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Investigating Coupon Effects on Household Interpurchase Behavior for Cheese

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The knowledge of a household's shopping behavior such as its purchasing pattern and response to a change in marketing variables is essential for retailers to succeed in today's market which is highly competitive and consumer-oriented. Retailers who are not able to uncover the various needs of customers and then facilitate the fulfillment of those needs are doomed to failure (Wysocki, 2005). The household shopping frequency, linkage between household's purchase pattern and its demographic profile, and the various response behaviors of households to the marketing environments are all valuable information for retailers to determine their marketing targets and strategies. For example, direct marketing companies target their customers via customized offers at a time when they are most likely to buy (Vakratsas and Bass, 2002). Retailers set up their promotion schedules parallel with household purchase frequencies in order to successfully induce households to purchase more of their products. Therefore, accurately interpreting and modeling consumers' shopping behavior and their response to marketing variables will continue to be an important research topic for marketing economists, as it has been for more than two decades.

In this study, we investigate the influences on household purchase timing decisions. Specifically, the duration between two consecutive purchases (interpurchase time) of a given household for a specific product is studied, and the factors that have potential effects on the duration are analyzed. These factors include household demographic variables, marketing variables such as price, or consumer demand enhancing promotions such as coupons. These variables have effects not only on household purchase quantity, but also on household interpurchase time. The primary

objective of this study is to analyze household purchase behavior for store-bought cheese products through the interpretation of the variations of their interpurchase times. Previous studies on household cheese purchase behavior have focused only on one segment market (Gould, 1997). However, others have found that households could be segmented into different groups according to their purchasing rates or purchasing frequencies, which is also the reciprocal of interpurchase times (Gupta and Chintagunta, 1994; Vakratsas and Bass, 2002). For example, among cheese purchasing households, 40% buy cheese products on average once every two weeks (frequent buyers), and 60% buy cheese products on average once every six weeks (infrequent buyers). Households in different segments usually have different intensity of response to price and promotional activities (Richards, 2000).

In this study, we first assume that there exist different household segments characterized by their purchase timing decisions. Then we adopt a model that relates household demographic variables to the underlying segments through household purchase history. The model categorizes the households into different segments according to their characteristics. Since households in different segments have a different intensity of response to price and promotional activities, we are able to accurately derive the effects of coupon or other marketing variables on household interpurchase times, or the purchase frequencies through the segmentation of the market. Furthermore, we can identify and characterize household segments in terms of their purchasing rates and their propensity to accelerate purchases due to marketing-mix activities. As a result, measures of different responses of buyers in different segments to marketing-mix activities in their purchase timing decisions can be ascertained from this analysis. The results provide

useful information on optimal design of retailer's promotional strategies.

Econometric Model

Interpurchase times are the durations or spells between two consecutive purchases. They are random variables and follow a certain probability distribution. The interpurchase time distribution captures the effect of the time elapsed since the last purchase on the timing of the next purchase. This distribution, in general, is also influenced by marketing variables and household characteristics. Directly defining the distribution usually leads to a very complicated or even intractable estimation in the model, and the interpretation of the results is not intuitive to the underlying economic event. An alternative approach of a hazard function has thus been proposed and widely used in the literature. Between hazard and probability density functions there is a one-to-one correspondence, so that the distribution of the interpurchase times can be studied by examining either of the two functions. A hazard function is the conditional probability of spells that will be completed at current duration given that they lasted until now, in contrast to the unconditional probability of spells that complete at any circumstances. Hazard function, in other words, is the rate at which events occur, which makes it intuitively appealing to study purchase timing decisions (Jain and Vilcassim, 1991). Technically, the hazard function needs to be only finite and nonnegative, whereas the probability density function must also integrate to one, making the empirical work easier. Below, we start the econometric model from the specification of the hazard function.

We assume household *i* faces an occasion for it to make purchases. The purchase choice occasion can be the calendar time, for example, week 1, week 2, and so on. We

further define t_{j_i} as the duration time since the last purchase until occasion j_i. t_{j_i} is measured in the unit of time such as 1 week, 2 weeks, and so on. If we use j_i to index all the purchase occasions of household i, where j_i takes 1, 2, until J_i, then t_{j_i} is the interpurchase time and is a random variable that follows a certain distribution. J_i is actually the total number of the interpurchase times household i experiences and it varies across households. The hazard function of t_{j_i} can be defined as:

