A Study on

Consumers Choice Behavior

Using Multivariate Analysis

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Takashi Usami

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by
Takashi Usami

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Under the supervision of
Professor Toshio Nakagawa

Department of Industrial Engineering,
Aichi Institute of Technology
Toyota, Japan

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Abstract

It has become very difficult to sell new products on the market owing to the world-wide economic depression. This is so that a market is complicated rapidly, and there is a big difference in the modern society and new generation. It has become very important to plan and develop new products which reflect the sense of the times and answer to the consumer sense of values. The development of new products has to be made by knowing both consumer needs and selection behavior. These are called *quality requirement of consumers*. For this purpose, it is necessary to collect the data widely from consumers and to analyze them statistically and scientifically. Moreover, it is also important to study the theoretical methodology of marketing research.

This thesis utilizes four models to comprehend and analyze quality requirement of consumers using the theory of multivariate analysis:

1. Huff Model
2. Principal Component Analysis and Entropy Model
3. Entropy Model and Herniter Model
4. Conjoint Analysis

The above four models would contribute effectively to the predictions of quality requirement of consumers for new products, future market structures and shares. By such kinds of knowledge, manufactures or companies could have good opportunities to market new products.

Finally, the results derived from this thesis are summarized and future studies are described.

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Chapter 1

Introduction

In the present economic situation of the world, it has become increasingly difficult for most companies to stay afloat. The market has been over-saturated with similar products, and thus, it has become important to consider and predict how to stir up the great interest in consumers. Also, the economy in many countries has fallen into stagnation or recession. As the result, consumers have less money for spending, and have become more sensitive to selection of their purchases. The main objective of the thesis is to support companies with the process of providing new products to the market. There are many methods to investigate consumer needs and behavior from the development of products to their selling. The most important problem which companies are facing is to find out what kinds of products will be sold on the market. There are several methods of approaching toward such problems. The following four techniques are utilized in this thesis:

1. Using Huff model, the probability of consumers patronizing a particular establishment is calculated and the number of average visitors is calculated from the result.
2. In order to find consumer needs and the weight, they are analyzed, using principal component analysis and entropy model in information theory.
3. For further discernment of consumer preferences, entropy model and Herniter model are used.
4. Using conjoint analysis, the final concept of an optimal product is given and the importance of an attribute is analyzed.

1.1 Review of Literatures

This thesis describes the selection behaviors of consumers, using mainly multivariate analysis: First, we research in where consumers buy products, and in what kind of quality consumers buy new products. This is called *quality requirement*. Furthermore, structures of quality requirements are surveyed, and finally, new products to sell are suggested.

In this section, we summarize the results of typical mathematical marketing models: It is for the main purpose to obtain ratios of choosing stores which consumers establish. In this thesis, using the methods of probability and statistical theories, the number of persons to choose stores is estimated, and the amount of proceeds is predicted: Reilly (1929) proposed the law of retail attraction which is a formula to explain the spread of goods in a commercial area. Converse (1949) presented the formula of branch point from 1943 to 1948 based on Reilly's law. Huff (1964) subdivided commercial areas into some business places which are retail accumulations such as shopping centers, department stores and supermarkets, and examined individual goods in addition to shopping goods. Itakura (1998) suggested the usage of modified Huff model. Aida (1993) used Huff model for a geographical convenience prediction of stores. Using the result of Huff model, Asano (1994) predicted the number of visitors of stores. Yamada et al. (2003) predicted the number of average visitors when the number of consumers which can park is changed.

We explain briefly the above models: The fundamental concept is that consumers select their favorite brands by the degree of their preferences (Muto (1986)). Purchase probabilities of each brand based on such concept are estimated and calculated, using the preference data of consumers. Teramoto (2001) predicted the market share when a new product is sold.

The entropy model has been considered in many fields of marketing science and applied to the studies of share prediction and evaluation of selection probabilities. Using this model, Herniter (1973) divided consumers into two strata; the non-fixed stratum of those who have not decided their purchases, and the fixed stratum of those who purchase only one brand, and explained the market structure of the non- fixed stratum by calculating the stratum ratio. This has greatly developed the theory of consumer demand. Using the algorithm and maximum entropy principle in information theory, Gensch and Soofy (1995) evaluated the selection probability and examined the marketing structure. Brockett et al. (1995) investigated the effectiveness of information theory as a statistical approach to use in marketing research, and applied it to the logarithm linear model, entropy model, logit model and brand switching model. Ito (1987) calculated the weight ratio of several factors for women preferences in fashion. Using this model, Teramoto (1999) also calculated the selecting rate of several factors for women preferences in perfume.

We take out different images or product concepts of consumers and make the perception positioning: Consumers evaluate products and have a product concept of some attributes. Using factor analysis, we can gather information of manufacturing auto protocol in two or three dimensions (Urban, et al. (1987), and Urban and Hauser (1993)). The conjoint analysis, which is one of the marketing research techniques, is mainly used in such a situation (Luce and Tukey (1964)). Using the orthogonal array, the consumer preferences are analyzed, and their levels for some attributes (e.g., container, category, size etc.) are measured. Several product plans, including different levels of attributes, were proposed by Katahira (1989).

1.2 Organization of Thesis

This section describes the organization of this thesis. This thesis is divided into Introduction, Chapters 2-5, Conclusions and Bibliography.

Firstly, in Chapter 2 we consider a geographical convenience model of stores, using modified Huff model. We calculate the ratios that consumers choose stores and the number of average visitors. This chapter estimates market shares of six department stores in Nagoya and the number of average visitor.

Chapter 3 estimates consumer needs and the importance, using multivariate analysis and entropy model. This is one of an important prediction to estimate consumer needs on new product development. To test this means, it is investigated through two questionnaires. Using the technique of multivariate analysis, consumer needs are estimated. Further, using the technique of entropy model, those importances are calculated.

Chapter 4 makes the analysis of market share structure of watches for young men, using entropy model and Herniter model. Preferences for four factors of selected kinds of watches are analyzed (e.g., functions, design, belt and display). The factors of preferences for each item are investigated on the market, and then, by applying collected data to entropy model, their rates are numerically obtained. It is shown that more than 50% of consumers have already decided a factor of preferences for their favorite brand. Further, there are two groups of consumers; one selects according to only one factor of preferences and the other selects according to several factors.

In Chapter 5, while designing a new product, it is vital to grasp consumer evaluation of present products. It is crucial for the product experimental design to clarify the degree of consumers and preferences of product attributes. The conjoint analysis, which is one of the marketing research techniques, is mainly used in such a situation. We take up soft drink as an example, which becomes enormously popular. Using the orthogonal array, the consumer preferences are analyzed, and their levels for some attributes (e.g., container, category and size) are measured. Next, several product plans, including different levels of attributes, are proposed and an optimal product is presented.

Finally, Chapter 6 summarizes the results derived in this thesis and states briefly several remaining and future problems to be solved.

Chapter 2

Estimation of Choice Behavior Using Huff Model

This chapter estimates the probability of consumers who go shopping to a particular department store in Nagoya city, using modified Huff model. This modified Huff model is a type of calculation designed for evaluating the probability of consumers patronizing a particular establishment. Specifically, the probability that consumers in that area will purchase something at the store is directly proportional to its floor space and inversely to the square of its distance from their houses. At present, there are six department stores in Nagoya city. Store A is a new store which was opened four years ago (2000), and it was much talked about. Store B is especially popular among young people. Stores C and D specialize in grocery, and store E is popular among consumers who do shopping on their way back home. Finally, store F has the largest floor space in Japan and also has the biggest sale in Nagoya city.

We research the data of floor spaces, populations of edge cities and time distances for six department stores. As a result, the selection rates of consumers for each store are as follows: A is 16.01%, B is 2.58%, C is 19.71%, D is 18.65%, E is 19.59% and F is 23.47%. Store F has the highest rate. These shares of department stores are in proportion to their sales. By this method, it would be possible to estimate the selection rates of department stores from a little data such as floor spaces and distances. This method would be useful to estimate the losses of other existing stores when a new store is planning to open in this area.

2.1 Introduction

The sales of department stores in Japan have gradually diminished because consumers hesitate to make purchases owing to the recent depression. Recently, many stores, where prices are cheap and qualities are good, have opened in the near suburbs. To compete with these stores, department stores keep a large stock of goods and have developed their own original brands. The competition between department stores and other stores are getting keener yearly in the market.

Department stores at present have developed their own brands positively, and also, have extended and opened actively their new stores. However, if a new store opens, it would be difficult to improve and reconstruct it. So that, it would be necessary to do wide research in many circumstances, firstly beforehand when a new store opens.

This chapter estimates the probability of consumers who go shopping to department stores in Nagoya city, using modified Huff model. This model is a type of calculation designed for evaluating the probability of consumers patronizing a particular store. From the data of floor spaces, populations and time distances, we compute the selection rates of consumers for six department stores in Nagoya city. This method would be possible to estimate the selection rates of department stores from a little data such as floor spaces and distances. Moreover, this would be useful to estimate the losses of other existing stores when a new store is planning to open in this area.

During the recent recession, the sales of department stores in Japan have decreased, and a major department store went bankrupt in 2000. There have appeared a lot of stores where qualities are good and prices are cheap. On the other hand, department stores have coped with other stores by their own brand and numerousness of merchandise assortment. However, the brand of department stores had deteriorated during these past several years. Therefore, they have become price competition between other stores, and in addition, have to establish their branches which have a brand power positively. However, the repair of stores is not simple, and it is also difficult to stand them up again. Therefore, it is necessary to research it tightly beforehand when firstly a new store is built. A main purpose of this study is to estimate the probability of choosing a new department store when it will be built.

