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EMPIRICAL GENERALIZATIONS IN THE MODELING OF CONSUMER CHOICE

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Are there general algebraic laws which describe how consumers make choices from sets of alternatives? In this paper we review the verdict of research which has sought to answer this question. We focus on the functional forms which have been found to best characterize three component processes of consumer choice: those of attribute valuation, attribute integration, and choice. Our central conclusion is that there exists support for three major generalizations about the form of consumer decision processes: (1) subjective attribute valuations are a nonlinear, reference-point dependent, function of the corresponding objective measure of product attributes; (2) the integration rule which best describes how these attribute valuations are integrated to form overall valuations is multiplicative-multilinear, characterizing an overweighting of negative attribute information; and (3) the choice rule which links overall valuations of an option to the likelihood that it is chosen from a set is a member of a family of functions which recognize the attribute-wise proximity of a considered alternative to others in the set. The evidence supporting these generalizations is reviewed, as well as their implications for future theoretical and applied work in consumer choice modeling.

(Choice Models; Decision Making; Context Effects; Multiattribute Models)

1. Introduction

Underlying much of the work in individual choice analysis in economics, marketing, and psychology is the assumption that most decision problems can be modeled in terms of *multiattribute choice systems* which link objective measures of the attributes of options (for example, observed prices and product qualities) to observed choices. Such systems assume that the process of choice can be described by three fundamental component relations (Anderson 1970, Louviere 1988, Lynch 1985):

(1) The *valuation rules* which map objective measures of product attributes to their perceived attractiveness;

(2) The *integration rules* which map perceptions of the attractiveness of attributes to overall impressions of attractiveness; and

(3) The *choice or behavioral rules* which map overall impressions to overt behaviors, most commonly choices.

In this paper we suggest a series of empirical generalizations which appear to best characterize each of these component relations as they arise in the context of consumer choices among product options. Specifically, we find support for three major generalizations about the form of consumer decision processes:

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(1) Attribute valuations are a nonlinear, reference-point dependent function of objective product attributes;

(2) The algebraic integration rule which best describes how valuations are integrated into overall valuations is multiplicative-multilinear, a form which can accommodate the frequent empirical finding of overweighting of negative attribute information; and

(3) Overall valuations of an option are linked to choices by a function which recognizes the proximity or similarity of the option to others in the set. This function describes a set-specific distortion of the multiattribute preference surface which usually rewards distinctive options.

In the paragraphs which follow we will elaborate the nature, basis, and limits of these generalizations. We will conclude by discussing their implications for current applied and theoretical research in choice and judgment modeling in marketing.

Generalization 1. Attribute Valuations are Nonlinear and Reference-Dependent

The attempt to develop generalizations about the functional relationship between the observed attribute value of economic goods and their perceived values or utilities is one of the oldest lines of inquiry in economics and mathematical psychology. In the early eighteenth century, for example, Bernoulli (1738, summarized in Jones 1974) proposed what remains today one of the most robust empirical regularities in the social sciences: the law of diminishing returns in perception. Specifically, Bernoulli proposed that the utility an individual associates with a given level of wealth will increase as a logarithmic function of its objective value; i.e., if w is an objective measure of one's possessions, then there exists a scaling constant a such that $U(w) = a \log(w)$, $a \geq 0$. The near universality of this principle was later suggested in the mid-nineteenth century by the psychologist Fechner, who observed that this same principle also characterizes individual sensory judgments, such as weight, brightness, and sound.

Although the general idea that sensory magnitudes are associated with diminishing returns was initially met with strong empirical support, psychologists as early as Fechner discovered that the *parameters* of this relationship tend to vary with the context of judgment, or the characteristics of other stimuli being judged (e.g., Hollingworth 1909). Probably the most well-known work along these lines is that completed by Helson (1943, 1964), who suggested that sensory metrics are inherently defined relative to points of reference, or *adaptation levels*. This idea was later elaborated in the work of other mathematical psychologists such as Anderson (1970) and Parducci (1964), who suggested the general view that any judgmental response can be characterized as a combination of two effects: an absolute effect of a stimulus on judgment, and a relative one due to context (see, e.g., Anderson 1970). A broader review of the effect of context and experience in psychophysics is provided by Poulton (1968).

