[*Jpn. J. Rural Econ.* Vol. 6, pp. 20-30, 2004]

Re-estimating per Capita Individual Consumption by Age from Household Data

Masamitsu Tanaka,* Hiroshi Mori† and Toshio Inaba‡

Mori and Inaba proposed an estimation method of deriving individual consumption by age from macro data classified by age of household head (HH), using quadratic programming, 1997. We replaced their approach by regression with weights which are determined by the magnitude of standardized residuals, following the leads of Huber, 1981 and Minotani, 1992. Using our revised method which provides objective statistics, the estimates of per capita individual consumption of fresh fruit and fresh fish, respectively, by non-adults are substantially larger and those for the young adults somewhat smaller in our studies than in previous studies. It seems quite apparent that Japanese children and young adults have decreased their at-home consumption of these products substantially in recent years. Those older than 50 years of age seem to have maintained their consumption at relatively high levels.

Key words : individual consumption by age, macro data by age of household head (HH), household age composition by HH age, quadratic programming, weighted regression, standardized residuals, gradual changes between successive age groups.

1. Introduction

Japanese food consumption is said to have reached the stage of "maturity" where economic factors such as income and prices do not play as dominant a role in determining consumption as before (Tokoyama and Egaitsu [30] ; Tokoyama [31]).

Morishima found that substantial differences existed in Japanese individual consumption of rice by age and generation,[1)] analyzing panel data from *Family Income and Expenditure Surveys* (*FIES*) by the Japanese government's Bureau of Statistics (Morishima [25]).[2)] Simple per capita consumption of selected food groups by broad age groups of household head for the two periods of 1980 and 2000 is provided in Table 1.

It has been widely recognized in macroeconomic circles that individual consumption/saving varies by age (Modigliani [19] ; Ando and Kennickell [1] ; Deaton and Paxson [4]). As long as the population and/or households stay stationary in age structure, an economy can be treated as a unity, even if wide differences exist in consumption by age. Actual economies, however, and Japanese society in particular, have been changing rapidly in age structure. In 1980, the households where household heads (HH) were 60 years old and over accounted for 13.9% of all households covered by *FIES* and their share increased to 34.0% in 2000. The share of the households where HH were under 39 years old decreased from 38.0% to 20.7% over the same period (Table 2).

Morishima's investigation has been followed by Ishibashi in much greater scale in respect to commodities and periods covered (Ishibashi [8] [9] [11] [12]). Comprehensive as their analyses may be,[3)] it is not easy for non-government institutions to have access to the *FIES* panel data.[4)] Even Ishibashi, who works for National Agricultural Research Center, finds it virtually impossible to trace the data back into the past as she wishes.

The Bureau of Statistics started to publish household purchases of various goods and

* Nippon Research Institute
† Senshu University
‡ Waseda University

Table 1. Per capita household consumption of selected food products by age groups of household head (HH), 1979-1981 and 1999-2001*

HH age groups	Rice (kg/year)	Rice (kg/year)	Fresh fish & Shellfish (kg/year)	Fresh fish & Shellfish (kg/year)	Eating-out (thou yen)**	Eating-out (thou yen)**
(years old)	1979-81	1999-01	1979-81	1999-01	1979-81	1999-01
Average	45.10	30.53	14.49	13.35	43.93	53.9
-39	33.01	16.49	11.18	6.13	48.12	52.57
40-59	51.77	29.95	15.78	13.15	46.03	54.12
60-	53.81	42.38	18.46	19.27	37.63	51.18

*Age groups and years are simple averaged by the authors ; **2000 constant yen.
Sources: *Family Income and Expenditures Survey*, various issues.

