JAMES M. LATTIN and RANDOLPH E. BUCKLIN*

When consumers are exposed to pricing and promotional activity by frequently purchased packaged goods, they may develop expectations that are used as points of reference in evaluating future activity. The authors build a model to test for the presence of these reference effects on brand choice behavior. The approach differs from previous research in two ways: (1) the model includes reference effects of promotion in addition to reference effects of price and (2) a threshold model is introduced to capture the formation of the consumer's promotional reference point. The authors calibrate a model of brand choice using IRI scanner panel data on ground coffee. The findings suggest that promotional activity has significant reference effects on consumer response.

Reference Effects of Price and Promotion on Brand Choice Behavior

Each year, companies spend billions of dollars on trade promotion to induce retailers to offer stronger merchandising support (e.g., price reduction, feature, special display) for their brands. Though recent research has documented the success of pricing and promotion in stimulating immediate sales response (e.g., Guadagni and Little 1983; Gupta 1988; Neslin, Henderson, and Quelch 1985), there is concern about the long-run implications of such activity. Some industry experts contend that frequent price discounting blurs the distinction between the deal price and the baseline price of a product (*Marketing News* 1985). If consumers come to expect deals as the rule rather than the exception, discount prices lose their ability to boost sales. To use price discounting effectively, managers must understand the link between pricing activity and consumer expectations.

One stream of research investigating this link is based on the notion that the consumer establishes a *reference price* for a brand or product (Monroe 1979; Winer 1986). The reference price reflects the expectations of the consumer, which are shaped by the past pricing activity of the brand. The consumer then evaluates the future price of the brand in relation to this reference point and his or her response is related to the disparity between the two. Hence, consumer response to an *unexpected* price decrease (a "pleasant surprise") is greater than the response to an *expected* price decrease. The reference price framework is consistent with several psychological theories of consumer behavior and price perception, including adaptation-level theory (Helson 1964) and assimilation-contrast theory (Sherif 1963). Empirical work by Winer (1986) and Raman and Bass (1986) supports the presence of general reference price effects in consumer brand choice behavior.

Product pricing, however, is not the only activity influencing the expectations of consumers. In recent years, retail promotion (by which we mean nonprice merchandising activity such as special displays and store features) has had an increasingly important effect on consumer choice behavior. For example, Fader and McAlister (1988) suggest that the proliferation of promotional activity in many product categories may be training consumers to buy on promotion. If so, consumer expectations about future promotional activity are just as important

*James M. Lattin is Associate Professor of Marketing and Management Science and the James and Doris McNamara Faculty Fellow for 1988–89, Graduate School of Business, Stanford University. Randolph E. Bucklin is Assistant Professor, Anderson Graduate School of Management, University of California, Los Angeles.

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to understanding consumer choice behavior as consumer expectations of price.

We investigate the reference effects of price *and* promotion on consumer choice behavior. Our model is based on the premise that consumers form expectations about the future marketing activity of a brand from their past exposure to such activity. The model reflects not only reference price, but also the consumer's promotional reference point for a brand. We further assume that consumers use these points of reference in evaluating a brand at each purchase opportunity and that consumer response is influenced by the disparity between their reference points and the actual price and promotional status of the brand. These assumptions enable us to calibrate a brand choice model and test for the presence of reference effects.

Our approach differs from previous research in two ways. First, we offer a unique characterization of the way in which prior promotional activity by a brand affects subsequent brand choice behavior. Other researchers (notably Dodson, Tybout, and Sternthal 1978) have used attribution theory to argue that the consumer is less likely to repurchase a brand after a prior promotional purchase than after a nonpromotional purchase. Empirical work by Guadagni and Little (1983) also suggests that a prior purchase off promotion is a stronger reflection of brand loyalty than a prior purchase on promotion. These explanations, however, center on the occurrence of a promotional *purchase,* whereas our explanation involves only *exposure* to a brand on promotion. Our goal is to show that there is evidence for the promotional reference effect even when the incidence of prior promotional purchase is controlled for in the model.

Second, our approach differs in that we use a threshold model to capture the formation of the consumer's promotional reference point for a brand. We assume that when the consumer has had little or no recent exposure to promotional activity, he or she will not expect to see the brand on promotion in the future; that is, the consumer thinks of the brand as a nonpromoted brand. When the brand goes on promotion and the consumer's exposure rises above a certain point, his or her point of reference changes to reflect the brand's recent promotional status; that is, the consumer expects to see the brand on promotion in the future and begins to think of the brand as a promoted brand. The consumer's point of reference for a brand (either "promoted" or "nonpromoted") is determined by whether or not recent exposure to promotional activity by the brand is above or below a threshold level. The model separates the effects of promotion frequency (which operates on exposure, determining whether the consumer thinks of the brand as promoted or nonpromoted) from depth of discount (which determines the point-of-reference price level). In this way, the threshold model differs from the continuous expectations models offered by Winer (1986) and Raman and Bass (1986).

We test the proposed model with IRI scanner panel data on ground coffee. In building the model, we attempt to control for other factors that might be confounded with the reference effects of price and promotion. For example, previous research (e.g., Winer 1986) examined reference price effects without distinguishing between long-term changes in regular price and short-term promotional price changes. Such an approach may not account for the natural differences between regular price elasticity and short-term promotional price elasticity (Rao and Sabavala 1980), which are then potentially confounded with reference price effects. To control for this confounding, we add a term in the model to capture the interaction between price and promotion.

Our reference effects model suggests that too much promotion and price discounting may adversely affect brand choice behavior. Though price promotion makes the brand more attractive and increases consumer response, a consumer exposed to frequent price promotion may become accustomed to finding the brand available on promotion at a discounted price. This shift in reference point changes the way the consumer frames the choice problem. The result is a diminished level of consumer response to the brand—a "wearout" effect over time for promotion and price discounting. For manufacturers, the implication is that overly intensive promotion may increase expectations and ultimately undermine consumer response. We offer an illustration of these effects for ground coffee.

