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<th><strong>Title</strong></th>
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<td>Higuchi, Yuki; Takeyasu, Kazuhiro</td>
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Analysis of the Preference Shift of Customer Brand Selection among Multiple Genres of Automobile and its Matrix Structure

Yuki Higuchi*, Kazuhiro Takeyasu**

Abstract: It is often observed that consumers select upper class brand when they buy next time. Suppose that former buying data and current buying data are gathered. Also suppose that upper brand is located upper in the variable array. Then transition matrix becomes upper triangular matrix under the supposition that former buying variables are set input and current buying variables are set output. Takeyasu et al. (2007) analyzed the brand selection and its matrix structure before. In that paper, products of one genre are analyzed. In this paper, brand selection among multiple genre and its matrix structure are analyzed. For example, there is a case that customer selects bracelet or earrings besides selecting upper brand of necklace she already has. Such cases often happen. Analyzing such structure provides useful applications. Unless planner for products does not notice its brand position whether it is upper or lower than other products, matrix structure makes it possible to identify those by calculating consumers’ activities for brand selection. Thus, this proposed approach enables to make effective marketing

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plan and/or establishing new brand.

**Keywords:** brand selection, matrix structure, brand position

1. **INTRODUCTION**

It is often observed that consumers select upper class brand when they buy next time after they are bored to use current brand. Suppose that former buying data and current buying data are gathered. Also suppose that upper brand is located upper in the variable array. Then transition matrix becomes upper triangular matrix under the supposition that former buying variables are set input and current buying variables are set output. The analysis of the brand selection in the same brand group is analyzed by Takeyasu et al.\(^{[6]}\).

In this paper, we expand this scheme to products of multiple genres. For example, we consider the case of necklace. If she is accustomed to use necklace, she would buy higher priced necklace. On the other hand, she may buy bracelet or earring for her total coordination in fashion. Hearing from the retailer, both can be seen in selecting upper class brand and selecting another genre product.

Therefore, this analysis is very meaningful for the practical use, which occurs actually. If transition matrix is identified, we can make various analysis using it and s-step forecasting can be executed. Unless planners for products notice its brand position whether it is upper or lower than other products, matrix structure makes it possible to identify those by calculating consumers' activities for brand selection. Thus, this proposed approach makes it effective to execute marketing plan and/or establish new brand.

Quantitative analysis concerning brand selection has been executed by Yamanaka\(^{[5]}\), Takahashi et al.\(^{[4]}\). Yamanaka\(^{[5]}\) examined purchasing process by Markov Transition Probability with the input of advertising expense. Takahashi et al.\(^{[4]}\) made analysis by the Brand Selection Probability model using logistics distribution.

Takeyasu et al.\(^{[6]}\) analyzed the preference shift of customer brand selection for a single brand group. In this paper, we try to expand this scheme to products of multiple genres, and various analysis is executed. Actually, this
scheme can often be seen. Such research is quite a new one.

Hereinafter, matrix structure for a single brand group is clarified for the selection of brand in section 2. Expansion to multiple brand selection is executed and analyzed in section 3. s-step forecasting is stated in section 4. A questionnaire investigation to Automobile Purchasing case is examined and its numerical calculation is executed in section 5. Application of this method is extended in section 6. Section 7 is a summery.

2. BRAND SELECTION AND ITS MATRIX STRUCTURE

(1) Upper Shift of Brand Selection

Now, suppose that \( x \) is the most upper class brand, \( y \) is the second upper class brand, and \( z \) is the lowest class brand. Consumer’s behavior of selecting brand might be \( z \rightarrow y, y \rightarrow x, z \rightarrow x \) etc. \( x \rightarrow z \) might be few. Suppose that \( x \) is current buying variable, and \( x_b \) is previous buying variable. Shift to \( x \) is executed from \( x_b, y_b, \) or \( z_b \).

Therefore, \( x \) is stated in the following equation. \( a_{ij} \) represents transition probability from \( j \)-th to \( i \)-th brand.

\[
x = a_{11}x_b + a_{12}y_b + a_{13}z_b
\]

Similarly,

\[
y = a_{22}y_b + a_{23}z_b
\]

and

\[
z = a_{33}z_b
\]

These are re-written as follows.

\[
\begin{pmatrix}
x \\
y \\
z
\end{pmatrix} =
\begin{pmatrix}
a_{11} & a_{12} & a_{13} \\
0 & a_{22} & a_{23} \\
0 & 0 & a_{33}
\end{pmatrix}
\begin{pmatrix}
x_b \\
y_b \\
z_b
\end{pmatrix}
\]

Set
\[
\mathbf{X} = \begin{pmatrix} x \\ y \\ z \end{pmatrix}, \quad \mathbf{A} = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ 0 & a_{22} & a_{23} \\ 0 & 0 & a_{33} \end{pmatrix}, \quad \mathbf{X}_b = \begin{pmatrix} x_b \\ y_b \\ z_b \end{pmatrix}
\]

then, \( \mathbf{X} \) is represented as follows.

\[
\mathbf{X} = \mathbf{A} \mathbf{X}_b \quad (2)
\]

Here,

\[
\mathbf{X} \in \mathbb{R}^3, \mathbf{A} \in \mathbb{R}^{3\times3}, \mathbf{X}_b \in \mathbb{R}^3
\]

\( \mathbf{A} \) is an upper triangular matrix.

To examine this, generating following data, which are all consisted by the data in which transition is made from lower brand to upper brand,

\[
\mathbf{X}^i = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}, \quad \mathbf{X}_b^i = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}, \quad i = 1, 2, \ldots, N
\]

parameter can be estimated using least square method.