$$(1) \qquad H_0(t_{j_i}) = \exp(\gamma_0 + \gamma_1 \ln t_{j_i}),$$

where γ_0 and γ_1 are parameters. Equation (1) implies that the hazard function of interpurchase time t_{j_i}, i.e., the probability of making purchase given that no purchase has been made up to time t_{j_i} depends on t_{j_i}, the time duration since the last purchase, in a monotonic relationship. Equation (1) gives a Weibull distribution of t_{j_i}.[1] The hazard function defined in (1) is increasing in duration t_{j_i} if $\gamma_1 > 0$, decreasing if $\gamma_1 < 0$, and constant if $\gamma_1 = 0$. Thus, the Weibull distribution captures the various duration dependences according to the value of γ_1. Duration dependence indicates that the conditional purchase probability increases or decreases with the time elapsed since the last purchase. If the probability increases with the time elapsed since the last purchase, it's called a positive dependence. If the probability decreases with the time elapsed since the last purchase, it's called a negative dependence.

The hazard function defined by (1) depends only on the time elapsed since the last purchase. However, price, promotion activities, and other marketing variables will

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[1] If we let $\alpha = 1 + \gamma_1$ and $\gamma = \dfrac{\exp(\gamma_0)}{1+\gamma_1}$, then (1) can be written as $H_0(t) = \gamma\alpha t^{\alpha-1}$. This format is widely used in the literatures.

influence household purchase decisions. To capture the effects of marketing variables, (1) is modified as below:

$$(2) \qquad H(t_{j_i}) = H_0(t_{j_i}) \cdot \phi(X_{j_i}\beta),$$

where $H_0(t_{j_i})$ is defined in (1) and $\phi(X_{j_i}\beta)$ is given as below:

$$(3) \qquad \phi(X_{j_i}\beta) = \exp(X_{j_i}\beta),$$

where X_{j_i} is a vector of marketing variables that influence household purchase timing and β is a vector of conformable parameters. The use of exponential is to guarantee that the hazard function is nonnegative. The interpretation of β, the coefficient of X_{j_i}, is similar to that in a regression model. For example, if β is positive, then the probability of purchase increases as X_{j_i} increases. As to the magnitude of the effects of X_{j_i}, when the kth variable x_k increases by one unit, the probability (hazard) changes by $(\exp(\beta_k) - 1)100\%$ (Jain and Vilcassim, 1991).

In the literature, equation (1) is called the "proportional hazard formulation." It contains two parts: the baseline hazard $H_0(t_{j_i})$ and a shifter $\phi(X_{j_i}\beta)$. If the effects of the marketing variables X_{j_i} are ignored, then the purchase timing decision is characterized only by the baseline hazard function and hence, the corresponding probability density function. The effects of X_{j_i} are to shift the hazard from its baseline.

Equation (2) captures the effects of marketing variables. However, it assumes the hazard function is invariant across households. For example, the purchase probability is the same for two households if they face the same marketing environment no matter how different their demographic characteristics are. The simple way to incorporate household heterogeneity is to include household characteristic variables into X_{j_i}. However, doing

so ignores household unobserved heterogeneity such as rate of consumption, specific preferences over the product, etc. For example, the effect of household income on purchase probability depends on household consumption rate. In this study, we adopt a different model to capture household heterogeneity in their hazard function. We follow the framework of Kamakura and Russell (1989), Gupta and Chintagunta (1994), and Vakratsas and Bass (2002), and assume that the households can be partitioned into relatively homogeneous groups that differ substantially in purchase behavior. Specifically, we segment households according to their purchase frequencies and assume that different marketing segments have different sensitivities to the change of marketing variables. Suppose that there exist *S* segments in the cheese market. A household belonging to segment *s* has a segment specific hazard function as below:

$$(4) \qquad H^s(t_{j_i}) = H_0^s(t_{j_i}) \cdot \phi(X_{j_i}\beta^s),$$

where $H_0^s(t_{j_i}) = \exp(\gamma_0^s + \gamma_1^s \ln t_{j_i})$, and $s = 1, 2, \cdots S$. In contrast to (2), the baseline hazard and the marketing shifter in (4) are all segment specific.