Table 2. Distribution of Japanese households by age groups of household head (HH) covered by government's *Family Income and Expenditures Survey*, 1980 and 2000

HH age groups	1980	2000
Total	10,000	10,000
-39 (years old)	3,799	2,065
40-59	4,807	4,539
60-	1,394	3,396

Sources : Ibid.

services by age groups of household head in 1979. Several researchers have relied on this data to identify differences and changes in consumption by age. In most cases, those household data classified by HH age groups, simply divided by the number of persons in respective household, are used as proxies for individual consumption by age. Except for the case of fresh fish and fresh fruit in recent years, which demonstrate extremely wide variations between the younger and the older households, this simplistic approach might lead to questionable conclusions. A typical four-member household comprises two adults of the same age as the HH and two children. Infants do not eat much food other than milk, fruit juice and the like. So, dividing household consumption by 4 may likely underestimate the consumption by young parents in their 20s. On the other hand, high teens generally eat much more of staple foods like rice and meat than their parents in their 40s, for example. So, simply divided data might overestimate the individual consumption by adults in their 40s.

Matsuda and Nakamura (1993) used these simply divided data to identify age/cohort/period effects on individual consumption of rice [17]. When used for time-series analyses, this simplistic approach tends to give rise to an erroneous conclusion. Suppose that a typical four-member household where the HH was in his late 20s consumed 40 kg of rice in 1980 and the same size household where the HH was in his early 40s consumed 80 kg in 1995, for example. It may be seriously mistaken to estimate that the young adults in their late 20s consumed 10 kg (40/4) of rice in 1980 and the same (birth) cohorts increased their consumption to 20 kg (80/4) when they reached middle age in 1995. It may be quite likely that the other two members of the household, infants in 1980, did not eat much rice then, but they ate more rice than their parents when they were high teens in 1995.

Mori and Inaba (1997) proposed a unique method to derive individual consumption by age from the *FIES* household data classified by HH age groups, incorporating the estimated age composition matrix by HH age groups [20]. A group of researchers have tried to deconstruct age/period/cohort effects on Japanese food consumption, using individual consumption data derived from the Mori and Inaba model (Mori et al. [21][24]).

They have faced several criticisms for their cohort analyses, the first one of which concerns the accuracy or dependability of individual consumption estimates by age from the *FIES* household data on top of Nakamura's Bayesian cohort model, which they employed.

In this paper the authors would like to concentrate on the statistical procedures to derive individual consumption by age from the *FIES* annual report data classified by HH age

Table 3. Purchase of fresh fruit by age groups of household head (HH), 1993 to 1996 : an excerpt of the younger households only

HH age groups	1993		1994		1995		1996	
	#tabulated	Q. (kg/y)	#tabulated	Q. (kg/y)	#tabulated	Q. (kg/y)	#tabulated	Q. (kg/y)
All HHs. average	7962	114.22	7960	113.95	7923	108.40	7927	104.56
-24 yrs. old	43	36.30	43	29.84	50	54.09	45	36.20
25-29	287	44.17	319	41.04	279	39.06	286	38.63
30-34	654	61.88	669	60.68	614	52.70	627	51.33
35-39	865	88.73	894	78.60	826	71.30	800	68.67
40-44	1089	107.85	1062	101.98	1000	93.16	902	87.54
45-49	1015	122.08	1049	116.70	1098	112.03	1096	105.80
50-54	—	—	—	—	—	—	—	—

Sources : *FIES*, various issues.

groups. Only after a certain recognition is granted to the estimates of individual consumption by age, one should be able to move to the further application and development of Nakamura's Bayesian cohort analysis.

2. Mori and Inaba Model Reiterated

The *FIES* annual report publishes average household consumption by 10 HH age groups, -24, 25-29, …, 60-64, and 65- years old.

$$\sum_{i=1}^{15} C_{ij} X_i = H_j \qquad (1)$$

Where

C_{ij}=number of persons in the ith age group in the jth HH age group

X_i =average per capita consumption by persons in the ith age group (to be estimated)

H_j=average household consumption of jth HH age group (from *FIES* annual report)

In this study, there are 10 equations (j=1 to 10), and 15 unknowns (i=1 to 15) that correspond to individual age group classifications : 0-9, 10-14, 15-19, …, 65-69, 70-74, and 75-. To solve the equation system (1), 5 more equations must be added or the number of unknowns cut in such a way as to reclassify individual age groups into, say, 20-29, 30-39, and the like. Mori and Inaba first prepared 5 additional equations, such as

$$1.2X_n - 1.0X_m = 0 \ (n \neq m) \qquad (2)$$

implying that the average consumption by individuals in the mth age group is 20 percent greater than that of the nth group.

