

A Reference Price Model of Brand Choice for Frequently Purchased Products

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A brand choice model that incorporates both reference and observed prices is proposed for frequently purchased products. The model is composed of a probability-of-purchase component and a reference-price-formation component. Empirical testing of the model using coffee UPC scanner panel data demonstrates that for two of the three brands, the model predicts probability of purchase better than do standard demand models that utilize only current observed brand prices.

A considerable amount of recent empirical research, both econometric and conjoint-based, has focused on how marketing mix variables affect household demand for frequently purchased products (see, for example, Elrod and Winer 1982; Guadagni and Little 1983). These studies typically show that retail price or promotion-adjusted price explains more variance in consumer demand than do other marketing-mix variables.

There is, however, considerable evidence from both marketing and economics supporting the notion that, from the consumer's perspective, price is a complex construct that is multidimensional in nature and not composed of only retail price. Other prices discussed in the literature are reservation price (Scherer 1980), perceived price (Monroe 1973), and evoked price (Rao and Gautschi 1982). Besides being complex, prices from the consumer's perspective are dynamic for many product categories. In particular, observed retail prices either before or after adjusting for promotions can fluctuate greatly over time. These changes in observed prices could be a result of manufacturers changing strategies, retailers running short-term pricing deals, or consumers using coupons.

An important consequence of dynamic observed prices is that uncertainty develops about the "true" price of a brand. This is one of the problems cited with price-related promotions—in particular, with in-store price reductions. For example, if promotions resulting in a discounted price are run too frequently, consumers may get used to the lower price and resent paying the normal price when the promotion stops (Ogilvy, Benson, and Mather 1977). The implication is that consumers develop personal forecasting rules for price that

enable them to compare the historical deal-induced prices to the normal price. In other words, households may anticipate prices, compare them to observed prices, and develop decision rules based upon the discrepancy.

The purpose of this study is to develop and test a simplified model of consumer behavior emphasizing (1) the multidimensional nature of price when examining it from the consumer's point of view—in particular, the importance of reference prices, and (2) the concept of households forecasting prices and utilizing these forecasts when making brand choices.¹ The model is simplified in that it restricts those factors affecting choice to primarily marketing mix variables, especially price. The goal is to better our understanding of how price enters the choice process, since as Rao (1984) recently pointed out, relatively little is yet known at the consumer level about how price information is used in making brand choice decisions. The model can also be viewed as an attempt to understand behaviorally how consumers react to frequent price-related promotions by manufacturers and retailers.

BRAND CHOICE MODEL

The consumer model developed in this article rests on the assumption that the key factors affecting demand are related to brand attributes via either the marketing mix or the consumer's purchase experience (e.g., which brand was last purchased). As stated earlier, no case is made for a general model of consumer choice. Simplicity is utilized to produce a model that contains important factors related to choice and that is empirically estimable.

It is hypothesized that the underlying brand purchase process is split into two components. One component

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¹A model for durable purchasing behavior utilizing some of the price concepts described in this paper has been developed by Winer (1985a). In addition, a purchase quantity model can be added to the brand choice model described in this paper (Winer 1985b).

is operative during the intervening time between shopping trips. During this period, a household's disposition towards a brand is affected by (1) the brand chosen on the previous purchase occasion, and (2) advertising exposure relative to competition. Regarding the prior purchase factor, much research, both empirical (e.g., Kuehn 1962; Shoemaker and Shoaf 1977) and theoretical (e.g., Howard and Sheth 1969), has specified learning factors in models of consumer choice. Advertising exposure is a relevant marketing mix variable for virtually all frequently purchased products.

During this "at home" period, it is suggested that a set of reference prices are formed for the brands in the consumer's evoked set. A reference price is defined here as the consumer's perceived current price of a brand; it could also be termed an anticipated price, since it is the price a consumer expects to observe at point-of-purchase. Reference price is discussed by Erickson and Johansson (1985; as a "price belief"), Gabor (1977; as the "price image" of a brand), Monroe (1973), and others. These reference prices are updated during the interpurchase period if new information is received, e.g., advertising, coupons, and so on.

