"CONPRO*DOGIT: A NEW BRAND CHOICE MODEL INCORPORATING A CONSIDERATION SET FORMATION PROCESS"

by

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CONPRO* DOGIT: A New Brand Choice Model Incorporating A Consideration Set Formation Process

Theoretical Development

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ABSTRACT

In this paper, an individual level choice model is developed for the utility-maximizing consumer which explicitly recognizes the use of heuristics to confine choice to a subset of available alternatives. A rational choice set formation process is integrated probabilistically within a random utility framework. Conceptually, the model integrates previously suggested formalizations based on search theory and decision costs. Operationally, the model relies on the random utility assumptions of the multinomial logit model. Recognizing the different contexts, constraints, and uncertainties characterizing consideration set selection versus choice, a distinction is made between portfolio utility and dominance utility. Hence, the processes are assumed to be driven by different utilities. Algebraic insights are provided into the role of consideration sets within the derived parsimonious representation of brand choice. The results indicate that membership in the consideration set enhances a brand's equity through reduced vulnerability from certain competitive tactics.

Key Words: Choice; Consideration Set; Dogit
INTRODUCTION

The development of parsimonious models of the individual consumer's choice process has an extensive tradition in marketing. Describing choice as a rational process has helped in our understanding and explanation of outcomes of observed choice occasions. The choice rule of utility maximization has played a central role in that regard. Individual consumers are described as attaching a utility (or value) function to various choice alternatives, and choice is described as the outcome of comparing the utility of the different alternatives. Although different specifications and operationalizations have been suggested for the utility functions, they commonly contain a deterministic (or explainable) component and a stochastic (or unexplainable) component. The latter is included to recognize the imperfect representation characterizing parsimonious models and the numerous uncertainties surrounding the individual consumer when making a choice decision. This basic modeling approach has been accepted as insightful and the modeling efforts described in this paper fall within that tradition.

The rational process of utility maximization leads the individual consumer to choose the alternative with the highest utility. Hence, choice results from a relative comparison conditional on a choice set. Until recently, little attention has been devoted in the brand choice literature in marketing to the process by which such choice sets are formed. Indeed, most operationalizations in the brand choice literature define choice as the selection of a particular brand from all those available. The assumption enables parsimonious representation (and, hence, ease of estimation) of brand choices such as in the popular multinominal logit model (McFadden 1974). Many empirical results on brand choice using single source data are derived from models which have this inherent characteristic (see, e.g. Gensch and Recker 1979, Guadagni and Little 1983, Gupta 1988, Lattin and Bucklin 1989).

Equating the choice set with all available alternatives conflicts, however, with extensive behavioral evidence which suggests that consumers restrict their deliberations to a much narrower set of brands (see, e.g., Bettman 1987, Payne 1983). Consumers seem to rely on heuristics to narrow down the choice set in an attempt to simplify the choice task. Meyer and Kahn (1989) state that the process by which brands enter the consideration set has been almost universally ignored. This is rather surprising in light of recent results which indicate that choice set definition has significant implications on the robustness of choice predictions (see, e.g., Swait and Ben Akiva 1986). The importance of recognizing these heuristics has been addressed recently by Hauser and Wernerfelt (1989, 1990) who formalize the process
of choice set formation in a rational fashion using search theory. They fall short, however, of operationalizing their formalizations and integrating the heuristic arguments into a complete rational model of choice. Building on the information search paradigm advocated in Hauser and Wernerfelt (1990), Roberts and Lattin (1990) provide an operationalization, similar to that of Ben Akiva and Lerman (1985), of the incremental benefit derived from including another alternative in the consideration set. The search cost, however, is assumed constant and, in contrast to Shugan (1980), totally independent of the utility profile of the brands. This simplified representation is integrated into a multinomial logit model assuming the consideration set equals the choice set (both defined discretely). A broader perspective on these recent developments with a review of pertinent research questions is provided in Shocker et al. (1991).

The objective in this paper is to embed a rational choice set formation process into a familiar random-utility choice-model framework without sacrificing parsimony. Consistent with Manski's (1977) choice paradigm, choice is modeled as a sequential process. In a first process, a consideration set of alternatives is identified discretely by balancing incremental benefit and decision costs. Incremental benefit is measured as suggested by Hauser and Wernerfelt (1990) and operationalized as in Roberts and Lattin (1990). Decision cost is operationalized according to Shugan's (1980) "cost of thinking" concept. At the time of choice, given a specific usage or consumption occasion, a choice set is defined probabilistically. A utility maximizing choice rule parsimoniously describes probabilities of choice for each alternative in the choice set. In this formulation choice is not limited to alternatives in the consideration set and, in contrast to previous work, the expansion and contraction of consideration sets as the individual searches for information is fully captured.

A distinctive feature of the operationalization is the difference in utility formalization of the consideration set formation process and the choice process itself. The rational consideration set formation process is driven by portfolio utility whereas rational choice is driven by dominance utility. The distinction is made to recognize the important differences in contexts, constraints, and uncertainties arising in both processes. This distinction enables a comprehensive modeling of short-term and long-term effects on choice. As illustrated in this paper, it also enables an insightful analysis of the differential protection from and vulnerability towards tactical moves executed by brands that either belong or do not belong to the consideration set of an individual consumer. In that respect, the paper hopes to illustrate the strategic role of consideration sets and justifies the considerable research attention the topic is currently receiving.
Consistent with Manski’s (1977) choice paradigm, a brand choice model is developed on the idea that a consumer follows a three-stage process in making a choice decision. In the first stage, the consumer decides on a subset of brands which will be evaluated on an ongoing basis. The simplifying heuristic used to identify this consideration set implies a trade-off between decision costs and the incremental benefit of choosing from a larger set of brands. This rule of balancing consumption utility and evaluation costs was suggested by Hauser and Wernerfelt (1990). Their adherence to search theory in formalizing the rule is supplemented here with Shugan’s (1980) development on decision costs. The result is a rational, comprehensive rule which discretely identifies the brands which will be evaluated on an ongoing basis.

In the second stage, the maximum utility which can be derived from selecting a brand belonging to the consideration set constitutes the standard or benchmark against which the individual consumer will evaluate the consumption utility of alternatives available at the time of choice. The incremental benefit to be derived governs the inclusion of these alternatives in the choice set. Recognizing the random character of utilities and the uncertainty the consumer experiences in evaluating an available alternative, the choice set is defined probabilistically. Specifically, the incremental benefit constitutes the likelihood of an available brand being evaluated seriously and, hence, belonging to the choice set.

In the third stage, the rational, utility-maximizing consumer will select a brand from the choice set. The process model is summarized in Table 1. The probabilistic nature of the choice set is integrated in a logit-type model framework discussed momentarily. In analytic structure, the final choice model is similar to the "competing destinations model" described in Fotheringham (1988).

As shown in Table 1, a distinction is made here between consideration set and choice set. The consideration set consists of brands which are being evaluated on an ongoing basis (i.e., without a specific usage or consumption occasion in mind), and is analogous to the definition adopted by Hauser and Wernerfelt (1990). The choice set contains the brands which are available (i.e., the consumer has the option to choose the brand if he/she decides to do so) and are evaluated seriously at the time of choice. The definition of choice set is similar to the "relevant set" definition of Hauser and Wernerfelt (1989). The serious evaluation at the time of choice is limited to the brands available in the store at the time the consumer selects an alternative given a specific usage or consumption occasion. As store
availability is modeled discretely (i.e., the brand is on the shelf or not), the probabilistic
definition of choice set (recognizing its latent character, Shocker et. al. 1991, p. 188) results
in specifying a likelihood of membership over the subset of brands which are in the store
where and when the consumer makes a choice. Note that consideration as defined here is
much stronger than awareness; i.e., a consumer might be aware of brands he/she never
really evaluates.

The process governing brand evaluations is assumed to be rational. Hence, the apparent
heuristic, as it is described in the consumer behavior literature, of confining choice to a
subset of alternatives is based entirely on rational arguments. The consumer decides in
some rational fashion to include certain brands in the consideration set and to exclude
others. At the time of choice, a rational rule will govern the inclusion of brands into the
choice set from which the consumer will choose a brand in some rational fashion.