1.1. *Context Effects in Economic Valuations*

In contrast to psychophysics, the idea that context will matter in preferences for economic goods is far more recent and controversial. Specifically, the classical theory of the consumer offers a strong account of how individuals should assess the marginal disutility of the prices paid for goods: true to Bernoulli's original formulation, posted prices commonly are presumed to be viewed as *income displacements*, the value of which given by reference to a single, context-free wealth curve (see, e.g., Kreps 1990). More specifically, consumer choice is viewed as the solution to a maximization problem, in which all possible actions, across all possible consumer expenditures, are evaluated in terms of a single function of the attributes of these actions (e.g., Lancaster 1971). Thus, knowledge of the marginal value of an attribute of an option is seen as supremely portable, independent of the elements of a particular choice set under consideration.

Recent behavioral analyses of product choice, however, would seem to reject this hypothesis as an account of how consumers form valuations of prices in market settings. Much in the same way that the perceived value of sensory stimuli depends on the contextual background against which they are judged, the attractiveness of a given price has been found to depend heavily on the context of the past and current context of prices faced by the consumer (e.g., Thaler 1980, 1985; Winer 1986).

A simple thought experiment, due to Tversky and Kahneman (1981), nicely illustrates the context-dependence of price valuations. The classical theory of the consumer suggests that a savings of a given amount, say \$10, should have the same marginal valuation, independent of the amount spent. However, consistent with many observations in the pricing literature, this does not seem to be true: a \$10 savings on a purchase that was originally \$40 seems to have much more impact than if it were on a purchase that was originally \$1000.

In contrast to research on sensory judgment, contextual effects in price and product attribute valuations seem to be driven by two, rather strong, hypotheses:

1. The major locus of context effects in attribute valuations has been the idea of a single perceptual parameter, termed a *reference point*; and

2. The function which scales attribute valuations relative to this reference point is *asymmetric*, with marginal valuations being concave for values above the reference point of an attribute and convex below it. This function, therefore, displays *loss aversion*: the marginal disutility of decreases in value relative to the reference point tend to be greater than the marginal utility of gains (Tversky and Kahneman 1991). Because valuation has both absolute and relative components, if there is a general law of product attribute judgment, it might look something as follows. Let x_{ij} be a monotonically scaled measure of the objective value of product option j on attribute i, and x^*_{ijt} be a reference value for attribute j of i in context t. Any marginal valuation of j on i in choice set or context t, v_{ijt}, will be given for an individual by the following mixture of absolute and relative valuation functions:

$$v_{ijt} = \alpha u(x_{ij}) + (1 - \alpha)y(x_{ij}, x^*_{ijt}), \quad (1)$$

where α is a nonnegative mixture parameter ($0 \le \alpha \le 1$), $u(-)$ is an absolutely scaled (concave) value function, and $y(x_{ij}, x^*_{ijt})$ is a reference-dependent function given by:

$$y(x_{ij}, x_{ijt}) = d[\lambda y_n(x_{ij} - x^*_{ijt})] + (1 - d)[y_p(x_{ij} - x^*_{ijt})]. \quad (2)$$

In (2), d is a binary operator such that $d = 1$ if $x_{ij} < x^*_{ijt}$ and 0 otherwise, $y_n(-)$ is a convex function, $y_p(-)$ is a concave function, and λ is a nonnegative scaling weight capturing the degree of loss aversion evident in attribute valuations (see, e.g., Kahneman and Tversky 1991; Hardie et al. 1993).