2.2 Macro-Measurement Method

Commercial area investigation has two methods of micro-investigation and macro-investigation: Macro-investigation is the simple method of deskwork. There are usually the following three methods in retail business: (1) Reilly's law, (2) law of Converse and (3) Huff model (Aida (1993)).

(1) Reilly's Law

Reilly (1929) proposed the law of retail attraction which is a formula to explain the spread of goods in a commercial area: There are cities A and B in a certain region, and C between A and B. Then, the percentage of consumers living in C who go shopping to A or B is in proportion to populations of A and B, and in inverse proportion to square of distances from C to A and B. That is, Reilly's law is expressed as

$$\frac{C_a}{C_b} = \frac{\frac{P_a}{D_a^2}}{\frac{P_b}{D_b^2}}, \qquad (2.1)$$

where C_a (C_b) is consumer shopping movement to A (B),

P_a (P_b) is population of A (B),

D_a(D_b) is distance from town C to A (B).

It was lately suggested that the distances should be changed to the power of three in (2.1), when the populations of two cities are remarkably different (Itakura (1998)).

(2) Law of Converse

Converse (1949) presented the formula of branch point in the commercial area of cities A and B from 1943 to 1948 based on Reilly's law, in which is given by

$$B_b = \frac{C_b}{1+\sqrt{\frac{P_a}{P_b}}}, \tag{2.2}$$

where B_b is branch point from B between A and B,

C_b is consumer shopping movement to B,

P_a (P_b) is population of A (B).

(3) Huff Model

Huff (1964) subdivided a commercial area into some business places which are retail accumulations such as shopping centers, department stores and supermarkets as one unit, and examined individual goods in addition to shopping goods. Further, he investigated populations, distances and retail areas of business places, and formed the probability model in which the formula is given by

$$P_{ij} = \frac{\frac{S_j}{T_{ij}^{\lambda}}}{\sum_{j=1}^{n} \frac{S_j}{T_{ij}^{\lambda}}}, \tag{2.3}$$

where P_{ij} is probability that a consumer of spot i goes to business place j,

S_j is retail area of business place j,

T_{ij} is duration time that a consumer of spot i goes to business place j,

λ is drag coefficient of time distance, which is given by minus and drag factors such as railroad crossing, river, wide road crossing, rapid slope, dangerous zone, and so on (Asano (1994)).

Using the formula, Huff computed the quotient category absorption powers between each place and the account of shopping secondment proportions of each place (Itakura (1998)).

Ministry of Economy, Trade and Company in Japan modified Huff model as follows: Probabilities that consumers buy something in a business area is in proportion to its area and is in inverse proportion to square of distance to its area (Commentary (1990)). This is called *modified Huff model*. At present, most consumers move to their destination by automobiles, trains and buses. Thus, it would be practical in actual fields to use the time taking to destination in place of distance.

2.3 Results

There are six department stores in Nagoya city. We collect the data of floor spaces and amount of sales for each store in Table 2.1, populations of districts in Nagoya city and near cities, and distances from a main station to each store in Table 2.2. Using these data, we compute the probabilities that consumers in districts and cities go shopping to each store in Table 2.3.

Table 2.1 Floor Space, Capital and Sales of Stores

	Floor Space	Capital	Sales Amount
A	55,429	10,000	6,113
B	8,929	2,720	1,750
C	69,909	973	8,411
D	67,090	4,962	3,647
E	67,814	2,028	6,161
F	104,709	9,765	11,121

(Ref. Japan Department Store Associations (May 2002))

Table 2.2 Populations of City and Time Distances from Main Station

City and District	Household	Population	Time Distance		
			Nagoya (A, B, E)	Sakae (C,D)	Yabacho (E)
Chikusa-ku	70,703	149,917	11	7	10
Higasi-ku	31,002	66,179	11	11	12
kita-ku	69,663	167,008	10	5	6
Nishi-ku	58,985	140,556	15	13	20
Nakamura-ku	60,681	133,945	1	7	11
Naka-ku	35,714	65,549	4	0	1
Syouwa-ku	50,839	105,567	10	7	6
Mizuho_ku	44,617	103,700	17	14	17
Atsuta-ku	26,874	62,926	7	12	10
Nakagawa-ku	80,336	211,413	12	16	19
Minato-ku	56,973	151,735	20	14	13
Minami-ku	59,756	146,998	10	13	12
Moriyama-ku	58,518	156,323	22	17	19
Midori-ku	75,753	209,994	13	16	15
Meitou-ku	65,779	153,950	23	19	21
Tenpaku-ku	65,021	153,713	19	16	15
Kasugai	106,445	291,024	20	17	23
Seto	47,211	132,345	32	25	28
Ichinomiya	92,794	276,096	10	16	17
Tsushima	21,813	65,846	12	18	21
Kounan	32,921	98,244	20	30	34
Tokai	37,564	100,702	18	22	21
Okazaki	117,477	340,417	34	37	36

(Ref. Yahoo Japan and Aichi-Prefecture (January 2002))

Table 2.3 Probability that Consumers go to A – F

District	A (%)	B (%)	C (%)	D (%)	E (%)	F (%)
Chikusa-ku	9.28	1.50	28.91	27.74	11.36	21.22
Higasi-ku	15.52	2.50	19.57	18.78	18.99	24.63
kita-ku	5.71	0.92	28.80	27.64	6.98	29.95
Nishi-ku	14.84	2.39	24.92	23.92	18.16	15.77
Nakamura-ku	40.81	6.57	1.05	1.01	49.92	0.64
Naka-ku	0.52	0.08	42.31	40.60	0.64	15.84
Syouwa-ku	7.89	1.27	20.31	19.49	9.65	41.40
Mizuho_ku	12.63	2.03	23.49	22.54	15.45	23.86
Atsuta-ku	24.09	3.88	10.34	9.92	29.47	22.30
Nakagawa-ku	22.08	3.56	15.67	15.04	27.02	16.64
Minato-ku	8.40	1.35	21.63	20.76	10.28	37.57
Minami-ku	19.38	3.12	14.47	13.88	23.72	25.43
Moriyama-ku	11.04	1.78	23.32	22.38	13.51	27.97
Midori-ku	18.40	2.96	15.32	14.70	22.51	26.11
Meitou-ku	12.09	1.95	22.34	21.44	14.79	27.39
Tenpaku-ku	11.23	1.81	19.98	19.18	13.75	34.05
Kasugai	13.82	2.23	24.13	16.91	16.91	19.75
Seto	11.23	1.81	23.21	22.28	13.74	27.72
Ichinomiya	24.98	4.02	12.31	11.81	30.56	16.33
Tsushima	24.39	3.93	13.67	13.12	29.84	15.05
Kounan	24.17	3.89	13.55	13.00	29.58	15.80
Tokai	18.43	2.97	15.56	14.93	22.54	25.57
Okazaki	16.24	2.62	17.30	16.60	19.87	27.37

Table 2.4 shows the shares of six department stores. This indicates that the highest share is store F, because it is wide and its shares of remote districts are high. The next high store is store C, because shares in near areas of C are high, and traffic conveniences are better than those of other stores. The shares of stores C, E and D are almost the same. The share of store E is high in the suburbs of Nagoya because traffic conveniences from such suburbs are good. The share of store B is extremely lower than the other stores, because its floor space is too small.

Table 2.4 Shares of Department Stores

Department Store	Share
A	16.01%
B	2.58%
C	19.71%
D	18.65%
E	19.59%
F	23.47%

We show the relation between the amount of sales and shares of each store in Figure 2.1. The amount of sales becomes high as shares become high. However, the share of store D is high, but its sale is low. This reason is that consumers would go to this store, but might not buy many things. It would be necessary to clear up the cause from another angle.

Using the above results, we estimate the average number of visitors to each store, which is given by

$$E_j = \sum_{i=1}^{n} P_{ij} \times C_i , \qquad (2.4)$$

where E_j is average number of visitors to store j,

P_{ij} is probability that a consumer of spot i goes shopping to store j,

C_i is population of spot i.

Figure 2.1 Sales and Concern of Shares

Table 2.5 Number of Average Visitors

Department Store	Number of Average Visitors
A	815,464
B	131,459
C	1,420,266
D	1,344,697
E	997,854
F	1,434,962

We show the average number of visitors in Table 2.5. There are many consumers in stores F, C and D, but the amount of sales of A is more than C and D. This reason is that store F can display a large number of goods since its floor space is large. Many consumers do not visit to store A, but its amount of sales is high. Most consumers who go shopping to A might buy something in this store.

2.4 Conclusions

We have revised the modified Huff model, because it is necessary to reconsider the means of transportation, and to change from distance to time. As the example of six department stores in Nagoya City, we have got the shares of each store. The selection rates of consumers for each store are as follows: A is 16.01%, B is 2.58%, C is 19.71%, D is 18.65%, E is 19.59% and F is 23.47%. Store F has the highest rate. Each estimated share of department stores is approximately in proportion to its amount of sales. Therefore, this method in this chapter would be reasonable to estimate statistically shares of each store.

Chapter 3

Estimation of Quality Requirements Using PCA and Entropy Model

This chapter studies consumer needs in new products, using principal component analysis (PCA) and entropy model. A questionnaire is distributed to 300 people and asks questions regarding consumer needs in new cars. The respective selecting rates of brand, performance and economical efficiency are 40%, 33% and 27%. Because most of consumers buying cars are young, we do again a questionnaire to 130 young males. As a result, the respective selecting rates of comfort, recreation and performance are 70%, 28% and 2%. When a new product is developed by these techniques, important quality requirements can be estimated.