**BASIC CHOICE MODEL STRUCTURE**

In the tradition of random utility models, the utility that an individual consumer $i$
attaches to brand $j$ can be expressed as

$$ U_{ij} = \sum_l a_{ijl} f(X_{ijl}) + \mu_{ij} $$

$$ = V_{ij} + \mu_{ij} $$

where $V_{ij} = \sum_l a_{ijl} f(X_{ijl})$ denotes the deterministic utility component, and $\mu_{ij}$ denotes the
random utility component. The deterministic component $V_{ij}$ is modeled as a function of
explanatory variables, $X_{ijl}$ for all $l$. Model (1) is the fundamental random utility hypothesis
underlying a large number of rational choice models.

The choice rule is one of utility maximization, so that the probability that individual
consumer $i$ selects brand $j$ equals
<table>
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<td>Consideration Set</td>
<td>Brands that are evaluated on an on-going basis (no specific usage or consumption occasion in mind)</td>
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<td>Choice set</td>
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$P_{ij} = \begin{cases} 1 & \text{if } U_{ij} > U_{ik} (k \in J; k \neq j) \\ 0 & \text{otherwise} \end{cases}$

where $J$ denotes the set of all brands in the category of interest (i.e., the universal set as defined in Shocker et al. 1991).

The utility-maximizing choice rule implies that brands are compared on a compensatory basis rather than on the basis of individual components (i.e., the $X_{ij}$'s in the deterministic utility component $V_{ij}$) as is the case in other (conjunctive) choice rules; the utility framework adopted here, however, does enable tradeoffs between brand specific utility components. Since exact utilities are unknown,

$P_{ij} = \text{Prob.} [U_{ij} > U_{ik} (k \in J, j \neq k)]$

which, following McFadden (1974) equals

$P_{ij} = \int_{-\infty}^{\infty} g(\mu_{ij} = x) \prod_{k \neq j} \int_{-\infty}^{x} g(\mu_{ij} = y) \, dy \, dx$

where $g()$ represents the probability density function of the random component of utility in (1).

Consider now an individual consumer who considers choice set $M \in J$, which is of uncertain composition (i.e., $M$ can be considered as "fuzzy"). Then, following Fotheringham (1988),

$P_i = \text{Prob.} [P_i (j \in M), U_{ij}) P_i (k \in M), U_{ik} (k \in J; k \neq j)]$

where utility associated with a particular brand is weighted by the probability of that brand being in set $M$ that consumer $i$ considered (i.e., $P_i (j \in M)$ is the probability that brand $j$ is in the choice set of consumer $i$). The probabilistic representation of choice set $M$ is consistent with its latent nature (Shocker et al. 1991) and analogous to Hauser and Wernerfelt (1990) and Roberts and Lattin (1990). Accordingly,
Assuming that the random utility components \( \mu_{ij} \) are independent and identical distributed (i.i.d.) according to a Type - 1 Extreme Value distribution (following McFadden 1974), then

\[
P_{ij} = P_i (j \in M) \int_{x = -\infty}^{+\infty} g(\mu_{ij} = x) \prod_{k \neq j} P_i (k \in M) \int_{y = -\infty}^{V_{ij} \cdot V_{ik}} g(\mu_{ik} = y) \, dy \, dx.
\]

Expression (2) describes the basic model structure. Its components will be formalized hereafter. Model (2) is called CONPRO*DOGIT. CONPRO implies that the model will explicitly incorporate a rational consideration set formation process; i.e. \( P_i (j \in M) \) in (2) will be derived in a rational fashion. DOGIT implies that the model belongs to the class of choice models which "dodge" the Independence of Irrelevant Alternatives property characterizing the familiar logit model. These characteristics are described and illustrated more fully below.

The CONPRO*DOGIT model in (2) is related to a number of well-known, choice models. It is rather evident from the expression that the structure is entirely compatible with a Luce choice model formulation. Because of this link, we can rely on Meyer and Kahn (1989, p. 27) to show the choice model's relationship to Tversky's Elimination-By-Aspects (EBA) model. The traditional multinomial logit model and the nested logit model are special cases of the CONPRO*DOGIT model. In the multinomial logit model, all brands available in the market are considered to be part of the choice set. Hence, in the notation adapted above, \( P(j \in M) = 1 \) for \( j \in J \) and model (2) reduces to the multinomial logit as derived by McFadden (1974).

The nested logit model is based on the assumption that the choice set is known. \( M \) is no longer fuzzy, but is known exactly. Adopting the above notation, this assumption can be expressed as

\[
P(j \in M) = 1 \text{ for } j \in M
\]
\[
= 0 \text{ for } j \notin M
\]
which implies that

\[ P_{ij} = \begin{cases} \frac{\exp(V_{ij})}{\sum_{j \in M} \exp(V_{ij})} & \text{for } j \in M \\ 0 & \text{for } j \notin M \end{cases} \]

Moreover, in structure the basic choice model in (2) is not unfamiliar. The consideration set formation process underlying the model is formalized next.

**FORMALIZATION OF CHOICE SET FORMATION PROCESS**

The three-stage choice process briefly described above is further formalized in this section. We first derive the rational rule by which brands enter (and leave) the consideration set. The likelihood of being in the choice set is derived subsequently. Finally, a parsimonious choice model is derived recognizing the probabilistic nature of the choice set. These formal concepts are operationalized using utility model (1) with the random component having a Type-1 Extreme Value distribution (i.e., identical to those underlying McFadden's multinomial logit).

**Stage 1:**

The brands that will be considered on an ongoing basis are identified using a sequential sampling process which balances consumption utility and evaluation cost, as formalized by Hauser and Wernerfelt (1990). They suggest that a brand will be added (deleted) if the expected maximum utility of choosing from \((n + 1)\) brands minus the expected maximum utility of choosing from \(n\) brands exceeds (does not exceed) the additional cost of evaluating this additional brand. Specifically, the \((n + 1)^{th}\) brand is added if

\[ E[\max(n + 1)] - E[\max(n)] \geq d_{n+1}. \]  

where \(E\) is the expectations operator, \(\max(n)\) denotes the maximum utility which could be derived from choosing among \(n\) brands, and \(d_{n+1}\) denotes the cost of evaluating the \((n+1)^{th}\) brand. Using similar arguments, dropping a brand from the consideration set is a result of
E[\max (n)] - E[\max (n - 1)] \leq d_n.

More specifically, we start with a consideration set from t - 1 of size n (where n < m, m being the total number of brands in J). All other (m - n) brands are candidates to enter the consideration set at time t; all n brands in the consideration set are candidates to leave at time t. The sequence in which brands will be added or dropped depends on the incremental benefit, or the left side of equation (3). For brands not yet included, this means the incremental benefit to be realized by adding the brand to those already in the set. For those brands currently in the set, this means the incremental benefit over that of the other (n-1) brands in the set. For brands not yet in the consideration set, the sequence of processing moves from the brand with the highest incremental benefit to the one with the lowest. In contrast, for those brands already in the set, the sequence moves from the brand with the lowest incremental benefit to the brand with the highest, since the weakest brands are the most likely to be dropped at an early time. To determine whether an add or a drop decision will be made, the incremental benefit of the brands currently in the set is subtracted from the maximum incremental benefit of all brands, either in or out of the set. These differences are then compared to the incremental benefits of the potential entrants to determine the largest value. If a new brand has the largest value, it is considered for inclusion in the set. If an existing brand has the largest value, it is considered for deletion.

The implication of this procedure is that the consideration set can expand and contract over time with good brands entering and tending to stay in. The sequence of deliberation is similar in spirit to that of Hauser and Wernerfelt (1990), but is different from that of Roberts and Lattin (1990). Their process starts at every point in time with an empty consideration set, and brands are evaluated for entry in sequence of descending utility using inequality (3) with a fixed decision cost. In contrast to the process described above, this approach does not allow for a full characterization of the dynamics of the consideration set as the consumer searches for information.

