ . The utility gain leads to the same preference structure and implied indifference curves, so without loss of generality the utility when consuming product  $x_i$  at period  $t$  can be expressed as the summation of the marginal utilities derived from the additional amounts of the compounding attribute categories. In line with the previous section, for the partial utility functions  $u(stkat)$ , we assume a general cubic formulation that nests the inertial, variety seeking, and hybrid behaviors as particular cases. The utility function remains as follows:

$$\begin{aligned} u_{x_i}(t) &\simeq \sum_{j=1}^J b_{ji} u'_j [stkat_j(t)] - p_{x_i}(t) = \\ &= \sum_{j=1}^J b_{ji} [\alpha_{0j} + \alpha_{1j} stkat_j(t) + \alpha_{2j} stkat_j^2(t)] - p_{x_i}(t) \end{aligned} \quad [12]$$

As in the previous section, some simulations were run to determine the consumption pattern, departing from a zero level of attributes. Formally, given the initial stock of attributes,  $stkat_{j0}$ , the consumer will choose the optimal consumption sequence for the  $t$  periods to maximize the utility at every period, subject to the stocking processes for every attribute and the consumption technology:

$$\begin{aligned} \max_{x_i(t) \in X} \quad & \sum_{t=1}^{\infty} (1 - \delta)^t \sum_{j=1}^J b_{ji} [\alpha_{0j} + \alpha_{1j} stkat_j(t) + \alpha_{2j} stkat_j^2(t)] - \\ -p_{x_i}(t) \quad & t = 1, 2, \dots \end{aligned} \quad [P]$$

subject to:

$$\begin{aligned} stkat_j(t) &= b_{ji} + (1 - \lambda_j) stkat_j(t - 1) \quad \forall i, \forall j, \forall t \\ stkat_j(0) &= stkat_{j0} \quad \forall j \end{aligned}$$

In this version of the model with indivisible goods, a consumption pattern for a limited horizon of  $t$  periods is a sequence  $\{x(1), x(2), \dots, x(T)\}$ ,  $x(t) \in X$  where the agent selects one of the possible  $I$  products in each period. When the choice set is discrete, the dynamic programming techniques using first-order conditions can not be used to characterize the optimal solution, and the demand functions have to be determined by comparing the derived utility from choosing any of the  $I^T$  possible patterns. As in previous section, for expositional purposes we restrict the marginal utility function (12) to the functional form derived from equation [10], where the utility range is normalized to the  $[0,1]$  interval, presenting a saturation point at level  $stkat = 1$  (see Figure 4). For every period the consumer is assumed to choose among two existing products, fully characterized by an attribute (e.g. flavor) with two categories (e.g. strawberry and vanilla), each one contained in one product. A time horizon of 20 periods and a inverted-U marginal utility function ( $c = 0$ ) are also assumed. For every period, the budget and the price for each product are set to one ( $m = p_1 = p_2 = 1$ ).

We have analyzed two different cases corresponding to different consumption technologies. The amount of attribute in case  $a$  is lower than in case  $b$ , so it will take more periods for a consumer in case  $a$  to accumulate the same level of attributes than in case  $b$ . The rest of the parameters remain equal in both cases. In order to analyze the effect of rational agents considering future utilities, we have run simulations for every possible value of the future discount parameter  $\delta \in (0, 1]$ . The demands for both goods and the implied optimal patterns in the attribute space are depicted in Figure 8.

