Contributing Factors for Expenditure Patterns of One-person Household in Japan

Noriko Hashimoto and Takaharu Araki

Due to changes of the Japanese society, such as trend toward the nuclear family, tendency to marry late and increase in the unmarried population, the average number of people per household continues to decrease. Nowadays, one-person household is the major household structure in Japan, in terms of numbers. We use the micro data of National survey of Family Income and Expenditure to examine expenditure patterns of one-person households, which vary by attributes such as age, gender, job condition, annual income and type of residence. We try to detect the structure of attributes and spending pattern of households by means of Bayesian network.

Keywords: *National survey of Family Income and Expenditure,* micro data, one-person household, household attributes, expenditure pattern, problem of zero observation, Bayesian network

1. Preface

The average number of people per household in Japan is still on a declining trend. *Census* reports that the average size of a household decreased from 3.22 persons per household in 1980 to 2.99 in 1990, 2.67 in 2000 and 2.56 in 2005.

This downward trend owes the changes in Japanese family composition. The *Census* of 2005 shows 26.5% of Japanese families are families of two, 18.7% are those of three, 15.7% are those of four and 9.5% are those of five and more. The increase of one-person households is stunning and they make up 29.5% of Japanese families in

---

2005. Currently, one-person household is the major household structure in Japan, in terms of numbers. Besides, due to the various reasons, such as the declining number of births and marriage, the tendency to marry later and of rapidly aging, the structure of one-person household undergoes great changes. In this situation, it is imperative to grasp the situation of one-person household accurately.

As the spending patterns are believed to be different from types of households, we focus on attributes of households, such as sex, occupational state, age-group, income level and residence types and try to grasp their consumption patterns.

We use micro data of *National survey of Family Income and Expenditure* that is approved for use[1] to understand the expenditure behavior of one-person households. In previous paper (Hashimoto (2007)), we use 1989, 1994 and 1999 surveys and found out some possibilities that age and gender are crucial factors to affect spending patterns. In this article, we change the setup to enlarge the analysis in following two ways. First, we also use the 2004 survey and examine any changes or transitions over the year[2]. Second, we use Bayesian network analysis to model the relationships among attributes and the structure of expense items.

The composition of this paper is as follows: In section 2, we describe the data for empirical analyses. In section 3, we study the one-person households in Japan from various attributes, such as sex, occupational state, age-group, income level, residence types and so on.

In section 4, we use Bayesian network analysis to detect the causal relationship among attributes, the hierarchical structure among item classification and the spending pattern of households. We also calculate expenditure elasticities with making consideration of zero observations problem. Section 5 offers a brief summary.

---

[1] From 2004 until 2008, we could use certain micro data as the COE program by Research Centre for Information and Statistics of Social Science, Institute of Economic Research, Hitotsubashi University. This program provided micro data of official statistics to applicants. Once approved, applicants were able to use applied micro data for six month period. Three surveys that include *National survey of Family Income and Expenditure* were available for research. After this trial providing, from 2009, official micro data provided via certain programs by the National Statistics Center under new Statistics Act.

[2] As the suppression treatment is conducted in each application, the provided data differ from application to application. So, the data of 1989,1994 and 1999 used in Hashimoto (2007) and those used in this analysis are different in a precise sense.

2. Data

The *National survey of Family Income and Expenditure* (hereinafter called NFIE) is conducted every five years since 1959 by the Statistics Bureau, Ministry of Internal Affairs and Communications. It covers all parts of Japan and is a comprehensive inquest for households' expenditure, saving and debt, holdings of durables and possession of properties such as residence and land. To get detailed results which can not be obtained by usual family surveys, NFIE investigates considerable numbers of households to capture the households characteristics by their age group, income level, inhabiting districts and so on. The survey is conducted in autumn and the sample number is around 60,000.

However, because of the suppression treatment, the numbers of provided data are reduced from the original. The numbers of trial providing data are shown in Table 1[3].

In section 3, we grasp the characteristics of one-person households via their attributes, such as sex, age-group, occupational state, residence, income and property state by using NFIE micro data of 2004 and compares the results with those obtained by data of 1989, 1994 and 1999.

Table 1 The number of households in provided NFIE micro data

Year	One-person household	General household	Total
1989	3,288	44,778	48,066
1994	3,772	44,803	48,575
1999	4,013	45,537	48,550
2004	4,001	44,006	48,007

3. The characteristics of the one-person household

3.1 Age and Gender compositions

First, we examine the transition of the age[4] composition. See Figure 1, 2, 3 and 4, each of which shows age distribution of all one-person

---

3 "General households" stands for families whose members are two and above.
4 All the age over 80 are described "80".

households of respective data period.

To figure out age composition, we sort out age into three groups; youth (under the age of 35), middle age (35 to 59) and the aged (60 years old and above)[5].

In 1989, many of the one-person households are distributed in the youth layer. However, because of the gradual decrease of youth and sharp increase of the aged layer, the major age group of one-person households was the aged layer after 1994. The weight of the aged layer grow constantly and steadily larger.

To examine these transitions more precisely, we go over the age composition by gender. See Table 2. To observe the age composition, the ratios of middle age group remain consistent around 22% in these 15 years, while those of youth decrease sharply from 44% to 25% and those of the aged jump 20% point to 53% conversely.

The gender (male vs. female) distribution shows a ratio of four to six. This tendency varies a little over the years and male-to-female ratio decreases slightly. Part of the reason is decreasing young male households, 12.0% points down in these 15 years, but the primary factor is the sharp increase of elderly female households. Aged female households are almost doubled and its weight is up about 15% points within this period.

Next, we examine age and gender composition at the same time. From 1989 to 2004, the ratios of middle age group are consistent around 22%, but male ratio slightly increases (+2% point) and female one slightly decreases (-3% point). In youth, as the ratio of youth fell off from 44.2% to 24.8%, both male and female households decrease remarkably. Especially, the shrinkage of live-alone male youth from 1999 to 2004 is large (-7% point). On the other hand, in the aged layer, male ratio has doubled (+5% point) and female ratio makes a marked rise of 15% point. Now, the ratio of elderly women living alone reaches 43.0%. The increase of aged single population of recent 5 years is distinguished, regardless of gender. In summary, the increase in the aged categories is mainly explained by the addition of female seniors until 1999, and is boosted up by the male single population in 2004.