In order to operationalize the rule in (3), the distribution of the maximum utility and the decision cost of evaluating an additional brand need to be derived. Maintaining the same distributional assumptions as above (i.e., \( \mu_{ij} \) is distributed according to a Type-1 Extreme Value distribution), the probability density function of the random utility component in (1) equals

\[
p(\mu_{ij}) = \exp[-\mu_{ij} - \exp(-\mu_{ij})] \quad \text{for all } j.
\]
The characteristics of this distribution are described in Johnson and Kotz (1970, Chapter 21). In the utility domain, we have

\[ p(U_{ij}) = \exp \left[ - (U_{ij} - V_{ij}) - \exp (- (U_{ij} - V_{ij}))) \right] \quad \text{for all } j \]

with terms as defined in (1). The corresponding cumulative density equals

\[ F_j(x) = \exp \left[ - \exp (- (x - V_{ij})) \right] . \]

Accordingly, the cumulative density of the maximum utility given \( n \) brands which are considered on an ongoing basis equals

\[
F_{\text{max},i}(x) = \prod_{j=1}^{n} F_j(x) \\
= \exp \left[ - \sum_{j=1}^{n} \exp (- (x - V_{ij})) \right] \\
= \exp \left[ - \exp (- x) a_i \right]
\]

with \( a_i = \sum_{j=1}^{n} \exp (V_{ij}) \). Note that \( a_i \) equals the numerator of the choice probabilities in a traditional multinomial logit model of choice.

If now \( a_i = \exp b_i \), then \( b_i = \ln a_i \), or

\[ b_i = \ln \left( \sum_{j=1}^{n} \exp (V_{ij}) \right) . \]

Accordingly,

\[ F_{\text{max},i}(x) = \exp \left[ - \exp (- (x - b_i)) \right] \]

which shows that the cumulative density of the maximum utility is the cumulative density of a Type-1 Extreme Value distribution with modal value equal to \( b_i \). This derivation is consistent with the results derived in Ben Akiva and Lerman (1985).

Given that the mean of the Type-1 Extreme Value distribution is a constant (Euler's constant) away from the modal value, the left side of the rule in (3) can be expressed as

\[ E[\text{max}(n+1)] - E[\text{max}(n)] = b_i(n+1) - b_i(n) \]
where $b_i(n+1)$ denotes the modal value for the maximum density in (4) over $(n+1)$ brands. Hence,

$$E[\max (n+1)] - E[\max (n)] = \ln \sum_{j=1}^{n+1} \exp (V_{ij})$$

which in a multinomial logit sense equals the log of the odds ratio of selecting any brand from a set of $n$ versus selecting it from a set of $(n+1)$ brands. Note that the ratio is invariant up to an additive constant just as utilities defined in (1) are determined up to an additive constant.

The decision cost $d_{n+1}$ in (3) can be operationalized using the "cost of thinking" framework described in Shugan (1980). Shugan (1980) postulates that the cost of evaluating different alternatives against one another is directly proportional to the perceptual complexity in comparing alternatives, and is inversely related to both the difference in preference between the alternatives and the confidence at which the selection must be made. Specifically, Shugan suggests that individual $i$'s potential cost of comparing two brands $j$ and $k$ equals

$$f_p = \frac{\text{Var}(U_{ij}) + \text{Var}(U_{ik})}{(1 - \alpha)[E(U_{ij}) - E(U_{ik})]^2}$$

where $\alpha$ denotes the confidence level at which the selection must be made. In a behavioral sense, $\alpha$ can be interpreted as a measure of involvement. Given the random utility assumptions made above, it can be shown that

$$f_p = \frac{2 \beta}{(1 - \alpha)[V_{ij} - V_{ik}]^2}$$

where $\beta$ denotes the constant variance of the Type-1 Extreme Value distribution (see Johnson and Kotz 1970, p. 278). One of the implications of the constant variance is that the scale invariance of Shugan's (1980) general results has been lost.

Following the arguments of Shugan (1980) where the cost of evaluation is independent for each alternative, the cost of evaluating the additional brand can then be expressed as
\[ d_{n+1} = \frac{2 \beta}{(1 - \alpha)} \sum_{j \neq n+1} \frac{1}{(V_{ij} - V_{in+1})^2}. \]

Moreover, the decision to add the \((n + 1)\)th brand to the consideration set would depend on the inequality

\[
\ln \left( \frac{\sum_{i=1}^{n+1} \exp(V_{ij})}{\sum_{j=1}^{n} \exp(V_{ij})} \right) \frac{2\beta}{(1-\alpha)} \sum_{j=n+1} \frac{1}{(V_{ij} - V_{in+1})^2}. \tag{5}
\]

Dropping the \((n+1)\)th brand already belonging to the consideration set would depend on the reverse inequality. Hence, with the add/drop sequence as discussed above, one proceedes until a change in the consideration set occurs (either a drop or an add depending on the inequality); at that point the incremental benefits are recalculated on the basis of the new set configuration and a new sequence is determined. One then proceeds through the new sequence until no changes occur and the composition of the consideration set \(C\) at time \(t\) is defined. A numerical example illustrating the process is discussed in Appendix A.

Note that the right hand side of equation (5), the decision cost, has a number of appealing properties. First, as the level of involvement increases, the factor \((1 - \alpha)\) decreases and hence, decision costs increase. Accordingly, lower involvement makes the consideration set expand. This is consistent with Sherif and Hovland's (1964) notion that the latitude of acceptance expands with low levels of involvement (Assael 1984, p. 95). Second, the more dissimilar the brands (in terms of deterministic utility), the lower the decision cost. One could argue that the decision cost is limited because of the ease of discrimination. Moreover, the directional properties of the decision cost components are theoretically appealing.

**Stage 2:**

When a brand enters the consideration set \(C\), it will raise the maximum utility the consumer can derive from selecting a brand among those belonging to the set. That maximum represents in an aggregate or composite sense how well the consumer could do utility wise if a choice had to be made at this time. It is argued here that this maximum forms a reference point against which the consumer will evaluate individual brands at the time of choice (given a specific usage or consumption occasion). In other words, it is argued that the likelihood of seriously evaluating an alternative can be defined as the probability that the
consumption utility of a brand is larger than the maximum utility which could be derived from the brands which are considered on an ongoing basis. Specifically, the probability that individual \( i \) will seriously evaluate brand \( j \), conditional on brand \( j \) being available at the time of choice, is defined as

\[
P_i (j \in M) = \text{Prob.}(U_{ij} > b_i)
\]

or

\[
P_i (j \in M) = \text{Prob.}(\mu_{ij} > b_i - V_{ij})
\]

where \( b_i \) denotes the modal value of the maximum density in (4), and \( M \) denotes the choice set. The modal value is used on the basis of (a) the skewed nature of the underlying distribution, (b) analytic simplicity, and (c) the fact that the mean is a constant away from the modal value. Furthermore, it makes intuitive sense to use the most likely value of the maximum as the benchmark for comparison. Moreover,

\[
P_i (j \in M) = 1 - \exp[-\exp(-b_i - V_{ij})]
\]

with \( b_i = \ln \left[ \sum_{j \in C} \exp(V_{ij}) \right] \) as defined above. A graphical representation of this probability is shown in Figure 1.

This probability of belonging to the choice set has a number of interesting properties. Consider, for example, the special case where the deterministic utility component for all \( m \) brands currently in the consideration set \( C \) is identical, or \( V_{ij} = V_i \) for all \( j \in C \). Accordingly,

\[
b_i = \ln n + V_i,
\]

Moreover,

\[
P_i (j \in M) = \text{Prob.}(\mu_{ij} > \ln n) = 1 - [1/\exp(1/n)].
\]

This relationship indicates that as the size of the consideration set increases, the probability of evaluation decreases. In other words, as more brands are in the consideration set, it becomes more difficult for a new one to enter the choice set unless its consumption utility is substantially high (and, hence, it replaces an alternative in the consideration set). This illustrates the notion of differential advantage which argues that a new brand entering an
established market will get attention and do well when it is perceived to be significantly superior to existing brands on relevant dimensions. The result also highlights an order-of-entry effect. If brands have identical utilities, the likelihood of belonging to the choice set is larger for brands which enter early because they are more likely to be in the consideration set. Although not pursued further here, the consideration set formation process outlined above offers an interesting avenue for studying order of entry effects and first-mover advantages.

Note, furthermore, that the derivative of $P_i (j \in M)$ in (6) with respect to $b_i$ is clearly negative. Accordingly, anything which increases the modal value of the maximum will reduce the likelihood of belonging to the choice set for later brands. Analytic results in Appendix B show that this likelihood increases with:

(a) a decrease in the number of brands in the consideration set;
(b) a decrease in the mean and variance of the utilities of the brands in the consideration set; and
(c) an increase in the uncertainty or noise in the utility distributions.

Some interesting strategic conclusions could be drawn from these results. For example, condition (c) implies that a possible strategy for a new brand entering an established market could be to create noise or even question the brand evaluations made by consumers. In this instance, the likelihood of the new entrant being in the choice set would be enhanced irrespective of whether it has a significant differential advantage.