The *S* marketing segments are characterized by household purchase frequency or the interpurchase time, since the two are reciprocal. For example, the households have an average interpurchase time of two weeks belonging to the same segment, and the households have an average of interpurchase time of four weeks belonging to another segment, etc. We further relate household characteristics to its probability of being in a certain segment. In other words, the probability of a given household being to a certain segment can be determined by the household characteristics. Following Gupta and Chintagunta (1994) and Vakratsas and Bass (2002), we define the probability of household *i* being in segment *s* as below:

$$(5) \qquad p_i^s = \frac{\exp(Z_i \bar{\alpha}^s)}{\sum_{k=1}^{S} \exp(Z_i \bar{\alpha}^k)},$$

where Z_i is a vector of household characteristic variables and $\bar{\alpha}^s$ is a vector of conformable parameters. Since the sum of the probabilities defined in (5) over all the segments is one, we normalize (5) with respect to the parameters of segment *S*, the last segment, as below:

$$(6) \qquad p_i^s = \frac{\exp(Z_i \alpha^s)}{1 + \sum_{k=1}^{S-1} \exp(Z_i \alpha^k)},$$

where $\alpha^s = \bar{\alpha}^s - \bar{\alpha}^S$ which is the difference in the effect of Z_i on the probability of belonging to segment *s* from the effect of Z_i on the probability of belonging to segment *S*. Given estimates of α^s, we can compute a probability of membership for a given household in each of the *S* segments in the market according to Z_i, the household characteristics, using (6). Therefore, it is possible to uniquely assign households according to the computed probabilities to segments with differential sensitivity to marketing variables as defined in (4).

Model Estimation

The parameter estimates of the model specified from (1) through (6) can be jointly obtained using the maximum likelihood estimation procedure. For a household (*i*) with Z_i characteristics that has p_i^s probability of membership belonging to segment *s* which has differential sensitivities to marketing variable *X*, the likelihood of this household of occurrence of a sequence of interpurchase time t_{j_i} ($j_i = 1, 2, \cdots J_i$) can be expressed as:

$$(7) \qquad L_i = \sum_{s=1}^{S} p_i^s L_i^s \,,$$

where p_i^s is given by (6) and L_i^s is the segment specific likelihood function for household *i*. Given the hazard function in (4), the survival function of interpurchase time t_{j_i}, i.e., the probability of the non-purchase duration since the last purchase elapsed up to time t_{j_i}, can be derived as:

$$(8) \qquad F^s(t_{j_i}) = \exp\left(-\frac{\exp(\gamma_0^s + X_{j_i}\beta^s)}{1+\gamma_1^s} t_{j_i}^{\,1+\gamma_1^s}\right).$$

Thus, the corresponding probability density function can be expressed as:

$$(9) \qquad f^s(t_{j_i}) = H^s(t_{j_i}) \cdot F^s(t_{j_i}) .^2$$

Finally, the segment specific likelihood function for household *i* with a total of J_i interpurchase times can be written as:

$$(10) \qquad L_i^s = \left[\prod_{j_i=1}^{J_i-1} f^s(t_{j_i})\right] \cdot [f^s(t_{J_i})]^d \cdot [F^s(t_{J_i})]^{1-d} \,,$$

where *d* is an indicator variable equaling 1 if the last interpurchase time is completed and 0 if it is still undergoing (censored) due to the cut-off date of the survey. The joint likelihood for all the households is then given as below:

$$(11) \qquad L = \prod_{i=1}^{N} L_i \,,$$

where *N* is the total number of households.

The number of segments (*S*) has to be determined before carrying out the model

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[2] From (9), we have $H^s(t) = \dfrac{f^s(t)}{F^s(t)}$. Those familiar with the economics of sample selection will recognize the hazard rate as the inverse of Mills' ratio.

estimation. Following Kamakura and Russell (1989), Gupta and Chintagunta (1994), and Vakratsas and Bass (2002), we systematically vary *S* and then calculate Bayesian Information Criterion (BIC) (Allenby,1990) or Akaike's Information Criterion (AIC) (Judge et al. 1980, p. 423). The number of segments (*S*) is chosen at the minimum BIC or AIC. BIC and AIC are defined as:

$$(12) \qquad BIC = \ln(L) - (q/2)\ln(n) \text{ and } AIC = -2(\ln(L) - q)/n,$$

where L is the maximum likelihood value of the model, q is the number of parameters, and n is the total number of observations.

Application of the Model

There have been many household cheese studies in the literature. However, no study has ever tried to segment the cheese market. As we mentioned above, the purpose of segmenting the market is to better understand household purchase behavior and to provide accurate information for retailers to target and promote their products.

Data and Variables

ACNielsen home scanner panel data for dairy products containing various cheese varieties are used for this analysis. The data provide cheese purchase information on a weekly basis for a period of four years from 1996 through 1999 for more than 30,000 U.S. households. Table 1 provides a summary on U.S. household cheese purchases derived form the ACNielsen data. Almost every U.S. households (99.4%) purchased the cheese products within the four-year period. However, the households made purchases only 30% of the weeks over a total of 208 weeks (52 weeks a year for four years). Therefore, the technique to increase household purchase frequencies, or reduce their

interpurchase times, becomes more relevant.