We first discuss the reference effects of price and promotion on consumer response and present our proposed models of reference point formation and brand choice behavior. Then we report the results of our empirical tests. We conclude with some suggestions for future research.

MODELING REFERENCE EFFECTS

In the following development we focus on conditional brand choice behavior. In other words, once the consumer has decided to buy from the product category, how do price and promotion affect his or her decision to purchase a particular brand? We begin with a discussion of reference effects and provide a framework to characterize the reference effects of promotional activity. We then propose a model of consumer utility incorporating these reference effects and relate utility to consumer response with a multinomial logit model. Finally, we present models of reference price and promotional reference point formation.

Reference Effects

Price. Previous research on reference price effects has been well grounded in several psychological theories of consumer behavior (for a review, see Sawyer and Dickson 1984). These theories suggest that response is based on an evaluation of price in relation to some point of reference. For example, Helson's (1964) adaptation-level theory, applied to price perception, suggests that consumer response to price may depend on some established

comparison price. This point of comparison may change over time as the consumer adapts to changing conditions. In the same vein, assimilation/contrast theory (Sherif 1963) holds that consumer response depends on whether or not price is within a certain "latitude of acceptance," which also implies a comparison between actual price and a reference point.

Building from this body of theory, Winer (1986) investigated the nature of reference price effects on brand choice. He proposed a linear probability model in which the probability of purchase for brand i is a function of the observed price of brand i (expressed relative to the prices of other brands) and the difference between the observed price and the reference price for the brand. The latter term is designed to capture the positive or negative effects of price expectations (referred to by Winer as a "sticker shock" effect for nondurable goods). For example, when the observed price of the brand is higher than the reference price (i.e., the actual price is higher than the price the consumer expects to pay), there is a negative impact on purchase probability. Winer found evidence that consumer response is related significantly to the disparity between reference price and observed price.

Promotion. Recent research suggests that promotional activity has considerable impact on consumer response (e.g., Fader and McAlister 1988; Guadagni and Little 1983; Gupta 1988) and is at least as salient to consumers as a change in the price of the brand. In a study of purchase behavior and price perceptions, Dickson and Sawyer (1986) found that nearly 50% of consumers correctly identified the deal status of the brand purchased, a proportion closely comparable to the percentage of consumers who could correctly recall the purchase price of the brand.

Promotional activity such as a special display or feature (in the absence of a store coupon) serves to draw the consumer's attention to the brand and thereby enhances his or her evaluation of it. Because promotion is often (but not always) accompanied by a price discount, promotion also may alert consumers to a possible increase in the value of the brand. Under these circumstances, it is reasonable to expect reference effects of promotion on consumer response. For example, a consumer is unlikely to respond as favorably to an unpromoted brand when he or she expects to find it on promotion. Conversely, finding another brand unexpectedly on promotion might signal a "special opportunity" and evoke a greater response than a brand promoted all the time. Just as with price, we assume that consumers evaluate promotions in relation to a point of reference and respond accordingly.

Reference Effects on Consumer Response

We establish the link between reference effects and consumer response in two steps. First, we propose a model of consumer utility in which we specify the reference effects of price and promotion on the consumer's utility for buying a given brand on a particular choice occasion. Second, we relate utility to actual brand choice behavior through a multinomial logit choice model.

Utility. Previous work in modeling brand choice behavior (e.g., Guadagni and Little 1983) suggests that the utility function should include a term designed to capture the consumer's idiosyncratic preference for the brand. The discussion in the preceding section suggests that consumer utility should also include the following four terms: (1) the price of the brand, (2) the promotional status of the brand, (3) the disparity between actual price and reference price, and (4) the disparity between the actual promotional status and the promotional reference point. The first two terms capture the direct effects of price and promotion and the third and fourth terms capture the reference effects.

The possible interactions between price and promotion also should be considered. Frequently, price discounts are accompanied by special promotional support from the retailer (e.g., an end-of-aisle display or a featured advertisement). These promotional events often elicit much greater consumer response than unpromoted changes in the regular price of the product, a phenomenon noted by Rao and Sabavala (1980) and empirically documented by Guadagni and Little (1983). In many categories, promoted price discounts are irregularly scheduled and difficult to anticipate, resulting in large discrepancies between observed price and reference price. To avoid confounding the difference between promoted and nonpromoted price elasticity with the presence of reference price effects, we include a term to capture the interaction between price and promotion.

We write our model of consumer utility as

$$(1)\qquad u_{it}^h = \mu_{it}^h + \gamma_0 Z_{it} + \gamma_1 P_{it} + \gamma_2 Z_{it} P_{it} + \delta_1 (P_{it} - RP_{it}^h) + \delta_2 (Z_{it} - PRP_{it}^h)$$

where:

t = a subscript denoting a purchase occasion for consumer h,
u_{it}^h = the utility to consumer h of purchasing brand i on purchase occasion t,
μ_{it}^h = consumer h's idiosyncratic preference for brand i on occasion t (influenced by nonmarketing factors such as brand preference, choice inertia, etc.),
P_{it} = the purchase price of brand i on occasion t,
Z_{it} = the promotional status of brand i on occasion t (0 or 1),
$(P_{it} - RP_{it}^h)$ = the disparity between actual price and the reference price for brand i on occasion t, and
$(Z_{it} - PRP_{it}^h)$ = the disparity between actual promotional status and the promotional reference point for brand i on occasion t.

In equation 1, the coefficient γ_0 captures the direct effect of promotion, γ_1 captures the direct effect of price, and γ_2 captures any interaction between promotion and price. The coefficient δ_1 captures the reference effect of price. Because a positive disparity in ($P - RP$) has a negative effect on utility (i.e., the consumer is disappointed to find the brand priced higher than expected), we expect $\delta_1 < 0$. The coefficient δ_2 captures the reference effect of promotion. Because a positive disparity in ($Z - PRP$) has a positive effect on utility, we expect $\delta_2 > 0$. For parsimony, we assume that the parameters γ_0, γ_1, γ_2, δ_1, and δ_2 are the same across consumers and that the term μ_{it}^h accommodates the remaining variance in response across consumers and over time. (The specification of μ_{it}^h is developed subsequently.)