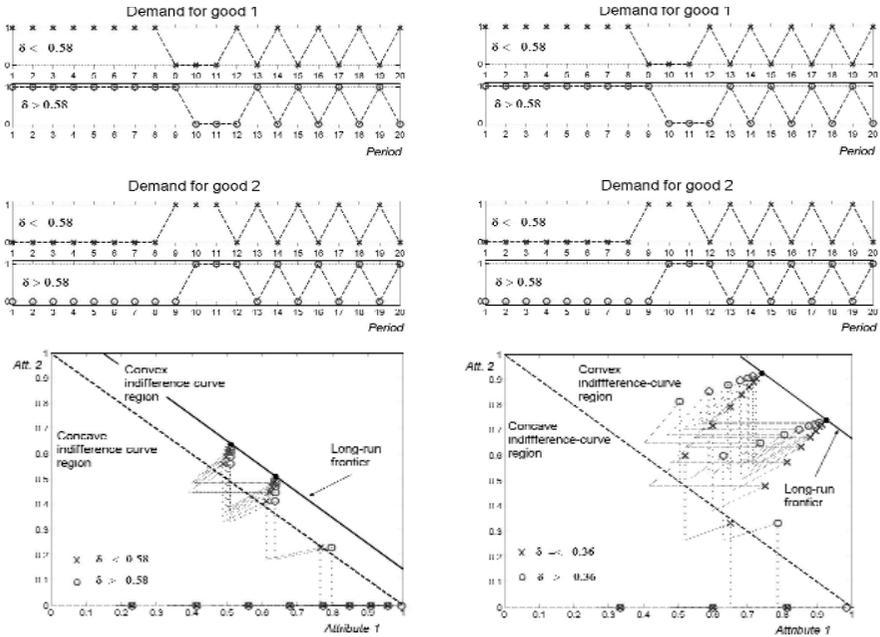
In the previous section the goods were assumed to be divisible and the agent seeks variety by consuming simultaneously both products. However, simultaneous consumption of several goods is not possible in the indivisible-good version, and the resulting variety-seeking behavior implies switching among the existing items. As expected, when a inverted-U marginal utility function is considered for both categories of attributes the optimal consumption path follows the same qualitative behavior than the one presented in the continuous-choice-set version: the consumer behaves inertially during several periods until a high level of familiarity with the product containing the implied category is reached. At that level the decreasing marginal utility regions have been reached and the agent switches to consume a new unfamiliar product during several periods. Once the level of familiarity with

the available products is high, the consumer shifts among them from period to period, seeking variety. As the finite horizon  $T$  increases, the consumption pattern converges to a long-run equilibrium where the consumer alternates purchases between the two products.

FIGURE 8  
Demands for goods and optimal path in the attribute space, departing from a zero level of attributes, and the following parameter values:

$$m = 1, p_1 = p_2 = 1, \lambda_1 = \lambda_2 = 0.2, c = 0, T = 20$$

$$\text{Case } a : B = \begin{vmatrix} 0.23 & 0 \\ 0 & 0.23 \end{vmatrix} \quad \text{Case } b: B = \begin{vmatrix} 0.33 & 0 \\ 0 & 0.33 \end{vmatrix}$$



The future-discount parameter  $\delta$  does not affect the long-term optimal consumption pattern in a significant way. The results are qualitative similar for every possible value in the domain  $(0, 1]$ . However, future-discount behavior affects the transitional dynamics, as forward-looking agents switch to the variety-seeking pattern earlier (see Figure 8). A myopic agent ( $\delta = 1$ ) behaves inertial, consuming good 1 until reaching the convex-indifference region. Despite the optimal path is the same for consumers with a high future-discount parameter ( $\delta > 0.58$  and  $\delta > 0.36$  in cases  $a$  and  $b$  respectively), forward-looking agents with low future discount rates ( $\delta < 0.58$  and  $\delta < 0.36$  in cases  $a$  and  $b$  respectively) switch to the second product earlier. As a result, the variety-seeking behavior is approached earlier. This pattern allows forward-looking agents to invest in the second attribute earlier, sac-

rificing present utility in the concave indifference-curve region for a higher future utility when being in the convex indifference-curve one.