The second component of the underlying brand purchase process is the point-of-purchase part. Along with observing relative brand prices, consumers are assumed to observe the prices of the brands in the evoked set and to compare them to the reference or anticipated prices. The reference prices are used as adaptation levels (Helson 1964) for the observed prices. In other words, households are conjectured to compare the prices they actually see to the reference prices, and the discrepancies affect the probability of purchasing for a brand. This comparison approach can be justified from several other research perspectives as well (Sawyer and Dickson 1984). Using Gabor and Granger's (1964) acceptable price ranges, it can be hypothesized that consumers compare their most acceptable price to the actual price or price last paid. Assimilation-contrast theory (Monroe 1971; Sherif 1963) implies that consumers contrast observed prices with their acceptable range. Thaler (1985) refers to the discrepancy between reference and actual price as transaction utility. Thus, there is a body of literature supporting the notion that consumers compare price concepts to some internal standard.

Based on the preceding discussion, and assuming a linear form, the model describing the probability of purchasing a brand is the well-known linear probability model (Doyle 1977; Theil 1971, Ch. 12):

$$PROB_{ijt} = \alpha_0 + \alpha_1 PURCH_{ijt-1} + \alpha_2 ADV_{ijt} + \alpha_3 (RP_{ijt}^r - RP_{ijt}^o) + \alpha_4 RP_{ijt}^o + \epsilon_{ijt}, \quad (1)$$

where

$PROB_{ijt}$ = the (unobserved) probability of buying the j th brand on the t th product category purchase occasion

$PURCH_{ijt-1}$ = an indicator of whether brand j was bought on the previous purchase occasion

ADV_{ijt} = relative advertising exposure of brand j to household i prior to purchase occasion t

RP_{ijt}^o, RP_{ijt}^r = relative variants of the observed and reference prices, respectively

ϵ_{ijt} = stochastic error

Relative quantities are used for the independent variables due to the relative nature of the dependent variable and since the households are assumed to be comparing brands; i.e., competitive effects are accounted for. The relative quantities could be computed in several ways, a common approach being to take the ratio of the relevant price to the market average, e.g., $RP_{ijt}^o = P_{ijt}^o / \bar{P}_{it}^o$.

Hypotheses for the coefficients are as follows. Both α_1 and α_2 should clearly be positive, while α_4 should be negative. The variable $RP_{ijt}^r - RP_{ijt}^o$ is somewhat like a "sticker shock" effect for frequently purchased goods. As a result, the expected sign of α_3 is positive since observed relative prices less than anticipated relative prices should positively contribute to $PROB_{ijt}$ and vice versa. Rao and Gautschi (1982) argue for a similar impact of such discrepancies from market price on satisfaction rather than probability of purchase.

REFERENCE PRICE FORMATION MODELS

Equation 1 could be estimated directly, given household measures of P_{ijt}^r —the reference price. However, not only are such quantities generally unavailable from conventional data sources, but it is possible that such variables would be very difficult to measure. Few studies have attempted to develop ratio scale measures of this concept. Gabor and Granger (1964) have measured actual price recall, but that is a backward rather than a forward-looking measure. The most useful reference prices, for example, would have to be measured just before the next product category purchase is made rather than just after a purchase has been made. Economists have often adjusted survey responses such as "up" or "down" to a future price direction question, but these adjustments are highly judgmental in nature (cf., Carlson and Parkin 1975).

Therefore, an alternative approach to direct measurement is to develop rival models of the formation processes of the unobserved variables that can (1) be used to indirectly estimate the reference prices, and (2) be tested against each other for predictive ability. The observed prices, P_{ijt}^o , are assumed to be exogenous; even if a consumer has a coupon before the shopping trip, the ultimate transaction price is still outside his/her control.