Given the large size of the panel, we randomly selected a 10 % sample of households to keep the model estimation timing within an acceptable range. To avoid extremely long interpurchase times, we excluded those households that made 4 or fewer purchases in the entire four-year period (two purchases or less per year). The number of households in the final data set is 2,117. In this study, various cheese products are aggregated into a single commodity, and the cheese interpurchase time is recorded in the unit of weeks. Figure 1 plots the aggregated distribution of the interpurchase times for all households from the final data. It is skewed upward (right) and can be approximated by the Weibull distribution.

The marketing variables, i.e. the vector of X in the model assumed to influence the household purchase probability or the hazard rate function, are unit value, coupon and the lag purchase. The unit value is the amount the household actually paid for cheese per pound, which is derived from household expenditures and quantities of the aggregated cheese commodity. This derived unit value captures both the price and the quality of the cheese commodity, which is aggregated from various types of cheese varieties selected by household at each purchase (Deaton, 1988; Cox and Wholgenant, 1987; Dong, Shonkwiler, and Capps, 1998). As a consequence, the unit value is endogenous. To correct for the endogeneity, we run an auxiliary regression for unit value,[3] then we use the predicted unit value to replace the derived unit value in the model estimation. Coupon is the redeemed values of any type coupons used to purchase cheese including the manufacturer's and store's. Both unit value and coupons could effectively change

[3] We don't have the missing value problem as in Deaton, 1988; Cox and Wholgenant, 1987; Dong, Shonkwiler, and Capps, 1998. Here we need only handle the endogeneity issue.

household purchase timing decisions. The lag purchase is the cheese quantities bought on the previous purchase occasion, which is used as a proxy for the unobserved household inventory (Jain and Vilcassim, 1991). The household characteristic variables, i.e., the vector of Z, assumed to determine the probability of household membership of each marketing segment are household size, income, educational acquisition, employment status, age, and ethnicity. Table 2 provides a summary on these variables.

Estimation Results

Model estimation was implemented using GAUSS software. The likelihood function of (11) was maximized using the BHHH algorithm (Berndt, et al, 1977). The standard errors of the parameters were obtained from the inverse of the negative estimated Hessian matrix of the likelihood function. We estimated the model by setting the number of the segments (*S*) being equal to 1, 2, until 9. The likelihood values, AIC, and BIC for the 9 models are summarized in Table 3. Based on these values, we chose a four-segment marketing structure. Similar to the unrevealed product studied by Kamakura and Russell (1989), the AIC and BIC are not quite minimized at the point of *S* being equal to 4. However, they don't change appreciably after four segments are extracted. Table 3 shows that AIC and BIC are consistent, so either of them can be used for this purpose.

Parameter estimates of the four-segment cheese market are presented in Table 4. The baseline hazard parameters, γ_0 and γ_1, are both significantly different from zero at the level of 5% and above for all the four market segments, which implies that the baseline hazard rate played an important role in household purchase timing. Figure 2 draws the baseline hazard functions for all the four segments. The hazard rate for Segments 1 and 2

are monotonically increasing while Segments 3 and 4 are almost constant over time. These results indicate that Segments 3 and 4 are duration independent while Segments 1 and 2 have positive duration dependence. Note that the positive duration dependence implies that the purchase probability increases with the duration time since the last purchase increases. The baseline hazard captures the intrinsic, unobserved reasons of why the households in different segments behave differently in making purchases of the product.

The influence of marketing variables on the hazard rate function is segment specific as assumed above. The response of the hazard rate to the change of unit value is expected to be negative, i.e., an increase in the unit value would decrease the household purchase probability. We found it is true for all the segments in our empirical results. In addition, segments 1 and 2 are more sensitive to the unit value than segments 3 and 4. Coupon is found to increase the purchase probability in all the segments except in segment 2, which is not statistically significant. Segment 4 has the largest coupon effect followed by segment 3. The lag purchase is found to decrease the purchase probability in Segments 1, 2, and 3, while it has no significant effect on Segment 4.

The effects of household characteristic variables on the membership probabilities for the first three segments are also provided in Table 4. Note that these numbers are relative to the fourth segment due to the normalization. Household size, income, employment, age and ethnicity are all significant factors to determine the segment membership probabilities. Below we discuss the segment classification in more detail.

Cheese Marketing Purchase Segmentation

Based on the estimation results discussed above, we are able to characterize the

four cheese purchase market segments according to their purchase behavior and the response to the marketing variables. The results are presented in Table 5.