Note that the likelihood that a brand will be in the choice set is conditional on it being available at the time of choice. In other words, the probability $P_i (j \in M)$ in (6) can be interpreted as the joint likelihood of (a) brand $j$ being available for selection to consumer $i$ and (b) the utility of brand $j$ being larger than the model value of the maximum density in (4). For simplicity, availability is modeled here discretely as a zero/one variable indicating whether or not consumer $i$ has the option to select brand $j$ at the time of choice. A more explanatory model could conceivably be developed recognizing store choice behavior and out-of-stock patterns.

Stage 3

The probabilistic definition of the choice set can be integrated in model (2), and the probability that consumer $i$ will choose available brand $j$ becomes
Type 1 Extreme Value
Probability Density Function

Figure 1
Likelihood of Belonging to the Choice Set \( P_i (j \in M) \)

Mean
(\text{Euler's constant} = 0.577)
The choice probabilities derived from model (7) have some interesting and intuitively appealing characteristics. To illustrate, we return to the numerical example described in Appendix A. At the current time t, there are 5 brands in the market; brand 5 is a new entrant and is similar to brand 4 (i.e., $V_4 = V_5 = 5$). At (t - 1) the consideration set contained brands one and four; at t the consideration set becomes only brand three as shown in Appendix A. The probabilities of choice at t, assuming all brands are available, are shown in Table 2. For comparison purposes, we also show the probability values obtained from the traditional multinomial logit model. Furthermore, we make a distinction between the situation where brand 5 has been introduced versus when it has not so we can comment on the probability shifts given a new entrant.

The result of incorporating consideration set formation is rather evident. By comparing results across the two models, we see that brands in the consideration set have higher choice probabilities in the CONPRO*DOGIT model, whereas brands not in the consideration set have much lower choice probabilities than those of the traditional logit model. Corresponding with intuition, being a standard or benchmark for comparison (and, hence, being considered on an ongoing basis) raises the likelihood of being chosen.

The shifts in the probabilities given the new entrant illustrate the absence of the independence of irrelevant alternatives (IIA property). The IIA property which characterises many choice models (including the logit model) implies that "... when a new brand or service is introduced, it obtains market share proportional (according to overall utility) from all other brands or services, regardless of substitutability" (Currim 1982, p. 209). This proportionality is clearly visible in the logit probabilities with each of them dropping 4% as brand 5 is introduced. A different pattern characterises the CONPRO* DOGIT probabilities: the only choice probability to drop significantly is that of the dominant brand. That brand is also the only member of the consideration set. Although the new entrant does cannibalise the dominant brand, the latter's probability of choice remains substantially larger than in the logit case. These results seem to be in line with the asymmetric dominance effect shown in Huber, Payne, and Puto (1982) where a new alternative does not necessarily hurt the more similar one.
The IIA property also imposes the constraint that the ratio of choice probabilities for any two brands is invariant with respect to the existence or non-existence of other brands (Corstjens and Gautschi 1983, p. 26). This is clearly not the case in the probabilities derived from the CONPRO*DOGIT model. The origin of this lies in the probabilities of each brand being in the choice set (i.e., $P (l \in M)$ for all $l$ in (7)). An aspect of similarity is incorporated in generating the consideration set as described above; brand similarity/dissimilarity is often used to illustrate the unappealing character of IIA. The similarity can enter on either side of the inequality regulating entrance and exit from the consideration set. Incremental benefit (i.e., left side of inequality) might increase with dissimilarity; by the same token, brand similarity can reduce decision costs (i.e., right side of inequality) because of evaluation economies. Hence, despite the independence utility assumption often considered the origin of IIA (Currim 1982), the CONPRO* DOGIT model shown in (7) does not exhibit the characteristics often associated with this unappealing property.

DOMINANCE VERSUS PORTFOLIO UTILITY

The deterministic utility component $V_{ij}$ in the basic utility function (1) has been the singular explanatory component incorporated in the consideration set (and, hence, choice set) formation process and in the final choice process (among the available brands belonging to the choice set $M$). For several reasons, it might be more realistic and appropriate to make a distinction between the explanatory variables of the two processes. First, the objective of each process is different. As discussed above, the brands in the consideration set are reference points or benchmarks for their product category; they are evaluated on a continuous basis as being representative for that category. At the time of choice (in a specific store environment having a particular consumption or usage occasion in mind), the objective is selection of a single brand. Hence, the consideration set formation process has as objective the identification of a set of brands spanning in some representative manner the product category to which they belong. The choice process has as objective the selection of a single, preferred brand. As people will focus their comparisons at levels most relevant to their ultimate satisfaction (Corfman 1991), consideration set comparisons and actual choice comparisons are likely to imply different levels of abstraction.

Second, the perspective taken by the individual is different for the two processes, which implies rather different uncertainties. The choice process results in the terminal state of a brand being selected. Expectations or anticipations of future value or utility do not play a
significant role; given a specific usage or consumption occasion, the individual makes the evaluation at the point of purchase and a brand is selected. In the consideration set formation process, in contrast, future uncertainties play an extensive role. In defining "representativeness" of certain brands for a product category, an individual consumer will take into account possible future usage and consumption occasions. Although he might find little use for a brand with a specific attribute profile at this point in time, the consumer might well incorporate that brand into his consideration set as he anticipates a possible usefulness in the future. Hence, the consideration set formation process actively incorporates future usage or consumption expectations and as such is much more long term; choice incorporates only a specific (and not too distant) usage or consumption occasion as a constraint on the evaluation criterion and, as such, is much more short term.

Third, the constraints in the two processes are quite different. Choice is merely limited by budget, availability, and a specific usage or consumption occasion. The whole process is then played out within a specific store environment over a very short time period. The consideration set formation process has different constraints. It probably develops more slowly over time and is concerned with representation given future usage or consumption occasions. Hence, for example, budget might be less of an issue.

In an explanatory sense, the appropriateness of making a distinction between the two processes is further supported by considering specific factors that might influence one but not the other. For instance, television advertising might play an important role in the formation of consideration sets, but most likely plays a minor role when the consumer makes an actual choice in a specific store environment. On the other hand, in store promotions, end-of-aisle displays, etc. are likely to play a dominant role in the actual choice ("the moment of truth"), and feature less in the consideration set formation process. Interpreting experimental results, Nedungadi (1990) points to the separate roles of brand consideration and brand evaluation in any choice process. In line with the argument developed here, he concludes that external factors might have important and quite separate influences on the brand-consideration stage than on the evaluation (or choice) stage (Nedungadi 1990, p. 274).

To capture these differences, we make a distinction between the utility function underlying the process of choice set formation, and the utility function underlying actual choice. We refer to these as "portfolio" utility and "dominance" utility to indicate their roles (and the roles of their explanatory variables) in the consideration set formation and choice processes. With this difference, the modeling process described above, in contrast to the work in Hauser and Wernerfelt (1990) and in Roberts and Lattin (1990), implicitly recognizes the
## Table 2
Numerical Example of Choice Probabilities<sup>a</sup>

<table>
<thead>
<tr>
<th>Brand</th>
<th>Utility</th>
<th>Multinomial Logit</th>
<th>CONPRO * DOGIT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Without New Brand</td>
<td>With New Brand</td>
</tr>
<tr>
<td>1</td>
<td>6</td>
<td>0.1140</td>
<td>0.1094</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0.0021</td>
<td>0.0020</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>0.8420</td>
<td>0.8082</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>0.0419</td>
<td>0.0402</td>
</tr>
<tr>
<td>5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5</td>
<td>0.0402</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Choice probabilities for numerical example developed in Appendix A; at time (t-1), C = {1, 4} and at time t (given utilities in the table) C = {3} as shown in Appendix A.

<sup>b</sup> Brand 5 is considered as a new entrant with utility identical to the existing brand 4.
dynamic character of the consideration set both within and across usage occasions (Shocker et al. 1991) and, at the choice set level, it captures usage-driven heterogeneity.

Stated analytically, the distinction between dominance and portfolio utility provides choice probabilities equal to (from expression (7)):

$$
\Pr_{ij} = \frac{[\exp(V_{ij})][1 - \exp[-(b_i - \bar{V}_{ij})]]}{\sum_{k \in J} [\exp(V_{kj})][1 - \exp[-(b_k - \bar{V}_{kj})]]}
$$

with $b_i = \ln \left[ \sum_{i \in C} \exp(\bar{V}_{ij}) \right]$ where $V_{ij}$ (for all $j \in J$) denotes the "dominance" deterministic utility component, and $\bar{V}_{ij}$ (for all $j \in J$) denotes the "portfolio" deterministic utility component for brand $j$.