Brand choice. By linking utility to consumer purchase behavior, we establish a relationship between the reference effects of price and promotion and consumer response to the brand. If we assume that the consumer buys the brand offering maximum utility and that any random effects on utility are distributed independently and identically across brands according to the double-exponential distribution, the likelihood of purchasing brand i can be written as

$$p_{it}^h = \exp(u_{it}^h)/\Sigma_k \exp(u_{kt}^h) \tag{2}$$

where p_{it}^h = the probability that consumer h chooses brand i on purchase occasion t.

The multinomial logit model in equation 2 enables us to express purchase behavior toward brand i as a function of consumer utility for all available brands. Thus, we avoid the need to employ a constructed *relative price* like that used by Winer (1986) to capture competitive pricing effects. Though the consumer's utility for purchasing brand i is simply a function of price, promotion, and reference effects for brand i alone, the consumer's response toward brand i is a function of price, promotion, and reference effects for all available brands.

Reference Point Formation

Because consumer reference points are difficult if not impossible to measure directly, we present the following models to capture these constructs indirectly. The models are based on the premise that a consumer's exposure to the brand's point-of-purchase price and promotional activity determines his or her point of reference for evaluating future marketing activity by the brand.

Promotion. We begin by focusing on the formation of the consumer's promotional reference point (*PRP*). We assume that the promotional reference point is based on the consumer's prior exposure to promotional activity by the brand. If the consumer has had relatively little exposure to the brand on promotion (i.e., if there has been no promotional activity by the brand on recent purchase occasions), we assume the consumer expects to find the brand off promotion. If the consumer's exposure to promotional activity is high, we assume the consumer expects to find the brand on promotion. Because consumers see promotional activity as either present or absent, it makes sense to think of this construct in discrete terms: either the consumer expects to find the brand available on promotion ($PRP = 1$) or not ($PRP = 0$). The continuous adaptation/expectation models proposed by Winer (1986) and Raman and Bass (1986) are not directly appropriate in this context because they do not permit an "either/or" representation.

We therefore propose a threshold model of *PRP* formation, determined by the consumer's level of exposure to the brand at the point of purchase. Each time the consumer encounters a given brand (i.e., has the opportunity to notice it and actively process information about it), we say that he or she is *exposed* to the brand. If consumer h is exposed to brand i only in the absence of promotional activity, he or she has no reason to expect future promotional activity. Hence, at low levels of exposure to promotion, the consumer thinks of the brand as a nonpromoted brand and establishes a $PRP = 0$. If consumer h encounters brand i predominantly on promotion, he or she is more likely to use the recent promotional status of the brand as a basis for evaluation on future choice occasions. Hence, at high levels of exposure to promotion, the consumer thinks of the brand as a promoted brand and establishes a $PRP = 1$. At some point the exposure to the brand on promotion "outweighs" the exposure to the brand off promotion and the consumer's point of reference shifts.

We model consumer h's exposure to promotion by brand i as an exponentially weighted average of its promotional status on previous purchase occasions. Thus, we let

$$x_{it}^h = \lambda\, x_{it-1}^h + (1 - \lambda) Z_{it-1} \tag{3}$$

where:

x_{it}^h = consumer h's exposure to promotional activity by brand i at purchase occasion t,
Z_{it-1} = 1 if brand i was on promotion on purchase occasion $t - 1$ and 0 otherwise, and
λ = a smoothing parameter (between 0 and 1 and constant across consumers) reflecting the carryover of exposure from occasion $t - 1$ to occasion t.

Note that if consumer h is never exposed to brand i on promotion, x_{it}^h is equal to zero. If consumer h encounters brand i only when it is on promotion, x_{it}^h approaches one over time.

We assume that consumer h is exposed to marketing activity in the product category only on occasions when a purchase is made. Because consumers may evaluate price information and decide to postpone purchase (perhaps holding out for a better deal), this assumption is a simplification. With most sources of scanner panel data it is impossible to determine whether or not a shopper has had the opportunity to consider a brand actively on any given visit to the store. We also assume that consumer h is exposed to any marketing activity by brand

i on every purchase occasion, whether the consumer buys brand i or another brand in the category. Research by Dickson and Sawyer (1986) suggests that this assumption may overstate exposure because consumers are not always aware of discount availability even for the brands they buy. Nevertheless, equation 3 has precedent (see Guadagni and Little 1983; Lattin 1987; Srinivasan and Kesavan 1976) and parsimoniously captures the first-order effects of exposure.

We now define consumer h's promotional reference point for brand i on occasion t as

$$PRP_{it}^h = \begin{cases} 1 & \text{if } x_{it}^h \geq \theta \\ 0 & \text{if } x_{it}^h < \theta \end{cases} \tag{4}$$

where θ = a threshold parameter between 0 and 1 that is constant across consumers. Equation 4 specifies $PRP_{it}^h = 1$ when exposure exceeds the threshold and $PRP_{it}^h = 0$ when exposure falls below the threshold.

Price. Unlike the discrete promotional reference point, reference price is modeled as a continuous construct determined by the consumer's exposure to the price of the brand on previous purchase occasions. Though one might argue that consumers are capable of distinguishing special discount prices from the regular base price of the brand (in effect, maintaining two points of reference for price), the evidence presented by Dickson and Sawyer (1986) suggests that the consumer's awareness of price is not that finely tuned. Furthermore, price should be treated as a separate construct from promotion because the two constitute different types of marketing activity.

We model consumer h's reference price for brand i on occasion t by using an exponentially weighted average like the one used in equation 2.

$$RP_{it}^h = \lambda RP_{it-1}^h + (1 - \lambda)P_{it-1} \tag{5}$$

If we assume that the dynamics of exposure to price are the same as those of exposure to promotion, it is appropriate to use the same smoothing constant λ for both *RP* and *PRP*.