3.1 Introduction

For the last several years the economic recession in Japan has caused a relative market slump. It has become more and more difficult to sell various products. The main reasons are as follows: The generation that purchases products has greatly changed, and the market structure has become much complicated. New product development has to turn scrupulous attention into sudden change and diversification of a market. The factor which consumers want to buy in a market is called *quality requirement*. When a new product is developed, we have to find its quality requirement. That is, it is important to investigate how quality requirement of a new product consumers concern about, and to find its concept.

A lot of methods to grasp quality requirement on this problem were suggested (Asano (1999)), using factor analysis (Yoshida, et al. (1979)). In this Chapter, we suggest which is the most important in quality requirement, without grasping what quality requirement is: We make clearly the structure of variables to specify quality requirement of new products, by using principal component analysis and entropy model. Principal component analysis is used to gather variables of quality requirement, and entropy model is used to maximize the choice action which fills free will under certain limitations.

A procedure of analysis is shown by the flowchart of Figure 3.1. Based on conventional experience about products, we investigate from various angles and grasp outlines of products. When a product which is developed newly into a market, we concern about what kind of consumers should be its target one. Further, we investigate quality requirement of a whole market and decide fit generations from the result. Next, a questionnaire is made. It is necessary to investigate on a questionnaire as follows: We decide a product oneself, and its company or classification. Therefore, we send the first questionnaire only in a maker to catch an outline of quality requirement, and do the second one to catch concretely quality requirement. From the data of questionnaire, we grasp something of quality requirement, using principal component analysis and analyze it, using entropy model. Finally, using these results, we examine which quality requirement is important.

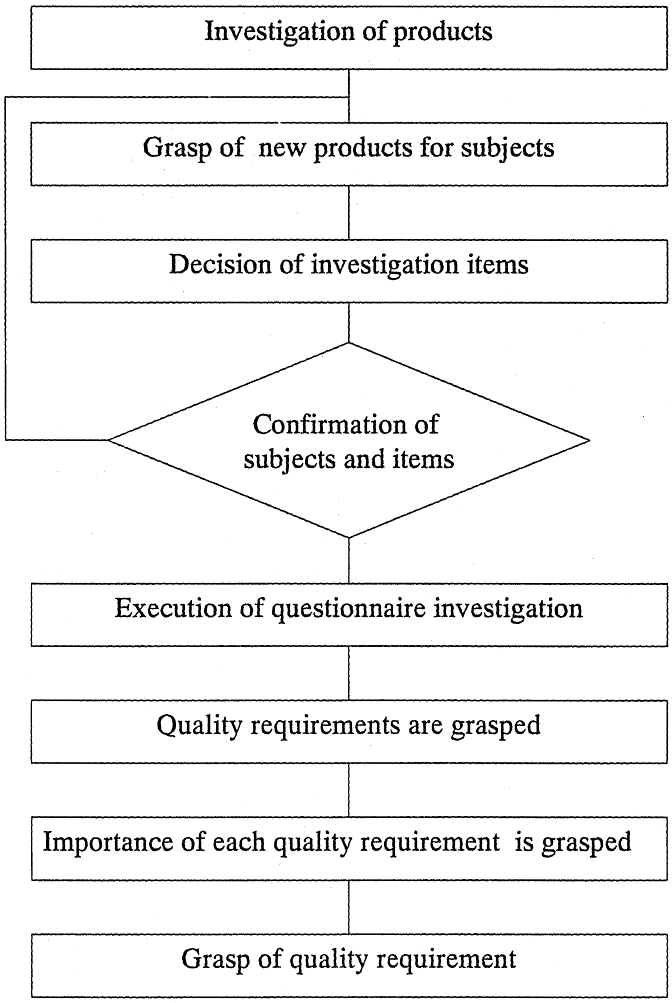


Figure 3.1 Flowchart of Analysis

3.2 Background of Model and Theory

(1) Principal Component Analysis

The technique to choice behaviors is called *principal component analysis*: Principal component analysis is very effective to clarify a variation of quantities (Ishiwata (1991), Ishihara et al. (1991), Okada and Imaizumi (1994), Okada et al. (1987), Tanaka and Wakimoto (1991) and Uchida (1998)). By the analysis we get new variables composed of a dispersion tendency of data with plural variations of quantities, and an index of eigenvalue. Eigenvalue shows which principal component so that its value is high is important. Further, we gather a lot of variations of quantities, and obtain some representative quality requirements which can explain a phenomenon.

(2) Entropy Model

We call an amount of information *degree of fuzziness* and call its expected value *appearance probability of entropy*. An amount of information is defined as follows: When a certain data are classified with probability p_1, p_2, p_3, ..., p_n where $\sum_{i=1}^{n} p_i = 1$, an amount of information H is

$$H = -\sum_{i=1}^{n} p_i \times \log p_i \,. \tag{3.1}$$

We call this amount of information H *entropy with* p_1, p_2, p_3, ..., p_n (Kunisawa (1991)). This is very effective to grasp selection behaviors freely.

It is supposed that two discrete probability distributions $\boldsymbol{p}=(p_1, p_2, p_3, \ldots, p_n)$ and $\boldsymbol{q}=(q_1, q_2, q_3, \ldots, q_n)$ are given where $\sum_{i=1}^{n} p_i = \sum_{i=1}^{n} q_i = 1, p_i > 0, p_i > 0$ ($i = 1, 2, \ldots, n$). Then, the estrangement of these two distributions is, for any $\boldsymbol{q}$,

$$D(\mathbf{p},\mathbf{q}) = \sum_{i=1}^{n} p_i \times \log \frac{p_i}{q_i}. \tag{3.2}$$

We call this $D(\mathbf{p},\mathbf{q})$ *discriminant function of Kullback* (Kullback (1958)).

Under a certain limitation, we can form an optimal model which obtains a selection ratio p_i to make $D(p,q)$ be the smallest. We call this model *entropy model*. It is a technique to minimize the expected value of an amount of information under a certain limitation. As one technique to resolve this model, iterative scaling method is convenient (Darroch and Ratchiff (1972)). That is, under c following conditions:

$$h_s = \sum_{s=1}^{c} a_{si} p_i \quad (s=1, 2, 3, \ldots, c), \tag{3.3}$$

we resolve a problem to minimize the objective function

$$D(\mathbf{p},\mathbf{q}) = \sum_{i=1}^{n} p_i \times \log \frac{p_i}{q_i}. \tag{3.4}$$

We give the following produce of computing the problem:

Procedure 1: $p_i^{(0)} = q_i$ (i=1,2,3,…,n) is defined as an initial distribution (the 0th approximation distribution).

Procedure 2: The first approximation distribution $p_i^{(1)}$ (i = 1, 2, 3, …, n) is

$$p_i^{(1)} = p_i^{(0)} \times \prod_{s=1}^{c} \left(\frac{h_s}{h_s^{(0)}} \right)^{a_{si}} \quad (i = 1, 2, 3, \ldots, n), \tag{3.5}$$

where

$$h_s^{(0)} = \sum_{i=1}^{n} a_{si} \times p_i^{(0)} \quad (s = 1, 2, \ldots, c). \tag{3.6}$$

Repeating Procedure 2, it converges to $\lim_{t \to +\infty} p_i^{(t)} = p_i$ and its limit distribution is given by p_i (i = 1, 2, …, n).

3.3 Method and Results

(1) Outline of Investigations and Questionnaires

First, we investigate an outline of quality requirement found in an entire market. Therefore, the questionnaire is made for the following 26 items; riding comfort is good, design is good, engine is good, environment is considered, it gets good mileage, it gets bad mileage, safety is high, failure is few, it is happy in the price, it is dissatisfied with the price, model is abundant, sedan is enhanced, RV is enhanced, a compact car enhances, it is easy to use it for daily life, it is easy to use it when making an excursion, room is wide, room is narrow, television CM is good, after-sales service is good, there are a lot of shops, there are a lot of options, there are a lot of popular models, family has gotten on, it is easy to drive, and there is individuality. This is made for nine companies (Toyota, Nissan, Honda, Mitsubishi, Mazda, Subaru, Suzuki, Daihatsu Kogyo Co., Ltd., and Benz) which are well-known in Japan. We put the questionnaire to about 300 males and females from high teens to 50 generations. However, there is problem of being not able to make a deep question of subjects because the question is done by two choices and its survey is different according to the sense of subjects.

The core of buying cars is young males, however, they do not necessarily have a lot of money and will buy used cars more than new ones. The questionnaire is made again from these reasons, and quality requirement of used cars for young males is investigated. Moreover, the investigation item is recreated to the item in which the sense of subjects can be controlled easily. Ten models (MR-2, LEGACY4WD, Odyssey, FAIRLADY, Leopard, Step wagon, Corolla levin, Estima, SOARER and SKYLINE) of used cars that sold well are selected (Car Censer (1999)).

A questionnaire that evaluates the following 28 items is put to about 130 young males; goodness in view from driver's seat, area and livability around driver's seat, goodness of sitting feelings of riding comfort and seat, easiness of driving on parking lot and narrow road to do, number of doors and the body type are suitable for the usage, the indoor quietness, running easiness in bad condition such as snow roads, height of durability (lasting long and robustness), area and livability of rear seat, price, engine performances of pickup and acceleration, etc., size and usability in trunk room, easiness of getting on and off to do, abundance and usability of seat arrangement, addressing, goodness of fuel cost, abundance of body color, height of safety, reputation of car, enhancement of comfort and convenient equipment, design style of appearance, stability of high speed operation, stability in sinuous road, responsible concern for the environment (automotive emission and recycling, etc.), overheads of tax and maintenance expense, etc., there is no tiredness even if getting on for a long time, goodness of making exterior and interior, and reliability (the failure is few) height.