---

[5] This classification is applied in the survey of the *Income and Expenditure Survey for One-person households* (The Statistics Bureau, Management and Coordination Agency). Although 10 years old age classification is used in NFIE itself, we use this classification for comparison.
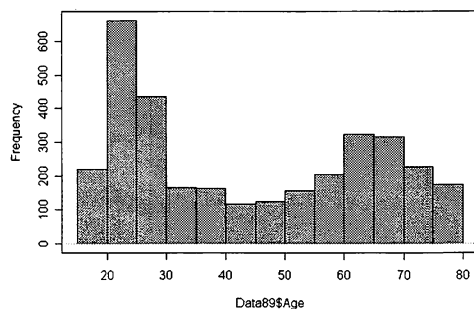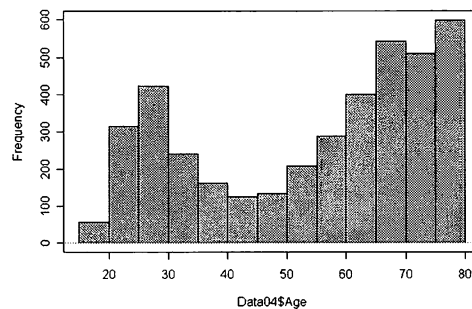
Figure 1 Age distribution in 1989 (All households)
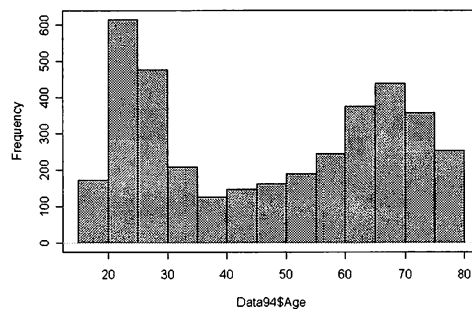
Figure 2 Age distribution in 1994 (All households)
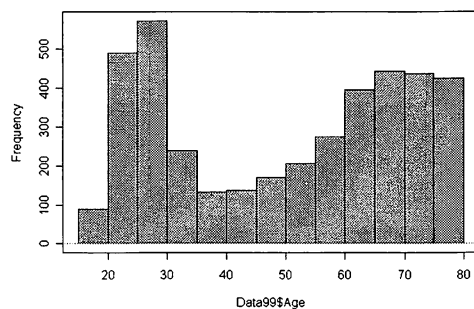
Figure 3 Age distribution in 1999 (All households)

Figure 4 Age distribution in 2004 (All households)

Table 2 Age and gender compositions of the one-person household

Year	Male	under 35	35 to 59	above 60	Female	under 35	35 to 59	above 60
1989	1365 (41.5%)	900 (27.4%)	294 (8.9%)	171 (5.2%)	1923 (58.5%)	552 (16.8%)	456 (13.9%)	915 (27.8%)
1994	1518 (40.2%)	963 (25.5%)	343 (9.1%)	212 (5.6%)	2254 (59.8%)	479 (12.7%)	502 (13.3%)	1273 (33.7%)
1999	1590 (39.6%)	897 (22.4%)	412 (10.3%)	281 (7.0%)	2423 (60.4%)	444 (11.1%)	507 (12.6%)	1472 (36.7%)
2004	1469 (36.7%)	617 (15.4%)	447 (11.2%)	405 (10.1%)	2421 (63.3%)	376 (9.4%)	434 (10.8%)	1722 (43.0%)
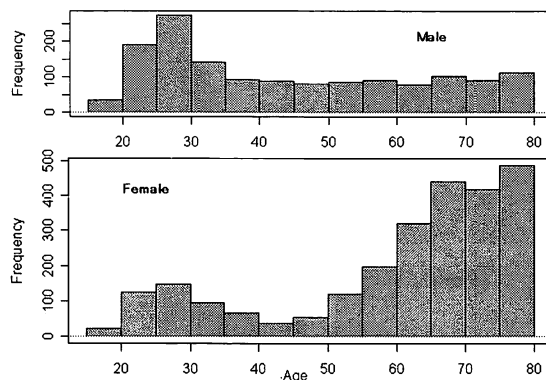
Figure 5 Age distribution in 2004
(by gender)

Table 3 The rate of youth living with parents in2004

Age	25 to 29	30 to 34	35 to 39	40 to 44	45 to 49	50 to 54	55 to 59
Male	64.0%	45.4%	33.4%	33.5%	32.2%	27.8%	21.2%
Female	56.1%	33.1%	19.8%	14.9%	15.5%	9.3%	8.5%

source: *Household Census* (National Institute of Population and Social Security Research)

Figure 5 shows the age composition by gender in 2004.

For Male (upper stand), one-person households still centers in one location, the youth layer (under 35). The number of persons in middle age and the aged categories (35 and above) are uniformly small in numbers. However, comparing age distributions of previous years, the number of elderly male single population increase in 2004. Different pattern is observed for female (lower stand), where fewer one-person households are distributed into the youth layer and many are into the aged layer (60 and above). Age composition for female is apparent bi-modal as a result.

The main reason for increase of elderly single population is aging. In addition, according to the recent *Household Census*[6], the ratio of

---

6 *Household Census* is done by the National Institute of Population and Social Security Research every five years. In the report of 2004, it says that the ratio of persons over 65 who live with their son is 28.1% (33.1% in 1999) and that of with their daughter is 13.1% (14.0% in 1999) .

living with his/her elderly parents goes down.

Meantime, the decrease of single households in youth may look inconsistent with the tendencies described in preface. It is evident that more young people remain single longer because of the growing tendency of low and late marriage. However, because of the little growth of income due to the prolonged recession, living alone is difficult for some young people. In response to this situation, the percentage of youth that live together with their parents is fairly high as shown in Table 3[7]. As a result,it seems that the rate of the youth layer in NFIE one-person household data decreases.

3.2 Employment Situations

In this section, we observe the employment situations of single households (Table 4). Most of the people are at work, but the rate is declining as the aged households increase. The participation rates are 72.8% in 1989, 67.4% in 1994, 61.7% in 1999 and 55.7% in 2004.

As shown in Figure 6, almost all the households in the youth layer are occupied without regard to gender in 2004. This tendency is the same as other observational periods. The rate of households without occupation in the middle aged layer remains low throughout the period, about 5% for male (mostly for person over age 55) and a round 15% for female (mostly for person over age 50). In the end, almost all men

Table 4 The employment situations of single households

Year	1989	1994	1999	2004
With occupation	2,394	2,542	2,475	2,229
employee	2,102	2,274	2,190	1,899
permanent worker	1,990	2,068	1,959	1,658
part-timer	112	206	231	241
without occupation	894	1,230	1,538	1,772

---

[7] Based on the recent published report of 2009, this tendency accelerates as of now. See following table of the rate of youth living with parents.

