A Dynamic Model of Consumer Preference

Tomoaki Tabata†
Faculty of Management, Tokyo Fuji University
Shinjuku, Tokyo 161-8556, JAPAN
Email: tabata@fuji.ac.jp

Takashi Namatame
School of Commerce, Senshu University
Kawasaki, Kanagawa 214-8580, JAPAN
Email: takashi@isc.senshu-u.ac.jp

Abstract - It is an important thing more than before that companies grasp the structure of consumer behavior in their marketing activities, because consumers’ needs have been diversified and individualized recently. One of the most important purposes to analyze consumer behavior is to investigate an influence factors to decide the purchase. From the viewpoint of research, various models have been suggested (e.g., the probabilistic utility model), and concept of utility or preference was constructed in their models. Most of these models object static situation. However, it is thought that consumer preference has dynamic structure because consumer’s decision-making process passes often for a long term. Thus, it is important for us to consider consumer preference as dynamic model in terms of long-term sales promotion especially. To our best knowledge, such a model is hardly found. Then, in this study, we suggest a dynamic model for the change of the consumer’s preference in the observation period. This will help to develop a strategy in long-term sales promotion.

Keywords: Consumer behavior, Consumer preference model, Long-term sales promotion strategy

1. INTRODUCTION

Recently, many companies have contended with diversification or individualization in consumer needs constantly. In their marketing activities, it is important more than before that they grasp the structure of consumer behavior. One of the most important purposes to analyze consumer behavior is to investigate an influence factor to decide the purchase. In this research area, various models have been suggested with Howard-Sheth model (1969) as a start. They modeled the concept of the consumer behavior and follows added the concept of utility or preference for it. Especially, so-called the probabilistic utility model is used often. Most of these models are static concerning with time transition. However, in a process which a consumer chooses a product or service and purchases, it is common that her/his decision making process passes for a long term; for example, a case of purchasing a car that is not able to buy readily. Moreover, same menus are not served on a dining table every day. As shown in these examples, it is nature that consumer preference changes dynamically. It is thought that it is important for us to consider consumer preference as dynamic model in terms of long-term sales promotion especially. However, to our best knowledge, such a model has not been shown. Then, in this study, we suggest a dynamic model for the change of the consumer preference in the observation period. This will help to develop a strategy in long-term sales promotion. Moreover, we show an example using a real purchase data to investigate the validity of our model.

2. MODELS FOR CONSUMER BEHAVIOR (CONSUMER PREFERENCE)

2.1 Howard-Sheth Model

There are many cases in which results in the sector of various behavioral sciences are applied to the models of the consumer behavior in marketing. Among them, Howard and Sheth structured the consumers’ process towards purchase (See Figure 1), and comprehensively prescribed the concept of the consumers’ behavior. Although they structured the elements as difficulties for observations behind them, presentation of such frameworks significantly influences on the study afterwards, as the basic point for various studies.

† : Corresponding Author
2.2 Utility (Preference) Model

2.1.1 Multi-Attribute Attitude Model

They define as sub-structural explicit type model for the part from Brand Comprehension to Purchase at output level in the Howard-Sheth Model, especially for the explicit-structured parts. This is a model to describe how to chose is made among all recognized products. The search for attributions directly relating to the consumers choices enables us to contribute to the creation of products-concept, so this model has been used a lot.

It is Multi-Attribute Attitude Model as a core in Sub-structural explicit type model, which has been developed from Fishbein’s expectation-value theory in the field of social psychology. (see Fishbein, 1980) When we set $U_j$ as an attitude toward selection-object $j$, $z_{ij}$ to $z_{in}$ as an evaluation of attributes, $a_1$ to $a_n$ as weight on attributes (level of consideration), then we can express the basic structure as below:

$$U_j = a_1 z_{ij} + a_2 z_{2j} + \cdots + a_n z_{nj}$$

(1)

In this case, $U$ is determined with the parameter $a$ and data $z$, so it will have an issue such as the larger subjective effect versus weaker predictability. However, it is still effective as an item providing the rough frameworks to structure of household preference.

2.1.2 Ideal Vector Model

There is an approach considerable to estimate the evaluation ($z$) of attributions and the selected data ($U$) at the same time whereas Multi-Attribute Attitude Model is to determine $U$ from data $z$ and parameter $a$. One of those is Ideal Vector Model. This model is to indicate the directionality of attributes combinations, in view of individual consumer. The combinatorial direction shows an ideal attribute. With the addition models, the utility $U_j$ with the about object $j$, when r-kind of attributes exists:

$$U_j = \alpha_1 (the \ level \ of \ attribute \ 1 \ for \ object \ j) + \ldots + \alpha_r (the \ level \ of \ attribute \ r \ for \ object \ j)$$

(2)

This is prescribed (as shown above). So, when the order of purchase on the n-kind of objects is given, the parameter \{ $\alpha_1, \ldots, \alpha_r$ \} has to be determined to make the order of size of $U_j$ agree to the order of data as much as possible. Regarding the parameter derivation method, it’s possible to use some methods, e.g., PREFMAP or RANKLOGIT.