(2) Results

The result of a questionnaire to investigate quality requirement is described. Because this questionnaire is dichotomous question, it is added up simply, is analyzed on the basis of this result, and is examined what quality requirement is. Marking clearly the structure of variations of quantities, we can gather suitable variables using principal component analysis. It is shown in Figure 3.2. Thus, we can gather three principal components whose contributing rates are more than 3% in order to reduce errors due to the collection of variables. These three principal components are named as follows: The first one whose contributing rate is the highest is *performance*, the second one whose rate is secondly high is *economical efficiency* and the third one whose rate is thirdly high is *fashion and brand*. This is the quality requirement of consumers in a market.

An entropy model is suitable to examine the ratio of selecting these quality requirements from data provided by principal component analysis. Some high items of principal component loading for each quality requirement are shown. The data which add up the number of people to apply to the item are used.

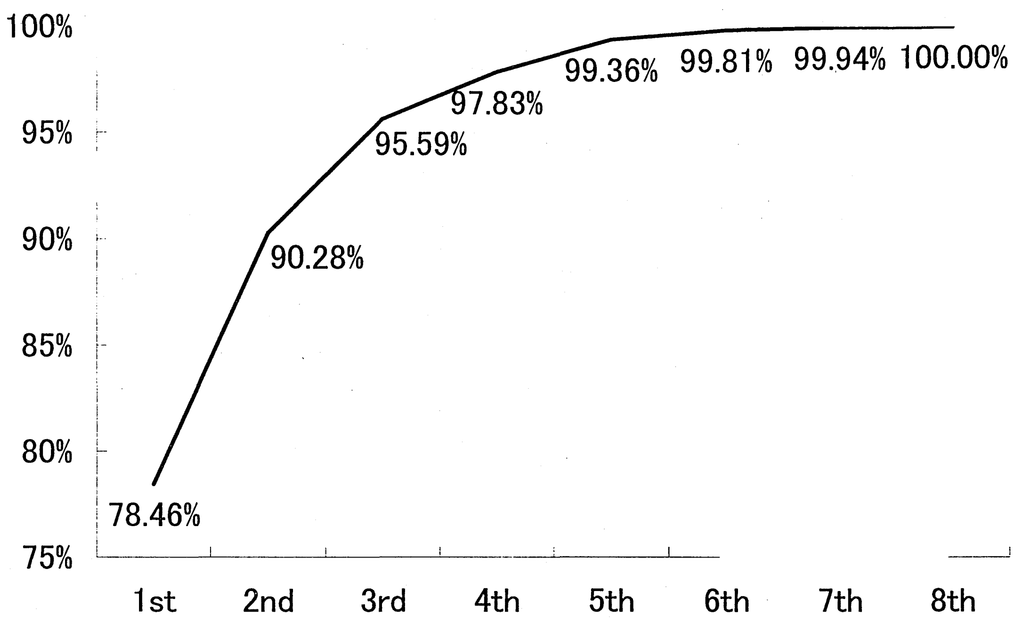


Figure 3.2 Result of Accumulation Contributing Rate (The First Time)

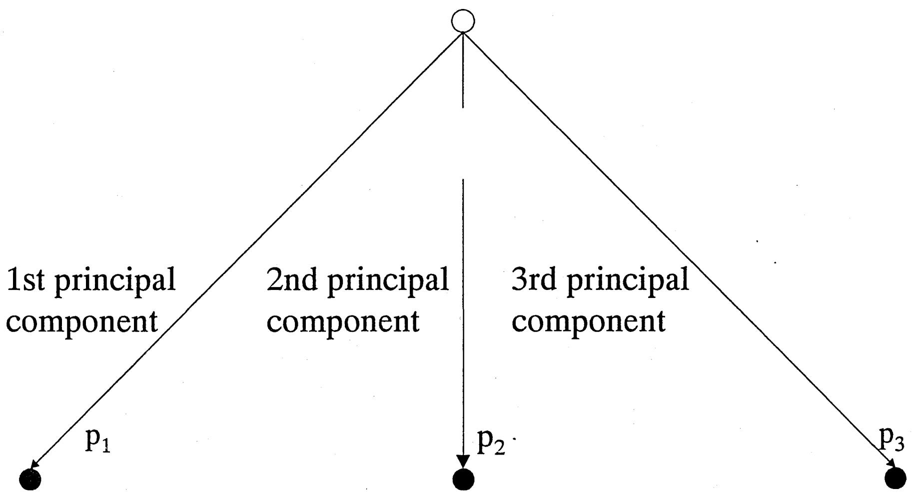


Figure 3.3 Market Structure of Quality Requirements

A market structure model of quality requirement is expressed in a tree such as Figure 3.3. For principal component i (i = $1, 2, 3$), n_{si} is assumed to be the value added up high items of principal component loading in maker s except the item which consumers do not desire, h_s is the share of maker s, and p_i is a ratio of selecting principal component i. Then, a pulse duty factor q_i for principal component i is defined as

$$q_i = \frac{\sum_{s=1}^{9} n_{si}}{\sum_{k=1}^{3}\sum_{s=1}^{9} n_{sk}} \quad (i=1, 2, 3) \tag{3.7}$$

When a questionnaire is done, it is assumed that the share h_s do not change. That is, it has the following constraint:

$$h_s = \sum_{i=1}^{3} \frac{n_{si}}{\sum_{j=1}^{9} n_{ji}} \times p_i \quad (s = 1, 2, \ldots, 9). \tag{3.8}$$

An estrangement frequency of p_i and q_i (i = $1, 2, 3$) is from (3.2),

$$\mathrm{D}(p,q) = \sum_{i=1} p_i \times \log \frac{p_i}{q_i}. \tag{3.9}$$

Under the constraint of (3.8), we seek p_i (i = $1, 2, 3$) which minimizes $\mathrm{D}(\mathbf{p},\mathbf{q})$ in (3.9). By iterative scaling method, we have p_1 = 0.328, p_2 = 0.273 and p_3 = 0.399, which are shown in Figure 3.4.

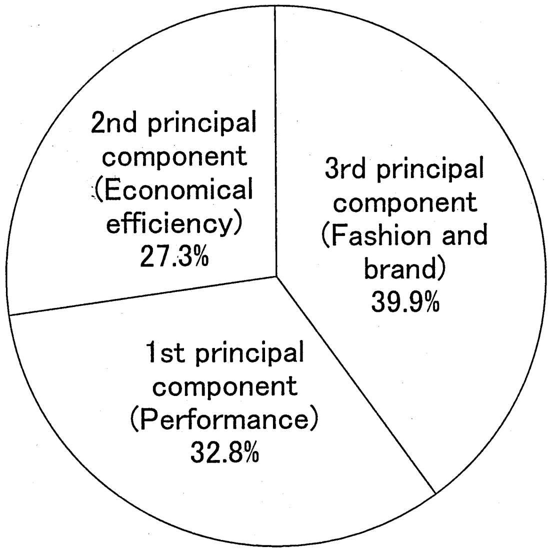


Figure 3.4 Graph of Analysis Result of Questionnaire (The First Time)

Furthermore, we describe the result of a questionnaire to investigate the quality requirement for young males. This questionnaire is done in four phases of choice methods in each item, where evaluation points are from one to four from a lower rank. By using the same technique as before, the result is shown in Figure 3.5. We adopt contributing rates of more than 3% in order to reduce errors due to collections, and can gather three principal components. The number of quality requirement is the same as the result of the first questionnaire.

These three principal components are named as follows: The first one whose contributing rate is the highest is *performance*, the second one whose rate is secondly high is *livability*, and the third one whose rate is thirdly high is *leisure*. It is the quality requirement for young males in a market.

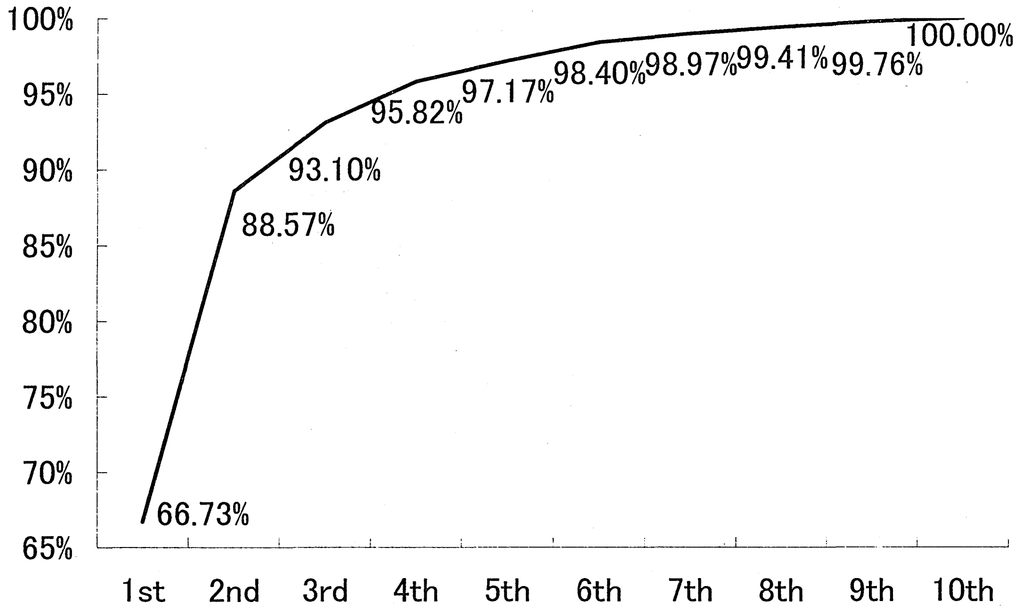


Figure 3.5 Result of Accumulation Contributing Rate (The Second Time)

Next, we analyze the quality requirement, using entropy model. A market structure model of quality requirement is expressed in a tree such as Figure 3.3. Similarly, noting that there are 10 models of used cars, a pulse duty factor q_i for principal component i ($i = 1, 2, 3$) is

$$q_i = \frac{\sum_{j=1}^{10} n_{ji}}{\sum_{k=1}^{3}\sum_{j=1}^{10} n_{jk}} \quad (i = 1, 2, 3), \tag{3.10}$$

and the share $h_s(s=1,2,\ldots,10)$ has the constraint

$$h_s = \sum_{1=1}^{3} \frac{n_{si}}{\sum_{j=1}^{10} n_{ji}} \times p_i \quad (s = 1, 2, \ldots, 10). \tag{3.11}$$

An estrangement frequency of p_i and q_i ($i=1,2,3$) is given in (3.9).