The future discount parameter shapes the transitional dynamics towards the long-run values. When hybrid utility functions are considered, forward-looking agents have a higher propensity to seek variety in the transition. Noteworthy, changes in the exogenous prices for a product may lead to a new long-run equilibrium, so despite experienced consumers have been purchasing a certain category of products for a long time, data are not necessarily in the steady state. The utility function may depend on several marketing variables, like price, discounts, features, etc., so changes in exogenous variables like price and promotional activities constantly shift the consumption paths out of the steady state. The products are considered as a bunch of attributes, so every time a consumer responds to a shift in an exogenous variable, like a price reduction or a sales promotion for an item, the stock levels for the several categories change. In general, when the market conditions change (e.g. a price change for a product, or a new product available in the market) myopic agents are more likely to behave inertial for consecutive periods, while forward-looking agents are more likely to accumulate attribute levels simultaneously. Forward-looking behavior has managerial implications for firms when taking marketing decisions (e.g. launching products offering new attributes, extending existing product lines with new flavors, or implementing promotional actions affecting price).

#### *4.1 Empirical illustration*

In order to provide evidence for the studied hybrid behavior, we now present the results from estimations of the attribute-based partial utility functions from Equation [12], assuming myopic agents. Noteworthy, models on consumer choice base the decisions on the utility derived from consumption whereas the data used for estimations refer to purchases. Consumer choice models assume that in every period the consumer faces a choice process, leading to a purchase decision. The models further assume that consumption is an instantaneous process in which the consumers derive utility from the jump in the attribute levels. From period to period the attribute levels depreciate, but the consumption and the implied utility are both assumed to be instantaneous and coincide with the purchase.

The available scanner data only refer to the observed purchases while there may be multiple consumptions between two consecutive choice occasions. However, the assumption that consumption and utility are instantaneous and only take place with the purchase is standard in the literature of consumer choice, as data are only available for purchases. The more frequent purchases, the less bias between purchase and consumption, so choice models are commonly estimated with data from frequent purchase products.

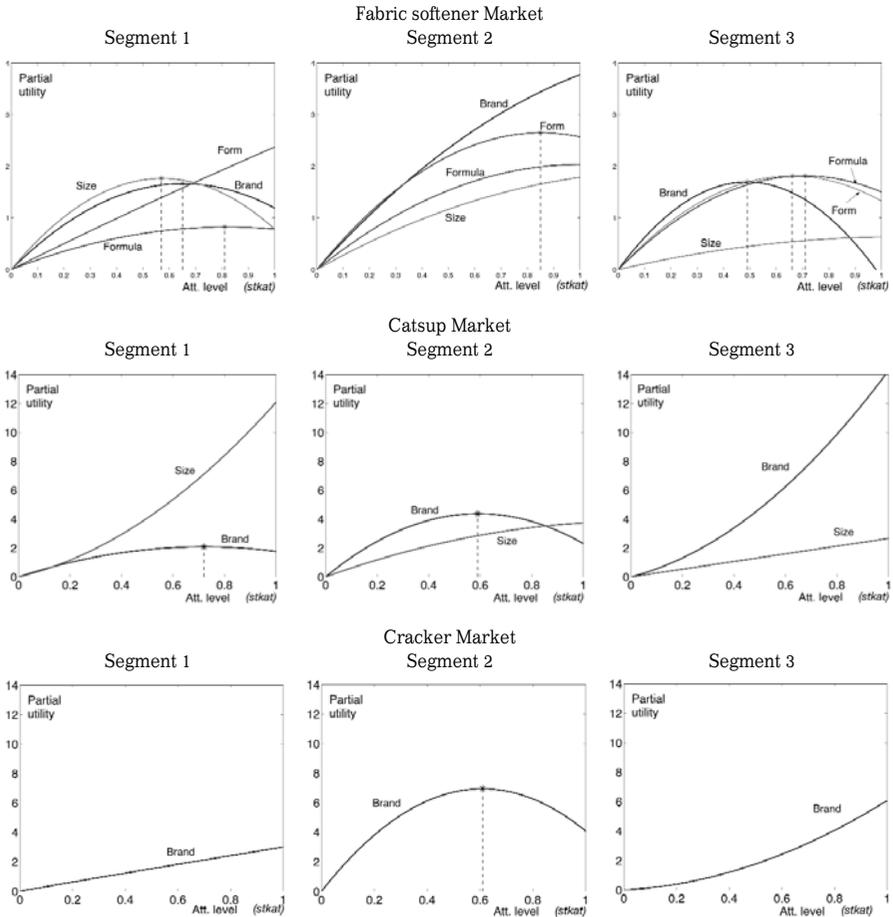
For this empirical exercise we use three different panels of households. The first scanner dataset, previously used by Fader and Hardie (1996; hereafter F&H), contains information on 9781 purchases of fabric softener over a  $2\frac{1}{2}$ -year period (January 1990 to June 1992) among 594 households. The second dataset, previously used by Jain, Vilcassim, and Chintagunta (1994), and Roy, Chintagunta, and Haldar (1996), consists of 300 households making 2,798 purchases of catsup. The third dataset, also used by the former authors, contains information on 2,509 purchases of saltine crackers among 100 households. For the detailed description of the datasets and the estimation results of several alternative state-dependence specifications of the utility function, see Jiménez-Martín and Ladrón de Guevara (2007). Therefore, in this section we focus on the analysis of the resulting partial utility functions and the evidence and implications of hybrid patterns.