Age	30 to 34			35 to 39		
Year	1999	2004	2009	1999	2004	2009
Male	39.0%	45.4%	47.9%	24.0%	33.4%	41.6%
Female	22.9%	33.1%	36.5%	15.8%	19.8%	24.3%

(i) Occupied person   (ii) Not Occupied person
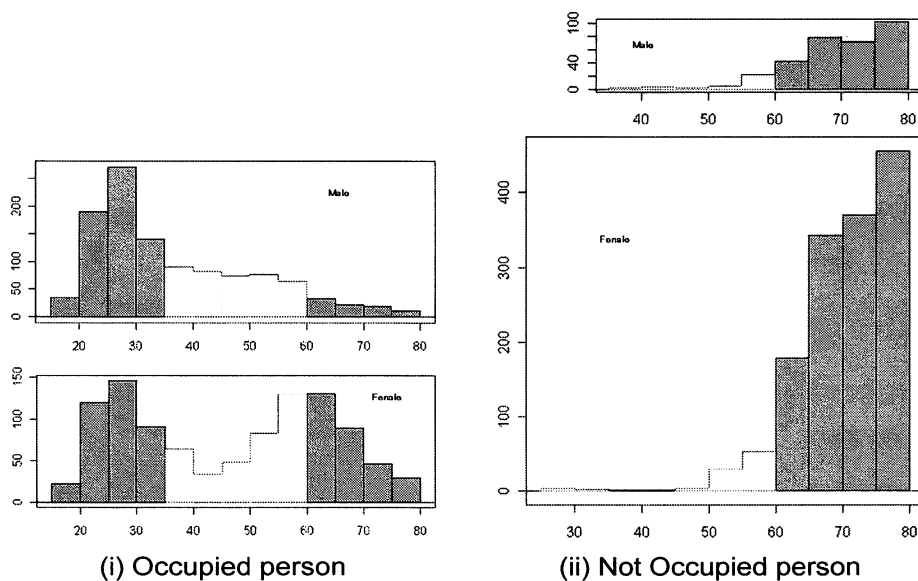
Figure 6   Age distribution of households in 2004
(by occupational states)

(i) Male   (ii) Female
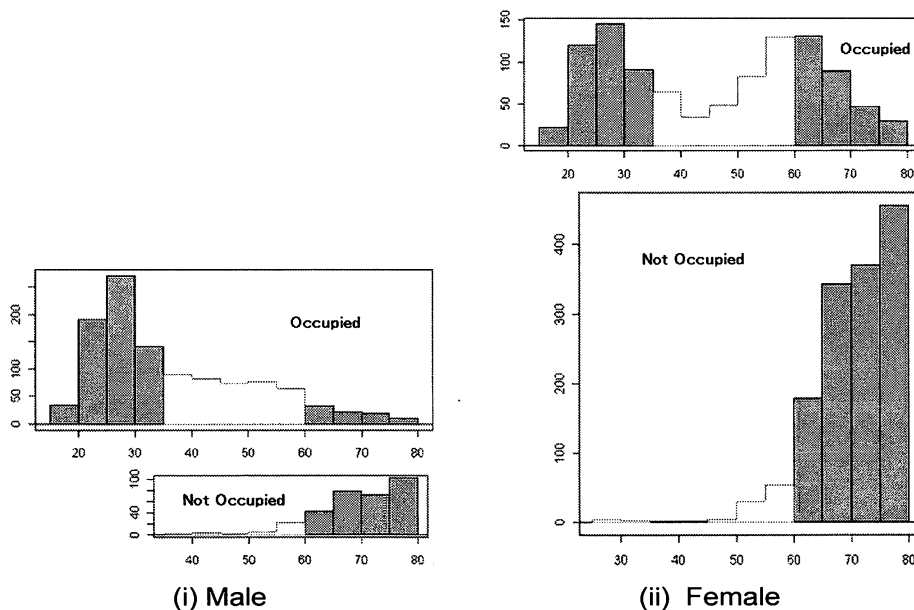
Figure 7   Age distribution of households in 2004
(by gender)

under 55 years old and women under 50 years old are occupied[8] (Figure 7). Most aged households are unoccupied. For male, around 75% household is unoccupied in 2004. This rate is a little higher than other observational period[9]. On the other hand, the jobless percentage for female fell a little and is 79.7% in 2004[10].

From 1989 to 1999, male participation rate is around 90% and decline only slightly over the years (91.2% in 1989, 89.7% in 1994 and 87.3% in 1999), while female participation rate falls sharply (60.1% in 1989, 52.8% in 1994 and 44.8% in 1999). However, in 2004, sharp decline is observed in male participation rate (78.5%) and a slight decline for female rate (40.4%).

Among people with occupation, the majority remains employed. The employment rate is around 88 to 89% until 1999 and 85% in 2004. Employees are divided in two categories: permanent workers and part-timers. Most of the people are permanent workers, but their rate is declining (94.7% in 1989, 90.9% in 1994, 89.5% in 1999 and 87.3% in 2004).

A lower 90% of the part-timers are female (Table 5). The aged female dominates the number, but their ratio is low (around 6%) and stable. The ratio of middle-aged women is highest and reaches over 15% (11.0% in 1989, 13.1% in 1994, 15.4% in 1999 and 17.7% in 2004). The ratios of part-timers in the youth layer extend a little.

Table 5 The number of part-timers in single households

Year	Male				Female			
	All	under 35	35 to 59	above 60	All	under 35	35 to 59	above 60
1989	14	3	6	5	98	9	42	47
1994	25	10	6	9	181	24	70	87
1999	22	6	5	11	209	36	81	92
2004	31	7	12	12	210	24	77	109

---

8 The occupational states of one-person households are stable from 1984 to 1999, but somewhat different tendencies are observed in 2004. Until 1999, almost all men under 60 years old and women under 55 years old are occupied.

9 A lower 70% of elderly male household is unoccupied from 1989 to 1999.

10 The unoccupied ratio for female rises over the years (73.1% in 1989 and 79.4% in 1994) and reaches 85.6% in 1999.

3.3 Residence Status

Next, we examine the type of residence for single households.

As the classification varies from year to year, we divided dwellings into following four categories.

1) owned houses

2) privately owned rented houses (including rented room)

3) public (local public and public corporation) owned rented houses

4) company owned houses (company housing and dormitory)

Table 6 shows the change in owned dwellings. In 1989, the dwellings of single person households were mainly divided into three types, owned houses, privately owned rented houses and company owned houses. People who lived in public owned rented houses were few (5.0%).

Although public owned rented houses are still minor in recent years, the percentage increased slightly (5.8% in 2004). On the other hand, dwellers in company owned houses decreased evidently. The percentage of 30.9% in 1989 goes down to 14.8% in 2004. Although the number of dwellers in privately owned rented houses slightly increased, its share falls slightly (31.1% in 1989 to 28.4% in 2004). The home ownership substantially increased as a result. The percentage jumped up from 33.0% in 1989 to 51.0% in 2004 and reached a majority.