Like the promotional reference point, reference price is determined by the consumer's exposure to marketing activity by the brand. Hence, a relationship between *PRP* and *RP* is likely. When there has been little or no promotional activity by the brand during the consumer's recent purchase occasions (i.e., $PRP = 0$), *RP* will reflect the regular price of the brand on those previous occasions. When the consumer has experienced considerable promotional activity by the brand (i.e., $PRP = 1$), *RP* will reflect the price of the brand on those promotional occasions, which are likely to involve special discounts from the regular price. Thus, to the extent that promotional activity is accompanied by special price discounts, *PRP* and *RP* will have negative covariance.

A special case of the models in equations 3 through 5 arises when the carryover parameter λ equals zero. In this case, the terms x_{it}^h and RP_{it}^h are completely determined by price and promotion on the previous purchase occasion. Thus, exposure on occasion t is either zero or one (depending on whether or not brand i was promoted at time $t - 1$) and the reference price is the last observed price for brand i. Under this condition the threshold parameter θ becomes unnecessary and equations 4 and 5 simplify to

$$PRP_{it}^h = Z_{it-1} \tag{6}$$

$$RP_{it}^h = P_{it-1}. \tag{7}$$

In this form, our model of reference price is very similar to the specifications used by Raman and Bass (1986) and Winer (1986). In fact, equation 7 is a special case of the extrapolative expectations regression model offered by Winer, in which the coefficient of P_{it-1} equals 1 and the trend component is absent. Our model has the added benefit that when $\lambda > 0$, there is some "stickiness" in the reference terms over time.

ESTIMATION AND TESTING

In this section, we test our hypotheses about the reference effects of price and promotion on consumer response. We begin by describing the data used to calibrate the proposed model framework. Then we propose a cross-sectional operationalization of the brand choice model and report and discuss the results of our empirical tests.

Data

We calibrated our proposed model of brand choice with IRI scanner data for ground coffee. We began by identifying the items (i.e., stockkeeping units denoted by a unique UPC) purchased most frequently by more than 1000 IRI scanner panelists from six stores in Pittsfield, MA. During a 75-week period (weeks 61 to 135 of the study), nearly 80% of ground caffeinated coffee volume was accounted for by 10 different items (all 16 oz size). Because items of the same size and brand are usually priced and promoted together, we combined these 10 items into four choice alternatives (as shown in Table 1): Hills Brothers, Folgers, Maxwell House, and Chock Full O'Nuts. These data were used to initialize and calibrate our model.

Table 2 summarizes the pricing and promotional activity for each of the four brands across all six stores over the last 50 weeks of data (the calibration period for the proposed model). These data show considerable variation in pricing activity (across all brands and stores, price ranged from a low of \$1.58 to a high of \$2.91) as well as relatively frequent promotion (defined as either feature or special display for any one of the UPC items that make up the brand). The data also show a strong negative correlation between price and promotion—that is, special discount in price is almost always accompanied by feature or display.

We further refined our sample by selecting only those panelists who had made at least three purchases of any of the four brands in any of the six stores. We also eliminated as nonrepresentative a small number of panelists

Table 1
DESCRIPTION OF THE 10 STOCKKEEPING UNITS FOR THE BRANDS

Brand	*UPC number*	*Item description*	*Size (oz)*
1. Hills Bros.	1840000137	HILLS BROS REG COFFEE	16
	1840000138	HILLS BROS AUTO DRIP	16
2. Folgers	2550000004	FOLGERS REGULAR COFFEE	16
	2550000005	FOLGERS ELECTRIC PERK	16
	2550000006	FOLGERS DRIP COFFEE	16
3. Maxwell House	4300070134	MAX HSE REGULAR COFFEE	16
	4300070135	MAX HSE DRIP COFFEE	16
	4300070733	MAX HSE ELECTRA PERK	16
	4300070780	MAX HSE AUTO DRIP	16
4. Chock Full O'Nuts	7103800001	CHK FLL O NUTS COFFEE	16

who had purchased more than 100 lbs of coffee, which left 577 panelists who purchased ground coffee on 4720 purchase occasions during the model calibration period. We divided this remainder randomly into two groups: 300 panelists formed the calibration sample (2420 purchase occasions) and 277 panelists formed the holdout sample (2300 purchase occasions) for purposes of model validation.

Cross-Sectional Operationalization

Because the purchase histories of most panelists are not long enough for reliable individual-level calibration, we calibrated our consumer response model cross-sectionally (see also Lattin 1987). To do so we first needed a specification of idiosyncratic preference μ_{it}^h to capture the variation in preference across consumers and over time. Guadagni and Little (1983) solved this problem by creating a measure of *brand loyalty* using an exponential smoothing model of the past purchase behavior of each panelist. This loyalty measure is able to track the differences in purchase behavior across consumers and over time, but it is not capable of separating these two components of variance (i.e., cross-sectional and longitudinal). As pointed out by Lattin (1987), in using a single loyalty term one implicitly assumes that differences across consumers and differences over time contribute equally to the heterogeneity in base-level utility. If such an assumption is inappropriate, it could have a distorting effect on our reference price and reference promotion terms because these constructs are also designed to capture longitudinal variance in consumer response. In addition, we must be careful to distinguish between prior promotional purchase and prior nonpromotional purchase because research (e.g., Dodson, Tybout, and Sternthal 1978; Guadagni and Little 1983; Shoemaker and Shoaf 1977) suggests that a prior purchase on promotion is not as strong an indicator of brand preference as a prior purchase off promotion.