Two alternative reference price formation processes will be tested.

Extrapolative Expectations Hypothesis (EEH)

$$P_{ijt}' = \delta_0 + \delta_1 P_{ijt-1}^o + \delta_2 TREND + \epsilon_{ijt} \quad (2)$$

This model is very close to the expectation assumption made by Ferber (1953), and is a simplified version of the reduced form of the adaptive expectations model (Nerlove 1958). Equation 2 indicates that a household's perception of the current price of a brand is formed by the most recent observed price and a trend. Since P_{ijt}' is assumed to be formed prior to shopping, the prior period observed price is highly relevant. An implied assumption about Equation 2 is that consumers notice the prices of all brands when they purchase a brand in the category since reference prices are assumed to be formed for all brands in the consumer's evoked set.

Rational Expectations Hypothesis (REH)

In the early 1960s, John Muth became disturbed about the widespread use of the extrapolative assumption for expectations formation in macroeconomic models used to help set economic policy. As he put it, "to make dynamic economic models complete, various expectational formulas have been used. There is, however, little evidence to suggest that the presumed relations bear a resemblance to the way the economy works" (1961, p. 315). His proposal was that ". . . expectations, since they are informed predictions of future events, are essentially the same as the predictions of the relevant economic theory" (1961, p. 316). In other words, he believed that over time, economic agents (e.g., consumers) discover the decision rules used to set the levels of the expectational variables. Each consumer, however, has his/her own error drawn from a distribution with mean zero implying (1) different expectations across consumers, but (2) that each expectation is an unbiased estimate of the true value. In other words,

$$P_{ijt}^o = P_{ijt}^r + \mu_{ijt}, \quad (3)$$

with the disturbance having mean zero.²

This implies that assuming expectations are formed rationally, a model describing how a brand price is adjusted over time by management would also be the model utilized by consumers to form their expectations. A simple such model is (see also Houston 1977):

$$P_{ijt}' = \theta_0 + \theta_1 P_{jt-1} + \theta_2 MS_{jt-1} + \theta_3 TREND + \nu_{ijt}, \quad (4)$$

where P_{jt} is the retail price set by the firm for brand j , MS_{jt} is the brand's market share, and the errors are drawn from distributions with mean zero.

Equation 4 hypothesizes that (1) firms set price based on historical price levels and market performance, and (2) consumers learn this decision rule and develop ex-

pectations accordingly.³ The first assumption is derived from the basic notion that costs, competitors, and customers affect pricing decisions. Assuming variable costs do not change in the short run, prices should be highly related between short intervals. The lagged market share term is incorporated to capture consumer demand and competitor performance. The coefficient λ_2 probably would be positive as low share brands would generally seek to gain share in frequently purchased categories by cutting price. The second assumption is key to the REH; its strong informational requirement has been challenged (cf., Friedman 1979), but it remains perhaps the most highly researched area in economics. In addition, experiments in economics have shown that individuals can behave in a manner consistent with predicted behavior, given that expectations are formed rationally (Plott and Sunder 1982). Consequently, it is felt that some attempt to test the REH in a consumer demand context is warranted.

ESTIMATION

Data

The data are from a scanner panel of 1318 households in a large midwestern city.⁴ Available information includes purchasing histories of coffee on a daily basis, prices paid, demographic data, the store where coffee was bought, and daily advertising for coffee in local newspapers. The period of observation covers 429 days.

An unusual characteristic of coffee is that the product is segmented by major grind types—ground coffee, drip, and electric perk, according to taste preference and household's brewing technology.⁵ Since prices vary between the grinds, the segments must be separated in the analysis. The alternatives are to: (1) analyze only one grind, say ground (cf., Gaudagni and Little 1983), (2) develop separate grind models for each household, or (3) assign each household to a grind type based upon its purchase history. Because Option 1 would rule out many families from the analysis that do not consume the selected grind, and Option 2 would result in considerable data analysis, it was decided to select Option 3. Although few households purchased only one grind exclusively, the assigned grind accounted for an average of 86 percent of all purchases.