Suppose

\[
\mathbf{X}^i = \mathbf{A} \mathbf{X}_b^i + \mathbf{\varepsilon}^i \quad (5)
\]

where

\[
\mathbf{\varepsilon}^i = \begin{pmatrix} \varepsilon_{1i}^i \\ \varepsilon_{2i}^i \\ \varepsilon_{3i}^i \end{pmatrix}, \quad i = 1, 2, \ldots, N
\]

and minimize following \( J \)
\[ J = \sum_{i=1}^{N} \varepsilon_i^T \varepsilon_i \rightarrow \text{Min} \] (6)

\[ \hat{A} = \left( \sum_{i=1}^{N} X_i^i X_b^i \right) \left( \sum_{i=1}^{N} X_b^i X_b^i \right)^{-1} \] (7)

\( \hat{A} \) which is an estimated value of \( A \) is obtained as follows.

In the data group which are all consisted by the data in which transition is made from lower brand to upper brand, estimated value \( \hat{A} \) should be upper triangular matrix.

If following data which shift to lower brand are added only a few in equation (3) and (4),

\[ X' = \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix} \quad X_b^i = \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix} \]

\( \hat{A} \) would contain minute items in the lower part of triangle.

(2) Sorting brand ranking by re-arranging row

In a general data, variables may not be in order as \( x, y, z \). In that case, large and small value lie scattered in \( \hat{A} \). But re-arranging this, we can set in order by shifting row. The large value parts are gathered in upper triangular matrix, and the small value parts are gathered in lower triangular matrix.

\[
\begin{pmatrix}
  x \\
  y \\
  z
\end{pmatrix}
\begin{pmatrix}
  \circ & \circ & \circ \\
  \circ & \circ & \circ \\
  \circ & \circ & \circ
\end{pmatrix}
\]

Shifting row

\[
\begin{pmatrix}
  z \\
  x \\
  y
\end{pmatrix}
\begin{pmatrix}
  \varepsilon & \varepsilon & \circ \\
  \circ & \circ & \circ \\
  \varepsilon & \circ & \circ
\end{pmatrix}
\]

(8)
(3) **Matrix structure under the case skipping intermediate class brand is skipped**

It is often observed that some consumers select the most upper class brand from the most lower class brand and skip selecting the intermediate class brand.

We suppose \( v, w, x, y, z \) brands (suppose they are laid from upper position to lower position as \( v > w > x > y > z \)).

In the above case, selection shifts would be

\[
\begin{align*}
&v \leftarrow z \\
&v \leftarrow y
\end{align*}
\]

Suppose they do not shift to \( y, x, w \) from \( z \), to \( x, w \) from \( y \), and to \( w \) from \( x \), then Matrix structure would be as follows.

\[
\begin{pmatrix}
v \\
w \\
x \\
y \\
z
\end{pmatrix} =
\begin{pmatrix}
a_{11} & a_{12} & a_{13} & a_{14} & a_{15} \\
0 & a_{22} & 0 & 0 & 0 \\
0 & 0 & a_{33} & 0 & 0 \\
0 & 0 & 0 & a_{44} & 0 \\
0 & 0 & 0 & 0 & a_{55}
\end{pmatrix}
\begin{pmatrix}
v_b \\
w_b \\
x_b \\
y_b \\
z_b
\end{pmatrix}
\]

(9)

3. **EXPANSION OF THE MODEL TO MULTIPLE GENRE PRODUCTS**

Expanding Eq.(2) to multiple genre products, we obtain following equations. First of all, we state the generalized model of Eq.(2).

\[
X = AX_b
\]

(10)

Where

\[
X = \begin{pmatrix}
x^1 \\
x^2 \\
\vdots \\
x^p
\end{pmatrix}, \quad X_b = \begin{pmatrix}
x^1_b \\
x^2_b \\
\vdots \\
x^p_b
\end{pmatrix}
\]

(11)
Analysis of the Preference Shift of Customer Brand Selection among Multiple Genres of Automobile and its Matrix Structure

\[
A = \begin{pmatrix}
  a_{11} & a_{12} & \cdots & a_{1p} \\
  0 & a_{22} & \cdots & a_{2p} \\
  \vdots & \vdots & \ddots & \vdots \\
  0 & 0 & \cdots & a_{pp}
\end{pmatrix}
\]

(12)

Here

\[
X \in \mathbb{R}^p, A \in \mathbb{R}^{p \times p}, X_b \in \mathbb{R}^p
\]

If the brand selection is executed towards upper class, then A becomes as follows.

\[
A = \begin{pmatrix}
  a_{11} & a_{12} & \cdots & a_{1p} \\
  0 & a_{22} & \cdots & a_{2p} \\
  \vdots & \vdots & \ddots & \vdots \\
  0 & 0 & \cdots & a_{pp}
\end{pmatrix}
\]

(13)

Expanding above equations to products of 3 genres, we obtain following equations.

\[
\begin{pmatrix}
  X \\
  Y \\
  Z
\end{pmatrix} =
\begin{pmatrix}
  A^{11} & A^{12} & A^{13} \\
  A^{21} & A^{22} & A^{23} \\
  A^{31} & A^{32} & A^{33}
\end{pmatrix}
\begin{pmatrix}
  X_b \\
  Y_b \\
  Z_b
\end{pmatrix}
\]

(14)