Per advice from Professor T. Kawaguchi, Kyushu University, Mori and Inaba modified the model to make the solution less rigid and more "robust" (Mori and Inaba [20] : p. 181), allowing for the error term in each equation, i. e., $H_j - \sum C_{ij}X_i = E_j$, and $1.2X_n - 1.0X_m = E_n$, in the case of (2) shown above. Parameters, average per capita individual consumption by age to be estimated, are determined in such a way as to minimize the sum of squared residuals, including those for the additional assumption equations.

In the case of the main food groups, such as rice, fresh fruit and fresh vegetables as a whole, respectively, there is some side-evidence, for example, in the *National Nutrition Surveys*, to substantiate possible relationships between age groups in per capita consumption. In the case of minor food groups, such as beef and mandarin oranges, no objective information is available to ascertain inter-age relationships.

Mori and Inaba later introduced the assumption of zenshinteki henka, gradual changes between successive age groups, suggested by Nakamura's Bayesian cohort model (Nakamura [26]). Instead of arbitrarily assuming relationships between age groups, such as $1.2X_n - 1.0X_m = E_n$ as shown above, they introduced the more intuitive assumption,

$$1.0X_k - 1.0X_{k+1} = E_k \approx 0 \quad (k = 1 \text{ to } 14) \qquad (3)$$

to cover the entire age range, from the youngest to the oldest age groups. On top of 10 equations for HH age groups from -24 up to 65- years old, they added 14 assumption equations of gradual changes between successive age groups.

To estimate the parameters in the above model, they used the "quadratic programming method" designed by Kawaguchi (Mori and Inaba [20]). Because younger households, HH age groups under 25 and 25-29 years of age, have fewer tabulations and show erratic fluctuations in consumption from year to year (Table 3), they are down-weighted in proportion to the relative size of tabulation samples. One of the technical difficulties that confronted Mori and Inaba and their colleagues in later studies (Mori and Gorman [23] ; Mori, Lowe, Clason and Gorman [24] ; Mori, Clason, Dyck and Gorman [21]) was whether and how to differentiate in weight the first 10 equations of household consumption by HH age groups and the additional 14 assumption equations of gradual changes in individual consumption between successive age groups. If the last 14 assumption equations or part of them are heavily weighted, compared to the first 10, estimated parameters will be close to one another, impacted by the assumption of $X_i - X_{i+1} \approx 0$. On the other hand, if these assumption equations are very lightly weighted, estimates for some parameters will likely be unstable, reflecting, in part, erratic fluctuations in the original data for any HH age groups, as shown in Table 3.

The HH age groups in *FIES* annual reports average 3-4 persons per household. As a rule of thumb, the assumption equations representing per capita individual consumption of successive age groups are proportionately (per capita vs. family) down-weighted, i. e., 0. 3, compared to 1. 0 assigned to each of the household equations. Every equation in each category, (1)-(10) or (11)-(24), is uniformly weighted at the outset, except for the youngest HH age groups as mentioned above.