Now we take a look into the rate of type of dwellings by their

Table 6 The change of possessed dwellings

Year	owned houses	privately owned rented houses	public owned rented houses	company owned houses
1989	1086 (33.0%)	1023 (31.1%)	163 (5.0%)	1016 (30.9%)
1994	1443 (38.3%)	1128 (29.9%)	218 (5.8%)	983 (26.1%)
1999	1720 (42.9%)	1138 (28.4%)	228 (5.7%)	927 (23.1%)
2004	2040 (51.0%)	1136 (28.4%)	232 (5.8%)	593 (14.8%)

attributes.

Table 7 shows the rate of dwellers' attributes for each type of housings. Regardless of data period, the tendencies of dwellers for owned houses and privately owned rented house remain stable. Senior and female residents are dominant in owned houses. Elderly male tends

Table 7 The type of dwellers (by house classification)

Year	Gender	Age	owned houses	privately owned rented houses	public owned rented houses	company owned houses
1989	Male	to 34	2.0%	24.0%	17.2%	59.4%
		35 to 59	5.1%	12.2%	9.2%	9.7%
		over 60	10.0%	4.8%	6.7%	0.2%
	Female	to 34	0.8%	22.8%	10.4%	28.8%
		35 to 59	20.3%	18.2%	21.5%	1.4%
		over 60	61.7%	18.0%	35.0%	0.4%
1994	Male	to 34	1.9%	21.2%	9.2%	68.8%
		35 to 59	6.8%	11.6%	7.3%	10.0%
		over 60	10.1%	4.3%	5.0%	0.7%
	Female	to 34	1.4%	23.8%	4.1%	18.4%
		35 to 59	16.8%	17.8%	18.3%	1.9%
		over 60	63.0%	21.3%	56.0%	0.2%
1999	Male	to 34	1.7%	19.9%	3.1%	68.3%
		35 to 59	7.0%	13.0%	6.1%	13.9%
		over 60	11.1%	6.0%	7.9%	0.4%
	Female	to 34	1.5%	23.1%	7.9%	14.9%
		35 to 59	14.5%	16.6%	22.4%	1.9%
		over 60	64.2%	21.4%	52.6%	0.5%
2004	Male	to 34	1.1%	19.8%	5.2%	60.4%
		35 to 59	7.7%	15.1%	4.3%	18.2%
		over 60	13.2%	8.5%	14.7%	0.8%
	Female	to 34	0.9%	21.3%	5.2%	17.4%
		35 to 59	10.7%	15.4%	12.9%	1.9%
		over 60	66.4%	19.9%	57.8%	1.3%

not to live in private owned rented houses. There is substantial decline in youth male residents for public owned rented houses and young female residents for company owned housings.

Table 8 shows the rate for type of dwellings by age and gender. For young male, the most popular residence is company owned houses. Its

Table 8 The type of possessed dwellings (by attributes)

Year	Gender	Age	owned houses	privately owned rented houses	public owned rented houses	company owned houses
1989	Male	to 34	2.4%	27.3%	3.1%	67.1%
		35 to 59	18.7%	42.5%	5.1%	33.7%
		over 60	63.7%	28.7%	6.4%	1.2%
	Female	to 34	1.6%	42.2%	3.1%	53.1%
		35 to 59	48.5%	40.8%	7.7%	3.1%
		over 60	73.2%	20.1%	6.2%	0.4%
1994	Male	to 34	2.9%	24.8%	2.1%	70.2%
		35 to 59	28.6%	38.2%	4.7%	28.6%
		over 60	68.9%	22.6%	5.2%	3.3%
	Female	to 34	4.2%	56.2%	1.9%	37.8%
		35 to 59	48.2%	40.0%	8.0%	3.8%
		over 60	71.4%	18.9%	9.6%	0.2%
1999	Male	to 34	3.3%	25.3%	0.8%	70.6%
		35 to 59	29.4%	35.9%	3.4%	31.3%
		over 60	68.0%	24.2%	6.4%	1.4%
	Female	to 34	5.6%	59.2%	4.1%	31.1%
		35 to 59	49.1%	37.3%	10.1%	3.6%
		over 60	75.0%	16.5%	8.2%	0.3%
2004	Male	to 34	3.6%	36.5%	1.9%	58.0%
		35 to 59	35.1%	38.5%	2.2%	24.2%
		over 60	66.7%	23.7%	8.4%	1.2%
	Female	to 34	5.1%	64.4%	3.2%	27.4%
		35 to 59	50.2%	40.3%	6.9%	2.5%
		over 60	78.6%	13.1%	7.8%	0.5%

percentage reaches almost 70% until 1999. In middle age layer, the rate of privately owned rented house is the first place, and followed by that of owned houses. However the differences of these ratios become small recently. For female, the popularity of company owned houses in the youth layer goes down by half in these years. Instead, the popularity of privately owned rented house goes up. As for the aged population, the rate of owned houses dominates both male and female residents.

3.4 Annual income conditions

At last, let us see the distribution of yearly income. Figure 8 shows the yearly income of all one-person households in 2004[11]. The distribution is uni-modal and skewed to the right. As the distributions are skewed, we use not the mean but the median to grasp the central tendency of income.

Table 9 shows the transition of annual income of one-person households. Q1 and Q3 stands for the first and the third quartile respectively.

Annual income consists not only of salary but also business earnings, rent, dividend, pension, sending money and other benefits. Median of yearly income for all households increased in 1994/1999, but reduced a little in 2004[12]. As other attribute-based medians changed in a similar way, we demonstrate only the value for 2004 afterwards. (Hereafter, the values in parentheses are medians. The unit is 10 thousand yen.)
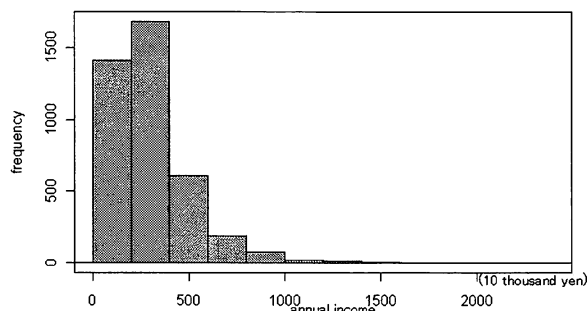
Table 9 Annual income of single households (all households)

Year	Q1	Mediann	Average	Q3
1989	150.0	235.0	264.7	332.0
1994	170.0	280.0	319.8	400.0
1999	178.0	280.0	326.7	415.0
2004	168.0	255.0	303.2	388.0

(unit:10 thousand yen)

---

[11] The shapes of the distribution are similar regardless to data year and attributes.
[12] By contrast, average values grow consistently. This discrepancy may be caused by a widening of the income gap among one-person households.