Where

\[
X = \begin{pmatrix}
  x^1 \\
  x^2 \\
  \vdots \\
  x^q
\end{pmatrix},
X_b = \begin{pmatrix}
  x_b^1 \\
  x_b^2 \\
  \vdots \\
  x_b^q
\end{pmatrix},
Y = \begin{pmatrix}
  y^1 \\
  y^2 \\
  \vdots \\
  y^q
\end{pmatrix},
Y_b = \begin{pmatrix}
  y_b^1 \\
  y_b^2 \\
  \vdots \\
  y_b^q
\end{pmatrix},
Z = \begin{pmatrix}
  z^1 \\
  z^2 \\
  \vdots \\
  z^r
\end{pmatrix},
Z_b = \begin{pmatrix}
  z_b^1 \\
  z_b^2 \\
  \vdots \\
  z_b^r
\end{pmatrix}
\]

(15)
Re-writing Eq. (14) as:

\[ W = AW_b \]  

(17)  

then, transition matrix \( A \) is derived as follows in the same way with Eq. (7).

\[ \hat{A} = \left( \sum_{i=1}^{N} W^i W_b^T \right) \left( \sum_{i=1}^{N} W_b^i W_b^T \right)^{-1} \]  

(18)

Here,

\[ W = \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}, \quad W_b = \begin{pmatrix} X_b \\ Y_b \\ Z_b \end{pmatrix} \]  

(19)

\[ A = \begin{pmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \end{pmatrix} \]  

(20)
If the brand selection is executed towards upper class brand in the same genre, transition matrix, for example $A_{11}, A_{22}, A_{33}$, become upper triangular matrix as seen in 2. Suppose $X$ as bracelet, $Y$ as earring and $Z$ as necklace. If we only see $Z$, we can examine whether there is an upper brand shift in $A_{33}$. But there is a case that brand selection is executed towards other genre products. There occurs brand selection shift from a certain brand level of $Z$ to a certain brand level of $X$ or $Y$. For example, suppose there are five levels in each $X, Y, Z$ and their levels include from bottom to top brand level. In that case, if there is a brand selection shift from the middle brand level in $Z$ to another genre product, we can obtain interesting result by examining how the brand selection shift is executed toward the same level or upper level of another genre product. If we can see the trend of brand selection shift, we can foresee the brand selection shift towards another genre brand. Retailer can utilize the result of this to make effective marketing plan. We confirm this by the numerical example in 5.

Next, we examine the case in brand groups. Matrices are composed by Block Matrix.

4. $s$-STEP FORECASTING

Now, we see Eq.(14) in time series. Set $X, Y, Z$ at time $n$ as:
\[
X_n = \begin{pmatrix}
x_1^n \\
x_2^n \\
\vdots \\
x_p^n
\end{pmatrix}, \quad Y_n = \begin{pmatrix}
y_1^n \\
y_2^n \\
\vdots \\
y_q^n
\end{pmatrix}, \quad Z_n = \begin{pmatrix}
z_1^n \\
z_2^n \\
\vdots \\
z_r^n
\end{pmatrix}
\]

(23)

then, Eq.(14) can be re-stated as:

\[
\begin{pmatrix}
X_n \\
Y_n \\
Z_n
\end{pmatrix} =
\begin{pmatrix}
A_{11} & A_{12} & A_{13} \\
A_{21} & A_{22} & A_{23} \\
A_{31} & A_{32} & A_{33}
\end{pmatrix}
\begin{pmatrix}
X_{n-1} \\
Y_{n-1} \\
Z_{n-1}
\end{pmatrix}
\]

(24)

where suffix is written in the lower part of right hand side because there arises a multiplier in the equation of forecasting.

\(s\)-step forecasting is executed by the following equation.

\[
\begin{pmatrix}
X_{n+s} \\
Y_{n+s} \\
Z_{n+s}
\end{pmatrix} =
\begin{pmatrix}
A_{11} & A_{12} & A_{13} \\
A_{21} & A_{22} & A_{23} \\
A_{31} & A_{32} & A_{33}
\end{pmatrix}^s
\begin{pmatrix}
X_n \\
Y_n \\
Z_n
\end{pmatrix}
\]

(25)

Set

\[
A^s = \begin{pmatrix}
A_{11} & A_{12} & A_{13} \\
A_{21} & A_{22} & A_{23} \\
A_{31} & A_{32} & A_{33}
\end{pmatrix}^s =
\begin{pmatrix}
A_{11}(s) & A_{12}(s) & A_{13}(s) \\
A_{21}(s) & A_{22}(s) & A_{23}(s) \\
A_{31}(s) & A_{32}(s) & A_{33}(s)
\end{pmatrix}
\]

(26)

then we can obtain the following equation.

When \(s = 2\),

\[
A^2 = \begin{pmatrix}
A_{11} & A_{12} & A_{13} \\
A_{21} & A_{22} & A_{23} \\
A_{31} & A_{32} & A_{33}
\end{pmatrix}
\]

\[
= A_{11}^2 + A_{12}A_{11} + A_{13}A_{11} + A_{11}A_{12} + A_{12}A_{12} + A_{13}A_{13} + A_{11}A_{13} + A_{12}A_{13} + A_{13}A_{13}
\]

(27)
When $s = 3$, we can obtain the following equation. Here, matrix becomes so large, therefore we state them by each block matrix.