Table 2
SUMMARY OF PRICING AND PROMOTIONAL ACTIVITY BY FOUR BRANDS IN SIX STORES

	Brand 1	*Brand 2*	*Brand 3*	*Brand 4*
Store 11	.18[a]	.23	.19	.33
	.11[b]	.16	.20	.45
	−.63[c]	−.73	−.62	−.84
Store 12	.23	.33	.22	.29
	.16	.45	.32	.35
	−.73	−.84	−.60	−.83
Store 13	.19	.22	.09	.18
	.20	.32	.12	.39
	−.62	−.60	.03	−.73
Store 14	.33	.29	.18	.23
	.45	.35	.39	.39
	−.84	−.83	−.73	−.62
Store 15	.31	.28	.06	.24
	.51	.27	.39	.28
	−.56	−.73	−.15	−.58
Store 16	.22	.18	.06	.21
	.32	.39	.13	.25
	−.60	−.73	−.12	−.58

[a]Standard deviation of price (in dollars).
[b]Proportion of weeks on promotion.
[c]Correlation between price and promotion.

We therefore propose the following model of idiosyncratic preference using three measures of past purchase behavior.

$$\mu_{it}^h = \alpha_i + \beta_1 BL_i^h + \beta_2 LP_{it}^h + \beta_3 LPP_{it}^h \tag{8}$$

where:

α_i = the brand-specific constant (i.e., intercept term) for brand i,
BL_i^h = consumer h's loyalty to brand i, measured by the proportion of purchase occasions in which consumer h selected brand i during an initialization period (the term BL, which is constant over time, is designed to capture the heterogeneity in preference *across consumers*),
LP_{it}^h = the relative impact of recent choice behavior, measured by whether or not consumer h last purchased brand i on occasion $t - 1$, and
LPP_{it}^h = the relative impact of recent choice behavior on promotion, measured by whether or not consumer h last purchased brand i on promotion on occasion $t - 1$ (the terms LP and

LPP are designed to capture the heterogeneity in preference *for a given consumer over time*).

For parsimony, we assume that the parameters α_i, β_1, β_2, β_3 are constant across consumers. Note that when $\beta_1 = 0$ and $\beta_3 = 0$, our approach for capturing individual differences in utility simplifies to the approach used by Winer (1986) in his linear probability model.

Substituting equation 8 into 1 and then equation 1 into 2 yields our complete model of consumer response. To provide the measures required by the model, we divided the data into two periods. We used weeks 61 through 85 to calculate the measure BL_i^h and to initialize x_{it}^h. We used the next 50 weeks of data (weeks 86–135) to calibrate the logit model in equation 2 by choosing parameters α_1, β_1, β_2, β_3, γ_0, γ_1, γ_2, δ_1, and δ_2 to maximize the following log-likelihood function.

$$(9) \qquad LL = \Sigma_h \Sigma_t \Sigma_k \Delta_{kt}^h \ln(p_{kt}^h)$$

where $\Delta_{kt}^h = 1$ if consumer h purchased brand k on purchase occasion t and zero otherwise.

Empirical Results

We test the proposed framework by calibrating a series of three models. We begin by calibrating a baseline model (model 1), which excludes reference effects. We then calibrate two models (models 2 and 3) embodying reference effects. In model 2 the parameter λ, which determines the carryover of prior exposure to price and promotion, is set equal to zero and *PRP* and *RP* are given by equations 6 and 7, respectively. In model 3 we set $\lambda > 0$ and *PRP* and *RP* are given by the more general forms in equations 4 and 5. We then use a likelihood ratio test of models 2 and 3 relative to model 1 to assess the significance of the hypothesized reference effects. The goodness-of-fit of each model is given by the U^2 coefficient measured relative to a model in which all parameters except the brand-specific coefficients α_i are constrained to zero (see Guadagni and Little 1983; see also R_M^2 as reported by Winer 1986). The estimated coefficients for each of the nested models are reported in Table 3.

Model 1. Baseline model. The first model reflects only the direct effects of price and promotion (including any possible interaction) on consumer response; the coefficients of all terms describing reference effects are constrained to zero (i.e., $\delta_1 = 0$ and $\delta_2 = 0$). For idiosyncratic preference, we find that brand loyalty BL_i^h is positive and significant ($\beta_1 = 1.67$, $t = 16.8$). We also find that prior purchase LP_{it}^h is a strong indicator of idiosyncratic preference ($\beta_2 = 1.75$, $t = 15.8$) when the brand is purchased off promotion. However, we also note that the coefficient of prior promotional purchase LPP_{it}^h is negative and significant ($\beta_3 = -.99$, $t = -7.2$). This find-

Table 3
PARAMETER ESTIMATES FOR NESTED MODELS OF BRAND CHOICE

	Model 1	*Model 2* ($\lambda = 0$)	*Model 3* ($\lambda > 0$)	
α_1	.807	.808	.870	
	(9.70)	(9.45)	(9.37)	
α_2	.699	.724	.789	Brand-specific constants
	(9.08)	(9.30)	(9.48)	
α_3	1.297	1.348	1.495	
	(15.50)	(14.71)	(13.40)	
β_1	1.674	1.665	1.675	Brand loyalty (*BL*)
	(16.82)	(16.81)	(16.85)	
β_2	1.750	1.674	1.702	Last purchase (*LP*)
	(15.85)	(14.98)	(15.35)	
β_3	−1.163	−.987	−1.072	Last purchase on promotion (*LPP*)
	(−9.44)	(−7.18)	(−8.36)	
γ_0	−1.336	−1.581	−1.653	Promotion (*Z*)
	(−1.36)	(−1.62)	(−1.69)	
γ_1	−3.608	−3.839	−4.579	Price (*P*)
	(−9.08)	(−9.20)	(−9.25)	
γ_2	1.096	1.078	1.078	Promotion × price (*ZP*)
	(2.70)	(2.68)	(2.68)	
δ_1	—	.271	1.004	(*P* − *RP*)
		(1.72)	(3.13)	
δ_2	—	.299	.377	(*Z* − *PRP*)
		(3.46)	(5.12)	
θ	—	—	.51	Threshold
Fit statistics				
LL	−2068.2	−2062.7	−2055.8	
U^2	.375	.377	.379	
Validation				
LL	−2023.3	−2012.3	−2018.2	

ing suggests that a prior purchase of a brand off promotion (given by $\beta_2 = 1.75$) has a significantly stronger impact on subsequent brand choice behavior than does a prior purchase on promotion (where the net effect is $\beta_2 + \beta_3 = .76$). In either case, prior purchase (on or off promotion) is a positive and significant indicator of brand choice behavior.