Figure 8 Yearly income distribution in 2004
(All households)

Table 10 Annual income of single households (by age and gender)

Gender	Age	Q1	Mediann	Average	Q3
Male	All	250.0	357.0	392.5	482.0
	to 34	300.0	372.0	370.4	450.0
	35 to 59	314.5	520.0	521.0	702.0
	over 60	180.0	261.0	284.4	341.0
Female	All	146.0	214.5	251.4	310.0
	to 34	196.8	276.5	298.8	382.2
	35 to 59	150.0	255.0	319.8	420.8
	over 60	137.2	198.0	223.9	273.0

(unit:10 thousand yen)

From Table 10, the yearly income for male (357.0) is considerably greater than that for female (214.5), as most of female single households are unoccupied, aged women who do not have much income flows.

In addition, considerable gender gaps of income are observed in the same age categories. The largest gap is found in middle aged layer and the median female annual income is less than a half of male income.

Table 11 shows the difference of income by the job status. The income of permanent employed person (370.0) is greater than those of unoccupied person (193.0) and also part-timers (187.0). Among the wage-earners, differences between permanent workers and part-timers

Table 11 Annual income of single households (by job status)

Job status		Q1	Mediann	Average	Q3
employed	permanent	260.0	370.0	408.5	500.0
	part-timer	129.0	187.0	207.0	256.0
without occupation		135.0	193.0	210.4	265.2

(unit:10 thousand yen)

are quite substantial. Not only in median values but also in other evaluated points, incomes of part timers are lower than those of unoccupied persons.

From the viewpoint of residence, households that live in company houses have higher revenue (400.0) throughout the data period (Table 12). This is probably due to the fact that the companies who can supply such housings are mostly major companies and pay high salaries. Residents of privately owned rented houses (260.0) succeed, while the incomes of owned houses' dwellers (231.0) remain moderate. Most badly-off households live in public owned rented houses (196.0).

In section 3, we examine several attributes of one-person households. Various patterns and characteristics are observed, but it seems that age and gender dominate other attributes. For instance, company house residents are youth and most of them are male. As incomes of male are larger than female ones in all age groups and income for male substantially increase in middle age and decreases in old age, the magnitude of company house resident can be explained.   Meantime,

Table 12 Annual income of single households (by residence type)

residence type	Q1	Mediann	Average	Q3
owned houses	156.0	231.0	276.0	334.2
privately owned rented houses	166.0	260.0	304.0	399.0
public owned rented houses	121.0	196.0	222.2	268.2
company houses	300.0	400.0	427.1	502.0

(unit:10 thousand yen)

owned houses are mainly occupied with the aged persons and their incomes are not so high in general. This explains the moderate income situation of owned house residents.

4. Empirical results of expenditure patterns of one-person household

4.1 Classification of expenditure data

In this section, we use item-classification expenditure data to grasp the characteristics of the expenditure behavior in single households.

In NFIE survey, households'consumption expenditure is divided into these 10 items: Food, Housing (Rent, Repair & Maintenance), Fuel, Light & Water charges, Furniture & Household utensils, Clothing & Footwear, Medical Care, Transportation & Communication, Education, Reading & Recreation and Miscellaneous.

Food expenditure is further classified into the following 13 items:Cereals, Fish, Meat, Daily products and eggs, Vegetables and seaweed, Fruits, Oils, Fats & Seasonings, Cakes & Candies, Cooked Food, Beverages, Alcoholic Beverages, Eating out and Charges of board.

While observing the expenditure patterns within the general categories, we noticed that the expenditure for education is rarely expensed in the one-person households, as the member constitutes only one adult. The contents of the education expenses are school (mainly, vocational school) fee and payment for reference books, so we added the education expenses to the reading & recreation.

As a result, we use the following 9-item classification for general categories.

      1.Food   2.Housing (Rent, Repair & Maintenance)
      3.Fuel, Light & Water charges
      4.Furniture & Household utensils
      5.Clothing & Footwear   6.Medical Care
      7.Transportation & Communication
      8.Reading & Recreation (include education)
      9.Miscellaneous

For food categories, charges for board are typical item for a single family survey. This is a charge paid for the food provided at company

dormitories and shared housings. As this charge is not widely spent, we decided to group charges of board expenses with eating out, as this includes meals at the company cafeteria. In the end, we use following 12-item classification for food categories as a result.

(1) Cereals (2) Fish
(3) Meat (4) Daily products and eggs
(5) Vegetables and seaweed (6) Fruits
(7) Oils, Fats & Seasonings (8) Cakes & Candies
(9) Cooked Food (10) Beverages
(11) Alcoholic Beverages
(12) Eating out (includes Charges of board)

4.2 Causal relationship among attributes and expenditure items

In section 3, we take up and examine several attributes of households. From the results gathered so far, we suppose age and gender are major contributing factors among attributes. In other words, other attributes are appeared to be reorganized from the viewpoint of age and gender. In this section, we use the framework of Bayesian network and detect the causal relationship among various attributes explicitly. We also apply this procedure to explain structures among expense items.

Bayesian networks are graphical models where nodes represent random variables and arrows represent probabilistic dependencies between them (Korb and Nicholson (2004)). As we are interested in causal relationship among factors, we use constraint-based algorithm which provides a theoretical framework for learning the structure causal models (Verma and Pearl (1991)). In this paper, we use R language and bnlearn package of R to learn Bayesian network structure and select Grow shrink algorithm to estimate Bayesian network (Scutari (2010)).

For estimation, every expenditure data are pre-processed by the addition of 0.1 and logarithmic conversion. As attributes are qualitative variable, expenditures are stratified and converted into factors when we model both qualitative and quantitative variables. Expenditure data remains as quantitive variable when we examine relationship among items of expenses only.

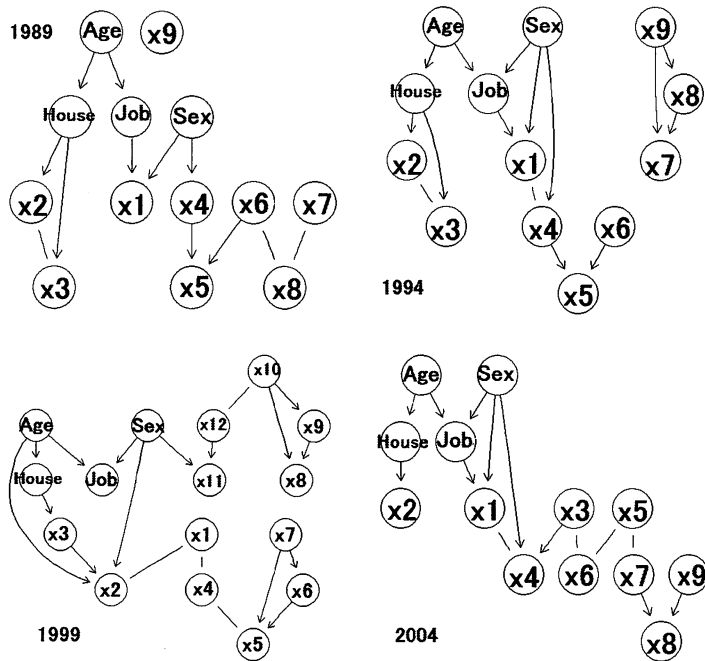Figure 9 shows the causal relationship among attributes and

**Figure 9   Transition of causal relationship among attributes
and expense items (General category)**

expense items of general category during observational period
(Symbols X1···X9 correspond to expense item numbers). In these
directed graphs, the relationship between A and B are displayed either
A->B or to B->A when they have (one-way) cause-and-effect relation-
ship. The arc A-B represents their relationship is bidirectional.