For the estimation we use a latent class approach that allows for capturing heterogeneity in preferences across segments of consumers  $s$  (see Bucklin and Gupta 1992, Chintagunta 1992 and Fader and Hardie 1996). All the three datasets used in the estimations contain information on retail promotional activities for every item  $i$  at every purchase occasion  $t$  (price and two dummy variables indicating special displays, and newspaper feature). Equation [12] is therefore extended to ac-

count for the effect of the set of the three marketing variables,  $Z_i(t)$ .<sup>6</sup> The utility function for the item  $i$  in the consumer's segment  $s$  is:

$$\nu_i^S(t) = \sum_{j=1}^J b_{ji} [\alpha_{0j}^S + \alpha_{1j}^S stkat_j(t) + \alpha_{2j}^S stkat_j^2(t)] + \beta^S Z_i(t) \quad \forall t, \forall x_i \in X \quad [13]$$

FIGURE 9  
Partial utility functions for each attribute, by segment



<sup>6</sup>As in the case with most linear models, additively separable specifications can usually produce good predictions and explains a large part of the total variance (Dawes and Corrigan 1974; Green and Srinivasan (1978); Johnson, Meyer and Ghose 1989). However, interactions can easily be included in the model, but because of the large number of potential interaction effects, the process of adding interaction terms should be driven according to the knowledge of the product category.

For the complete set of results see Jiménez-Martín and Ladrón-de-Guevara (2007) In this analysis we focus on the state-dependence behavior which is the central issue of our model, captured by the partial functions  $\alpha_{1j}stkat_j + \alpha_{2j}stkat_j^2$ . The partial utilities by segment and attribute for the three markets are illustrated in Figure 9. Considering multiple segments allows for capturing the significant heterogeneity on preferences across agents. For all the three markets, the segments present significant differences for every set of parameters, capturing the several sources of heterogeneity across consumers. In all the three markets the three-segment model provides the best fit of the data since it has significantly better evaluation criteria.

In relation to the state-dependent behavior, we find strong evidence of inertial behavior for low levels of attributes. The linear parameters  $\alpha_1$  are all positive and significantly different from 0 at a 5% level for all attributes, all markets, and all segments. This result implies a consistent inertial behavior for low cumulative levels of attributes, as acquiring products with unfamiliar characteristics consistently reinforces its further acquisition.