\[
A_{11}(3) = A_{11}^3 + A_{11}A_{12}A_{21} + A_{11}A_{13}A_{31} + A_{12}A_{21}A_{11} + A_{12}A_{22}A_{21} + A_{12}A_{23}A_{31} + A_{13}A_{31}A_{11} + A_{13}A_{32}A_{21} + A_{13}A_{33}A_{31}
\]
\[
A_{12}(3) = A_{11}A_{12}^2 + A_{11}A_{12}A_{21} + A_{11}A_{13}A_{32} + A_{12}A_{21}A_{12} + A_{12}A_{22}A_{21} + A_{12}A_{23}A_{32} + A_{13}A_{31}A_{12}
\]
\[
A_{13}(3) = A_{11}A_{13}^2 + A_{11}A_{13}A_{31} + A_{12}A_{21}A_{13} + A_{12}A_{22}A_{21} + A_{12}A_{23}A_{31} + A_{13}A_{31}A_{13}
\]
\[
A_{21}(3) = A_{21}A_{11}^2 + A_{21}A_{12}A_{21} + A_{21}A_{13}A_{31} + A_{22}A_{21}A_{11} + A_{22}A_{22}A_{21} + A_{22}A_{23}A_{31} + A_{23}A_{31}A_{11}
\]
\[
A_{22}(3) = A_{21}A_{11}A_{12} + A_{21}A_{12}A_{22} + A_{21}A_{13}A_{32} + A_{22}A_{21}A_{12} + A_{22}A_{22}A_{22} + A_{22}A_{23}A_{32} + A_{23}A_{31}A_{12}
\]
\[
A_{23}(3) = A_{21}A_{11}A_{13} + A_{21}A_{12}A_{23} + A_{21}A_{13}A_{33} + A_{22}A_{21}A_{13} + A_{22}A_{22}A_{23} + A_{22}A_{23}A_{33} + A_{23}A_{31}A_{13}
\]
\[
A_{31}(3) = A_{31}A_{11}^2 + A_{31}A_{12}A_{21} + A_{31}A_{13}A_{31} + A_{32}A_{21}A_{11} + A_{32}A_{22}A_{21} + A_{32}A_{23}A_{31} + A_{33}A_{31}A_{11}
\]
\[
A_{32}(3) = A_{31}A_{11}A_{12} + A_{31}A_{12}A_{22} + A_{31}A_{13}A_{32} + A_{32}A_{21}A_{12} + A_{32}A_{22}A_{22} + A_{32}A_{23}A_{32} + A_{33}A_{31}A_{12}
\]
\[
A_{33}(3) = A_{31}A_{11}A_{13} + A_{31}A_{12}A_{23} + A_{31}A_{13}A_{33} + A_{32}A_{21}A_{13} + A_{32}A_{22}A_{23} + A_{32}A_{23}A_{33} + A_{33}A_{31}A_{13}
\]

When $s = 4$, we state them by each block matrix as before.
\[ A_{12}(4) = A_{12} + A_{13} A_{12} + A_{21} A_{12} + A_{22} A_{12} + A_{23} A_{12} + A_{31} A_{12} + A_{32} A_{12} + A_{33} A_{12} \]

\[ A_{13}(4) = A_{13} + A_{13} A_{13} + A_{13} A_{13} + A_{13} A_{13} + A_{13} A_{13} + A_{13} A_{13} + A_{13} A_{13} + A_{13} A_{13} \]

\[ A_{14}(4) = A_{14} + A_{14} A_{14} + A_{14} A_{14} + A_{14} A_{14} + A_{14} A_{14} + A_{14} A_{14} + A_{14} A_{14} + A_{14} A_{14} \]

\[ A_{21}(4) = A_{21} + A_{21} A_{21} + A_{21} A_{21} + A_{21} A_{21} + A_{21} A_{21} + A_{21} A_{21} + A_{21} A_{21} + A_{21} A_{21} \]

\[ A_{22}(4) = A_{22} + A_{22} A_{22} + A_{22} A_{22} + A_{22} A_{22} + A_{22} A_{22} + A_{22} A_{22} + A_{22} A_{22} + A_{22} A_{22} \]

\[ A_{23}(4) = A_{23} + A_{23} A_{23} + A_{23} A_{23} + A_{23} A_{23} + A_{23} A_{23} + A_{23} A_{23} + A_{23} A_{23} + A_{23} A_{23} \]

\[ A_{32}(4) = A_{32} + A_{32} A_{32} + A_{32} A_{32} + A_{32} A_{32} + A_{32} A_{32} + A_{32} A_{32} + A_{32} A_{32} + A_{32} A_{32} \]
We can see from these that the number of items of $A_y(s) (i = 1, 2, 3) (j = 1, 2, 3)$, which is a $(i, j)$ part of $A^s$, is $3^{(s-1)}$.

5. A QUESTIONNAIRE INVESTIGATION AND NUMERICAL CALCULATION

A questionnaire investigation for automobile purchasing case is executed.

<Delivery of Questionnaire Sheets>
- Delivery Term: July / 2008 to July / 2009
- Delivery Place: Tokyo, Osaka, Hyogo, Nara, Kyoto, Wakayama in Japan
- Number of Delivered Questionnaire sheets: 700

<Result of collected Questionnaire Sheets>
- Collected Questionnaire Sheets: 271
- Collected data sets: 653

The questionnaire includes the question of the past purchasing history. Therefore the plural data may be gathered from one sheet. For example, we can get two data such as (before former automobile, former automobile), (former automobile, current automobile). Data are selected only the shift in the same genre, for example, shifts from sedan type to sedan type or light vehicle to light vehicle. As a result, we obtained 653 data sets. 258 cases are the upper shifts, 248 cases are the same rank movement, and 147 cases are the lower shifts. Lower shift consists of 22% in whole cases and the transition matrix corresponds to these facts as a whole.