2.1.3 Ideal Point Model

In ideal vector models, there are proportionate-relationships between attribute standard and effect. For example, the level effect falls down depending on attributes like sweetness, if it goes too much. This is Ideal Point Model to have taken this point into account.

Same as that in Ideal Vector Model, when consumers’ preference-order-data are given in this model, the position of ideal point is established to be correct so that closeness of distance from the point of each object on products-map can bend.

$$U_j = [\alpha_1 (the \ level \ of \ attribute \ 1 \ for \ object \ j)]^2 + \ldots + \alpha_r (the \ level \ of \ attribute \ r \ for \ object \ j)$$

(3)

This formula shows the distance from ideal point, so, smaller value is better.

2.1.4 Random Utility Model

The standard of preference for each object is decided stochastically, and it is a model assuming that the object that has maximum value is chosen. In this case, utility $U_j$ about object $j$ is expressed for a deterministic utility ($V_j$) and friendliness of the error factor ($\varepsilon_j$). By the distribution form of the error factor, there are several kinds of methods.

$$U_j = V_j + \varepsilon_j$$

(4)
We can compute probability of choice in the following form with extremely easy method, especially, when we assume first-class extreme value distribution (Gumbel distribution) about $\epsilon_j$. It is called as Multivariate Logit Model (McFadden, 1974). It seems that this is the most used model in the current preference analysis.

$$P_j = \frac{e^{\eta_j}}{\sum_{i=1}^{3} e^{\eta_i}} \tag{5}$$

3. Proposal Model

3.1 Outline of our model

The conventional model expressed a preference at one point of time. However, it is thought that attitude can be changed among consumers as the time is elapsed.

For example, in the case of considerably expensive product (i.e. durable products), it is not expected that he or she buys instantly. However, the variations on elements to make the consumers finally decide to buy are found; such as changes of interests, the devaluation because of the trend-changes during the waiting period so that the variance in preference is notable (Figure 2).

The conjugation of this attitude has been regarded as stochastic changes of effects with the models in the past, but it will be useful to take this deterministically.

On those issues, Mizuno (2002) has explained needs, there was nothing found in the form of proposal as specific marketing model.

Therefore, we will examine a model in the preference-formation process based on the adding model of the effect to explain the change of such preference.

Basic idea is to describe differential equation model for the changes, considering variables used in adding models (multi-attribute attitude model) as a function of time. In this case, we do not take error factors (random utility model) into account.

3.2 Hypothesis

On constructing the model, we set up the following hypotheses.

- The objects are mainly durable products.
- Preference for the object of consumers is determined by the evaluation of the attribute and its importance (the level of serious-consideration).
- The preference of consumer changes in time elapsing.
- The importance for the attribute evaluation changes in time elapsing, too.
- The change of the serious consideration degree affects the way of the change of preference, and the change of preference affects the way of the change of the serious consideration degree at the same time again.
- The degree of preference for the object is accompanied with natural decrease (if nothing is done): Analogy with the mechanism of diminishing marginal utility.

3.3 Notation

We show below the variables in our model.

- $U_i(t)$: value of preference of consumer $i$ for object $j$ in instant $t$
- $z_{ijk}$: consumer $i$’s evaluation of attribute $k$ in object $j$
- $a_{ik}(t)$: consumer $i$’s weight of attribute evaluation $z_{ijk}$ in instant $t$
- $h_{ik}$: feedback coefficient from $U_i(t)$ to $a_{ik}(t)$
- $w_{ij}$: parameter of attenuation
- $F_{ij}$: $\Gamma_{ik}$: external stimuli

3.4 Model Formula

We show our dynamic utility model as shown below.

$$\frac{d}{dt}U_i(t) = -w_{ik}U_i(t) + \sum_{k=1}^{M} a_{ik}(t)z_{ijk} + F_{ij}$$

$$\frac{d}{dt}a_{ik}(t) = -\gamma a_{ik}(t) + \sum_{j=1}^{L} h_{ijk}U_j(t) + \Gamma_{ik} \tag{6}$$

$(i = 1,2,3,\ldots,L; j = 1,2,3,\ldots,M; k = 1,2,3,\ldots,N)$

A certain selection $j$ (1, 2, 3, …, $M$) exists, and a consumer $i$ (1, 2, 3, …, $L$) gives her or his evaluation to each object from each attribute $k$ (1, 2, 3, …, $N$).

The give evaluations have been added up to a total figure, and it affects preference ($U_i(t)$) of consumers in the next point in time with a ratio (importance: $a_{ik}$).

It is thought that the preference ($U_i(t)$) among consumers will be decreased (under no input) with time-
elapse. However in some cases, external matters like advertisings and advices by other people could affect (\(F_j\)).

The importance \((a_k)\) on evaluation will be affected by preference \((U_j(t))\). In such cases, it often affect on the importance \(a_k\) at the next with certain ratio \((h_{ik})\).