The portfolio utility affects the likelihood of a brand being evaluated on an ongoing basis. In the tradition of operationalising deterministic utility components as linear additive functions, the $\bar{V}_{ij}$ component would consist of explanatory variables which affect the likelihood of a brand entering the consideration set. The dominance utility captures how one brand dominates another; $V_{ij}$ would consist of explanatory variables capturing that dominance. The implications of this distinction and the resulting characteristics of the proposed choice model are studied analytically next.

**DIRECT AND CROSS ELASTICITY PATTERNS**

An insightful avenue into the characteristics of the model and the role of the consideration set is to study direct (self) and cross-elasticity patterns. These patterns are dependent on (a) whether the decision variable (e.g., price) affects dominance utility, portfolio utility, or both, and (b) whether or not the brand belongs to the consideration set. We investigate here the short-term price elasticities with some simple but common linear utility functions (Allenby and Rossi 1991). Similar results could be derived for other decision variables affecting response. Hence, the price variable was selected for illustrative purposes, but the general pattern of results and the insights they provide can be directly extended to other decision variables.

When price affects dominance utility, we postulate (suppressing individual and time subscripts for notational convenience)
\[ V_j = \beta_o - \beta_p \ln p_j \]

with \( \beta_o, \beta_p > 0 \), where \( p_j \) is the price of brand \( j \) at one point in time, and \( \beta_o \) and \( \beta_p \) are model parameters. Alternatively, when price affects portfolio utility, we postulate

\[ \overline{V}_j = \alpha_o - \alpha_p \ln p_j \]

with \( \alpha_o, \alpha_p > 0 \). With these simple functions, direct and cross price elasticities can be derived. All algebraic derivations are contained in Appendix C. The resulting short-term price elasticities are summarised in Table 3.

Panel A of Table 3 shows the direct and cross elasticities when price only affects dominance. In this instance, price does not affect the consideration set formation; its influence is confined to the direct comparison of brands at the time of choice. Not surprisingly, the analytic expressions of the short-term elasticities are identical to those which could be derived from a traditional multinomial logit model (Allenby and Rossi 1991). However, as demonstrated numerically above, the choice probabilities predicted by the CONPRO* DOGIT model are more polarised than those predicted by the multinomial logit model; i.e., brands in the consideration set see their choice probabilities enhanced where those not belonging to the consideration set see their choice probabilities diminished. The differences in magnitude of the choice probabilities together with the results in Panel A imply some interesting patterns. First, brands which belong to the consideration set will have smaller - in absolute value - direct price elasticities (i.e., the factor \((P_i - 1)\), where \( P_i \) denotes the probability of choice for brand \( i \), is smaller in CONPRO*DOGIT than in the multinomial logit). By the same token, brands not belonging to the consideration set will be characterized by a relatively more price sensitive choice share. Second, the cross price elasticities for brands belonging to the consideration set with respect to price moves by brands not belonging to the consideration set are smaller. Hence, the CONPRO* DOGIT model suggests that brands belonging to the consideration set are somewhat shielded from their own price moves and those of other brands not part of the consideration set. However, brands belonging to the consideration set become somewhat more vulnerable to price moves by other brands in the consideration set. For example, the cross price elasticity of brand \( j \)'s choice relative to brand \( i \)'s price (\( i \) and \( j \) both belonging to the consideration set) equals

\[ \frac{\partial \ln P_j}{\partial \ln p_i} = \beta_p P_i \cdot \]
Given the polarization effect of the choice probabilities implied by the choice model derived here relative to the multinomial logit, $P_i$ will be larger since brand $i$ belongs to the consideration set; hence the magnitude of the cross elasticity will be relatively larger with the increased vulnerability directly proportional to the choice shares. This is a direct result from the fact that price is only affecting dominance utility. In sum, relative to the response patterns captured in the traditional logit model, the consideration set notion incorporated in CONPRO* DOGIT gives a brand which belongs to the consideration set extra protection against short-term tactical moves by competitors whose brands do not belong to the consideration set (and, hence, are not evaluated on a continuous basis). Its direct price elasticities are smaller in absolute value suggesting a lower price sensitivity which perhaps can be interpreted as an "equity" effect of belonging to the consideration set. There is, however, a relatively stronger vulnerability to price moves by other brands belonging to the consideration set with that vulnerability directly proportional to the brands choice share in the market.

Panel B of Table 3 shows the direct and cross price elasticities when price affects portfolio utility. Here, the price impacts directly on the formation of the consideration set. Only in a single instance do we observe a result analytically similar to the corresponding result in Panel A (and, hence, the traditional multinomial logit model elasticity expressions). This instance is described by neither brand belonging to the consideration set, which is intuitively reasonable. In all other instances, the expressions are more complicated. A number of interesting patterns can nevertheless be identified.

Focusing on the direct price elasticities in Panels A and B, it is easily shown that (assuming for the moment $\beta_p = \alpha_p$)

$$\beta_p (P_i - 1) > \alpha_p \delta_i (P_i - 1) \left[ \frac{1 - F(i \in M)}{P(i \in M)} \right]$$

since $\delta_i$, as defined in Appendix C, and the term in square brackets both are fractions. Hence, the direct price elasticity of a brand not belonging to the consideration set is higher when price influences portfolio rather than dominance. Other comparisons between corresponding entries in Panels A and B of Table 3 are more conditional and, hence, do not allow general statements on the differential impact of price on dominance versus portfolio utilities.

Comparing results within Panel B, we can draw the following unconditional conclusions on vulnerability: if the brand which makes the price move belongs to the consideration set, the
Table 3

Direct and Cross Price Elasticity Patterns\textsuperscript{a}

A. Price Only Affects Dominance

<table>
<thead>
<tr>
<th>Price</th>
<th>Choice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$i \in C$</td>
</tr>
<tr>
<td>$i \in C$</td>
<td>$\beta_p[P_i - 1]$</td>
</tr>
<tr>
<td>$i \notin C$</td>
<td>-</td>
</tr>
<tr>
<td>$j \in C$</td>
<td>$\beta_p P_j$</td>
</tr>
<tr>
<td>$j \notin C$</td>
<td>$\beta_p P_j$</td>
</tr>
</tbody>
</table>

C = consideration set; M = choice set; $P_i$ denotes the probability of choice for brand $i$. 
### Table 3 (Cont'd)

#### Direct and Cross Price Elasticity Pattern

**B. Price Only Affects Portfolio**

<table>
<thead>
<tr>
<th>Price</th>
<th>( i \in C )</th>
<th>( i \notin C )</th>
<th>( j \in C )</th>
<th>( j \notin C )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \delta_1 )</td>
<td>( \alpha_i P_i \sum_{k \in I} \frac{P(0 \notin M)}{P(0 \in M)} [\beta_k \cdot \gamma_0 \cdot \frac{1}{P_i}] )</td>
<td>( \alpha_i P_i \sum_{k \in I} \frac{P(0 \notin M)}{P(0 \in M)} )</td>
<td>( \alpha_i P_i \sum_{k \in I} \frac{P(0 \notin M)}{P(0 \in M)} [\beta_k \cdot \gamma_0 \cdot \frac{1}{P_i}] )</td>
<td>( \alpha_i P_i )</td>
</tr>
<tr>
<td>( \delta_2 )</td>
<td>( \alpha_i P_i \sum_{k \in I} \frac{P(0 \notin M)}{P(0 \in M)} )</td>
<td>( \alpha_i P_i \sum_{k \in I} \frac{P(0 \notin M)}{P(0 \in M)} )</td>
<td>( \alpha_i P_i \sum_{k \in I} \frac{P(0 \notin M)}{P(0 \in M)} [\beta_k \cdot \gamma_0 \cdot \frac{1}{P_i}] )</td>
<td>( \alpha_i P_i )</td>
</tr>
<tr>
<td>( \delta_3 )</td>
<td>( \alpha_i P_i \sum_{k \in I} \frac{P(0 \notin M)}{P(0 \in M)} [\beta_k \cdot \gamma_0 \cdot \frac{1}{P_i}] )</td>
<td>( \alpha_i P_i \sum_{k \in I} \frac{P(0 \notin M)}{P(0 \in M)} )</td>
<td>( \alpha_i P_i \sum_{k \in I} \frac{P(0 \notin M)}{P(0 \in M)} [\beta_k \cdot \gamma_0 \cdot \frac{1}{P_i}] )</td>
<td>( \alpha_i P_i )</td>
</tr>
</tbody>
</table>

\[ \delta_k = \exp(V_k) / \left[ \sum_{i \in I} \exp(V_i) \right] \] for all \( k \); \( \gamma_k = 1 \) when \( k = i \), and \( \gamma_k = 0 \) otherwise for all \( i \) and \( k \).
effect on the choice probabilities for other brands is identical irrespective of whether they belong to the consideration set. If the brand which makes the price move does not belong to the consideration set, then the cross price elasticities are smaller for brands that do belong to the consideration set than for those that do not belong to the consideration set. Hence, when price effects the portfolio utility of brands, a brand's choice will be partially shielded from price moves by competitive brands which do not belong to the consideration set.