Evidence to support equations (1) and (2) as a general characterization of product attribute valuations comes from a number of different domains and paradigms. There are, for example, abundant data supporting the existence of reference-point effects in questionnaire studies based on hypothetical choices (e.g., Kahneman and Tversky 1981, Dhar and Simonson 1992). In addition, reference effects have also been found to provide a consistent account of choice behavior in a number of field studies, including choices of auto insurance (Johnson et al. 1993), preferences for attributes of electrical power, (Hartman et al. 1991), and in selections of investments and health maintenance organizations (Samuelson and Zeckhauser 1988).

Evidence supporting loss aversion is also quite widespread. Within marketing, for example, there is significant evidence that reactions to price changes are greater for price increases than for price decreases (e.g., Monroe 1976). Likewise, within economics, loss aversion has been demonstrated to cause a reluctance to trade in experimental markets (Kahneman et al. 1990), and identified as a contributor to a bias toward maintaining the status quo (Samuelson and Zeckhauser 1988). In a context closely related to marketing, Viscusi et al. (1987) showed that there were strong asymmetries for reported preferences in the safety levels of hypothetical insecticides.

While the general form of expressions (1) and (2) have been widely supported in empirical work, fewer generalizations can be made about the specific *parameters* of these equations. One exception, perhaps, is that of the size of loss aversion, represented by the parameter λ in expression (2). Several authors have reported surprisingly similar estimates of λ—generally about 2—across a number of study contexts. Tversky and Kahneman (1991), for example, report estimates of λ ranging from 2 to 2.5 in experiments involving preferences for both real and hypothetical gambles. Likewise, in their work on auctions, Kahneman et al. (1990) report a mean ratio of selling prices to buying prices of goods of 2.29 (SD = 0.43) across sixteen experimental markets—a ratio which closely corresponds to direct estimates of λ. Finally, in a longitudinal study of brand choice behavior, Hardie et al. (1993) uncovered a λ value of 1.66 (SE = 0.30) for price increases, an estimate not dissimilar to that reported by Tversky and Kahneman.

Another striking similarity emerges when one looks at the estimated loss aversion for quality. Simonson and Tversky (1992) present evidence, based on questionnaires using hypothetical choices, that loss aversion for quality may be systematically greater than loss aversion for price. In a field analysis of consumer panel data, Hardie et al. (1993) found a very similar dominance of aversion for quality loss over that for price loss (they find $\lambda_q = 2.70 > \lambda_p$).

In contrast, there is much less agreement about the degree to which generalizations can be made about the relative influence of absolute versus referent-dependent components of valuation (the parameter α in (1)), the degree of curvature in the functions $u(-)$, $y_n(-)$, and $y_p(-)$, and the determinants of the reference point x^*_{ijt}. Indeed, it is also unclear whether a single reference-point parameter is sufficient to capture the locus of background effects in attribute perception (Tversky and Simonson 1993). Following in the tradition of work in context effects in sensory judgments, later work may reveal the need to develop a multidimensional account of background, including such features as range and frequency (e.g., Parducci 1964).

GENERALIZATION 2. ATTRIBUTE-INTEGRATION IS COMMONLY MULTIPLICATIVE-MULTILINEAR

Consider a simple decision problem in which a consumers is asked to form an overall judgment of the overall attractiveness of each of a series of products described by two or three attributes, where all attributes are set at feasible levels (for example, price and quality, where all prices are affordable and all qualities are at least minimally acceptable). A widely-supported generalization is that simple additive (or averaging) rules will provide a good account of the attribute integration process in such cases (e.g., Russo and Dosher 1983; Troutman and Shanteau 1976). That is, a modeler can be reasonably confident that the overall attractiveness of a given product i, given choice set t, V_{it}, will be well modeled by the linear-additive expression:

$$V_{it} = \sum_{k=1}^{m} w_k v_{ikt}, \tag{4}$$

where v_{ijt} is the marginal valuation of the kth attribute of product i as in expression (1), and w_k is a scaling weight associated with the marginal valuation of attribute k.