Household membership probabilities are calculated using (6). According to these probabilities, we assign a given household to one of the four segments with the largest probability. Given household purchase histories, the probabilities of household segment membership can be updated by means of an empirical Bayesian procedure. The prior probability calculated from (6) for household *i* belonging to segment *s* given its vector of purchase history can be updated as below (Kamakura and Russell, 1989; Bucklin and Gupta, 1992):

$$(13) \qquad P_i^s = \frac{p_i^s L_i^s}{\sum_{k=1}^{S} p_i^k L_i^k},$$

where L_i^s is the segment specific likelihood for household *i* and it can be derived from (10) after the parameter estimates are obtained. The probabilities from (6) are the prior and the probabilities from (13) are the posterior. Both the prior and posterior classifications of households are provided in Table 5.

The prior and posterior classifications are quite consistent. For example, the interpurchase times in weeks from the shortest to the longest are Segments 1, 2, 3, and 4; and the segment sizes (percentages of households) from the smallest to the largest are Segments 1, 4, 2, and 3 for both the prior and posterior. However, the magnitudes of interpurchase times, segment sizes, and others from prior and posterior are different. The difference may be due to the household observatory errors in making purchase decisions, the random effects of marketing environment, etc. The posterior classification is closer to the actual since it uses the information of the household purchase histories to update.

Below we will discuss the characteristics of the four-segment using the posterior classifications. The prior classification can be used for model predictions for a given group of households when their purchase histories are not available.

The Four-Segment Cheese Market

Based on Table 5, the four segments of cheese market can be characterized according to their members' purchase behavior, the response of their members to the marketing variables, and the characteristics of their members. Segment 3 is the largest market with about 35% of the households that have an average interpurchase time of slightly less than four weeks. Segment 2 is the second largest market with about 28% of the households, and Segment 4 is the third with 26 % of the households. Segment 1 is the smallest market with only 11% of the households. However, Segment 1 is the most frequently purchasing market with an average interpurchase time of slightly more than one and half weeks. Segment 4 is the most infrequently purchasing market with an average interpurchase time of about eight and half weeks. The second largest segment (Segment 2) is also the second most frequently purchasing segment with an average interpurchase time of 2.4 weeks. In terms of purchase quantity, Segment 1 is the largest followed by Segments 2, 3, and 4. That is, the more frequently purchasing segments are also purchasing more in average quantity. Segment 1 is the largest coupon redeemer followed by Segments 2, 3, and 4. The average unit value paid in all the four segments has no significant difference.

Segments 1 and 2 are frequently purchasing markets with a total of 39.1% of the households which jointly have an average interpurchase time of two weeks and an average weekly quantity purchase of 1.45 pounds. In contrast, Segments 3 and 4 are

infrequently purchasing markets with a total of 60.9% of the households which jointly have an average interpurchase time of 5.8 weeks and an average quantity purchase of 1.18 pounds per week.

Compared to the infrequently purchasing segments (3 and 4), the frequently purchasing segments (1 and 2) are also frequent in coupon usage. The frequently purchasing Segments jointly have an average redeemed coupon value of 14 cents per week, while the infrequently purchasing segments jointly have an average redeemed coupon value of 10 cents per week. However, according to Table 4, the frequently purchasing segments are more sensitive to unit value and less sensitive to coupons compared with the infrequently purchasing segments. In addition to the purchase habit determined by their baseline hazard with the parameters of γ_0 and γ_1, the probabilities of their purchase in the frequently purchasing segments are also influenced by the unit value and their inventory status captured by the lag purchases. Even though the frequently purchasing segments use more coupons in their purchases, the increase use of coupons would have a little (Segment 1) or no significant effects (Segment 2) on their purchase probabilities. This implies that the households in the frequently purchasing segments are loyal customers, and they will make purchases for the product with a little or no influence by coupons. In contrast, the infrequently purchasing segments are very sensitive to coupons. Retailers could use coupons or other promotion activities to induce the households in these segments to make more purchases.

Linking Household Characteristics to Marketing Segments

Table 5 shows that Segments 1 and 2 contain households of larger size, with more income, less female heads employed full time, and less African Americans, while

Segments 3 and 4 are just the opposite. Segment 4 contains both the households in the smallest size and the households being mostly African Americans. Segment 2 contains the households with the largest income and the least fully employed female heads.