Fundamental statistical result is exhibited in Table 1.

<table>
<thead>
<tr>
<th>Age</th>
<th>Sex</th>
<th>Occupation</th>
<th>Annual income (Japanese Yen)</th>
<th>Marriage</th>
<th>Kids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teens</td>
<td>26</td>
<td>Male</td>
<td>237 Student</td>
<td>71 Single</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0-3 million</td>
<td>71 Single</td>
<td>105</td>
</tr>
<tr>
<td>Twenties</td>
<td>70</td>
<td>Female</td>
<td>34 Officer</td>
<td>30 3-5 million</td>
<td>27 Married</td>
</tr>
<tr>
<td>Thirties</td>
<td>36</td>
<td></td>
<td>Company employee</td>
<td>140 5-7.5 million</td>
<td>41 Not filled in</td>
</tr>
<tr>
<td>Forties</td>
<td>67</td>
<td></td>
<td>Clerk of Organization</td>
<td>1 7.5-10 million</td>
<td>29 3 24</td>
</tr>
<tr>
<td>Fifties</td>
<td>62</td>
<td></td>
<td>Clerk of Organization</td>
<td>13 10-15 million</td>
<td>11 4 2</td>
</tr>
<tr>
<td>Sixties and over</td>
<td>26</td>
<td></td>
<td>Clerk of Organization</td>
<td>12 15 million or more</td>
<td>2 5 0</td>
</tr>
<tr>
<td>Not filled in</td>
<td>1</td>
<td></td>
<td>Clerk of Organization</td>
<td>1 Not filled in</td>
<td>1 Not filled in</td>
</tr>
<tr>
<td>Sum</td>
<td>271</td>
<td></td>
<td></td>
<td>271</td>
<td>271</td>
</tr>
</tbody>
</table>
Analyzing collected sheets based on Model ranked Table (Appendix1, Appendix2), we obtained the data sets as follows. In order to express them in the block matrix form, we consider the case of four variable blocks $\mathbf{T}, \mathbf{N}, \mathbf{H}$ and $\mathbf{O}$ as is described in 3. The variable $\mathbf{T}, \mathbf{N}, \mathbf{H}$ and $\mathbf{O}$ stands for Toyota, Nissan, Honda and Others respectively. Each of them consists of 5 ranks.

$$
\mathbf{T}_n = \begin{pmatrix} T^n_1 \\ T^n_2 \\ \vdots \\ T^n_5 \end{pmatrix}, \quad \mathbf{N}_n = \begin{pmatrix} N^n_1 \\ N^n_2 \\ \vdots \\ N^n_5 \end{pmatrix}, \quad \mathbf{H}_n = \begin{pmatrix} H^n_1 \\ H^n_2 \\ \vdots \\ H^n_5 \end{pmatrix}, \quad \mathbf{O}_n = \begin{pmatrix} O^n_1 \\ O^n_2 \\ \vdots \\ O^n_5 \end{pmatrix}
$$

(30)

$$
\begin{pmatrix} T_n \\ N_n \\ H_n \\ O_n \end{pmatrix} = \begin{pmatrix} A_{11} & A_{12} & A_{13} & A_{14} \\ A_{21} & A_{22} & A_{23} & A_{24} \\ A_{31} & A_{32} & A_{33} & A_{34} \\ A_{41} & A_{42} & A_{43} & A_{44} \end{pmatrix} \begin{pmatrix} T_{n-1} \\ N_{n-1} \\ H_{n-1} \\ O_{n-1} \end{pmatrix}
$$

Here,

$$
T_n \in \mathbb{R}^5 (n = 1, 2, \ldots), N_n \in \mathbb{R}^5 (n = 1, 2, \ldots), H_n \in \mathbb{R}^5 (n = 1, 2, \ldots), O_n \in \mathbb{R}^5 (n = 1, 2, \ldots), A_{ij} \in \mathbb{R}^{5 \times 5} (i = 1, \ldots, 5)(j = 1, \ldots, 5)
$$

We can express $\mathbf{T}, \mathbf{N}, \mathbf{H}$ and $\mathbf{O}$ as follows.

$$
\mathbf{T} = \{T_1, T_2, \ldots\}, \mathbf{N} = \{N_1, N_2, \ldots\}, \mathbf{H} = \{H_1, H_2, \ldots\}, \mathbf{O} = \{O_1, O_2, \ldots\}
$$

Now, we investigate all cases. Total numbers of shifts among each blocks are as follows.

1. $A_{11}$ Shift from $\mathbf{T}$ to $\mathbf{T}$ : 191
2. $A_{12}$ Shift from $\mathbf{N}$ to $\mathbf{T}$ : 27
3. $A_{13}$ Shift from $\mathbf{H}$ to $\mathbf{T}$ : 32
4. $A_{14}$ Shift from $\mathbf{O}$ to $\mathbf{T}$ : 47
5. $A_{21}$ Shift from $\mathbf{T}$ to $\mathbf{N}$ : 26
6. $A_{22}$ Shift from $\mathbf{N}$ to $\mathbf{N}$ : 33
7. $A_{23}$ Shift from $\mathbf{H}$ to $\mathbf{N}$ : 4
8. $A_{24}$ Shift from $\mathbf{O}$ to $\mathbf{N}$ : 30
9. $A_{31}$ Shift from $\mathbf{T}$ to $\mathbf{H}$ : 21
10. $A_{32}$ Shift from $\mathbf{N}$ to $\mathbf{H}$ : 12
11. $A_{33}$ Shift from $\mathbf{H}$ to $\mathbf{H}$ : 45
12. $A_{34}$ Shift from $\mathbf{O}$ to $\mathbf{H}$ : 19
13. $A_{41}$ Shift from $\mathbf{T}$ to $\mathbf{O}$ : 37
14. $A_{42}$ Shift from $\mathbf{N}$ to $\mathbf{O}$ : 28
15. $A_{43}$ Shift from $\mathbf{H}$ to $\mathbf{O}$ : 15
16. $A_{44}$ Shift from $\mathbf{O}$ to $\mathbf{O}$ : 86
In the case of $A_{1p}$, the details of shifts are as follows.