From Figure 9, following relations are found about attributes in any
observational year: 1) Age dominates occupational states and resi-
dence type, 2) Gender takes also influential position and affect 1.Food
and 4.Furniture and Household utensils expenditures, 3) occupational
states affects 1.Food expenditure (in consequence, Age affect indi-
rectly 1.Food expenses) and 4) residence types affect 2.Housing and
3.Fuel, Light & Water charges expenditures. Dominant positions of
age and gender are also observed in Figure 10 which represent the
causal relationship among attributes and expense items of food cate-
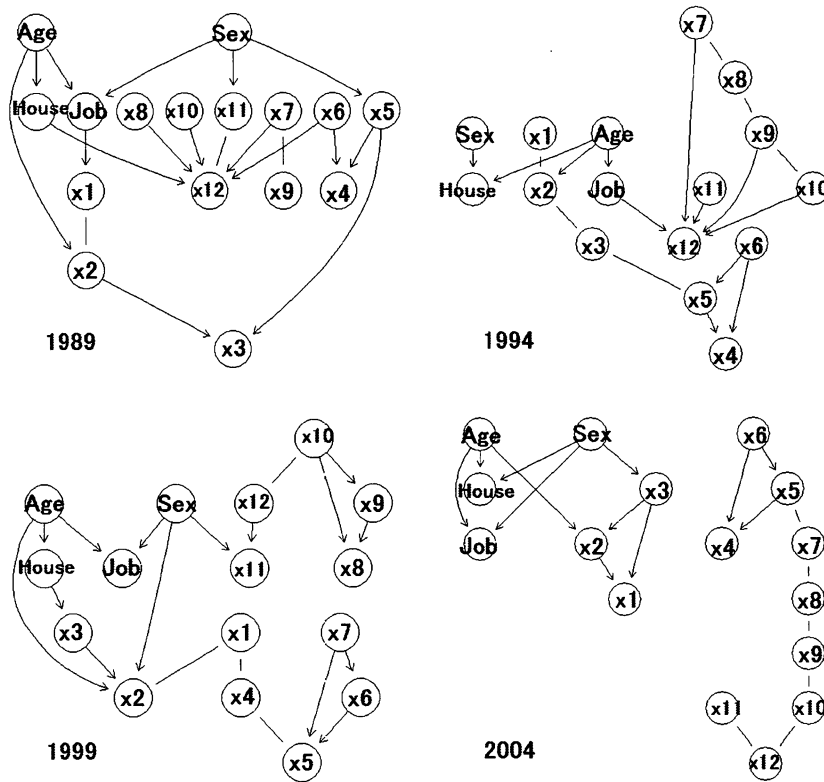gory (Symbols X1···X12 correspond to expense item numbers).

**Figure 10   Transition of causal relationship among attributes
and expense items (Food category)**

Next, we divide one-person households into six groups by age and gender and detect causal relationship among item expenditure in each group. Results are shown in Figure 11 (the aged layer) and Figure 12 (youth layer).

Age and gender difference are obvious. We examine the result of elderly female households particularly as the number of this group reaches nearly half of one-person households. From the right side of Figure 11, 2.Housing, 6.Medical Care and 8. Recreation take influential position. By contraries, 4.Furniture and Household utensils is dependent to every subject except for 3.Fuel, Light and Water charges. 3. Fuel expenditure is, in a sense, isolated as only two items (1.Food and 7. Transportation and Communication) are correlated. 1.Food, 5.
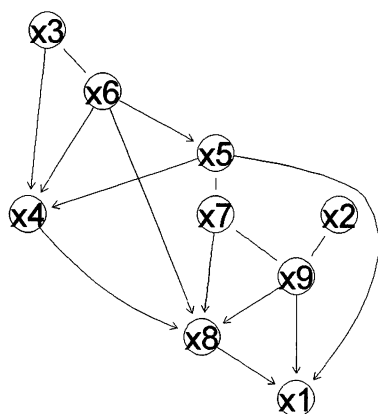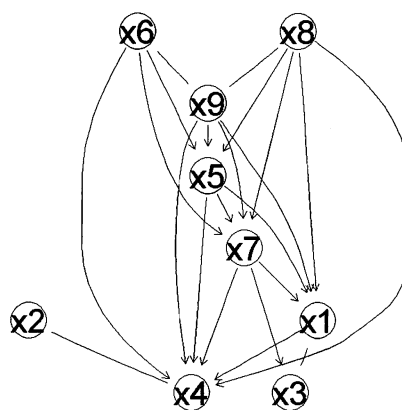
(i) Male elderly person   (ii) Female elderly person

Figure 11   Causal relationship among general 9-item expenses in 2004
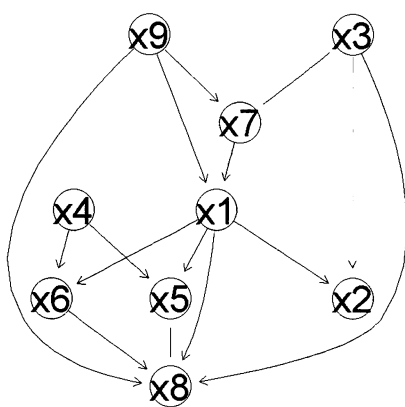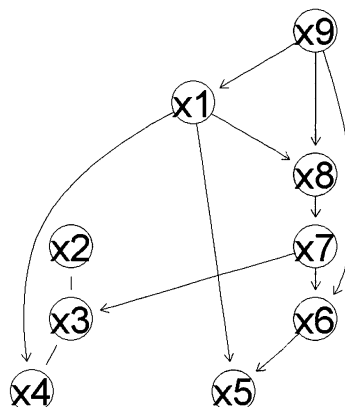
(i) Male young person   (ii) Female young person

Figure 12   Causal relationship among general 9-item expenses in 2004

Clothing and 7.Transportation and Communication take intermediary position, as they are affected by several item expenditures and affect several others. A few bidirectional relationships are found between 1. Food and 3.Fuel, 2.Housing and 4.Furniture, 6. Medical Care and 9. Others.