These results provide important information and can be used to craft appropriate coupon or other price promotional strategies to either maintain the purchase rate for the frequent buyers in Segments 1 and 2, or accelerate the purchase timing for the infrequent buyers in Segments 3 and 4. For example, retailers can customize their marketing activities by promoting the price attractiveness of the cheese commodity as a whole to infrequent buyers. In addition, they can customize their activities by implementing a variety of promotional programs for different individual products to frequent buyers. Given the ability and willingness of today's retailers to customize their offers, such a strategy is likely to be both feasible and attractive from a marketing perspective (Vakratsas and Bass, 2002).

Conclusions and Future Research

In this study, a market segmentation approach was developed and applied to analyze U.S. household cheese purchases. The segmentation is based on household interpurchase time or the hazard rate of purchases. The hazard rate, or the instantaneous probability of purchase given that no purchase has been made up to the given time, for a household belonging to a given segment is a function of household demographic and marketing-mix variables, and its baseline is assumed to follow a Weibull distribution. The optimal number of segments is selected such that the segmentation among alternatives maximizes the Akaike's Information Criterion or the Bayesian Information Criterion. The model is

flexible and is able to yield increasing, decreasing, or constant hazard rate functions.

Four segments were found in the U.S. household cheese purchase market. Two of the segments contain about 40% of the cheese purchase households, which are frequent buyers with an average interpurchase time of 2 weeks. These frequent cheese purchase households are larger in size, with higher income, less proportion of African Americans, and are insensitive to coupons. They are often referenced in the marketing literatures as loyal customers. In contrast, the other two segments contain about 60% of the cheese purchase households, which are infrequent buyers with an average interpurchase time of about six weeks. These infrequent cheese purchase households are smaller in size, with lower income, higher proportion of African Americans, and are sensitive to coupons. These households are usually the targets of marketing promotions.

Three extensions of the study await further research. First, as currently modeled, the Weibull distribution of the baseline hazard is monotonic. However, some non-monotonic distributions such as the log-logistic discussed by Kiefer (1988), or the distribution that is flexible for both monotonic and non-monotonic as introduced by Jain and Vilcassim (1991) can be adopted to replace the Weibull distribution. Such modification of the model would cause the estimation to be more difficult since the derivation of the probability density function from the new hazard specification is more complicated, or even no close form could exist for the corresponding probability density function. However, it would be worth the effort for some specific product such as coffee, which has a non-monotonic baseline hazard as found by Jain and Vilcassim (1991).

Second, since the market segmentation in this study based only on the purchase probability or the purchase frequency, the model could be extended to characterize

market segments by both the purchase frequency and the purchase quantity. Such an extension could enable us to derive the price and other elasticities for each market segments. Therefore, the effects of a promotion activity targeting a specific segment or a group of households could be quantitatively evaluated for both the targeted segment and the entire market as a whole. Third, as currently formulated, the model is only for the study of a single product. However, the model could be extended to study household choice among multiple products. In such a case, one could segment the market based on not only the purchase frequency and quantity, but also on what the household has purchased.

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Table 1. U.S. Household Cheese Purchases

% of purchase households	99.4
% of purchase occasions over purchase households	30.7
Weekly average purchase quantity over purchase households (lb)	0.42
Weekly average purchase quantity over purchase occasions (lb)	1.37
Weekly average paid unit value for purchase occasions ($/lb)	3.27
Average interpurchase time (weeks)	3.09

Table 2. Variable Descriptive

name	description	mean	Sd. error	minimum	maximum
Marketing variable					
Unit value	Unit value paid by household ($/lb)	3.550	0.808	1.797	10.425
Coupon	Value of coupon redeemed ($)	0.115	0.216	0	3.712
Lag purchase	cheese quantity made at last purchase (lb)	1.287	0.626	0.353	8.017
Household Characteristic Variables					
Intercept	constant	1	0	1	1
size	Household size	2.442	1.215	1	9
income	Household income ($1,000)	48.352	30.816	2.5	150
College	=1 if female head having a college degree or above	0.353	0.464	0	1
Full time	=1 if female head having a full time job position	0.408	0.451	0	1
Age	Age of female head	52.571	13.501	23	86
Black	=1 if the household is African American	0.055	0.226	0	1
Hispanic	=1 if the household is Hispanic origin	0.046	0.200	0	1

Table 3. Selection of Segment Number

S	Ln(*L*)/100	*q*	*AIC*	*BIC*/100
1	-2904.64	5	1.319	-2904.96
2	-2698.94	18	1.226	-2700.11
3	-2640.27	31	1.199	-2642.28
4	**-2610.64**	**44**	**1.186**	**-2613.49**
5	-2605.25	57	1.184	-2608.95
6	-2600.29	70	1.181	-2604.83
7	-2596.78	83	1.180	-2602.17
8	-2594.93	96	1.179	-2601.16
9	-2593.28	109	1.178	-2600.36