1. Shift from 5th position to 5th position of $T$ : 15
2. Shift from 5th position to 4th position of $T$ : 11
3. Shift from 5th position to 3rd position of $T$ : 4
4. Shift from 5th position to 2th position of $T$ : 5
5. Shift from 5th position to 1th position of $T$ : 0
6. Shift from 4th position to 5th position of $T$ : 3
7. Shift from 4th position to 4th position of $T$ : 25
8. Shift from 4th position to 3th position of $T$ : 17
9. Shift from 4th position to 2th position of $T$ : 12
10. Shift from 4th position to 1th position of $T$ : 2
11. Shift from 3th position to 5th position of $T$ : 0
12. Shift from 3th position to 4th position of $T$ : 13
13. Shift from 3th position to 3th position of $T$ : 2
14. Shift from 3th position to 2th position of $T$ : 4
15. Shift from 3th position to 1th position of $T$ : 1
16. Shift from 2th position to 5th position of $T$ : 24
17. Shift from 2th position to 4th position of $T$ : 3
18. Shift from 2th position to 3th position of $T$ : 19
19. Shift from 2th position to 2th position of $T$ : 8
20. Shift from 2th position to 1th position of $T$ : 0
21. Shift from 1th position to 5th position of $T$ : 0
22. Shift from 1th position to 4th position of $T$ : 1
23. Shift from 1th position to 3th position of $T$ : 1
24. Shift from 1th position to 2th position of $T$ : 1
25. Shift from 1th position to 1th position of $T$ : 1

Then, the vector $T, T_b$ for each case is expressed as follows.

1. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
2. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
3. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
4. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
5. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
6. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
7. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 1 \\ 0 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
8. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
9. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
10. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
11. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 1 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
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13. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
14. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
15. $T = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$, $T_b = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$
We calculate for the cases \( O, N, H \) in the same way. Substituting these to Eq. (18), we obtain the following equation.

\[
A = \begin{bmatrix}
5 & 8 & 4 & 2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 4 \\
1 & 24 & 12 & 12 & 5 & 0 & 2 & 1 & 1 & 0 & 0 & 2 & 1 & 1 & 4 & 3 & 0 & 5 & 3 & 5 \\
1 & 10 & 12 & 17 & 4 & 0 & 1 & 1 & 4 & 1 & 0 & 2 & 1 & 8 & 1 & 0 & 2 & 3 & 1 & 3 \\
3 & 3 & 13 & 25 & 11 & 0 & 1 & 2 & 1 & 3 & 0 & 1 & 1 & 2 & 2 & 0 & 1 & 1 & 4 & 4 \\
0 & 1 & 0 & 3 & 15 & 0 & 3 & 0 & 1 & 3 & 0 & 0 & 0 & 3 & 0 & 0 & 1 & 1 & 0 & 5 \\
1 & 1 & 0 & 1 & 1 & 0 & 2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\
0 & 3 & 2 & 5 & 0 & 0 & 5 & 4 & 4 & 0 & 0 & 0 & 3 & 0 & 0 & 0 & 0 & 1 & 2 & 1 & 6 \\
0 & 1 & 0 & 2 & 0 & 0 & 1 & 2 & 1 & 2 & 0 & 0 & 1 & 0 & 0 & 0 & 3 & 2 & 0 & 1 \\
0 & 0 & 0 & 0 & 0 & 0 & 2 & 7 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 2 & 0 & 2 \\
0 & 1 & 1 & 3 & 2 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 2 & 0 & 1 & 1 & 5 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 5 & 0 & 0 & 1 & 0 & 2 & 0 & 0 & 0 & 0 & 8 & 2 & 1 & 4 & 0 & 0 & 1 & 0 & 3 \\
0 & 2 & 2 & 0 & 0 & 0 & 0 & 3 & 0 & 0 & 0 & 2 & 2 & 1 & 0 & 0 & 0 & 3 & 0 & 1 & 2 \\
0 & 0 & 0 & 2 & 2 & 3 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 2 & 5 & 3 & 0 & 1 & 1 & 0 & 2 \\
0 & 2 & 1 & 0 & 1 & 0 & 0 & 2 & 1 & 1 & 1 & 3 & 0 & 0 & 7 & 1 & 1 & 0 & 0 & 3 \\
1 & 4 & 2 & 0 & 1 & 0 & 6 & 0 & 0 & 0 & 0 & 1 & 3 & 0 & 0 & 1 & 2 & 3 & 3 & 2 & 1 \\
0 & 3 & 1 & 1 & 0 & 1 & 3 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 2 & 0 & 1 & 5 & 2 & 2 & 2 \\
1 & 2 & 0 & 0 & 2 & 1 & 2 & 0 & 1 & 1 & 4 & 4 & 1 & 4 & 0 & 6 \\
0 & 0 & 0 & 2 & 2 & 3 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 3 & 0 & 1 & 2 \\
2 & 3 & 3 & 3 & 4 & 0 & 0 & 1 & 1 & 3 & 0 & 0 & 2 & 1 & 1 & 1 & 4 & 1 & 2 & 4
\end{bmatrix}
\]
Eq. (31) shows that it is close to an upper triangular matrix in each Block Matrix. Therefore we could obtain the result as assumed. On the other hand, shifts from one rank to another rank in the same car genre are as follows.
Each rank of the same level is condensed into one in the following equation.