Therefore, under 10 constraint in (3.11) we seek p_i ($i=1,2,3$) which minimizes $D(\mathbb{p}, \mathbb{q})$ in (3.9). Using iterative scaling method, we have $p_1 = 0.025$, $p_2 = 0.698$ and $p_3 = 0.277$, which are shown in Figure 3.6.

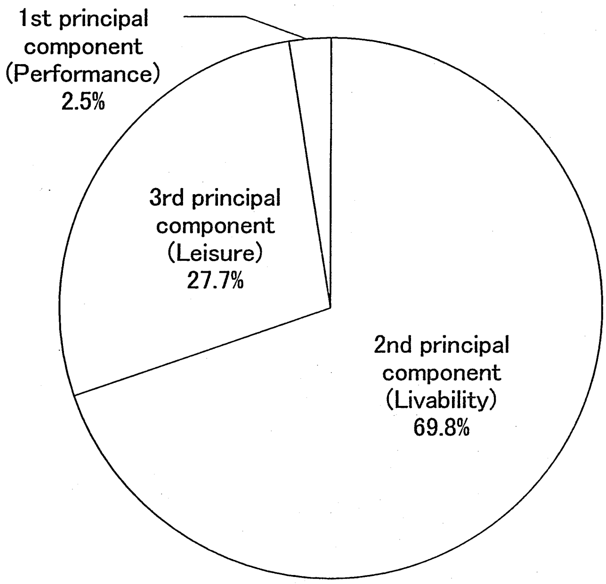


Figure 3.6 Graph of Analysis Result of Questionnaire (The Second Time)

3.4 Considerations

Quality requirement is understood by consolidating the questions into categories and by clarifying them, using principal component analysis. The answers of both questionnaires summarize the results well, and the effectiveness of this method is clear. In addition, using entropy model, we discern between particular categories in which consumers put on emphasis.

(1) Quality Requirement in Entire Market

Through the principal component analysis, 95% of potential car buyers put the main emphasis on 3 categories: *performance*, *economical efficiency*, and *fashion and brand*. In addition, *performance* and *economical efficiency* are the quality requirement that everyone demands. Naturally, nobody will buy cars where *performance* is no good and *economical efficiency* is bad. Moreover, the decision making of buying cars depends on mainly *fashion and brand*.

When an entropy model is applied from the consequence of principal component analysis, the quality requirement of *fashion and brand* is 39.9%, *performance* is 32.8%, and *economical efficiency* is 27.3%. As a result, it is understood that there are a lot of consumers who attach to *fashion and brand*. A realistic consequence by principal component analysis and an ideal consequence by entropy model have been obtained. In addition, cars could be sold well to any generation if performance is good, price is low, and cost of maintenance is low.

(2) Quality Requirement of Young Males

In the questionnaire to find the quality requirement of young males, it has been understood that a quality requirement that young males choose used cars is *performance*, *livability*, and *leisure* and its total is 93%. *Performance* is a type of sport cars accepted by young males, and *livability* does not apply to sport cars type so much. Because *livability* is not necessarily good, because sports cars value on their speed. Therefore, it is understood that all of young males do not necessarily want for a type of sport cars. In addition, the principal component score of suitable car for *leisure* like 4WD car is high. There are some persons who think that the car is one of tools to play.

When an entropy model is applied to the result of principal component analysis, a quality requirement of *livability* is 69.8%, and *leisure* is 27.7%, and *performance* is 2.5%. It has been understood that the favor car of young males is the most ideal car with good environment. This is not a sport car type, because items concerning cost cannot obtain the high estimate, and a type of sport cars is generally expensive. Therefore, it is effective and appropriate to understand the quality requirement of consumers in a market by using these methods.

3.5 Conclusions

In this chapter, two questionnaires of cars have been executed, their quality requirement has been found, and has been investigated how much proportion of each quality requirement is chosen. As a result, it is shown that important quality requirement is estimated, and these methods are effective. First, the quality requirement of cars is three results of *performance*, *economical efficiency*, and *fashion and brand*. In addition, the percentage of *fashion and brand* is 39.9%, *performance* is 32.8% and *economical efficiency* is 27.3%. When a new product is developed, an important item can be judged from three items because three quality requirements are not so different.

Moreover, the quality requirement of young males is investigated, because they cannot buy a new car by oneself. Thus, the questionnaire is made about used cars for males with age of 20-25 years old. By the method of choosing one from four ranks, three quality requirements are chosen: *performance*, *livability* and *leisure*. In addition, the respective percentages are 69.8%, 27.7% and 2.5%. Therefore, when a new product is developed, goodness is concluded as *livability* for young males.

Chapter 4

Evaluation of Preferences Using Herniter Model

Human selection is done according to several evaluation standards. There can be distinguished several factors within those evaluation standards, and it would be possible that they compound with each other.

This chapter investigates preferences of male college students regarding ten kinds of watches. The reason for the choice is given from five factors: functions, design, belt, display and others. The factors of preferences for each watch are investigated on the market, and by applying collected data to the entropy model, their rates are numerically obtained. It is shown that more than 55.2% of students have already decided the main factor of their preferences: 24.9% have selected for design, 12.8% for display, 10.1% for belt and 7.4% for functions. Further, there are two strata of consumers; one selects according to only one factor of preferences, and the other selects according to several factors.

4.1 Introduction

The entropy model has been considered in many fields of marketing science, and applied to the studies of share prediction and evaluation of selection probability: Herniter (1973) employed the entropy model and divided consumers into two strata: the non-fixed stratum, those who have not decided their purchases, and the fixed stratum of those who purchase only one brand. Further, he explained the market structure of the non-fixed stratum by calculating the stratum rate. It was shown in Ueda (1998), using the *many factors influence theory*, that the influences of price and the selling trend were quite big. Gensch (1995) evaluated the selection probability, using the information-theoretic algorithm and maximum entropy principle, and examined the technique using real marketing data. Brockett et. al (1995) researched the effectiveness of information-theoretic approach to various problems of market research regarding model selection, logarithm linear model, entropy model, logit model and brand switching model. Ito (1987) calculated the weight rate of several factors for female preferences in fashion using entropy model. We calculate the preference rates of each factor in the fixed stratum and the non-fixed stratum, using Herniter Model.

4.2 Results of Questionnaire

From a catalogue we select ten kinds of watches, which are popular and famous in Japan. To investigate the properties of watch preferences, we show some useful information which explains function, design, belt, display and others for male college students, and make the following two questions:

1. Do you like or dislike these watches? (Students are asked to put a work on any watches they like and dislike, regardless of the number).
2. By what reasons do you answer question 1? Select one factor from function, design, belt, display and others.

The questionnaire is put to 70 male college students, and Table 4.1 gives the results of question No.1. The positive and negative answers are not as polarized as one would expect. Further, Table 4.2 gives the results of question No.2, where n_{si} is the number of answerers who like watch s by factor i, r_i is the factor selection rate in the non-fixed stratum inside, h_s is the rate of liking watch s. It is shown that 45% of male college students decide their favorite watches according to design.

Table 4.1 Preference Rates of Watches

Brand S	Like		Dislike	
	Number of Persons n_s	Rate h_s (%)	Number of Persons n_s	Rate h_s (%)
No.1	17	9.34	27	10.47
No.2	21	11.54	23	8.91
No.3	12	6.59	32	12.40
No.4	25	13.74	19	7.36
No.5	11	6.04	33	12.79
No.6	14	7.69	30	11.63
No.7	23	12.64	21	8.14
No.8	21	11.54	23	8.91
No.9	23	12.64	21	8.14
No.10	15	8.24	29	11.24
Total	182	100.00	258	100.00

Table 4.2 Preference Rates of Factors

Contributing Factor i / Brand s	Number of Answers According to Selection Factor n_{si}				$\sum_{i=1}^{4} n_{si}$	Preferences Rate h_s (%)
	Function	Design	Belt	Display		
No.1	6	31	12	16	65	10.71
No.2	1	33	12	18	64	10.54
No.3	6	26	5	20	57	9.39
No.4	24	24	7	6	61	10.05
No.5	3	23	24	15	65	10.71
No.6	4	19	25	13	61	10.05
No.7	4	33	2	13	52	8.57
No.8	5	32	11	14	62	10.21
No.9	13	27	6	13	59	9.72
No.10	15	26	7	13	61	10.05
$\sum n_{si}$	81	274	111	141	607	100.00
$\sum\sum n_{si}$	607					
q_i	13.34%	45.14%	18.29%	23.23%		

4.3 Herniter Model

There are generally two types of consumers: In one stratum they choose a product according to only one from among these factors: function, design, belt or display, and in the other stratum they choose it according to several factors.

To analyze a market structure, we need to form a market model as a starting point. For instance, we can investigate the inside structure of market on the basis of preference rates of brands. One method is the entropy model that indicates the vagueness of consumer preferences. Further, we apply the Herniter model to preferences rates, and can investigate selecting behaviors of consumers (Herniter (1973)).