3. Problems Associated with the "Quadratic Programming Method"

When Lewis estimated Japanese per capita individual consumption of various food products by age groups using the Mori and Inaba model, she could not answer this quite reasonable question : "Why is estimated per capita consumption of beef and pork (not fish) by children and teens considerably lower than that by middle-aged groups ? "(Lewis [16]). In footnotes to the tables of estimates for individual consumption of fresh fish and fresh fruits, Mori and Gorman stated, "The estimates for the youngest age groups, 0-4 and 5-9 years of age, are not stable enough to be made public" (Mori and Gorman [23] : pp. 107-108). They had to recognize that per capita consumption of several food products, including fruit, fish and rice, by those under 20 years of age may be unreasonably underestimated, when compared to data reported in the *Nutrition Surveys* (October 1997～). Mori, Clason, Duck, and Gorman [21] chose to manipulate weights assigned to the assumption equations of gradual changes between successive age groups, so as to obtain intuitively "reasonable", or at least non-negative estimates, without objective reference criteria. Their "quadratic programming method" does not furnish statistics such as R^2 and t-values. When the estimate for individual consumption by any age group proves negative in value, one can judge with certainty that it is unreasonably underestimated. But even zero consumption cannot be judged "underestimated" by common sense alone.

Tanaka tried to derive individual consumption from the *FIES* household data with essentially the same model specification as Mori and Inaba, using the OLS application contained in *Excel* instead of the "quadratic programming method" (Tanaka [29]). In the next section, we will follow the lead of Tanaka in estimating per capita individual consumption by age, based on the same data sources, household consumption and family age composition classified by HH age groups.

4. LS Application in Deriving Individual Consumption

In this study, we used the same model specification as Mori, Clason, Dyck and Gorman [21]. On top of 10 household equations of

$$\sum_{i=1}^{15} C_{ij} X_i - H_j = E_j \quad (j = 1 \text{ to } 10 \ ; \ i = 1 \text{ to } 15) \tag{4}$$

14 assumption equations of gradual changes in per capita individual consumption between successive age groups,

$$1.0X_k - 1.0X_{k+1} = E_k \quad (k = 1 \text{ to } 14) \tag{5}$$

were added. We estimated parameters, X_i,

Table 4A. Estimates of per capita individual consumption of fresh fruit, 1996 : the case of uniform weights

Age group	X_i kg/person	t-value	Equation No.	Standardized residuals
0-9 yrs. old	4.92	0.70	1	+0.103
10-14	7.21	1.13	2	−0.207
15-19	9.75	1.64	3	−0.133
20-24	13.03	2.70	4	−0.068
25-29	16.17	4.93	5	+0.064
30-34	20.00	4.38	6	−0.035
35-39	26.04	4.28	7	−0.314
40-44	33.21	5.77	8	+0.715
45-49	39.31	9.23	9	−0.452
50-54	46.76	17.72	10	+0.310
55-59	56.17	31.00	11	+0.573
60-64	55.58	33.28	12	+0.637
65-69	61.66	19.06	13	+0.824
70-74	61.70	17.47	14	+0.789
75-	57.89	10.43	15	+0.960
			16	+1.518
			17	+1.799
			18	+1.530
			19	+1.808
			20	+2.363
			21	−0.148
			22	+1.526
			23	+0.784
			24	+0.352

using the least square method, i. e., to minimize !

$$\sum_{j=1}^{10} w_j E_j^2 + \sum_{k=1}^{14} w_k E_k^2 \qquad (6)$$

with w_j and w_k set at 1.0 and 0.3, respectively, as explained above. We found that both our approaches, the LS and Kawaguchi's "quadratic programming method," produced exactly the same parameter estimates, per capita individual consumption by age (when the same set of weights were applied), with the only difference being that the former provides various statistics such as R^2, standard errors for the parameter estimates and standardized residuals for all the equations mobilized.

As found by Lewis, Mori and Gorman and Mori, Clason, Dyck and Gorman (refer to the preceding section), the estimates for individual consumption by the young tend to be "unreasonably" low, compared to individual food intakes by age published in the latest issues of the *Nutrition Surveys*, when the first 10 equations representing household consumption and the last 14 equations are assigned the uniform weights, 1.0* and 0.3, respectively (*the youngest HH age groups are downweighted from the outset as mentioned earlier). However, if any equations with abnormally large standardized residuals are penalized with smaller weights, the estimated parameters tend to look more reasonable, with significant improvements in t-statistics, not only for the younger age groups but for the remaining age groups as well. The actual final case of iterative computation for fresh fruit in the year, 1996, for example, is shown in Tables 4A and B.