Moreover, a comprehensive set of results can be derived which give insight into the role of the consideration set notion. Their intuitive nature adds credence to the suggested modeling structure and warrants further research.
CONCLUSION AND FUTURE RESEARCH

In this paper, an individual level choice model was developed for the utility maximizing consumer recognizing explicitly in a compensatory sense the use of heuristics to confine consideration, evaluation and choice to a subset of alternatives. Building on traditional random utility assumptions and considering a sequential choice paradigm, a rational consideration set formation process is operationalized. A probabilistic definition of choice set based on the discrete outcome of the consideration set formation process is integrated in a parsimonious representation of choice.

In contrast to previous modeling attempts, the dynamics of expansion and contraction of the consideration set are explicitly recognized. Furthermore, the operationalization of the consideration set formation process is assumed to be driven by a portfolio utility which is different from the dominance utility driving selection at the time of choice. Algebraic results which are intuitively appealing clarify the role of the consideration set notion in this framework. The results suggest that competitive interactions among brands within the consideration set are different from both the competitive interactions among brands not belonging to the consideration set and the competitive interactions between brands in the consideration set and those not in the consideration set (i.e., interactions across both sets of brands). On the latter, the results established a reduced vulnerability of brands in the consideration set to competitive moves from those not in the consideration set.

The parsimonious nature of the model and the intuitive insights it provides warrant further research. Further analytic work is needed on the rational consideration set formation process. The operationalization of the decision costs as suggested by Shugan (1980) should be developed further addressing (a) the problem of scale variance arising from the distributional assumptions, (b) the existence of search economies throughout the formation process, and (c) inertia effects which could give rise to an asymmetry in decision costs between entry and exit decisions. Further modeling work is also possible on the element of brand availability which was incorporated here as a zero-one variable in defining the choice set.

Extensive empirical work is warranted. The specification and measurement of the variables contributing to the dominance and portfolio utilities need to be developed. The model structure provides some unique opportunities to integrate long-term effects arising, for example, from advertising into the consideration set formation process along with the short-term effects more traditionally integrated in empirically-validated choice models.
The estimation and validation of the model also provides a challenge. Integrating a consideration set formation process into a choice model adds a dimension of complexity to the heterogeneity issue. Furthermore, estimation approaches which integrate external information on consideration sets (as in Roberts and Lattin 1990) need to be validated against possible iterative approaches which consider consideration sets endogenously. Despite the extensive future work still needed, this paper has contributed an initial and promising model structure which provides a basis for that research.
FOOTNOTES

1. A more extensive review of the literature pertaining to consideration sets and search heuristics is provided in Roberts and Lattin (1990) and Shocker et. al. (1991).

2. This is also rather evident from the derivation of $P (l \in M)$ for all $l$; this probability is a function of other alternatives through $b = \ln \sum_{k \in C} \exp (V_k)$. 
REFERENCES


Appendix A: Numerical Example of Consideration Set Formation Process

Assume the deterministic utility values for 5 brands (m = 5) at time t are, respectively,

\[
\begin{align*}
V(1) &= 6 \\
V(2) &= 2 \\
V(3) &= 8 \\
V(4) &= 5 \\
V(5) &= 5
\end{align*}
\]

Furthermore, the composition of the consideration set at t - 1 is: 1 0 0 1 0, or \{1, 4\} (and, hence, n = 2). The level of confidence (involvement) is set at \( \alpha = 0.5 \).

Accordingly, we can compute the incremental benefits (add decisions) and the relative incremental benefits (drop decisions):

<table>
<thead>
<tr>
<th>C (I)</th>
<th>( \exp(V(I)) )</th>
<th>Incremental Benefit</th>
<th>Max - Incremental Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V(1) = 6</td>
<td>1</td>
<td>403.43</td>
<td>( \ln (1 + 2.7183) = 1.3133 )</td>
</tr>
<tr>
<td>V(2) = 2</td>
<td>0</td>
<td>7.39</td>
<td>( \ln (1 + 0.0134) = 0.0133 )</td>
</tr>
<tr>
<td>V(3) = 8</td>
<td>0</td>
<td>2980.95</td>
<td>( \ln (1 + 5.4018) = 1.8566 )</td>
</tr>
<tr>
<td>V(4) = 5</td>
<td>1</td>
<td>148.41</td>
<td>( \ln (1 + 0.3679) = 0.3133 )</td>
</tr>
<tr>
<td>V(5) = 5</td>
<td>0</td>
<td>148.41</td>
<td>( \ln (1 + 0.2689) = 0.2382 )</td>
</tr>
</tbody>
</table>

Hence, the derived sequence of consideration is: 3 (add), 4 (drop), 1 (drop), 1 (drop), 5 (add), 2 (add).

Outcome: 3 cannot be added (incremental benefit < decision cost) (1.8566 < 2.3760)
4 dropped (relative incremental benefit < decision cost) (1.5433 < 6.5798)

With the new consideration set configuration, we have

<table>
<thead>
<tr>
<th>C (I)</th>
<th>Incremental Benefit</th>
<th>Max-Incremental Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>V(1) = 6</td>
<td></td>
<td>( \ln (1 + 403.43) = 6.0025 )</td>
</tr>
<tr>
<td>V(2) = 2</td>
<td>0</td>
<td>( \ln (1 + 0.0183) = 0.0182 )</td>
</tr>
<tr>
<td>V(3) = 8</td>
<td>0</td>
<td>( \ln (1 + 7.3890) = 2.1269 )</td>
</tr>
<tr>
<td>V(4) = 5</td>
<td>0</td>
<td>( \ln (1 + 0.3679) = 0.3133 )</td>
</tr>
<tr>
<td>V(5) = 5</td>
<td>0</td>
<td>( \ln (1 + 0.3679) = 0.3133 )</td>
</tr>
</tbody>
</table>

The sequence of consideration now is 3 (add), 4 (add), 5 (add), 2 (add), 1 (drop).
Outcome: 3 added (incremental benefit = 2.1269 > decision cost = 1.6450).

For the new consideration set configuration, we obtain

<table>
<thead>
<tr>
<th>( C(I) )</th>
<th>Incremental Benefit</th>
<th>Max-Incremental Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( V(1) = 6 )</td>
<td>1</td>
<td>( \ln (1 + 0.1353) = 0.1269 )</td>
</tr>
<tr>
<td>( V(2) = 2 )</td>
<td>0</td>
<td>( \ln (1 + 0.0022) = 0.0022 )</td>
</tr>
<tr>
<td>( V(3) = 8 )</td>
<td>1</td>
<td>( \ln (1 + 7.3890) = 2.1269 )</td>
</tr>
<tr>
<td>( V(4) = 5 )</td>
<td>0</td>
<td>( \ln (1 + 0.0439) = 0.0429 )</td>
</tr>
<tr>
<td>( V(5) = 5 )</td>
<td>0</td>
<td>( \ln (1 + 0.0439) = 0.0429 )</td>
</tr>
</tbody>
</table>

The derived sequence of consideration becomes: 1 (drop), 4 (add), 5 (add), 2 (add), 3 (drop).

Outcome: 1 dropped (incremental benefit = 0.1269 < decision cost = 0.2500).