4.3 The frameworks to deal with zero expenditures

Micro data on household expenditure provide wide variety of useful information about consumer behavior, but the problem of zero expenditure often takes place.

The number of households who reports zero expenditure in NFIE data is shown in Table 13. Zero expenditures exist in all categories except 1.Food. They sometimes occur in considerable numbers[13].

Table 13 The number of zero expenditures

	1989	1994	1999	2004
1. Food	0	0	0	1
2. Housing	846	970	1,076	1,195
3. Fuel&Light	737	592	89	142
4. Furniture	371	409	364	240
5. Clothing	380	490	629	592
6. Medical care	937	925	801	544
7. Transportation	66	56	46	29
8. Recreation	71	63	82	60
9. Others	26	41	64	46
(1) Cereals	145	150	107	72
(2) Fish	633	654	675	453
(3) Meat	714	786	820	634
(4) Daily products	356	334	280	285
(5) Vegetables	603	617	556	331
(6) Fruits	532	799	796	667
(7) Seasonings	761	733	702	396
(8) Cakes	129	193	150	175
(9) Cooked food	231	153	120	48
(10) Beverages	240	231	230	146
(11) Alcohol	1,554	1,777	1,750	1,751
(12) Eating out	310	395	479	490

[13] The number of zero expenditures for 2.Housing may look charged out. As NFIE does not consider imputed rent, housing expenditures consist of rent and mending fees. In consequence, zero expenditure occurs for households who live in owned houses and do not expense mending fees. This covers over three fourths of households with owned houses.

To solve these problems, we use the procedures of Fry, Fry and Mclaren (2000, 2001) to deal with the zero expenditure problems in budget share models.

Applying compositional data analysis methodology (Aitchison (1986)) to budget shares, the model with suitable stochastic errors will be

$$\log\left(w_i/w_N\right) = \log\left(W_i/W_N\right) + v_{i,} \quad (i = 1, ..., N - 1)$$

where w denotes observed budget share, W denotes the deterministic component derived from economic theory and v stands for errors (Fry et al. (1996)).

As this approach cannot be applied when zero data (expenditures) exist, Fry et al. (2000) proposed following zero replacement techniques.

Consider the situation we observe a composition of M zeros and $N - M$ nonzero components for a certain household. M's are probably varying from household by household[14]. Fry et al. proposed that we replace zeros for τ_A and subtract $w_i \times \tau_S$ from nonzero components to vanish zeros and adjust nonzero shares to preserve ratio's order.

$$\tau_A = \delta(M + 1)\left(N - M\right)/N^2,$$
$$\tau_S = \delta M(M + 1)/N^2,$$

where δ is maximum rounding error[15]. Remaining issue is how to set τ_A,

---

[14] The following tables show how many households are reported for each M, zero expenditure item numbers in 2004. (9 item General category for upper stand and 12 item food category for lower stand.) For example, in youth male layer, 617 households exist. 255 households expenses for all the 9 items of general category and 32 households expenses for any 6 items but do not spend for any 3 items. (Zero expenditure items are vary from households to households.)

Gender	Age	0	1	2	3	4	5	6	households
	to 34	255	212	114	32	3	1		617
Male	35 to 59	166	157	81	27	10	4	2	447
	over 60	171	165	46	15	6	1	1	405
	to 34	277	78	16	5				376
Female	35 to 59	255	135	34	8	2			434
	over 60	842	697	132	42	5	4		1722

Gender	Age	0	1	2	3	4	5	6	7	8	9	10	11	12	households
	to 34	95	107	89	69	64	81	52	34	15	6	3	2		617
Male	35 to 59	151	118	72	29	28	15	15	10	5	3	1			447
	over 60	167	133	66	22	9	4	2	1	1					405
	to 34	138	135	66	22	9	1	2	3						376
Female	35 to 59	196	156	58	12	7	2	2	1						434
	over 60	653	729	247	63	16	9	2	1	1				1	1722

[15] Original procedure suggests subtracting τ_S from nonzero components. However, this procedure is not ratio preserving and cause problems in application for budget share model. Fry et al.'s method conquers this problem. Moreover, it is persuasive as the amount taken from the nonzeros is proportional to the size of

τ_S and δ. In terms of expenditure, the minimum value a zero should be replaced with is 1 (yen). So, we can set zero replacement τ_A as 1 divided by the certain value of total expenditure[16]. Once τ_A is settled, we can derive τ_S and δ. In the end, we can get the 'zero-replaced' data.

As a demand system, we adopt the Modified Almost Ideal Demand System (MAIDS) which was proposed by Cooper and McLaren (1992). MAIDS is the extended version of AI Demand System (Deaton and Muellbauer (1980)) and satisfies regularity over a wider region than AI Demand system does (McLaren et al. (1995)).

Adopting MAIDS specification, derived Engel curve in share form is

$$W_i = \frac{\alpha_i + \beta_i \log (Y/K)}{1 + \log (Y/K)},$$

where Y denotes total expenditure and K is a normalize factor and we set it as minimum total expenditure[17]. To satisfy adding-up, parameters should be $\sum \alpha_i = 0$ and $\sum \beta_i = 1$.

The expenditure elasticities of MAIDS is given by:

$$e_i = 1 + \frac{1}{W_i} \times \frac{\beta_i - W_i}{1 + \log (Y/K)}.$$

As in the previous section, we confirm that age and gender is the major factors to decide expenditure patterns of one-person household. So we use OLS method and estimate MAIDS framework Engel curves to compute expenditure elasticities[18] of age and gender categorized group to examine how age and gender affect the elasticities.

Table 14 shows expenditure elasticities for households[19] categorized by age and gender in 2004. Upper box is for general categories and lower stands for food categories.

Now, examine elasticities for six age and gender layers.

For general categories, 5.Clothing and 8.Recreation are assessed as luxuries for every layers. 7.Transportation and 9.Others are

---

nonzero values.

[16] Fry et al. (2000) tried several values of total expenditure to confirm the robustness of different values of τ_A's. We adopt the median value as we compare groups of different attributes'.

[17] By this normalization, regularity is satisfied all over the sample space (Cooper and McLaren (1996)).

[18] For the estimation of items in food categories, we use the expenditure of 1.Food as 'total expenditure'.

[19] Elasticities have obvious differences via evaluation points. We often observe very limited expense even at the median level for some items in some household groups. In the end, if we evaluate at the median level, several estimates of parameters do not satisfy the sufficient conditions for the regularity of MAIDS, that is all α_i's and β_i's are nonnegative. So, we use not median but mean point to evaluate elasticities in this paper.