\[
\hat{A} = \begin{pmatrix}
19 & 31 & 13 & 7 & 8 \\
6 & 67 & 34 & 33 & 31 \\
6 & 33 & 36 & 40 & 26 \\
6 & 9 & 29 & 51 & 35 \\
7 & 17 & 14 & 20 & 75 \\
\end{pmatrix} \begin{pmatrix}
44 & 0 & 0 & 0 & 0 \\
0 & 157 & 0 & 0 & 0 \\
0 & 0 & 126 & 0 & 0 \\
0 & 0 & 0 & 151 & 0 \\
0 & 0 & 0 & 0 & 175 \\
\end{pmatrix}^{-1}
\]

\[
\begin{array}{cccc}
19/44 & 31/157 & 13/126 & 7/151 & 8/175 \\
3/22 & 67/157 & 63/17 & 33/151 & 31/175 \\
3/22 & 33/157 & 2/7 & 40/151 & 26/175 \\
3/22 & 157/126 & 7/151 & 51/1 & 1/5 \\
7/44 & 17/157 & 1/9 & 20/151 & 3/7 \\
\end{array}
\]

Eq. (32) becomes to be an upper triangular matrix on the whole. Condensing each block matrix in Eq. (31) into one \([8], we can obtain Eq. (33).

\[
A = \begin{pmatrix}
191 & 27 & 32 & 47 \\
26 & 33 & 4 & 28 \\
21 & 12 & 45 & 19 \\
37 & 28 & 15 & 86 \\
\end{pmatrix} \times \begin{pmatrix}
275 & 0 & 0 & 0 \\
0 & 100 & 0 & 0 \\
0 & 0 & 96 & 0 \\
0 & 0 & 0 & 182 \\
\end{pmatrix}^{-1}
\]

\[
\begin{array}{cccc}
191/275 & 27/100 & 1/3 & 47/182 \\
26/275 & 33/100 & 1/15 & 1/19 \\
21/275 & 3/15 & 15/91 & 19/1 \\
37/275 & 7/25 & 5/32 & 43/91 \\
\end{array}
\]

Based on this equation, we can clarify the shift among car makers. Eq. (33) is by far the simple one compared with Eq. (31). A questionnaire investigation for automobile purchasing case is executed and the matrix structure stated in 2. can be confirmed on the whole. We consider as follows from these results.

a) The number of the shifts from Toyota to Toyota is 191. This is the
greatest number and takes the share of 29% of the total. In particular, the number of the shifts to Sedan type occupies the majority (91 cases). It has 74% of $A_{11}$ (shifts from Toyota to Toyota). From these data, the possibility that person who owned Toyota sedan typed car will buy the same one next time is high. Toyota sedan typed car is very popular.

b) Next, the number of the shifts from Honda to Honda is 45. This has the share of 7% of the total. “Step wagon”, “Odyssey” and “Fit” are Honda’s most popular cars. The number of the shifts to these cars occupies 37% of $A_{33}$ (shifts from Honda to Honda). From these data, we can observe that the Toyota’s share is largest and Honda has repeated customers in specific models.

c) Comparing with a), the number of the shifts from Nissan to Nissan is 33. This is the least among the shift to same company. The number of the shifts from Honda to Nissan is quite a few. It has less 0.6% share. On the other hand, the number of shifts from Nissan to Toyota or Honda is many. It has 6% share. Therefore, it is required to get repeaters for Nissan.

d) Comparing shifts from Toyota to Toyota and Nissan to Nissan, people shift to upper class clearly in Model Ranking Table. We can observe that Toyota and Nissan classify the luxury cars from popular cars definitely and such image penetrates consumers well.

e) For about shifts from 1st rank to 1st rank, the number of shifts from "Others" to "Others" is the most (12 cases). This is because the major shifts are from imported car to imported car of which holders may be high-income class. Among them, percentage of people who shift from Benz to Benz is the most (67%). Therefore we can expect that the share of people who ride on Benz is large in Japan. On the other hand, the shifts from 5th rank to 5th rank in $A_{44}$ consists by the shift from light vehicles to light vehicles, for example, “Wagon R”. The number of shifts from light vehicles to light vehicles is 17 cases in all 27 cases. From these data, we can see that consumers who purchase light vehicles once tend to purchase light vehicles again.

f) The number of the extreme shifts from 5th rank to 1st rank is a few (8 cases). But the number of shifts from 4th rank to 3rd rank occupies 6% of all (40 cases), and from 3rd rank to 2nd rank occupies 5% of all (34 cases), which implies that uptrend shift is gradual in automobile market.
6. APPLICATIONS OF THIS METHOD

Applications of this method are considered to be as follows. Consumers’ behavior may converge by repeating forecast under the above method and the total volume of sales of all brands may be reduced. Therefore, the analysis results suggest when and what to put a new brand into the market which contribute to the expansion of the market.