Sawa ([27] : chapter 6) and Minotani [18] advocate regression with weights when the condition of normal distribution of residuals does not hold in econometric analysis. Sawa suggests the use of reciprocals of residuals in absolute value as weights (p. 124), but this tends to lead to substantial differences in weight and Minotani suspects that it may not be very practical to apply this principle in view of the existence of very small residuals near zero (p. 180). Instead of applying varied weights to all equations, by the size of

Table 4B. Estimates of per capita individual consumption of fresh fruit, 1996 : the case of weighted regression

Age group	X_i kg/person	t-value	Equation No.	Standardized residuals
0-9 yrs. old	9.91	1.76	1	−0.152
10-14	11.36	2.23	2	−0.280
15-19	12.76	2.74	3	−0.136
20-24	13.80	3.81	4	+0.042
25-29	14.53	5.79	5	−0.035
30-34	16.94	4.71	6	+0.042
35-39	21.43	4.40	7	−0.069
40-44	29.02	6.23	8	+0.462
45-49	36.81	10.83	9	−0.535
50-54	46.12	22.61	10	+0.333
55-59	57.01	41.88	11	+0.500
60-64	55.94	44.86	12	+0.481
65-69	62.41	25.64	13	+0.358
70-74	61.86	23.82	14	+0.251
75-	57.77	14.14	15	+0.829
			16	+1.545
			17	+1.915
			18	+1.967
			19	+1.922
			20	+1.874
			21	−0.368
			22	+1.930
			23	+0.876
			24	+0.380

(reciprocals of) residuals in absolute value, Minotani penalizes weight only when the residuals exceed a certain number, "tuning constant" r (Minotani [18] : pp. 130-134), as follows :

$$w_i = \begin{cases} 1 \leftarrow |e_i{}^*| \leq r \\ \dfrac{r}{|e_i{}^*|} \leftarrow |e_i{}^*| > r \quad \text{where } e_i{}^* = e_i/\sigma. \end{cases}$$

The crucial question we face now is when and how to modify weights in weighted regression analysis. More concretely, at what number should we set a tuning constant r, and how should we determine which weights to penalize? Huber states, "the constant c (which corresponds to Minotani's r) regulates the amount of robustness ; good choices are in the range between 1 and 2, say $c=1.5$" (Huber [7] : p. 18). Minotani admits that there can be a wide range of numbers for r, from 1.0, the safest against the outlier, to 2.0, the loosest, although 1.345 is used throughout his illustration (p. 140 ; p. 164). We set the number of r at 2.0, as a rule of thumb or for a practical reason, i.e., to lessen the burden of manual iteration.[5] Whenever the standardized residuals in absolute value exceed 1.345, weights to be applied are automatically determined as : $1.345/e_i{}^*$ in Minotani ([18] : pp. 164-165). Finding that these weights do not necessarily produce the standardized residuals less than 1.345 (Minotani [18]), we manually searched for a set of weights that would lead to residuals less than 2.0 in absolute value for all equations in our case. A couple of equations that showed residuals smaller than 2.0 at the first run commonly popped up in residuals at the second (or the subsequent) run, in which the equations with residuals larger than 2.0 are penalized with weights smaller than 1.0 for the first 10 equations or 0.3 for the remaining 14 equations, respectively. We repeated the process manually to convergence (Huber [7] : pp. 18-19) where no equations showed standardized residuals larger than 2.0 in absolute value. Toward the end of this iteration process, in most cases, no appreciable improvements in statistics, standard error for the system or t-statistics for the

Table 5. Re-estimates of per capita individual at-home consumption of fresh fruit by age, 1979 to 2001

(kg/year)