Table 14 Expenditure Elasticities by age and gender in 2004

	Male			Female		
	Under 35	35 to 59	Over 60	Under 35	35 to 59	Over 60
1. Food	0.7300	0.6838	0.6521	0.7050	0.6211	0.6617
2. Housing	0.9153	0.7910	1.4841	1.0001	0.8530	1.5463
3. Fuel&Light	0.3228	0.2785	0.3197	0.3948	0.2554	0.3232
4. Furniture	0.9675	0.9347	1.0767	0.8483	1.0778	1.1604
5. Clothing	1.0513	1.3771	1.0256	1.1784	1.7758	1.3757
6. Medical care	0.8150	0.7606	0.9106	1.0361	0.8884	0.8906
7. Transportation	1.2859	1.2813	1.0995	0.9916	1.0389	1.0633
8. Recreation	1.4073	1.4035	1.3654	1.5192	1.3293	1.1839
9. Others	0.9351	1.3980	1.3205	1.1722	1.4558	1.3038
(1) Cereals	0.2340	0.2301	0.5467	0.4452	0.6961	0.9209
(2) Fish	0.3851	0.7571	0.6825	0.8780	0.9672	0.9637
(3) Meat	-0.0032	0.4540	0.5976	0.5679	0.8250	0.8959
(4) Daily products	0.3827	0.2049	0.6498	0.4548	0.5350	0.6419
(5) Vegetables	0.1214	0.2671	0.5789	0.6056	0.7178	0.7658
(6) Fruits	0.6404	0.4350	0.9787	0.6151	0.9090	0.9648
(7) Seasonings	0.2451	0.3741	0.5727	0.6207	0.6403	0.7812
(8) Cakes	0.6237	0.7822	0.9587	0.8140	0.9758	1.0977
(9) Cooked food	0.7120	0.5782	0.8202	0.8701	0.8751	0.9919
(10) Beverages	0.6850	0.7053	0.8688	0.8621	0.9013	1.0313
(11) Alcohol	1.2733	0.8905	0.9022	1.2901	1.4261	1.4028
(12) Eating out	1.3032	1.6288	1.9791	1.4052	1.5828	1.5963

(Elasticities are evaluated at the mean household.)

assessed as luxuries for five layers. 4.Furniture and 6.Medical care are also judged rather luxurious. Meantime, the basic need of 3.Fuel and Light and 1.Food are strongly estimated. Elasticities of 2.Housing is considerably high in especially the aged layers. But this should be treated by making an allowance for the definition of housing in NFIE. See notes 13).

For food categories, (11) Alcoholic Beverages and (12) Eating out are considered as luxuries. (8) Cakes, (9) Cooked food and (10)

Beverages are also judged as luxurious. On the other hand, (1) Cereals, (4) Daily Products (egg and milk) , (5) Vegetables and (7) Seasoning are estimated as basic needs' food. These consequences seem appropriate and can be understood in a practical manner[20].

Generally speaking, both for general and food categories, elasticities of most commodities grow (slightly) larger as the household grows older. While, elasticities for female are larger in most cases than those for male in the same age groups, exceptions are in 4.Furniture, 7. Transportation and 8.Recreation.

5. Summary and some remarks for future analysis

We use micro data of *National survey of Family Income and Expenditure* of 1989, 1994, 1999 and 2004 to examine the characteristics and expenditure patterns of one-person households. As there are vast variations by attributes, such as gender, age, job status, type of residence and annual income, we adopt Bayesian network procedure and detect that age and gender hold a dominant position over other attributes. Adopting methodology of Fry et. al. (2000) in dealing with the problem of zero observations into the MAIDS framework, we can obtain proper expenditure elasticities by age and gender.

As the aging of the general population progresses, the ratio of single households will continue to increase for a considerable period in the future. The change of population structure, such as the increase of the aged male layer, the sharp rise of the aged female layer and the decrease of youth layers of both gender, have a widespread impact on consumption and Japanese economy. To seize this trend and grasp the consumer intention precisely continue to be prime and important tasks.

We show that a number of somewhat different tendency and aspect are observed in 2004. Whether these phenomena are tentative or not remain obscure. Meanwhile, our analysis does not cover the fast and furious slowdown caused by Lehman's fall. How and what extent are one-person households affected by this circumstance? We hope next

---

[20] Even if we investigate the elasticities evaluated at the mean level, the behavior of male youth layer is rather peculiar, especially in food categories. That means the expenditure distribution for male youth is severely distorted and zero or scarce expenditures are often observed. These tendencies are mainly observed in material foods, such as fish, meat, vegetables and fruits.

investigation, in which 2009 NFIE data are analyzed, clarify these facts in immediate future.

References

Aitchison, J. A. (1986) *The Statistical Analysis of Compositional Data*, Chapman Hall.

Cooper, R. J. and K. R. McLaren (1992) "An empirically oriented demand system with improved regularity properties", *Canadian Journal of Economics*, 25, 652-67.

Cooper, R. J. and K. R. McLaren (1996) "A system of demand equations satis-fying effectively global regularity conditions", *Review of Economics and Statistics,* 78, 359-64.

Deaton, A. and J. Muellbauer (1980) "An almost ideal demand system", *American Economic Review*, 70, 312-26.

Fry, J. M., T. R. L. Fry and K. R. McLaren (1996) "The Stochastic Specification of Demand Share Equations: Reatricting Budget Shares to the Unit Simplex", *Journal of Econometrics*, 73, 377-85.

Fry, J. M., T. R. L. Fry and K. R. McLaren (2000) "Compositional Data Analysis and Zeros in Micro Data", *Applied Economics*, 32, 953-59.

Fry, J. M., T. R. L. Fry, K. R. McLaren and T. N. Smith (2001) "Modelling Zeros in Microdata", *Applied Economics*, 33, 383-92.

Hashimoto, N. (2006) "A preliminary note on expenditure patterns of one-person household in Japan*", Kansai University Review of Economics* 8, 43-61.

Hashimoto, N. (2007) "Expenditure patterns of one-person household in Japan, 1989 - 1999*", Kansai University Review of Economics* 9, 41-72.

Korb, K. and A. Nicholson (2004) *Bayesian Articial Intelligence*, Chapman and Hall.

McLaren, K. R., J. M. Fry, and T. R. L. Fry (1995) "A simple nested test of the almost ideal demand system", *Empirical Economics*, 20, 149-61.

Pourret, O., P. Naïm and B. Marcot (eds.) *Bayesian Networks A Practical Guide to Applications*, John Wiley and Sons.

R Development Core Team (2010). R: A Language and Environment for Statistical Computing, R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Scutari, M. (2010) "Learning Bayesian Networks with the bnlearn R Package", *Journal of Statistical Software* 35(3), URL http://www.jstatsoft.org/.

Verma, T.S. and J.Pearl (1991) "Equivalence and Synthesis of Causal Models", *Uncertainty in Articial Intelligence*, 6, 255-268.