There may arise following cases. Consumers and producers do not recognize the brand position clearly. But the analysis of consumers’ behavior let them know their brand position in the market. In such a case, strategic marketing guidance to select the brand would be introduced. Setting in order the brand position of various goods and taking suitable marketing policy, enhancement of sales would be enabled. Setting the higher ranked brand, consumption would be promoted.

7. CONCLUSION

Consumers often buy higher grade brand products as they are accustomed or bored to use current brand products they have.

In this paper, matrix structure was clarified when brand selection was executed toward higher grade brand. Expanding brand selection from single brand group to multiple genre brand groups, we could make much more exquisite and multi-dimensional analysis. And formulation of extension to the brand groups was executed using Block Matrix. s-step forecast model was also formulated. In numerical example, matrix structure’s hypothesis was verified concerning brand selection among multiple brands. Such research as questionnaire investigation of consumers’ activity in brand bag purchasing should be executed in the near future to verify obtained results.

In conclusion, we would like to thank Ms Ayane MITSUNO for her helpful support of this research.

REFERENCES

1987.


## Appendix 1. List of all cars

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<th>Honda</th>
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| Classic        |             |           |              |              |             |            |            |             |
| Cressida       |             |           |              |              |             |            |            |             |
| Cresta         |             |           |              |              |             |            |            |             |
| Corona         |             |           |              |              |             |            |            |             |
| Cefiro         |             |           |              |              |             |            |            |             |
| Corona         |             |           |              |              |             |            |            |             |
| Comfort        |             |           |              |              |             |            |            |             |
| Sprinter cielo |             |           |              |              |             |            |            |             |
| Century        |             |           |              |              |             |            |            |             |
| Tercel         |             |           |              |              |             |            |            |             |
| Chaser         |             |           |              |              |             |            |            |             |
| Duet           |             |           |              |              |             |            |            |             |
| Vista          |             |           |              |              |             |            |            |             |
| Platz          |             |           |              |              |             |            |            |             |
| Prinus         |             |           |              |              |             |            |            |             |
| Brevis         |             |           |              |              |             |            |            |             |
| Premio         |             |           |              |              |             |            |            |             |
| Progres        |             |           |              |              |             |            |            |             |
| Pronard        |             |           |              |              |             |            |            |             |
| Beta           |             |           |              |              |             |            |            |             |
| Mark X         |             |           |              |              |             |            |            |             |
| Mark II        |             |           |              |              |             |            |            |             |
| Lexus ES       |             |           |              |              |             |            |            |             |
| Lexus GS       |             |           |              |              |             |            |            |             |
| Lexus HS       |             |           |              |              |             |            |            |             |
| Lexus IS       |             |           |              |              |             |            |            |             |
| Lexus LS       |             |           |              |              |             |            |            |             |

<p>| MR2            | GT-R         | S2000     | Aloyone      |             |            |            |            |             |
| MR-S           | 180SX       | NSX       |              | FTO         | RX-3        |            |            |             |
| Corolla        | Exa          | Integra- |              | GTO         | MX-6        |            |            |             |
| Levin          | Gazelle     | type-R    |              | Cordia      | RX-7        |            |            |             |
| Cynos          | Silvia      | Prelude   |              | Starion     | Etude       |            |            |             |
| Supra          | Skyline-    |           |              |             | Autozuma<del>AZ-3|            |            |             |
| Starlet        | coupe       |           |              |             | Cosmo       |            |            |             |
| Sprinter       | Figaro      |           |              |             | Familia</del>astina|            |            |             |
| Sera           | Fairlady z  |           |              |             | Eunos~presso|            |            |             |
| Celica         | Micro C+O   |           |              |             | Roadster    |            |            |             |
| Soarer         | Lucino      |           |              |             |             |            |            |             |
| Lexus SC       |             |           |              |             |             |            |            |             |</p>
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*Sports car*
| IV | SX4 sedan | Ascot | Insight | Integra | Imprezza anesis | Exiv | Capella | Carina ED | Galant fortis | Cronus | Civic | Chaser | Vista | Vista ardeo | Primera | Bluebird | Bluebird sylphy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 180SX | Cavalier | Silvia | Supra | Smart | Celica | Prelude | Isis | Wish | Voxy | Edix | Caravan | Sienta | Chariot | Stream | Noah | Freed | Premacy | Bongo |
| Avenir | Caldina | Mark II | wagon | RAV-4 | Airtrek | Cami | Tribute | Forester |
| RVR | Corolla | rumion | Mini cooper | Raum | Runion |

| V | OR-X | Axela | Aerio | Carina | Corolla | Corolla II | Cruz | Corsa | Corona | Sunny | Gemini | City | Tercel | Tida | Pulsar | Familia | Festiva | Platz | Mirage | Lancer sedan | Leone | Logo |
| MR2 | Corolla levin | Sprinter | Sprinter—trueno | Acty van | Every | Chariot | Townace | Hjet | Prairie | Masterace | Liteace | Sprinter carib | Demio | Lancer cedia—wagon | Libero | Chevrolet | Pajero Jr | Rasheen |
| bB | iQ | Vitz | Cube | That’s | Swift | Note | Pyzar | Passo | Fun cargo | Fit | March | eK wagon | MAX | MR—wagon | Atrai—wagon | Alto | Vivio | Every—wagon | Otti | Opti | Jimmy | Sorum | Stella | Street | Sonica | Tanto | Bistor | Pino | Minica | Mira | Move | Meco | Life | Lapin | Rex | Wagon R | Acty truck | High bit—truck | Mighty boy |