It turns out, however that the domain of this generalization is quite limited. Although linear-additive models often *correlate* well with judgment data (see, e.g., Dawes and Corrigan 1974; Johnson et al. 1988), they repeatedly have been found to be inconsistent with the actual process of choice in more general product-choice settings where at least one of two conditions arise:

(1) Products contain attribute levels which may be seen as infeasible by some consumers (e.g., some prices are beyond a perceived budget constraint); and

(2) Products are described by a large number of attributes and/or the consideration set contains more than two options.

Drawing on data from methods ranging from eye movements (Russo and Dosher 1983) to verbal protocols (Bettman 1971) to search from information display boards (Payne 1976; Bettman and Jacoby 1976) and computer-based methods (Johnson et al. 1989), research have widely observed that choice and judgment often resemble a screening process, where consumers eliminate options from consideration (or provide them with low evaluations) without complete consideration of their value on all attributes. The most prevalent of these heuristics are conjunctive rules which characterize *apparent overweighting of negative information*: complete elimination of options which are perceived as being unattractive on key attributes, regardless of their performance on other attributes (e.g., Einhorn 1970). If such heuristics are used in a given judgment context, they imply support for *multiplicative-multilinear* models as a general algebraic characterization of the attribute integration process (e.g., Einhorn 1970; Louviere 1988).

To illustrate how multiplicative policies represent noncompensatory processes, imagine a consumer uses a conjunctive screening rule which evaluates the overall attractiveness of a series of product described by three attributes. Instead of forming overall impressions by trading off all attribute valuations, the consumer uses the conjunctive screening policy:

Rate as acceptable if: $(v_{i1} > t_1) \wedge (v_{i2} > t_2) \wedge (v_{i3} > t_3)$,

otherwise rate as unacceptable,

where v_{ik} is the scaled valuation of the kth attribute of option i, and t_j is a latent (unobserved) acceptability threshold for attribute j. As noted above, this is a heuristic which characterizes consumer evaluations in many product settings (e.g., Payne 1976). In natural settings, it will most likely be the case that these thresholds t will not be fixed points, but best characterized by a *distribution* of values. Specifically, in any given judgment context we might suggest that the probability that an attribute valuation v_{ik} will be greater than its associated threshold t_k can be empirically approximated by (for simplicity) a linear probability model, such that $\Pr(v_{ik} > t_k) = a + bv_{ik}$. Under this assumption, the empirical probability that option i will be rated as acceptable is:

$$V_i = \Pr(i = \text{acceptable}) = \Pr(v_{i1} > t_1) \times \Pr(v_{i2} > t_2) \times \Pr(v_{i3} > t_3)$$

$$= (a_1 + b_1 v_{i1}) \times (a_2 + b_2 v_{i2}) \times (a_3 + b_3 v_{i3})$$

$$= k_0 + k_1 + v_{i1} + k_2 v_{i2} + k_3 v_{i3} + k_4 v_{i1} v_{i2} + k_5 v_{i1} v_{i3} + k_6 v_{i2} v_{i3} + k_7 v_{i1} v_{i2} v_{i3},$$

where the ks are *nonnegative* collected parameters. In words, this expression implies that if consumers follow a conjunctive screening process with error when forming product judgments, overall impressions can be represented by a multiplicative-multilinear integration rule, a functional form which recognizes positive (fan-like) interactions along the various marginal attribute valuations. Consistent with this, research which has examined the functional form of decision processes in complex product judgment settings has repeatedly found support for multiplicative-multilinear forms, in settings ranging from grocery store evaluations (Louviere and Meyer 1981), to travel mode choice (Lerman and Louviere 1978), to housing evaluations (Johnson and Meyer 1984).