The direct effects of price and promotion are illustrated in Figure 1. The figure shows consumer utility over the actual range of price during the 50-week calibration period (with a nonpromoted price of $2.91 as a base case). Though the figure seems to show that consumer response is higher for nonpromoted brands at very low levels of price, there are in fact no instances in which a price below $1.79 was not accompanied by promotion.

As anticipated, price has a strong negative impact on utility ($\gamma_1 = -3.61$, $t = -9.1$). We also see a significant interaction between price and promotion ($\gamma_2 = 1.10$, $t = 2.7$), which suggests that promotion has a greater effect at higher levels of price (Figure 1). As an example, a promotional price cut from $2.49 (unpromoted) to $1.99 leads to an increase in consumer utility from 1.5 to 3.7, of which .3 (about 14%) is attributable to the direct effect of promotion. A promotional price cut from $2.49 (unpromoted) to $2.29 leads to an increase in consumer utility from 1.5 to 3.0, about 50% of which is attributable to promotion.

Model 2. Reference effects with $\lambda = 0$. We now relax the constraints on the terms involving the reference effects of price and promotion. According to a likelihood ratio test of model 2 against model 1, the addition of the two reference terms leads to a significant improvement in fit ($\chi^2_2 = 11.0$, $p < .01$). Examining the t-statistics for each term, we see that the reference effect of promotion is correctly signed and significant ($\delta_2 = .30$, $t = 3.5$). The reference effect of price, in contrast, is incorrectly signed and is not significant at the .05 level ($\delta_1 = .27$, $t = 1.7$).

Because *RP* and *PRP* have negative covariance (in fact, the correlations between RP^h_{it} and PRP^h_{it} range from $-.50$ to $-.70$ across the four brands, reflecting the negative correlation between price and promotion shown in Table 2), we might suspect that the signs of the estimated coefficients δ_1 and δ_2 are influenced by multicollinearity. In an attempt to assess this influence, we recalibrated model 2 including only one reference term at a time. Including only the term for reference price ($P - RP$) does not lead to a significant improvement in fit over model 1. Neither the likelihood ratio test ($\chi^2_1 = .1$) nor the t-statistic of the estimated coefficient ($\delta_1 = -.02$, $t = -.1$) is significant. Including only the term for the reference effect of promotion ($Z - PRP$) does have a significant effect. The likelihood ratio test against model 1 is significant ($\chi^2_1 = 8.2$, $p < .01$) and the t-statistic indicates that the estimated coefficient is correctly signed and significant ($\delta_2 = .22$, $t = 2.9$).

Note that the reference effects of promotion are potentially substantial. In the absence of reference effects, consumer utility for a brand available at an unpromoted price of $1.99 will increase by .30 when the brand is promoted (see Figure 1). In terms of reference effects, the overall impact of promotion on consumer utility is twice as large if the consumer has not had prior exposure to the brand on deal (i.e., $PRP = 0$). Note, too, that we are able to distinguish between the effects of prior promotional purchase (captured by the term *LPP*) and the effects of prior exposure to promotion (embodied in the term *PRP*).

Model 3. Reference effects with $\lambda > 0$. Model 2 assumes that the parameter λ in the exponential smoothing models of exposure and reference price is equal to zero. Though we obtain good fits and strong empirical support for this special case of our proposed framework, improvement of these results may be possible by relaxing the restriction that $\lambda = 0$. Unfortunately, this additional flexibility comes at a computational cost. Because of the discrete nature of the promotional reference point, the threshold parameter θ in equation 4 must be determined by grid search for given values of λ.

To illustrate the estimation procedure for the threshold model with nonzero parameter λ, we begin by setting $\lambda = .70$. This value suggests that an exposure to a brand on promotion has a half-life of about two purchase occasions (i.e., on the second occasion after an encounter with a promoted brand, the effect of that encounter on exposure is diminished by half). For the purposes of this illustration, we do not search exhaustively on the parameter λ.

To calibrate model 3, we begin by setting a value of θ and calculating PRP^h_{it} according to equation 4. We then

Figure 1
CONSUMER UTILITY AS A FUNCTION OF PRICE AND PROMOTION, SHOWING THE EFFECT OF A PROMOTED PRICE CHANGE FROM $2.49 (UNPROMOTED) to $1.99

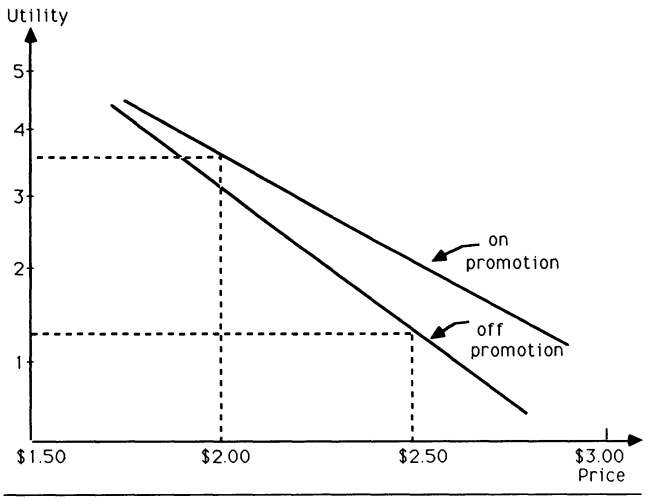
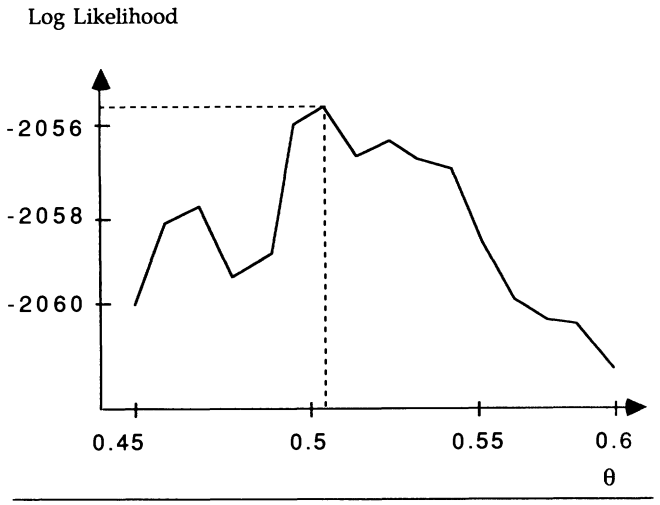