We also find strong evidence of non-linear behavior for most attributes. A total of 16 out of the 21 estimated parameters  $\alpha_2$  are negative and significantly different from 0 at a 5% level for most attributes and market segments. These values imply strictly concave partial utility functions. The concave utility functions present steeper slopes for the partial utilities at a zero level of attribute. In line with our theoretical model, this suggests maximum positive slopes and strong inertial purchasing patterns for new or unstocked attributes. Due to the concavity of the utility functions presenting  $\alpha_2 < 0$ , this reinforcement of previously purchased categories becomes weaker as the cumulative levels increase. However, for a hybrid behavior to be presented, the estimated function must present a maximum and a decreasing region on the domain (0,1). As the partial utility reaches a maximum, the critical level is overcome. Exceeding this critical value, every new acquisition of the attribute category reduces the probability of acquiring an item containing it in the new purchase, so the consumer starts to seek variety for this attribute category. The 10 critical levels for a switching behavior, when present, are depicted in dashed lines in Figure 9.

As illustrated in the partial utilities from figure 9, in the fabric softener market, segments 1 and 3 present a strong hybrid behavior for

most attributes, while segment 2 behaves inertial for all attributes but *form*. In the catsup market the partial utilities for the attribute *size* are inertial for all the three segments, so experienced consumers always buy the same *size*. However the partial utility functions for the attribute brand are hybrid for segments 1 and 2, so catsup consumers in these segments are more likely to switch after several consumptions of the same *brand*. For the Cracker market there is only one available *size* in the stores, so the only attribute characterizing products is *brand*. While inertial segments 1 and 3 present a stable and reinforcing preference for the usual brand, segment 2 in the cracker market also presents a hybrid behavior.

## 5. Conclusions

Importantly, no research on state-dependence choice models to date has studied the dynamics of the optimal consumption paths for non-durable goods. The aim of this paper is to provide a general economic framework allowing for the analysis of the consumption dynamics. This research presents an attribute-based dynamic model where rational consumers derive utility from the attribute inventories accumulated when items are consumed. In light of the empirical evidence of several state-dependence patterns, the model considers a general specification of the utility function that allows for the different types of behavior described in the literature: pure inertia, pure variety seeking and hybrid. The transitional dynamics and the steady-state conditions are characterized. Depending on the utility assumptions, the model may present a stationary consumption pattern that can be inertial, where the consumer only purchases one product, or a variety-seeking one, where the consumer buys several products simultaneously. The conditions for the inertial or variety-seeking steady state equilibrium are also determined.

The analysis of the transitional dynamics of the model is key to understand new-consumer patterns while getting used to the product category in growing markets as well as experienced-consumer reactions to a significant change in the market. The response of a regular and experienced consumer to a market change is also driven by the transitional dynamics. For instance, an innovation adopted in a frequently purchased product category, like the launch of a new packaging technology, if properly promoted, may induce trial, with a long-term effect

as an inertial consumer will eventually change habits in the long run, converging to a new inertial steady state.

The model proposed in this research considers two inter-temporal effects. The first one is produced by past consumption affecting the present utility through the cumulative stock of attributes. The second effect is originated by assuming forward-looking agents that discount the flow of future utilities when taking present decisions. For a hybrid utility function, forward-looking agents behave qualitatively similar to the myopic ones, but switch earlier from the inertial behavior to the variety-seeking one. However, depending on the preference structure, forward-looking assumptions may have relevant implications in the transitional dynamics and is a major issue to be considered in our future research. For instance, state-dependence and forward-looking assumptions are both key for understanding consumption of habit-creation products like alcohol or tobacco.

The theoretical framework developed in this research allows for the analysis of the impact of product-based strategies. New available combinations of attributes become available for consumers when firms launch new products or extend existing lines. However, a more general dynamic framework would be desirable to analyze the impact of other marketing strategies like launching advertising campaigns or implementing promotional activities. Many authors have proposed dynamic models to account for the impact of advertising, modeling the goodwill formed through advertising as a knowledge-investment process (see Fornell *et al.* 1985, Chintagunta and Jain 1992, and Chintagunta 1993 among others). Including these effects would bring additional complexity to the consumer choice models, and is not in the purpose of this paper. However, we consider extensions of dynamic consumer models including advertising and other marketing variables as a promising line of research to be explored in the future.