Table 4. Parameter Estimates for The Four-Segment Model

Variable	Segment 1	Segment 2	Segment 3	Segment 4
γ_0	0.7207* (0.0252)	0.0968* (0.0363)	-0.8683* (0.0536)	-1.3681* (0.0991)
γ_1	0.8356* (0.0043)	0.5004* (0.0032)	0.2737* (0.0033)	0.0441* (0.0047)
unit value	-0.3203* (0.0071)	-0.3035* (0.0021)	-0.1818* (0.0149)	-0.2055* (0.0272)
coupon	0.0100* (0.0043)	-0.0013 (0.0074)	0.0241* (0.0084)	0.0643* (0.0126)
lag purchase	-0.0357* (0.0021)	-0.0492* (0.0023)	-0.0392* (0.0032)	-0.0055 (0.0060)
Effects on membership probability relative to segment 4				
Intercept	-3.0541* (0.6378)	-1.7780* (0.5079)	-1.1198* (04602)	
Household size	1.1583* (0.0878)	0.8994* (0.0763	0.6271* (0.0726)	
Household income	0.0091* (0.0032)	0.0093* (0.0026)	0.0021 (0.0025)	
College	0.0983 (0.2017)	-0.0427 (0.1594)	0.1075 (0.1498)	
Full time	-0.4081 (0.2341)	-0.3996* (0.1931)	-0.0752 (0.1827)	
Age	-0.0150 (0.0086)	-0.0057 (0.0066)	0.0025 (0.0060)	
Black	-2.4943* (0.5480)	-1.7988* (0.3139)	-0.9819* (0.2442	
Hispanic	-0.1587 (0.3844)	-0.0144 (0.3425)	-0.3795 (0.3500)	

Note: 1. Standard deviations are in parentheses.
2. "*" indicates significant at the level of 0.05 or above.

Table 5. Cheese Market Segment Classification

	Segment 1		Segment 2		Segment 3		Segment 4	
	prior	**posterior**	prior	**posterior**	prior	**posterior**	prior	**posterior**
Market Segment Characteristics								
Interpurchase time (in weeks)	2.843	**1.596**	3.072	**2.390**	4.166	**3.878**	6.297	**8.476**
Average purchase quantity (in pounds)	1.820	**1.577**	1.544	**1.404**	1.278	**1.241**	1.016	**1.097**
Average unit value	3.049	**3.489**	3.488	**3.538**	3.549	**3.557**	3.650	**3.600**
value of coupon redeemed	0.091	**0.152**	0.128	**0.130**	0.116	**0.109**	0.097	**0.089**
Segment size								
Number of households	11	**234**	555	**593**	1036	**746**	515	**544**
Percentage of households	0.6	**11.1**	26.2	**28.0**	48.9	**35.2**	24.3	**25.7**
Household characteristics in each segment								
Household size	6.893	**3.319**	3.813	**2.817**	2.289	**2.334**	1.175	**1.803**
Household income	44.445	**57.785**	69.702	**54.473**	44.273	**46.085**	33.207	**40.732**
College	0.564	**0.394**	0.378	**0.353**	0.313	**0.350**	0.402	**0.340**
Full time	0.226	**0.398**	0.369	**0.386**	0.369	**0.407**	0.534	**0.439**
Age	39.910	**47.432**	43.737	**50.798**	56.062	**53.651**	55.338	**55.233**
Black	0.000	**0.020**	0.004	**0.031**	0.042	**0.056**	0.138	**0.095**
Hispanic	0.178	**0.070**	0.129	**0.062**	0.009	**0.035**	0.028	**0.032**