Three major brands accounting for 91 percent of the total coffee purchasing volume were analyzed. These brands will be called A, B, and C for reasons of confidentiality. Brand A has medium share of the overall

³Note that the error term in Equation 4 has an i subscript to permit individual consumer errors.

⁴Appreciation is expressed to SAMI, Inc. for supplying the data utilized in this study.

⁵There is actually a fourth grind type—automatic drip—that accounted for 17.6 percent of the coffee purchasing volume, but 73 percent of this grind's purchases were from only one brand, thus making probability-of-purchase notions rather senseless.

²Other properties of μ_{ijt} are also assumed, such as no serial correlation and homoskedasticity.

market and is a regional brand. Brand B has the highest share, charges the highest prices, and is a national brand. Brand C has the lowest share and is also a national brand.

Households with less than 10 purchases of their grind type were eliminated because of insufficient data to estimate the price expectation models. As a result, 222 households were utilized in the analysis.

Reference Price Estimation

Since P_{ijt}^r is not measured, it is necessary to utilize an estimation approach that substitutes for the unobservables in order to estimate the expectation formation hypothesis models. Imposing the unbiasedness property on the forecasts (termed "implicit expectations" by Mills 1962) based on Equation 3, we can substitute Equation 3 into Equations 2 and 4 to obtain:

$$(EEH) \quad P_{ijt}^o = \delta_0 + \delta_1 P_{ijt-1}^o + \delta_2 TREND + \epsilon_{ijt} + \mu_{ijt} \quad (5)$$

$$(REH) \quad P_{ijt}^o = \theta_0 + \theta_1 P_{jt-1} + \theta_2 MS_{jt-1} + \theta_3 TREND + \nu_{ijt} + \mu_{ijt} \quad (6)$$

The assumption of implicit expectations creates models for the reference prices in terms of observables, and since the errors still have zero mean, a conventional regression approach can be used to obtain unbiased estimates of the models' parameters. Once the coefficients have been obtained from Equations 5 and 6, predicted values of the dependent variable \hat{P}_{ijt}^o can be constructed representing estimates of P_{ijt}^r for each formation hypothesis. The specific estimation procedures were as follows.

Equation 5 (P_{ijt}^r , EEH assumption). The *TREND* variable is a number simply representing a sequential ordering of product category purchases. If brand j was purchased on category occasion t , P_{ijt}^o is the transaction price; if it was not purchased, P_{ijt}^o is the average of all other household purchases of that brand/grind combination on that day in the store. Estimation of Equation 5 was performed on the household level on a sequential basis using data from the first four brand j purchase occasions (since there are three coefficients), then five, etc., up to the number of category purchases. The predicted values of P_{ijt}^o , \hat{P}_{ijt}^o , which were used as estimates for the reference prices, were thus based only on price information available to the household at the time.

Equation 6 (P_{ijt}^r , REH assumption). Again, only data from those weeks when the category was purchased are utilized. The retail prices P_{jt} and market shares were computed from the appropriate weekly data from the 222 households, where P_{jt} is the average price paid. The estimation is performed in a sequential manner as was done for Equation 5. While P_{jt} and MS_{jt} are the same for all households, the θ s will vary since the dependent variable has an i subscript and thus differs between households.

In sum, by assuming alternative consumer forecasting models, reference prices can be computed from ob-

served data. While the actual values are not available, the forecasts are realistic estimates since they rely on panel data price information reflecting actual prices paid or prices paid by other households in the same store on the same day. Finally, advertising variables were constructed from the newspaper advertising data supplied with the panel data. The number of insertions in a medium were multiplied by circulation data to produce gross ratings points figures. The i subscript from ADV_{ijt} , therefore, must be dropped.