We run an empirical application with scanner datasets for several convenience goods. For this exercise we estimated the simplified version of the model for the myopic-agent case. The empirical results lend strong support to the importance of modeling consumer preferences in the attribute space in a manner that captures the dynamic accumulation of the compounding characteristics. The choices among the existing items reveal preferences not only for a brand, but also for several other underlying attributes, like size, formulas, flavors, etc. Our results suggest that an attribute-based model should allow consumer

preferences to vary among the constituent attributes. According to the empirical evidence presented here, consumers may present different state-dependence patterns for every attribute dependent upon the consumption history.

The empirical results also reveal significant non-linear structures for the partial utilities, and put forward that models should also be able to capture mixtures of inertia and variety seeking as a more complex state-dependence pattern. From a consumer-choice perspective, the major predictions of our theoretical framework are confirmed by the empirical illustration:

- The hybrid formulation has a superior fit compared to a linear state-dependence formulation.
- For every market studied, there are relevant hybrid segments presenting negative and significant non-linear coefficients. The estimated utility functions support the theoretical assumptions that consumers behave strongly inertial when the attributes are new, or their stock levels are low. This trend may be reversed and consumers may seek variety once the attribute has been accumulated continuously for several consumption periods.

Important managerial implications of this research can be emphasized. The results reveal the importance of modeling and estimating the different sources of loyalty presented in the purchasing patterns to understand consumers' preferences. In order to develop effective promotional strategies, firms need to know the preference drivers across segments. An inertial purchasing pattern for a brand may be a result of a preferred combination of attributes. If this is the case, consumers are loyal to the preferred brand, and the promotional efforts run by competitive products will only have a short-term effect. However, loyal purchasing patterns may also happen just because the purchased items contain attribute categories of a high level of familiarity for an inertial consumer. In this case, consumers simply do not switch to a competitive product because they are unfamiliar with its compounding attributes. For these inertial consumers, continuity promotional strategies aimed at increasing the level of familiarity for a competing product may have a long-term effect, as preferences are mainly driven by familiarity.

From a managerial perspective, the model offers a useful radiography of the competing products available in the market place for the cate-

gory studied. Unlike the alternative-specific choice models, estimating the attribute-specific preference structure provides meaningful and interpretable parameters. For some frequently purchased categories, like yogurts or ice cream, consumers seek variety in flavors while behaving inertial for brands (see Kim *et al.* 2002). This behavioral pattern has relevant managerial implications, as an appropriate line extension for the brand is needed to guarantee the required switching by consumers across the available product varieties while being brand loyal. The model may constitute a decision-making tool enabling estimation of the impact of several marketing strategies across segments to be evaluated, such as in relation to the launch of new products or possibly extending existing lines. The results of the hybrid model can also have implications for pricing and promotional activities, such as cross-promotional offers (e.g. for which groups of products and for which segments will a joint promotion be more effective, depending on the variety-seeking levels shown for the implied combinations of attributes).

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## Resumen

*Este artículo desarrolla un modelo dinámico de elección en el espacio de atributos con agentes racionales. El modelo presenta una senda estacionaria que puede ser de consumo inercial, donde se compra un único producto, o de consumo variado, donde se alterna la compra entre distintos productos.*

*Bajo el supuesto de preferencias híbridas, el consumidor tiene un comportamiento inercial durante varios períodos, cambiando a un consumo variado al acercarse al estado estacionario. Los resultados de las estimaciones del modelo con datos de scanner de tres categorías distintas confirman esta tendencia a la búsqueda de variedad a medida que el consumidor se familiariza con la categoría de producto.*

*Palabras clave: Modelos de elección, dependencia del estado, comportamiento híbrido.*

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