No brand can be added or dropped subsequently, and the final composition of the consideration set is: 0 0 1 0 0, and hence = \{3\}.
Appendix B: Likelihood of Serious Evaluation (Pᵢ (j ∈ E))

The effect of consideration set size, variance and mean of utilities on likelihood of evaluation can be assessed as follows. By definition,

\[ b_i = \ln \left( \sum_{j \in C} \exp (V_{ij}) \right). \]

Using a Taylor expansion, \( b_i \) is approximately equal to

\[ b_i \approx \ln \left[ \frac{n + n \bar{V}_i + (1/2) \sum_{j \in C} V_{ij}^2}{n} \right] \quad (B-1) \]

given \( n \bar{V}_i = \sum_{j \in C} V_{ij} \) where \( n \) denotes the number of brands in the consideration set.

Furthermore,

\[ \sum_{j \in C} V_{ij}^2 = n S_i^2 + n \bar{V}_i \]

with \( S_i^2 = \sum_{j \in C} (V_{ij} - \bar{V}_i)^2 / n. \)

Moreover, expression (B-1) becomes

\[ b_i \equiv \ln n \left[ 1 + \bar{V}_i + (1/2) \bar{V}_i + (1/2) S_i^2 \right]. \]

Taking partial derivatives, we obtain

\[ \frac{\partial b_i}{\partial n} = \frac{1}{n} \]

which is always larger than zero.
Furthermore,
\[ \frac{\partial b_i}{\partial V_i} = \frac{(1 + \bar{V}_i)}{\left[ 1 + \bar{V}_i + (1/2) \bar{V}_i + (1/2) S_i^2 \right]} \]
and
\[ \frac{\partial b_i}{\partial S_i^2} = \frac{1}{2 \left[ 1 + \bar{V}_i + (1/2) \bar{V}_i + (1/2) S_i^2 \right]} \]
which are both positive when \( \bar{V}_i \) is positive.

In sum, all three derivatives are generally positive which together with
\[ \frac{\partial P_i (j \in M)}{\partial b_i} < 0 \]
implies that \( P_i (j \in M) \) decreases as the number of alternatives in the consideration set, their mean utility value, and the variance in their utilities increases.

The effect of uncertainty (or noise) can be assessed by adding an uncertainty parameter to the Type-1 Extreme Value distribution as follows
\[ p (\mu_{ij}) = \Theta_i^{-1} \exp \left[ - \frac{\mu_{ij}}{\Theta_i} - \exp \left( \frac{\mu_{ij}}{\Theta_i} \right) \right] \]
where the variance of the random utility component \( \mu_{ij} \) is proportional to parameter \( \Theta_i \). Hence, larger values of \( \Theta_i \) would indicate increased uncertainty in the consumption utilities. It is straightforward to show that
\[ \frac{\partial P_i (j \in M)}{\partial \Theta_i} > 0 \]
which implies that the likelihood of evaluation increases with increased uncertainty (or noise).
Appendix C: Direct and Cross Price Elasticity Derivations

Dropping the individual subscript $i$ for notational convenience, the basic model in (2) equals

$$p_j = \frac{[\exp (V_j)] P (j \in M)}{\sum_{k \in J} [\exp V_k] P (k \in M)}$$

with $P (j \in M) = 1 \exp [- \exp [-b + \bar{V}_j]]$ and the terms defined as above.

Accordingly,

$$\ln P_j = V_j + \ln P (j \in M) - \ln \sum_{k \in J} [\exp (V_k)] P (k \in M)$$

and, hence, the self elasticity equals

$$\frac{\partial \ln P_j}{\partial \ln p_j} = \frac{\partial V_j}{\partial \ln p_j} + \frac{\partial \ln P (j \in M)}{\partial \ln p_j}$$

and

$$\frac{1}{\sum_{k \in J} [\exp (V_k)] P (k \in M)} \sum_{k \in J} \exp (V_k) \left[ P (k \in M) \frac{\partial V_k}{\partial \ln p_j} + \frac{\partial P (k \in M)}{\partial \ln p_j} \right].$$

Note that

$$\frac{\partial P (j \in M)}{\partial \ln p_j} = [P (j \in M) - 1] \left[ \exp (-b + \bar{V}_j) \right] \frac{\partial b}{\partial \ln p_j} - \frac{\partial \bar{V}_j}{\partial \ln p_j}$$

where $b = \ln \left[ \sum_{i \in C} \exp (\bar{V}_i) \right]$.

(1) **Price only affects dominance utility.**

Accordingly,

$$V_j = \beta_0 - \beta_p \ln p_j, \frac{\partial \bar{V}_j}{\partial \ln p_j} = 0, \frac{\partial b}{\partial \ln p_j} = 0, \text{ and, hence, } \frac{\partial P (j \in M)}{\partial \ln p_j} = 0.$$

In this instance, the self elasticity equals
\[
\frac{\partial \ln P_j}{\partial \ln p_j} = \frac{\partial V_j}{\partial \ln p_j} - \frac{1}{\sum_{k \in J} [\exp (V_k)] \mathbb{P}(k \in M)} \exp (V_j) \left[ \mathbb{P}(j \in M) \frac{\partial V_j}{\partial \ln p_j} \right]
\]

which can be written compactly as

\[
\frac{\partial \ln P_j}{\partial \ln p_j} = \beta_p [P_j - 1].
\]

The cross elasticity equals

\[
\frac{\partial \ln P_j}{\partial \ln p_i} = \frac{1}{\sum_{k \in J} [\exp (V_k)] \mathbb{P}(k \in M)} \exp (V_i) \left[ \mathbb{P}(i \in M) \frac{\partial V_i}{\partial \ln p_j} \right]
\]

which can be expressed compactly as

\[
\frac{\partial \ln P_j}{\partial \ln p_i} = \beta_p P_i.
\]

(2) Price only affects portfolio utility:

Accordingly, \( \bar{V}_j = \alpha_o - \alpha_p \ln p_j \) and \( \frac{\partial V_j}{\partial \ln p_j} = 0. \) We have to make a distinction between whether or not brand \( j \) belongs to the consideration set (i.e., brand \( j \) is evaluated on a continuous basis).

\( A \) \( j \notin C; \) hence, \( \frac{\partial b}{\partial \ln p_j} = 0 \)

In this instance,

\[
\frac{\partial \mathbb{P}(j \in M)}{\partial \ln p_j} = \alpha_p [\mathbb{P}(j \in M) - 1] [\exp (\bar{V}_j - b)].
\]

The self elasticity can then be expressed as

\[
\frac{\partial \ln P_j}{\partial \ln p_j} = \alpha_p [\mathbb{P}(j \in M) - 1] [\exp (\bar{V}_j - b)] \left[ 1 - \sum_{k \in J} [\exp V_k] \mathbb{P}(k \in M) \right]
\]
\[ \frac{1}{P(j \in M)} \alpha_p [P(j \in M) - 1] \exp (\bar{V}_j - b) [1 - P_j], \]

and, hence,

\[ \frac{\partial \ln P_i}{\partial \ln p_j} = \alpha_p \left[ \exp (\bar{V}_j - b) \frac{1 - P(j \in M)}{P(j \in M)} \right] (P_i - 1). \]

For the cross elasticity, we need to consider two cases: \( i \in C \) and \( i \notin C \). We first consider the case where brand \( i \) does not belong to the consideration set (i.e., \( i \notin C \) and, hence, we have the cross elasticity between two brands which do not belong to the consideration set).

\( a \) \( i \notin C \):

Hence \( \frac{\partial b}{\partial \ln p_i} = 0 \) and \( \frac{\partial P(j \in M)}{\partial \ln p_i} = 0 \).