Figure 2
RESULTS OF THE GRID SEARCH FOR THRESHOLD PARAMETER θ: MAXIMUM LIKELIHOOD OF −2055.8 OCCURS AT θ = 0.51



estimate the remaining model parameters by maximum likelihood according to equation 9. We repeat this process for all values of θ between .20 and .80 at intervals of .01. Figure 2 shows partial results of the grid search for the threshold parameter θ. Though not strictly unimodal, the functional form seems reasonably well behaved. The maximum likelihood value of −2055.8 occurs at θ = .51. This value for the threshold parameter has intuitive appeal; it suggests that when the weighted average of past exposure to the brand on promotion is more than one-half, the consumer thinks of the brand as a promoted brand (i.e., $PRP = 1$).

The estimates of the remaining coefficients for model 3 (for θ = .51) are reported in Table 3. According to the likelihood ratio test, model 3 affords a significant improvement in fit over model 1 ($\chi^2_3 = 24.8$, $p < .01$). As in model 2, we find that the reference effect of promotion is significant ($\delta_2 = .38$, $t = 5.1$). We find again that the reference effect of price is incorrectly signed[1] but, unlike that in model 2, the estimated coefficient is significant ($\delta_1 = 1.00$, $t = 3.1$). The fact remains that the anticipated reference effects on consumer response appear to be due to promotion rather than price.

Predictive validation. Both models 2 and 3 afford support for our hypotheses about the reference effects of promotion. We examine the generalizability of these findings by testing the ability of calibrated models 2 and 3 to predict the purchase behavior of the 277 households in the holdout sample in comparison with a model in which the reference effects of price and promotion are constrained to zero (model 1). Our goal is to show that across different groups of panelists, the predictive performance of the models embodying reference effects is superior to that of the model without reference effects; that is, that the improvement in fit for the proposed models is not simply attributable to capitalizing on idiosyncratic sampling variance.

The 277 households in the holdout sample made a total of 2300 purchases between weeks 86 and 135. Using the estimated coefficients of model 2 to predict their purchase behavior results in a log-likelihood value of −2012.3; for model 3 the fit is −2018.2. In both cases, the predictive performance in the holdout group is superior to that of model 1, which has a fit of −2023.3. This evidence supports the predictive validity of the reference effects models. However, the improvement in fit of model 3 over model 2 in the calibration sample does not hold up to validation.

To assess further the stability of our results, we performed the "flip side" of the double cross-validation by calibrating the models on the data from the 277 households in the holdout sample and using the results to predict the purchase behavior of the remaining 300 households. The pattern of estimated coefficients is the same as in Table 3. The grid-search value for the threshold parameter θ in model 3 is .42. The log-likelihood values for fit and prediction follow.

	Fit	*Prediction*
Model 1	−2007.3	−2086.1
Model 2	−1994.7	−2082.3
Model 3	−1992.5	−2078.5

A likelihood ratio test reveals that model 2 ($\chi^2_2 = 25.2$) and model 3 ($\chi^2_3 = 29.6$) afford a significant improvement in fit over model 1. Furthermore, both models 2 and 3 predict purchase behavior among the 300 households better than model 1. Finally, we note that the improvement in fit of model 3 over model 2 when calibrated on the 277 households *does* hold up to predictive validation. All of this evidence further supports the stability of our results.

DISCUSSION

We illustrate the reference effects of price and promotion on consumer response by looking at a "slice" of data from the calibration period. During the three-week period from week 121 to week 123, five of the six stores

[1]The unexpected sign of δ_1 may be due to the fact that the exponentially smoothed measure *RP* is capturing something other than the reference effect of price. Because the stores are likely to offer price discounts on only one brand at a time, an individual who always buys his or her favored brand at low price usually will be exposed to the competing brands at regular price. If so, *RP* reflects not only exposure but also patterns of purchase incidence. A relatively high value of *RP* might indicate that the individual does not seek choice occasions in which the brand is favorably priced, revealing a low level of utility for the brand. In this case, we would expect δ_1 to be positive; i.e., the higher the level of *RP*, the lower the value of $(P - RP)$ and the lower the level of consumer utility. Such an effect would be less pronounced in model 2, where there is no carryover effect of exposure. Because of the discrete threshold structure of *PRP*, the same problem is not likely to arise in evaluating the reference effects of promotion.

in the Pittsfield area offered promotions and price discounts on Folgers ground caffeinated coffee (Table 4). Consumers purchasing coffee during this period were exposed to this marketing activity, which potentially influenced their points of reference for price and promotion. We can assess the overall impact of the pricing and promotional activity during this period by comparing prior purchase behavior, points of reference (i.e., *PRP* and *RP*), and purchase probability measured before and after the period. For this discussion, we use the parameter estimates for model 2 reported in Table 3.

Promotional activity by Folgers may affect subsequent consumer response in two ways. First, features and displays (accompanied in many cases by special price discounts) increase utility and the likelihood of consumer purchases; these choices positively reinforce subsequent choice of Folgers. Second, however, exposure to the brand on promotion will tend to offset this reinforcing effect. Consumers who last purchased Folgers on promotion are significantly less likely to repurchase Folgers than those who last purchased off promotion. To the extent that regular buyers of Folgers (off promotion) are induced to buy on promotion, their probability of subsequent repurchase will decline. Also, exposure to Folgers on promotion increases the number of consumers with $PRP = 1$, which also has a negative impact on the probability of subsequent repurchase.