We would suggest, therefore, that the most supportable generalization about the function which describes how consumers integrate attribute information when forming overall impressions is the multiplicative-multilinear model (Louviere 1988; Keeney and Raiffa 1976)

$$V_i = \sum_{k=1}^{m} k_i v_{ik} + \sum_{k=1}^{m} \sum_{l \neq k}^{m} k_{kl} v_{ik} v_{il} + \cdots + k_{12 \ldots m} v_{i1} \cdots v_{im}. \quad (4)$$

It is important to stress that (4) is still a restrictive hypothesis about attribute integration. While it accommodates both additive decision rules and screening heuristics which overweigh negative information in judgment, the nonnegativity constraint precludes the model from representing *disjunctive* decision policies (rules which overweigh positive information), or completely configural judgment rules (those in which are not definable independent attribute valuation functions). Such policies, however, have been found to be the exception rather than the rule in studies of product judgment.

GENERALIZATION 3. THE CHOICE FUNCTION RECOGNIZES PROXIMITY

Perhaps the oldest empirical generalization which arises in the study of individual choice from sets is an axiom proposed by Luce (1959), which posits that choice probabilities can be modeled as a simple ratio of the attractiveness of each option to the sum of the attractiveness of all options under consideration. When applied to product choice problems, this hypothesis is most commonly represented in terms of the multinomial logit model,

$$\Pr(i) = \exp(V_i) / \sum_{j \in T} \exp(V_j), \quad (5)$$

where V_i is the overall attractiveness of option i (which could be given by the multilinear composition rule (4)), and T is the set of product options under consideration (e.g., McFadden 1981; Guadagni and Little 1983).

Other analyses of the behavior of choice data, however, have suggested that the empirical domain of Luce's axiom and its variants are limited. Specifically, (5) generally fails to describe individual choice probabilities when:

(1) the alternatives under consideration differ in similarity or substitutability; that is, when there are different natural groupings of options (e.g., Anderson et al. 1993; Meyer and Kahn 1990); and

(2) consumers use heuristic screening rules for making choices from sets (as described above).

Given these conditions, the probability that an item will be chosen from a set frequently has been found to be a function not only of its attractiveness relative to others in the set, but also its attribute-wise *proximity* or similarity to other options.

Work on the effect of item similarity on choice has offered support for two contrasting generalizations about how the similarity of an item to others in a choice set affects its choice likelihood:

(1) *The classic detraction or substitution effect*: all things equal, the probability that an option will be chosen from a set decreases with increases in its similarity to other options (e.g., Luce 1959; Tversky 1972; McFadden 1981); and

(2) *The attraction effect*: all things equal, paribus, the probability that an option will be chosen increases when a similar option is added to a set over which it has a decisive advantage (Huber et al. 1982; Tversky and Simonson 1993).

The substitution effect has been widely documented in a larger number of empirical investigations in individual choice (e.g., Tversky 1972; Deganzo 1979). The most common interpretation is that when individuals use choice processes which screens options based on the attractiveness of common features (such as form or type), items which share a greater similarity with other options in a set will have a lower likelihood of choice by risking elimination en mass. For example, if a consumer is otherwise indifferent between vacationing in the mountains or at the beach, a given beach resort will have a higher likelihood of being chosen if the overall consideration set contains fewer beach than mountain resorts.

On the other hand, although the attraction effect has also been well documented (e.g., Huber et al. 1982; Ratneshwar et al. 1987; Simonson and Tversky 1992), its theoretical basis is much less certain. The most dominant emerging explanation is that it is a consequence of consumers *choice ease* to screen alternatives when they are uncertain about their preferences. Specifically, given indecision over which option to select from a set, the presence of an alternative which offers a decisive advantage over another, similar option may be chosen as a tie-breaker (e.g., Mishra et al. 1993; Tversky and Simonson 1993). Consistent with this interpretation, there is evidence that the attraction effect is strengthened when consumers are presented with the prospect of justifying their choice to others (e.g., Simonson 1989), and weakened when options are described in terms of a more detailed set of attributes which provide another basis for choice (Ratneshwar et al. 1987).