The cross elasticity becomes then

\[ \frac{\partial \ln P_i}{\partial \ln p_i} = - \frac{1}{\sum_{k \in j} \exp V_k} P(i \in M) \left( - \alpha_p \right) \exp (V_i) \]

which can be expressed compactly as

\[ \frac{\partial \ln P_i}{\partial \ln p_i} = \alpha_p P_i. \]

\( b \) \( i \in C \):

In this instance

\[ \frac{\partial P(j \in M)}{\partial \ln p_i} = [P(j \in M) - 1] \exp (- b + \bar{V}_i) \left[ \frac{\partial b}{\partial \ln p_i} \right] \]

with \( \frac{\partial b}{\partial \ln p_i} = \frac{1}{\sum_{i \in C} \exp (\bar{V}_i)} \left( - \alpha_p \right) \).
The cross elasticity equals

\[
\frac{\partial \ln p_j}{\partial \ln p_i} = \frac{1}{P(j \in M)} (\alpha_p) [1 - P(j \in M)] [\exp (\overline{V}_j - b)] \left[ \frac{\exp (\overline{V}_i)}{\sum_{l \in C} \exp (\overline{V}_l)} \right] \\
- \frac{1}{\sum_{k \in I} [\exp (\overline{V}_k)] P(k \in M) \sum_{k \in I} \exp (\overline{V}_k)} \left[ \frac{\partial P(k \in M)}{\partial \ln p_i} \right].
\]

Note that for \( k \neq i \)

\[
\frac{\partial P(k \in M)}{\partial \ln p_i} = \alpha_p [1 - P(k \in M)] [\exp (\overline{V}_k - b)] \left[ \frac{\exp (\overline{V}_i)}{\sum_{l \in C} \exp (\overline{V}_l)} \right]
\]

and for \( k = i \)

\[
\frac{\partial P(i \in M)}{\partial \ln p_i} = P(i \in M) - 1 [\exp (-b + \overline{V}_i)] \left[ - \alpha_p \frac{\exp (\overline{V}_i)}{\sum_{l \in C} \exp (\overline{V}_l)} + \alpha_p \right] \\
= \alpha_p [1 - P(i \in M)] [\exp (\overline{V}_i - b)] \left[ \frac{\exp (\overline{V}_i)}{\sum_{l \in C} \exp (\overline{V}_l)} - 1 \right].
\]

Moreover, the cross elasticity becomes

\[
\frac{\partial \ln p_j}{\partial \ln p_i} = \frac{\alpha_p}{P(j \in M)} [1 - P(j \in M)] [\exp (\overline{V}_j - b)] \left[ \frac{\exp (\overline{V}_i)}{\sum_{l \in C} \exp (\overline{V}_l)} \right] \\
- \frac{\alpha_p}{\sum_{k \in I} [\exp (\overline{V}_k)] P(k \in M) \sum_{k \neq i} [\exp (\overline{V}_k)] [1 - P(k \in M)] [\exp (\overline{V}_k - b)] \left[ \frac{\exp (\overline{V}_i)}{\sum_{l \in C} \exp (\overline{V}_l)} \right]} \\
- \frac{\alpha_p}{\sum_{k \in I} [\exp (\overline{V}_k)] P(k \in M)} [1 - P(i \in M)] [\exp (\overline{V}_i - b)] \left[ \frac{\exp (\overline{V}_i)}{\sum_{l \in C} \exp (\overline{V}_l)} - 1 \right].
\]
With

$$\delta_k = \frac{\exp(\overline{V}_k)}{\sum_{i \in C} \exp(\overline{V}_i)}$$

and \( \gamma_{ik} = 1 \) for \( k = i \)

= 0 otherwise,

the cross elasticity can be expressed compactly as

$$\frac{\partial \ln P_j}{\partial \ln P_i} = \alpha_p \delta_i \sum_{k \in J} \left[ \frac{P_k [P(j \in M) - 1]}{P(k \in M)} \right] \left[ \delta_k (1 - \gamma_k \frac{\gamma_{ik}}{p_j}) \gamma_k \right].$$

\( \exists \) \in \( C \), hence, \( \frac{\partial b}{\partial \ln p_j} \neq 0. \)

In this instance

$$\frac{\partial P(j \in M)}{\partial \ln p_j} = \left[ P(j \in M) - 1 \right] \left[ \exp(\overline{V}_j - b) \right] \left[ \frac{\partial b}{\partial \ln p_j} \frac{\partial \overline{V}_j}{\partial \ln p_j} \right]$$

and, hence,

$$\frac{\partial P(j \in M)}{\partial \ln p_j} = \alpha_p \left[ 1 - P(j \in M) \right] \left[ \exp(\overline{V}_j - b) \right] \left[ \frac{\exp(\overline{V}_j)}{\sum_{i \in C} \exp(\overline{V}_i)} - 1 \right].$$

The self elasticity equals

$$\frac{\partial \ln P_j}{\partial \ln P_j} = \frac{\alpha_p \left[ 1 - P(j \in M) \right] \left[ \exp(\overline{V}_j - b) \right]}{P(j \in M)} \left[ \frac{\exp(\overline{V}_j)}{\sum_{i \in C} \exp(\overline{V}_i)} - 1 \right]$$

\(- \frac{1}{\sum_{k \in J} \left[ \exp(\overline{V}_k) \right]} \sum_{k \in J} \left[ \exp(\overline{V}_k) \right] \frac{\partial P(k \in M)}{\partial \ln p_j} \right]$$

\( = \frac{\alpha_p \left[ 1 - P(j \in M) \right] \left[ \exp(\overline{V}_j - b) \right]}{P(j \in M)} \left[ \frac{\exp(\overline{V}_j)}{\sum_{i \in C} \exp(\overline{V}_i)} - 1 \right] \)
This expression can be simplified to

\[
\frac{\partial \ln P_i}{\partial \ln p_i} = \alpha_p \delta_i \sum_{k \in I} \frac{P_k[P(k \in M) - 1]}{P(k \in M)} (\delta_k - \gamma_k)(1 - \frac{\gamma_k}{P_j}).
\]

For the cross elasticity, we need to consider two cases again: \( i \in C \) and \( i \in \bar{C} \).

(a) \( i \in \bar{C} \) (i.e., the brand which makes the price move does not belong to the consideration set, where the brand affected does belong to the consideration set); hence, \( \frac{\partial b}{\partial \ln p_i} = 0 \).

Accordingly, the cross price elasticity equals

\[
\frac{\partial \ln P_i}{\partial \ln p_i} = - \frac{\alpha_p}{\sum_{k \in I} [\exp(V_k)][P(i \in M) - 1][\exp(\overline{V}_i) - b]}
\]

\[
= - \frac{\alpha_p P_i[P(i \in M) - 1]}{P(i \in M)} \delta_i
\]

\[
= \alpha_p \frac{P_i[1 - P(i \in M)]}{P(i \in M)} \delta_i.
\]

(b) \( i \in C \) (i.e., both brands i and j belong to the consideration set); hence,

\[
\frac{\partial \ln P_i}{\partial \ln p_i} = \frac{1}{P(i \in M)} \frac{\partial P(j \in M)}{\partial \ln p_i}
\]

The cross elasticity in this instance equals

\[
\frac{\partial \ln P_i}{\partial \ln p_i} = \frac{1}{P(j \in M)} \frac{\partial P(j \in M)}{\partial \ln p_i}
\]

\[
- \sum_{k \in I} \frac{\exp(V_k)P(k \in M)}{\sum_{k \in I} \exp(V_k)P(k \in M)} \sum_{k \in I} [\exp(V_k)] \frac{\partial P(k \in M)}{\partial \ln p_i}.
\]
\[
\begin{align*}
&= \frac{1}{P(j \in M) - 1} \left[ \exp(V_j - b) - \alpha_p \frac{\exp(V_j)}{\sum_{l \in C} \exp(V_l)} \right] \\
&- \frac{1}{\sum_{k \in J} [\exp(V_k) P(k \in M)]} \sum_{k \in J} [\exp(V_k)] \left[ \exp(V_k - b) - \alpha_p \frac{\exp(V_k)}{\sum_{l \in C} \exp(V_l)} \right] \\
&- \frac{1}{\sum_{k \in J} [\exp(V_k)] P(k \in M)} \left[ \exp(V_i) \right] \left[ P(i \in M) - 1 \right] \left[ \exp(V_i - b) \right] \left[ \alpha_p - \alpha_p \frac{\exp(V_i)}{\sum_{l \in C} \exp(V_l)} \right]
\end{align*}
\]

Written alternatively,

\[
\frac{\partial \ln P_j}{\partial \ln p_i} = \alpha_p \left\{ \left[ \frac{1 - P(j \in M)}{P(j \in M)} \right] \delta_i \delta_j \\
+ \sum_{k \in J} \frac{P_k [P(k \in M) - 1]}{P(k \in M)} \delta_k \delta_i \\
+ \frac{P_i [P(i \in M) - 1]}{P(i \in M)} \delta_i (\delta_i - 1) \right\}
\]

which can be expressed compactly as

\[
\frac{\partial \ln P_j}{\partial \ln p_i} = \alpha_p \delta_i \left[ \sum_{k \in J} \frac{P_k [P(k \in M) - 1]}{P(k \in M)} \left[ \delta_k (1 - \gamma_{jk} - \frac{\gamma_{jk}}{P_j} - \gamma_{ik}) \right] \right].
\]
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