(1) Non-Fixed Stratum

Suppose that i (i = *1*, *2*, *3*, *4*) represents factors of watch; *1*: function, *2*: design, *3*: belt, and *4*: display. Letting r_i be the selecting rate of factor i in the non-fixed stratum, the selecting rate of watch s (s = *1*, *2*, ... , *10*) is the summation in the product of rate of factor i and r_i, i.e.,

$$h_s \equiv \sum_{i=1}^{4} \frac{n_{si}}{\sum_{t=1}^{10} n_{ti}} \times r_i \quad (s = 1, 2, \dots, 10). \tag{4.1}$$

Further, since the selecting rate of factor i is the rate of factor i for all factors, we have

$$q_i \equiv \frac{\sum_{s=1}^{10} n_{si}}{\sum_{j=1}^{4}\sum_{s=1}^{10} n_{sj}} \quad (i = 1, 2, 3, 4). \tag{4.2}$$

Thus, we consider the optimal problem that minimizes

$$D_1 \equiv \sum_{i=1}^{4} r_i \times \log \frac{r_i}{q_i}, \tag{4.3}$$

under the condition h_s given in (4.1).

We can solve the above problem by the iterative scaling method of Darroch and Ratchiff (1972), and give the following algorithm of computing procedure:

Step 0: Compute the selecting rate of watch s for factor i by

$$a_{si} \equiv \frac{n_{si}}{\sum_{t=1}^{10} n_{ti}} \quad (s = 1, 2, \ldots, 10;\ i = 1, 2, 3, 4). \tag{4.4}$$

Step 1: Give the 0-th approximate probability of r_i by

$r_1^{(0)} = q_1 = 0.1334$, $r_2^{(0)} = q_2 = 0.4514$, $r_3^{(0)} = q_3 = 0.1824$, $r_4^{(0)} = q_4 = 0.2323$.

Step 2: Compute the 1st approximate probability of r_i by

$$\begin{aligned} h_1^{(0)} &= \sum_{i=1}^{4} a_{1i} \times r_i^{(0)} \\ &= 0.0741 \times 0.1334 + 0.1131 \times 0.4514 + 0.1081 \times 0.1824 + 0.1135 \times 0.2323 \\ &= 0.1071, \end{aligned}$$

$$r_1^{(1)} = r_1^{(0)} \times \prod_{j=1}^{10} \left(\frac{h_j}{h_j^{(0)}} \right)^{a_{j1}}$$

$$= 0.1334 \times (0.0934 / 0.1071)^{0.0741} \times (0.1154 / 0.1054)^{0.0123} \times (0.0659 / 0.0939)^{0.0741}$$
$$\times (0.1374 / 0.1005)^{0.2963} \times (0.0604 / 0.1071)^{0.0370} \times (0.0769 / 0.1005)^{0.0494}$$
$$\times (0.1264 / 0.0857)^{0.0494} \times (0.1154 / 0.1021)^{0.0617} \times (0.1264 / 0.0972)^{0.1605}$$
$$\times (0.0824 / 0.1005)^{0.1852}$$
$$= 0.1410.$$

Step 3: Continue until probability r_i converges. In this case,

$r_1 = 0.1662, r_2 = 0.8327, r_3 = 0.0009, r_4 = 0.0001.$

(2) Herniter Model

Let p_i ($i = 1, 2, 3, 4$) be the selecting rate of factor i in the fixed stratum and p_5 be that of several factors. Then, we consider the optimal problem that minimizes

$$D_2 \equiv \sum_{i=1}^{4} p_i \times \log \frac{p_i}{0.1448} + p_5 \times \log \frac{p_5}{0.4210}, \tag{4.5}$$

under the condition of

$$p_i + p_5 \times r_i = q_i \quad (i = 1, 2, 3, 4). \tag{4.6}$$

By the same computing method, the solution is easily given by $p_1 = 0.0737$, $p_2 = 0.2493$, $p_3 = 0.1010, p_4 = 0.1283, p_5 = 0.4477$.

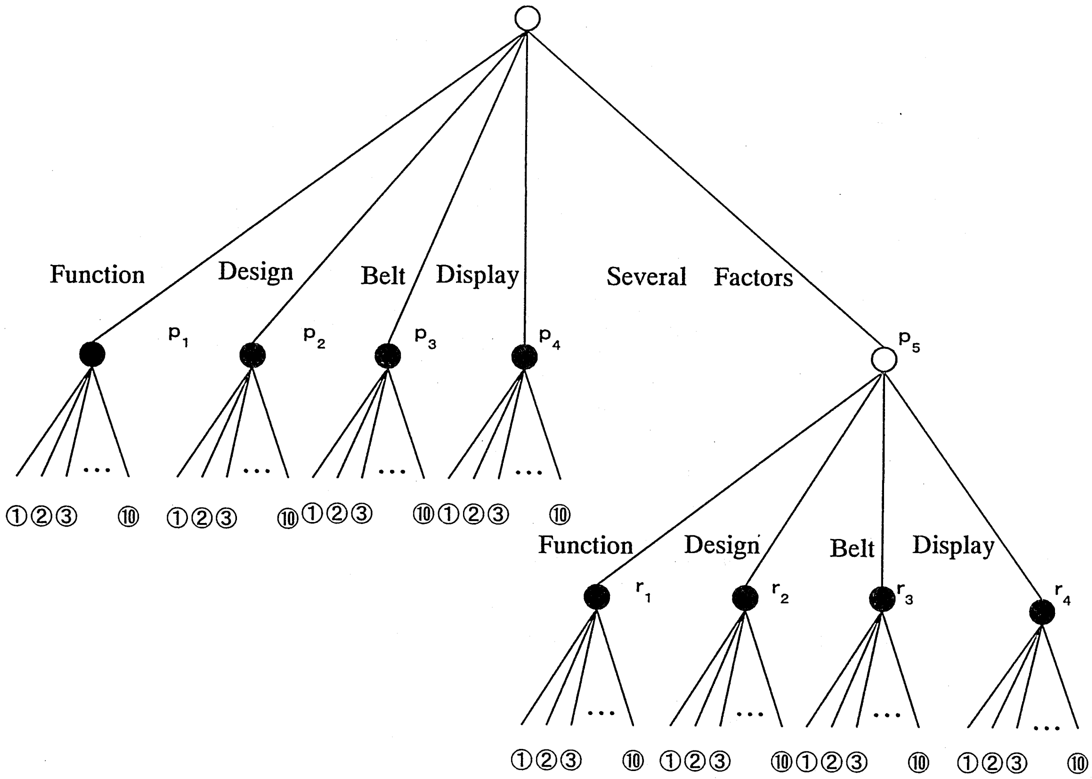


Figure 4.1 Tree of Herniter Model

(3) Transition Probability

We draw the tree of Herniter model in Figure 4.1 which shows the market shares of watch, where p_i (i = *1*, *2*, *3*, *4*) represents the rate of factor i in the fixed stratum and p_5 represents the rate of selecting other factors in the non-fixed stratum. It is shown from Figure 4.1 that consumers in the fixed stratum select the watch by the same preference rate p_i, and consumers in the non-fixed stratum select it by the stratification rate p_5 at the first step and after that, they select it by the preference rate r_i.

Suppose that L(n) denotes a factor by which consumers select a watch at the nth step, and an event $\{L(n) = i\}$ represents that consumers select a watch by factor i (i = *1*, *2*, *3*, *4*). Then, from (4.6) we easily have

$$\Pr\{L(n-1)=i\} = p_i + p_5 \times r_i \quad (i = 1, 2, 3, 4). \tag{4.7}$$

Thus, the joint probability is given by

$$\Pr\{L(n)=j, L(n-1)=i\} = \begin{cases} p_i + p_5 \times r_i^2 & \text{for } i = j, \\ p_5 \times r_i \times r_j & \text{for } i \neq j. \end{cases} \tag{4.8}$$

Because, when $i = j$, it is the sum of preference rate p_i in the fixed stratum and (rate p_5 in the non-fixed stratum) $\times$ (the rate r_i in the non-fixed stratum)^2. When $i \neq j$, it is (rate p_5 in the non-fixed stratum) $\times$ (preference rate r_i in the non-fixed stratum) $\times$ (rate r_j in the non-fixed stratum).

Therefore, the transition probability is

$$P_{ij} \equiv \Pr\{L(n)=j \mid L(n-1)=i\} = \begin{cases} \dfrac{p_i + p_5 \times r_i^2}{p_i + p_5 \times r_i} & \text{for } i = j, \\ \dfrac{p_5 \times r_i \times r_j}{p_i + p_5 \times r_i} & \text{for } i \neq j. \end{cases} \tag{4.9}$$

We give a numerical example of the transition probabilities in Table 4.3.

Table 4.3 Transition Probabilities P_{ij}

$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{pmatrix} 0.5811 & 0.4184 & 0.0005 & 0.0000 \\ 0.0996 & 0.8998 & 0.0006 & 0.0000 \\ 0.0007 & 0.0034 & 0.9959 & 0.0000 \\ 0.0000 & 0.0002 & 0.0000 & 0.9998 \end{pmatrix} \end{array}$$

From Table 4.3 we derive the following result: Consumers purchase watches for the reason of design at 58.1%, and change into function from design at 10.0%, and into design from function at 41.8%.

4.4 Conclusions

As a result of this study, we have understood that more than 55.2 % of consumers select watches according to already decided preferences. The percentage of each factor is as follows: Design is 24.9 %, display is 12.8 %, belt is 10.1 %, and function is 7.4 %. As for the preference factors among the non- fixed stratum, 83.3 % of consumers select according to design, 16.6 % to function, 0.09 % to belt, and 0.06 % to display. Attention should be paid to the fact that although it is estimated the non-fixed stratum is about 60 %, it is 44.8 % actually. In addition, in non-fixed stratum the percentage of selecting according to belt and display is very low, only about 0.1% each, while in the fixed stratum they are 10.1% and 12.8%, respectively. Belt and display are the factors which they cannot be ignored during product development. It is understood that in the case of watches, a high percentage of consumers already decides their preferences, and the order of factors in their preferences is design, display, belt, and function. From these results, it follows that the classification analysis of preference according to Herniter model is very effective for analyzing consumer behavior.