The central implication of both these regularities for individual choice models is that the simple ratio rule (5) does not appear to provide a general behavioral law of choice. Specifically, they imply that the overall utility associated with an option in choice is often affected by the characteristics of the choice set. Formally, such context-specific effects are consistent with the generalization:

$$\Pr(i) = \exp[U_i + S(T|i)] / \sum_{j \in T} \exp[U_j + S(T|j)], \tag{6}$$

where $S(T|i)$ is a context-specific effect which captures the perceived proximity of i to all other options in the choice set. As shown in Meyer and Kahn (1990), if individual choice made through a process of probabilistic elimination as defined by Tversky's (1972) elimination-by-aspects model, then $S(T|i)$ is a uniquely defined nonnegative scalar index of the distinctiveness of option i in the choice set. Similarly, the differential-effects models of Batsell and Polking (1985) and Cooper and Nakanishi (1983) are equivalent to (6) in the case where $S(T|i)$ is a linear combination of the measured attributes of all $j \neq i$ options in the choice set—forms which allow representation of attraction effects among pairs of options.

2. Discussion: Are There General Laws of Judgment and Choice?

Are there general laws which characterize how consumers evaluate attributes, integrate information, and make choices in product settings? The past 30 years of research in individual choice analysis would seem to provide support for three law-like empirical generalizations, corresponding to equations (2), (4), and (6) above:

(1) Subjective attribute valuations are a nonlinear, reference-point dependent, function of the corresponding objective measure of the attribute;

(2) The algebraic integration rule which best describes how valuations are integrated into overall valuations is a multiplicative-multilinear function which recognizes an overweighting of negative attribute information; and

(3) Overall valuations of an option are linked to choices by a function which recognizes the proximity or similarity of the to option to others in the set.

These generalizations hold two sets of implications for both applied and theoretical research in choice modeling in marketing. First, they underscore the need to actively consider context-contingent functional forms of choice models in applied work—forms which are frequently overlooked in commercial settings (e.g., Green and Srinivasan 1978). For example, (1) is consistent with the recent increased interest in models which recognize reference values of attributes, and (2) suggests that increased consideration should be given to multiattribute model forms which recognize interactions among product features. Although simple linear-additive models will usually correlate well with data, generalizations (1) through (3) suggest that they will often mischaracterize the actual process of choice—something which greatly diminishes their value as diagnostic devices.

Second, the generalizations also hold implications for the future direction research in choice modeling in marketing may take. Their overarching message is that choice processes are highly labile, as much a consequence of the choice environment as a determinant of how the decision maker acts with it. If there is a next major problem in the analysis of individual choice, therefore, it would be to work toward a formal understanding of the rules by which individuals *construct preferences* in light of the observed features of the judgment task (e.g., Payne et al. 1992).

A constructive view of choice would emphasize not only the idea that choice processes are built upon a series of heuristics, but that the values which they reflect are, at least some of the time, constructed in service of the choice task. At first blush, this may seem like very bad news for the business of modeling choice; a formal constructive theory of choice which could account for such effects might seem like an implausible goal.

However, it is an empirical reality that our current technology for modeling choice works, at least much of the time. We suggest, however, that the boundary conditions of the application of this technology corresponds, roughly at least, to some of the concerns raised by this review. Specifically, the idea that not all preferences are well constructed seems to map well into the idea that choice modeling is more difficult for really new products' attributes that have not been experienced by consumers. Thus work in understanding the constructive nature of choice is not a challenge, but an important change to the classical view that will have significant, if long-term, benefits to modeling choice.

In short, our sense is that a realistic vision is that future work in judgment and choice will be marked by a division of labors, with work in classic and constructive paradigms coexisting, though working toward differing goals. While the classic paradigm of rational choice will likely be of decreasing interest as a positive theoretical account of the actual process of choice, its relative parsimony almost certainly ensures its position as the dominant paradigm for work in applied choice modeling. On the other hand, while work toward constructive theories of choice may seem of less value—at least in the short run—in yielding model forms which significantly improve our ability to forecast choice behavior, it is heir to the intellectual goals which first motivated the first research in formal judgment modeling two hundred years ago, that of gaining a scientific understanding of the process underlying human economic behavior.

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