In addition, there are characteristics with \(a_k\) with time-elapse, and we could be forced to pay attention to particular attributes.

4. EXAMPLES OF NUMERIC DATA

4.1 Measurement of Preference

It is to estimate the effect value of the relative importance of each attribute and each standard, when relations on preference-order are given. With the profile cards which put each standard among attributes together, it is to compute the effect value of each standard for each attribute based on a reply about the preference-order of the subject destructively.

4.2 Parameter Estimation

With no external stimuli, we can express the aforementioned model describable in the differential equation of importance \((a(t))\) towards preference \((U(t))\) and attributes, in difference equation with time-value \(t\) as follows.

\[
U_j(t+1) = c_jU_j(t) + \sum_{i=1}^{N} a_i(t)\left(1 - w_j\right) \\
\alpha(t+1) = \lambda_j a_j(t) + \sum_{j=1}^{M} h_j \alpha_j(t) \\
\lambda_i = 1 - \gamma_i
\]

When \(\lambda_i = 0;\)

\[
U_j(t + 2) = c_jU_j(t + 1) + \sum_{j=1}^{M} h_j U_j(t) \tag{9}
\]

Then, we can estimate the parameters \((c_j)\) and \((h_{ik})\) by the alternation least-squares method if we can measure preference \((U_j(t))\) at plural timings.

4.3 Result and Discussion

Making a PC with 3 attributes, CPU, memory, and HDD capacity as subject, we will get the preference-order from 50 students of a university in Tokyo to get preference-order of products-specifications by 3-times repetitive questionnaires. The following are of the samples and the subject-products.

Table 1: Profile (PC spec)

<table>
<thead>
<tr>
<th>Profile No.</th>
<th>CPU</th>
<th>Memory</th>
<th>HDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Low</td>
<td>Large</td>
<td>Middle</td>
</tr>
<tr>
<td>2</td>
<td>Mid low</td>
<td>Large</td>
<td>Middle</td>
</tr>
<tr>
<td>3</td>
<td>Mid low</td>
<td>Large</td>
<td>Small</td>
</tr>
<tr>
<td>4</td>
<td>Mid high</td>
<td>Small</td>
<td>Large</td>
</tr>
<tr>
<td>5</td>
<td>High</td>
<td>Small</td>
<td>Middle</td>
</tr>
<tr>
<td>6</td>
<td>High</td>
<td>Middle</td>
<td>Small</td>
</tr>
</tbody>
</table>

Table 2: Preference of products

<table>
<thead>
<tr>
<th>Time</th>
<th>Profile1</th>
<th>Profile2</th>
<th>Profile3</th>
<th>Profile4</th>
<th>Profile5</th>
<th>Profile6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60.855</td>
<td>107.81</td>
<td>142.14</td>
<td>177.88</td>
<td>258.64</td>
<td>215.94</td>
</tr>
<tr>
<td>2</td>
<td>48.327</td>
<td>89.732</td>
<td>184.53</td>
<td>121.44</td>
<td>238.47</td>
<td>292.47</td>
</tr>
<tr>
<td>3</td>
<td>6.0437</td>
<td>104.14</td>
<td>124.47</td>
<td>211.17</td>
<td>173.62</td>
<td>245.95</td>
</tr>
</tbody>
</table>

Per the examples in Figure 3, it is found the variation of measured values at 3 points such as Product 5 to Product 6, then to Product 7, and the path of theoretical value of return is matched.

Figure 2: Changes of preference

In case of comparison between 2 products in terms of the higher preference, the ratio of matching between theoretical value and measured value is 0.67, so this study presents the process of consumers-preference-variation sufficiently, because the adaptability-rate is appropriate 70%.

5. CONCLUDING REMARKS

In this study, we have performed with time expansion towards the model that had showed preference-variations only at a single point in the previous studies. By performing in such manners, we could explain the change of consumers’ preference.
With this model, we are now able to perform dynamic marketing quantitatively in future. In another word, we could determine which method will be more effective, a constant rate of discount, or incremental rate of discount.

We have used attributes attitude model this time and performed time expansion, but we realize that we should apply time expansion to probability effect model.

We need to expand the random variable to stochastic processes, but the identification of this stochastic process will become very important in future when we perform the experiment.

REFERENCES


AUTHOR BIOGRAPHIES

**Tomoaki Tabata** is an Associate Professor in School of Management, Tokyo Fuji University. He received a Master Degree from Graduate School of Industrial and Management System Engineering at Waseda University, Japan in 1998. His teaching and research interests include marketing and data analysis in social science and information system. His email address is <tabata@fuji.ac.jp>.

**Takashi Namatame** is a Professor in School of Commerce, Senshu University. He received a Doctoral Degree from Graduate School of Management Science at Tokyo University of Science, Japan in 1999. His teaching and research interests include marketing science and management science. His email address is <takashi@isc.senshu-ua.ac.jp>.