Of 577 households in the full sample, 256 made 380 purchases of coffee between weeks 121 and 123. Folgers' share of incidence during this three-week period was just over 45% in comparison with an average market share of less than 27% during the entire 50-week calibration period. Clearly, the promotional activity by Folgers during weeks 121–123 was very successful in inducing consumers to purchase the brand. Of the 256 households that bought coffee during this period, only 14% (36 households) had last purchased Folgers before the promotion. Afterward, this proportion was just over 50% (129 households), a significant increase ($t = 10.1$). Most of these purchases, however, were on promotion. At the beginning of the promotional period, only 42% of the households that had last purchased Folgers (15 of 36) had purchased on promotion. At the end of the period, more than 90% of prior Folgers purchases had been made on promotion (118 of 129 households). Exposure to the brand on promotion (i.e., households with $PRP = 1$) also increased significantly, from 36% to just over 60% ($t = 5.5$), and reference price declined slightly, from \$2.36 to \$2.23 ($t = -5.8$).

Table 4
PRICING AND PROMOTIONAL ACTIVITY BY FOLGERS DURING WEEKS 121 TO 123

	Store					
Week	11	12	13	14	15	16
121	2.49[a]	2.49	2.39	1.86	1.86	2.49
	.00[b]	.00	1.00	1.00	1.00	.00
122	2.39	2.29	1.99	1.86	1.86	2.49
	1.00	1.00	1.00	1.00	1.00	.00
123	2.49	2.49	2.49	1.86	1.86	2.49
	.00	.00	.00	1.00	1.00	.00

[a]Price (in dollars).
[b]Promotion (= 1 if feature or display, 0 otherwise).

We can assess the net effect of these countervailing forces (i.e., the positive reinforcement of past purchase behavior versus the negative effects of past promotional purchase and exposure) by using model 2 to calculate the average probability of purchase before and after the three-week promotional period. In our calculations we assume that each brand is available at the same price (\$2.49) in each of the six stores and that there is no promotional activity. Under these conditions, our model suggests that average purchase probability increases slightly, but significantly, from .23 before the promotional period to .27 afterward ($t = 4.0$). Thus, for the case of Folgers promoting in weeks 121 to 123, the positive effects of promotion outweigh the negative ones. This finding need not be true in general. For a brand with a stronger franchise (i.e., with a large number of consumers willing to buy the unpromoted brand at regular price), the incremental effects of promotion may be more than offset by the negative dynamics in subsequent periods.

Note that an increase in average brand choice probability does not necessarily imply that we should expect increased sales of Folgers in the postpromotional period. Our model captures only brand choice behavior, conditional on category purchase. The increase in average choice probability from .23 to .27 is calculated over all 256 households making a purchase in the promotional period (the choice probabilities of the remaining households do not change). However, not all of these households are equally likely to be in the market for coffee before and after the period. In fact, those favoring Folgers are likely to be represented disproportionately among households taking advantage of a Folgers promotion. These households are correspondingly less likely to be in the market for coffee after the promotional period because of inventory effects. Thus, any change in the level of Folgers sales before and after a promotional period depends not only on the changes in brand choice probabilities, but also on any change in the mix of households in the market for coffee. In an examination of purchase incidence using the same IRI coffee dataset, Lattin and Bucklin (1988) found evidence of a decline in incidence after promotional activity.

The chosen illustration reflects only the incremental effects of a three-week price promotion by a single brand. A strength of the model is that it can be used to assess the potential effects of a substantial change in the promotional pricing environment. For example, the model could be used in simulation to explore the implications of decreasing the frequency of promotion for a given brand or for the category as a whole. Because our model is

adaptive (i.e., consumers' points of reference adjust to changes in the depth and frequency of price promotion in the category), it may prove useful in forecasting outside the range of the available data.

CONCLUSION

We propose and test a model of consumer response incorporating the reference effects of price and promotion. Our results support the notion that consumers form expectations based on their exposure to promotional activity and that those expectations influence the patterns of brand choice. By including both price and promotional variables in our model of consumer response, we are able to characterize explicitly the differences between promotional and nonpromotional price elasticity and to separate these effects from the reference effects of price and promotion.

We also provide a different rationale to explain the carryover effects of promotions on consumer response. Other researchers have focused on the differences between prior purchase and prior promotional purchase on subsequent brand choice; their rationales require that the promotional brand actually be purchased by the consumer. Our results suggest that if we control for prior promotional purchase, there is still a significant association between consumer response and *exposure* to the brand on promotion.

We present a threshold model of reference point formation, a special case of which is broadly consistent with the expectations models in the literature. For two different parameterizations of the reference point formation model ($\lambda = 0$ and $\lambda > 0$), our models incorporating reference effects outperform a model without reference effects in terms of both fit and predictive validity.

Future research. Several interesting and important questions remain for future research. First, further theoretical development and controlled experimental testing of our proposed framework are needed to rule out alternative explanations[2] of our findings and to identify causal mechanisms. In our study, we were limited to using indirect measures and making inferences about the associations among those measures. Experimental research using techniques such as those described by Dickson and Sawyer (1986) might help to improve our understanding and facilitate progress in modeling promotional reference points.

Second, we should extend our model to consider the reference effects of price and promotion on category purchase incidence. Consumers who are exposed to the product category during periods of high category value (i.e., when favored brands are offered on promotion at discounted prices) may establish expectations of high value in the future. In response, these consumers may be more likely to time their purchases to coincide with deal periods, effectively redistributing demand over time.

[2]For example, Neslin and Shoemaker (1989) point out that cross-sectional testing of consumer response can lead to an aggregation bias that may be interpreted as a dynamic effect. Though our cross-sectional model specification is designed to account for the heterogeneity in individual preference and past purchase behavior (using the measures *BL*, *LP*, and *LPP*), we cannot completely rule out aggregation bias without an individual-level test.

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