Chapter 5

Optimal Product-Design for New Products Using Conjoint Analysis

To design a new product, it is very important to grasp consumer evaluation of present products. It is indispensable for the product experimental design to clarify the degree of consumer preferences of product attributes. The conjoint analysis, which is one of the marketing research techniques, is mainly used in such situations: Soft drinks (including carbonated drinks, fruit juices, tea and coffee products) are very popular among young Japanese people, and so, they would be suitable for the subject of investigation. Using the orthogonal array, the consumer preferences are analyzed, and their levels for attributes such as container, category and size are measured. Next, several product plans, including different levels of attributes, are proposed. As a result, it is shown that males tend to prefer can as container, and females like paper pack or PET bottle. These results and the conjoint analysis used in this chapter would be useful for the planning of future products.

5.1 Introduction

The time when any product would sell has over in Japan, and now only the products that fulfill the consumer needs are sold well. In order to respond to consumer needs, companies have to study their preferences of goods and services, selection criteria of those goods, and attitudes toward the relationship between quality and price.

The expression of *soft drink* has a wider meaning in Japan than it is usually used in other countries. The term of *soft drink* somehow has come to mean, *drinks you can buy at a vending machine or a convenience store.* This will include carbonated drinks and fruit juices, but also tea and coffee products as well. But, since the market for red tea (vs. Japanese green tea) and coffee is different, these drinks are not included in this chapter. However, since Japanese green tea is considered by more different drink than red tea, it is treated here as well. Recently, soft drink companies in Japan have become very active and introduced many types of drinks aiming for different consumer types. For example, Calpis drink is sold in paper cups with reduced amount of only 100 yen. On the other hand, POCARI SWEAT drink is marketed as sports drink, and so, because of the special ingredient such as vitamin B1, vitamin C and calcium, it is sold at a higher price of 120 yen.

Therefore, it is necessary to examine what products are presently on the market and what products can still be introduced. A questionnaire is put to college students of 75 males and 131 females. The following questions are asked:

1. Which product do you purchase the most often?
2. Why do you choose this product?

3. What is the most appropriate price?
4. Which product has the best value at the present price?
5. What would be the best price to sell for both of them when both of the most popular and unpopular products are put on the market?

Since soft drinks are very popular among young people, this questionnaire is distributed to college students. Using conjoint analysis, an optimal product planning for a new soft drink is determined based on these data.

At first, students are asked to line up 16 kinds of drinks according to the order in which they would like to purchase them. Using this data and conjoint analysis, the most promising product is discerned, and the reasons for those are ascertained. Furthermore, we discern what are the most important attribute in soft drinks that would be necessary for mass production of a new product. Finally, an optimal plan for new products is made.

5.2 Conjoint Analysis

It would be rare that consumers are totally satisfied with all aspects of products. For example, good products are generally expensive, or inexpensive ones have poor quality. Using conjoint analysis, we can investigate the degree of importance which is given to particular aspects of products or services. It is one of techniques which give a concept of development of new products. Through a questionnaire, the consumer behavior is observed and the priority of choice-value or quality is given.

Further, while changing the levels of attributes, consumers are again asked to set the order of their preferences. Such kind of optimization is called *conjoint analysis method* (Green and Srinivasan (1999)). The conjoint analysis is based on the technique where opinions of consumers are not asked directly. Recently, even consumers themselves are not sure what they exactly want. As a new method of analysis, consumer preferences have recently surfaced, where their selection process is observed rather than asking direct questions. This is called *behavior analysis* (Katahira (1989)). When consumers are asked about the reason for their purchase, they generally give only answers like *the quality is excellent*, or *they trust the company*. Companies should not accept such simple answers at the face value. Even when consumers buy something at special sale or at great discount, they would still give the same routine answers. The conjoint analysis employs different strategies and all other present ways of investigating consumer preferences. The conventional methods can analyze general answers coming out of objective comparison, while the conjoint analysis is based on analyzing the subjective direct comparison of one item against another.

The conjoint analysis is displayed in a flow chart of Figure 5.1.

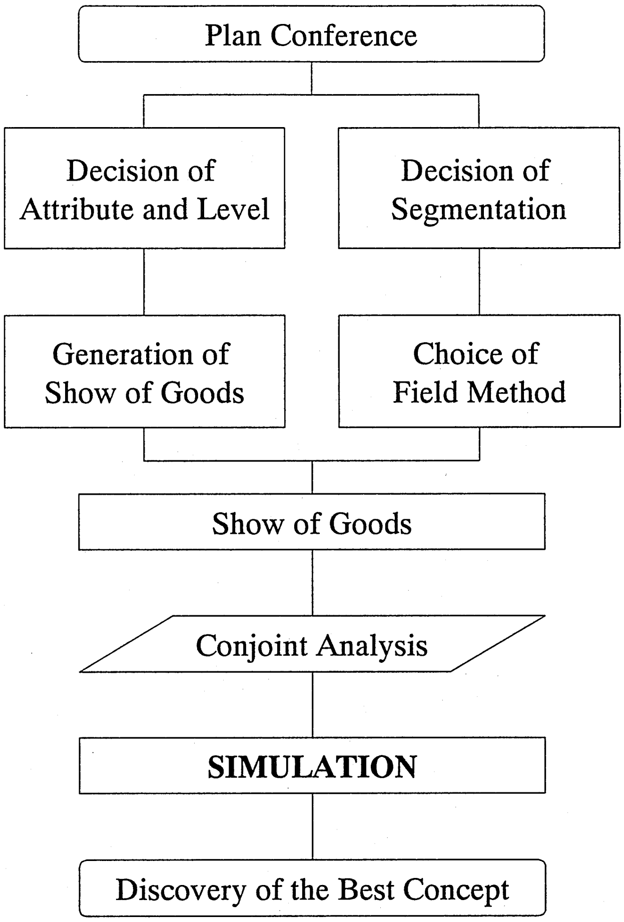
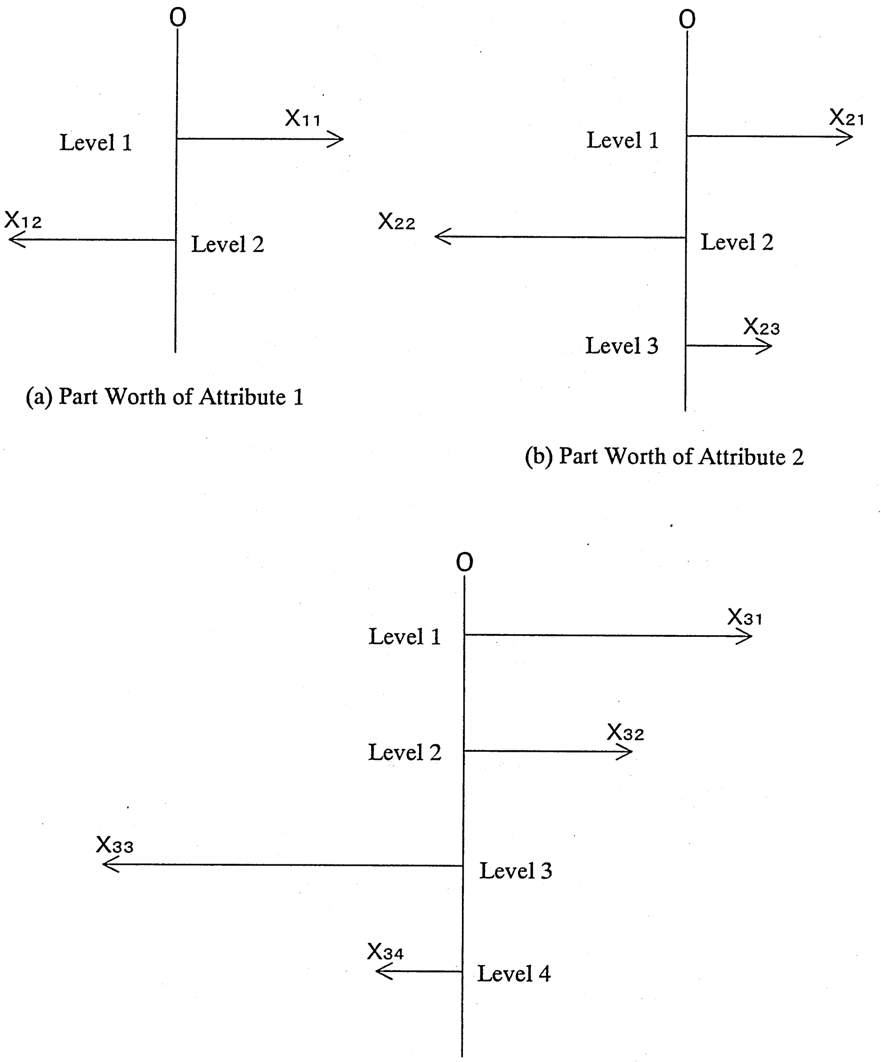


Figure 5.1 Flow Chart of Conjoint Analysis

This part worth value is obtained by the least squares method. A part worth x_{ij} is received as the result of attribute i and level j: If the level of attribute 1 is j, the level of attribute 2 is k, in the same way, the level of attribute p is m, then the sum $a_{jk...m}$ of part worth of each attribute is defined as

$$a_{jk\cdots m} = x_{1j} + x_{2k} + \cdots + x_{pm}. \tag{5.1}$$



(a) Part Worth of Attribute 1

(b) Part Worth of Attribute 2

(c) Part Worth of Attribute 3

Figure.5.2 Part Worth of Attribute i ($i = 1, 2, 3$)

The explanation is given in the following example: There are 3 attributes (p = 3), where attribute 1 has 2 levels ($c(1)$ = 2), attribute 2 has 3 levels ($c(2)$ = 3), and attribute 3 has 4 levels ($c(3)$ = 4). Each level in those three attributes carries out more partial effect as shown in (a), (b) and (c) of Figure 5.2. It can be seen from this figure that the part worth (x_{12}) of level 2 of attribute 1, and the part worth (x_{22}) of the level 2 of attribute 2, the part worth (x_{33}) of level 3 of attribute 3, and part worth (x_{34}) of level 4 of attribute 3 are all negative (Okada and Imaizumi (1994), Okamoto (1999) and Urban (1993)).