EMPIRICAL RESULTS

To demonstrate the price volatility facing the 222 households, intra-household means and standard errors of observed prices per ounce over the coffee purchase occasions were computed for each brand. The standard error, in particular, provides a measure of the variance in prices facing the households over time. The mean standard error for Brand A was 0.64 cents per ounce, 0.69 for Brand B, and 0.77 for Brand C. In other words, a 95 percent confidence interval around the mean observed prices would imply a range of about 3 cents per ounce or 48 cents on a one-pound container. Given that one-pound containers averaged \$1.90, such substantial variation around the mean price seems to support the high likelihood that price uncertainty existed.

Since the observed dependent variable in Equation 1 is only a 0-1 indicator of which brand was purchased, logit analysis is an appropriate estimation methodology. The sample of 222 households was randomly split in half to provide estimation and prediction samples. The 111 estimation families produced 2,173 coffee purchase occasions that formed the basic data for estimating Equation 1. The relative reference price and advertising variables were computed relative to market averages. The parameter estimates, developed using the SAS maximum-likelihood routine *PROC LOGIST*, are presented in Table 1. The reported R^2 was developed by McFadden (1974), and is defined by:

$$R_M^2 = 1 - \left(\frac{L_M}{L_0} \right)$$

where L_M is the maximum value of the log-likelihood function of the utilized model, and L_0 is the value assuming only an intercept model. The "percent correct" column is the percentage of purchases of the estimation sample correctly classified. These figures can be used as benchmarks against which the model's performance using the holdout sample can be compared.

In general, the results from the estimation sample indicate strong support for the model, particularly for Brands A and B.⁶ The logit coefficients are generally

⁶An explanation of the large differences in some coefficients between hypotheses for the same brand is that the *EEH* and *REH* assumptions generated quite different estimates of P_{ijt}^r . For example, for Brand A,

TABLE 1
PROBABILITY OF PURCHASE MODEL ESTIMATES (ESTIMATION SAMPLE)^a

Brand	Expectation assumption	Purchase _{t-1}	$RP^r - RP^o$	Relative advertising	Relative price	% Correct	R_M^2
A	Extrapolative	1.51 ^b (.74)	2.22 ^b (.85)	3.19 ^b (.94)	-3.15 ^b (.64)	70	.23
	Rational	1.47 ^b (.10)	19.72 ^b (5.45)	2.53 ^b (.99)	-23.47 ^b (5.37)	70	.24
B	Extrapolative	1.94 ^b (.10)	5.71 ^b (1.00)	2.01 ^b (.83)	-3.96 ^b (.69)	72	.35
	Rational	1.90 ^b (.10)	7.59 ^b (4.69)	.97 (.89)	-13.67 ^b (4.54)	72	.36
C	Extrapolative	1.46 ^b (.14)	1.30 (1.10)	2.55 ^b (.56)	-3.95 ^b (.81)	84	.20
	Rational	1.47 ^b (.14)	5.65 (6.48)	2.69 ^b (.62)	.92 (6.37)	84	.18

^a Numbers in parentheses are asymptotic standard errors.

^b $p < 0.05$, one-tail test.

TABLE 2
PROBABILITY OF PURCHASE MODEL VALIDATION RESULTS (HOLDOUT SAMPLE)

Brand	% Purchases	Expectation assumption	Tested model:		χ^2 vs. Rival model	Rival model: % correctly classified
			% Correctly classified	% Improvement over C_{pro}		
A	28.3	Extrapolative	79	34	6.42 ^b	73
		Rational	79	34	13.62 ^b	
B	61.0	Extrapolative	77	48	34.14 ^b	73
		Rational	78	50	2.75 ^a	
C	10.7	Extrapolative	91	12	1.4	91
		Rational	91	12	.76	