Figure 1. U.S. Household Cheese Purchase Frequency

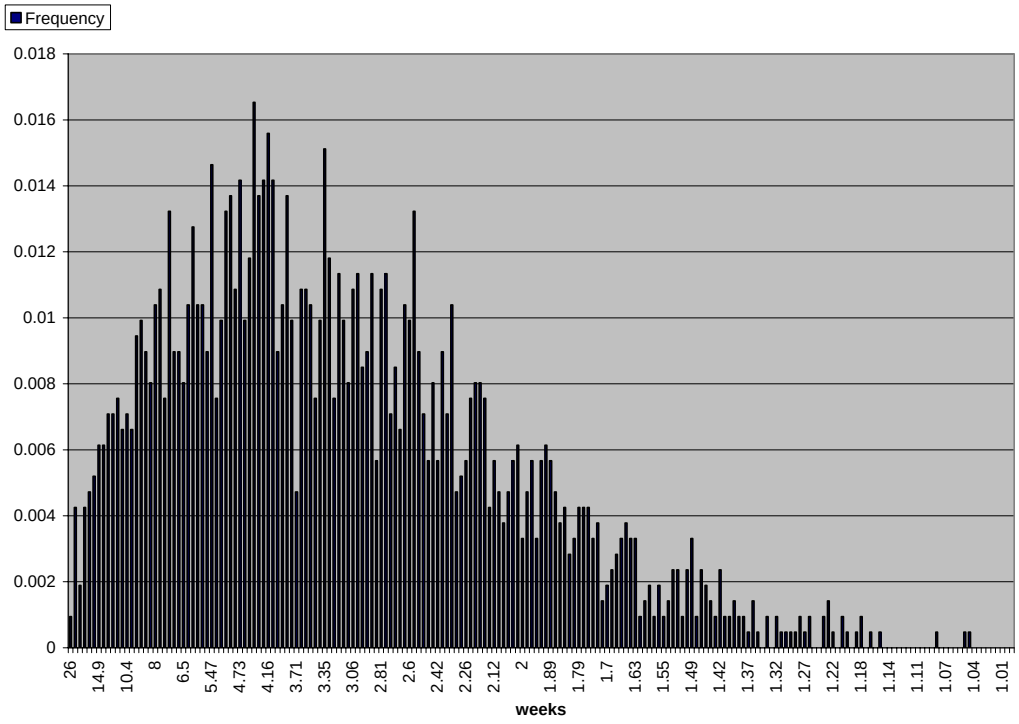
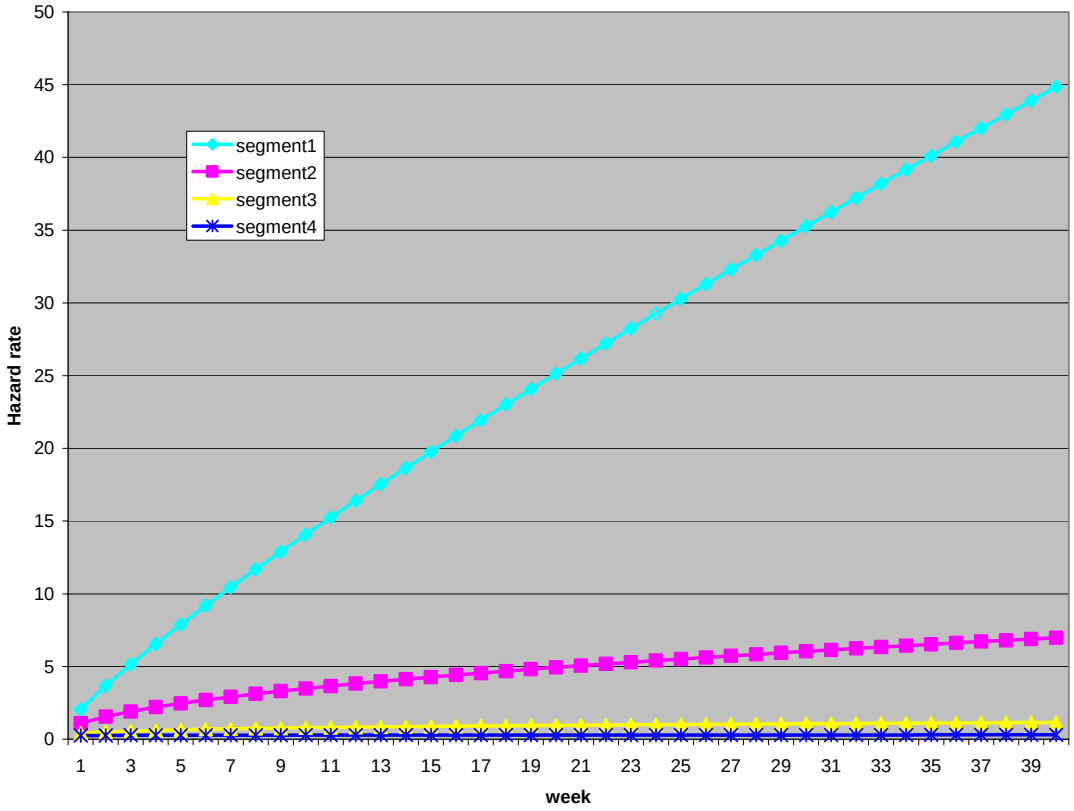
Figure 2. The Hazard Rate of the Four Segments