Next, the contribution rate is calculated as follows: The variance of the k-th attribute is

$$V_k = \frac{1}{m_k}\sum_{j=1}^{m_k}(u_{kj} - \bar{u}_k)^2 \quad (k = 1, 2, \ldots, m), \tag{5.2}$$

where m_k is the number of levels of the k - th attribute ,
u_{kj} is partial effect value of the j - th level,
$\overline{u}_k$ is the average of u_{kj} $(j = 1, 2, \cdots, m)$.

The contribution rates of the part worth of each attribute are calculated by their variances (Muto and Asano (1986), Asano (1999), Urban and Hauser (1993)). Thus, the contribution rate C_k of the k-th attribute is

$$C_k = \frac{V_k}{\sum_{l=1}^{n} V_l} \times 100 \quad (k = 1, 2, \ldots, m). \tag{5.3}$$

5.3 Results of Analysis

In the conjoint analysis, the variable that describes the specification of products is called *attribute*, and its concrete value is called *level*. Because both attribute and level give a great influence on the plan of products, both of them should be clear and precise. Then, in order to set up concrete standards, we make the research on the market. The attribute and level of soft drink are given in Table 5.1.

Table 5.1 Attribute and Level of Soft Drink

Attribute	Level
A. Container	1 = Paper pack 2 = PET bottle 3 = Paper cup 4 = Can
B. Category	1 = Juice 2 = Tea 3 = Carbonated drink 4 = Sports drink
C. Size	1 = M 2 = S 3 = L
D. Standardization of design	1 = Standardized 2 = Changed
E. Depth of taste	1 = Standard 2 = Rich 3 = Mild
F. Straw	1 = Necessary 2 = Unnecessary

In the present research, each of 2 attributes has 2 levels, each of 2 attributes has 3 levels, and each of 2 attributes has 4 levels. If all of possible types are presented, then the total would become $2 \times 2 \times 3 \times 3 \times 4 \times 4 = 576$. It would be impossible physically and practically to do the research for all 576 kinds.

Using the orthogonal array of an experimental design, the number of types is reduced to 16. The orthogonal array of soft drink is shown in Table 5.2 (Kamijyou (1984) and Katahira (1989)).

Table 5.2 Orthogonal Design of Soft Drink

Sample of Attribute	Container	Category	Size	Standardization of design	Deepness of taste	Straw
1	Can	Carbonated drink	S	Changed	Mild	Necessary
2	Can	Carbonated drink	M	Changed	Standard	Necessary
3	Paper pack	Juice	S	Standardized	Rich	Necessary
4	PET bottle	Tea	L	Standardized	Standard	Necessary
5	PET bottle	Juice	L	Changed	Rich	Unnecessary
6	Paper cup	Carbonated drink	M	Standardized	Standard	Unnecessary
7	Paper cup	Carbonated drink	L	Standardized	Mild	Unnecessary
8	Can	Sports drink	M	Standardized	Mild	Unnecessary
9	Paper pack	Juice	M	Standardized	Standard	Necessary
10	Paper pack	Tea	M	Changed	Rich	Unnecessary
11	PET bottle	Tea	M	Standardized	Rich	Necessary
12	Paper cup	Sports drink	L	Changed	Standard	Necessary
13	PET bottle	Juice	M	Changed	Standard	Unnecessary
14	Can	Sports drink	S	Standardized	Standard	Unnecessary
15	Paper pack	Tea	L	Changed	Standard	Unnecessary
16	Paper cup	Sports drink	M	Changed	Mild	Necessary

The part worth of soft drink is shown in Table 5.3, and its contribution rate is shown in Table 5.4.

Table 5.3 Part Worth of Soft Drink

Attribute	Level	Male n = 75	Female n = 131
A	1	0.671	1.475
A	2	0.673	1.498
A	3	-3.354	-1.561
A	4	2.010	-1.412
B	1	0.671	1.207
B	2	0.673	1.766
B	3	-0.672	-1.654
B	4	-0.672	-1.319
C	1	0.000	0.163
C	2	0.004	-0.158
C	3	-0.004	-0.005
D	1	0.000	0.005
D	2	0.000	-0.005
E	1	0.001	0.008
E	2	-0.003	0.149
E	3	0.002	-0.157
F	1	0.000	0.006
F	2	0.000	-0.006

Table 5.4 Ratio of Contribution

	Male (%)	Female (%)
A	89.96	49.03
B	10.04	50.15
C	0.00	0.43
D	0.00	0.00
E	0.00	0.39
F	0.00	0.00
Total	100.00	100.00

5.4 Conclusions

As a result of the simulation, the following optimal design is made: High proportions of both males and females put the main emphasis on container and category. As for the ratio of contributions, container is the most important for 89.96% of males, and they prefer juice or tea. The 50.15% of females stress the category, and they prefer tea. The container is the most important for 49.03%, and the preference is PET bottle. The 0.39% of females stress the depth for rich taste. From those results, the optimal design is shown in Table 5.5.

Table 5.5 Optimal Design of Soft Drink

	Male	Female
A. Container	Can	PET bottle
B. Category	Juice / Tea	Tea
C. Size	-	M
D. Standardization of a Design	-	-
E. Depth of Taste	-	Rich
F. Straw	-	-

Chapter 6

Conclusions

This thesis has suggested the following four scientific techniques in order to grasp consumer needs and behavior:

1. Modified Huff Model
2. Principal Component Analysis and Entropy Model
3. Entropy Model and Herniter Model
4. Conjoint Analysis

In modified Huff model, using Nagoya-shi districts and data of enviroment, we have shown that the selection rates of each store are: A is 16.01%, B is 2.58%, C is 19.71%, D is 18.65%, E is 19.59% and F is 23.47%. The number of average visitors are: A is 815,464 people, B is 131,459 people, C is 1,420,266 people, D is 1,344,697 people, E is 997,854 people and F is 1,434,962 people. Because it is necessary to reconsider the means of transportation, we have revised it from distance to time. As a result, store F has the highest rate, and each share is almost in proportion to sales. A floor space gives comparatively a big influence for coming to stores.

In modified Huff model, we have considered consumer needs for floor spaces and time distances, and investigated consumer needs at another side.

In principal component analysis and entropy model, two questionnaires were executed, the solicitation items of cars has been found, and the proportions of each quality requirement have been investigated. As a result, it has been shown to estimate what more important quality requirements are, and these methods are effective. First of all, we executed the alternative questionnaire without squeezing the age, and examined the outline of quality requirements of cars, which are three items of *performance*, *economical efficiency*, and *fashion and brand*. In addition, their values of percentage are: *fashion and brand* is 39.9%, *performance* is 32.8% and *economical efficiency* is 27.3%. When new products with three items are developed, important items can be judged from three items because they are not so different from other cars.

In addition, quality requirements of young men are investigated, because young men cannot buy a new car by oneself. Therefore, we made a questionnaire about used cars. Quality requirements are three items of *performance*, *livability*, and *leisure*, and their values of percentage are: *livability* is 69.8%, *leisure* is 27.7% and *performance* is 2.5%. Therefore, it is concluded that the goodness is the most important when a new product is developed.

In entropy and Herniter models, we have understood that more than 50% of consumers decide their preference factor about the selection of watch. The values of percentages of each factor are that design is 24.9 %, display is 12.8 %, belt is 10.1 %, and function is 7.4 %. As for the preference factors among the non-fixed stratum, 83.3 % of consumers select according to design, 16.6 % to function, 0.09 % to belt, and 0.06 % to display. We should pay the attention to the fact that although the non- fixed stratum would be thought to be 70-90 %, it is actually 45%. This indicates that a half of consumers in the case of watches, have already decided their preferences. The order of factors in their preferences is function, design, belt, and display. From those results, the classification analysis of preference according to Herniter model is very effective for analyzing consumer behavior.

In conjoint analysis, the following optimal plan for soft drink has been made: A high proportion of consumers put the main emphasis on the container. As for the ratios of contribution, 89.96% of males think that the container is the most important, and they prefer juice or tea. The 50.15% of females stress the category and they prefer tea. Further, 49.03% of females think that the container is the most important, the preference is PET bottle, and 0.39% of females stress the depth for rich taste.

Finally, there are consumer needs and some methods for analyzing marketing models using multivariate analysis:

1. Huff Model: Ratios of coming to stores and the number of average visitors are calculated for floor spaces and time distances.
2. Principal Component Analysis and Entropy Model: Consumer needs are given by preference data of each brand. This would be able to make the product development for consumer needs.
3. Herniter Model: Transition probabilities can be estimated by using market share vector, and the market structure can be evaluated.
4. Conjoint Analysis: It is a very useful method of obtaining an optimal planning, because it can evaluate quantitatively consumer preferences regarding several aspects of products.

The above five techniques are very efficient and beneficial in the actual performance of this analysis, and thus, directly make a target influence for the success of products on the market.

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