^a $p < 0.10$, χ^2

^b $p < 0.05$, χ^2

significant and have the expected sign in every case. The R_M^2 measures are consistent with other studies of this type (Guadagni and Little 1983). The discrepancies between the estimated anticipated prices and the observed prices are highly significant for Brands A and B. The implication is that (1) the positive ($RP^r - RP^o$) difference when the brands drop in price due to, say, an in-store promotion, is successful in inducing purchasing, and/or (2) the price increase seen when the brand goes back to normal price inhibits purchasing. Brand C customers are not sensitive to the discrepancy, and, using the extrapolative assumption that fits better than

the average value of ($RP_{ijt}^r - RP_{ijt}^o$) across the estimation households was -0.01 under the *EEH* assumption and -0.64 for the *REH*. There is no reason that the reference prices should be highly correlated between the *EEH* and *REH* assumptions since they imply quite different formation processes.

the rational assumption, are apparently sensitive only to observed price changes. Since it has the lowest share, it appears that consumers are not devoting much price information processing time to its purchasing. Of additional interest is the issue of which expectation assumption seems to best capture consumer purchasing behavior. As can be seen, the R_M^2 s are very close, indicating that both assumptions are equally plausible given the available data.

Table 2 presents the results of several validation checks on the proposed probability of purchase model on the holdout sample of 111 households. First, the classification results show a slight improvement over the estimation sample results from Table 1, indicating model stability. Second, all three classification results are substantial improvements over Morrison's (1969) proportional chance criterion, C_{pro} . Two other tests were run versus a nested version of Equation 1 derived

by eliminating the reference price variable, ($RP_{ijt}^r - RP_{ijt}^o$). This produces a more standard demand model incorporating only lagged behavior, relative advertising, and relative price. The first test was a standard likelihood ratio test using the nested model versus Equation 1. For both Brands A and B, the proposed model was significantly better than the alternative. Finally, based on the percentage of brand choices correctly predicted, Equation 1 again out-performed the alternative for Brands A and B.

DISCUSSION

Since many of the constructs utilized in this study were estimates of nonmeasured quantities, the reported results must be treated as indications of the underlying consumer behavior at best. However, given the nature of the available data, enough observations on prices were available at the household level to ensure that the estimated reference prices (P_{ijt}^r) were based on information that was actually available to the consumers at the time.

Research generated from this paper could be of several types. First, it is important from both academic and practitioner perspectives to have more certain evidence that observed price instability results in consumers forming reference prices, that these prices are compared to observed prices, and that the discrepancies between anticipated and observed behavior affect both brand choice and purchase quantity. Experimental research would be appropriate to address such issues. In addition, there are clearly substantial implications for optimal manufacturer pricing policies from this line of inquiry; "on-off" of price promotions may not be in the best long-term interests of the brand's consumer franchise. Normative research attempting to determine a firm's optimal promotion policy over time, assuming that consumers assess observed prices in the context of reference and expected future prices, could produce implied patterns different from those currently used in practice.

CONCLUSION

The model proposed in this article utilizes estimated reference as well as observed prices in modeling consumer buying behavior towards frequently purchased products. It is particularly appropriate for modeling how consumers react to point-of-purchase price promotions. The results indicate that, based on the assumed reference price formation processes, consumer brand choice decisions for two out of three major brands of coffee were strongly affected by discrepancies between expected and observed prices at the point of purchase.

The important managerial implication of the results is that manufacturers may be penalized in the long run by frequent short-term price-related deals since consumers make forecasting errors about the point-of-pur-

chase prices. An opposite strategy of infrequent price adjustments may allow price to become less important in the household brand choice process relative to advertising and product quality since observed prices at the point of purchase will be fully anticipated.

There are, of course, limitations to the study. First, the reference prices were not directly measured but computed based on assumed models with unknown measurement error. However, as was pointed out earlier, the constructs are very difficult to measure at best and are perhaps unobservable. Second, only heavy users were examined. Third, only one product category, coffee, was examined, thus raising the issue of external validity. Future research should emphasize both how price enters the consumer choice process and how reference prices can be better measured.

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