Age	0-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-
1979	34.7	35.2	37.8	39.8	41.5	46.1	44.6	52.4	57.1	62.4	60.2	66.4	64.2	60.4	55.4
1980	30.6	30.5	31.8	32.6	32.9	41.2	48.1	48.3	54.2	61.5	59.1	59.5	57.2	53.6	49.2
1981	28.4	30.5	32.0	32.8	33.8	35.4	39.3	43.5	49.7	53.0	52.8	59.8	57.0	53.2	48.6
1982	27.8	30.7	32.7	32.3	32.8	34.9	41.6	46.5	50.9	50.2	61.4	59.9	54.5	49.8	45.2
1983	27.3	27.7	27.2	28.3	31.1	35.2	42.8	51.5	52.3	58.0	66.1	64.5	60.1	55.4	50.6
1984	28.6	27.9	28.0	28.3	29.6	33.0	32.1	46.5	48.1	50.0	61.0	64.0	61.3	57.2	52.2
1985	23.5	23.7	23.5	23.5	24.8	29.5	33.7	42.8	49.9	52.5	60.3	62.7	61.0	57.4	52.5
1986	25.3	24.6	23.3	22.8	24.1	28.6	29.9	45.4	45.4	52.8	61.7	63.6	61.2	57.2	52.1
1987	21.0	22.2	22.8	23.4	24.7	27.9	38.5	46.8	48.7	51.3	68.0	63.0	63.4	60.8	56.1
1988	22.1	21.6	20.9	20.3	20.3	24.0	32.1	48.9	50.2	51.5	62.7	66.5	65.4	61.8	56.5
1989	19.9	20.8	20.4	19.2	20.0	24.2	29.3	38.5	48.9	49.2	57.3	58.5	61.0	59.3	54.9
1990	16.9	16.8	16.2	14.1	15.0	20.8	29.5	38.5	50.3	48.7	59.5	63.6	63.5	60.5	55.5
1991	13.8	14.1	14.2	14.7	16.0	18.3	29.3	37.1	49.2	51.0	56.5	61.8	61.3	58.1	53.3
1992	14.0	14.1	14.9	14.9	15.2	19.1	26.0	39.5	43.3	53.8	54.3	61.6	62.0	59.3	54.6
1993	13.4	13.8	14.1	14.3	15.7	18.9	27.7	35.0	44.8	46.9	55.9	61.1	64.4	62.7	58.0
1994	12.1	12.0	12.1	12.4	14.0	20.7	22.1	34.1	42.8	55.1	58.5	62.9	69.8	67.7	62.5
1995	11.7	11.7	11.7	13.1	14.2	17.3	20.6	30.5	42.6	47.9	55.2	58.8	63.8	62.8	58.4
1996	9.9	11.4	12.8	13.8	14.5	16.9	21.4	29.0	36.8	46.1	57.0	55.9	62.4	61.9	57.8
1997	8.5	10.0	11.2	11.8	12.9	15.4	24.1	30.1	37.0	49.9	56.9	57.9	65.2	63.7	59.1
1998	8.5	9.5	10.4	10.9	12.1	13.4	20.8	27.8	34.1	49.2	54.3	61.2	62.9	60.8	56.0
1999	9.5	9.9	10.6	11.1	12.0	15.1	17.8	28.6	32.5	43.9	50.9	62.6	65.5	63.9	59.2
2000	9.3	10.1	10.2	10.2	11.5	13.8	18.9	27.0	29.9	46.2	53.5	59.8	68.0	66.5	61.6
2001	10.5	10.9	10.7	10.4	10.6	12.4	15.8	23.1	31.8	43.0	58.6	59.4	65.7	63.7	58.8

Table 6. Estimates of per capita individual at-home consumption of fresh fish by age, 1979 to 2001

(kg/year)

Age	0-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-
1979	8.9	11.3	11.6	11.8	12.4	13.0	13.8	13.3	14.7	19.8	19.6	20.8	19.5	17.2	14.8
1980	7.9	10.1	10.4	10.9	12.0	13.2	15.4	15.4	17.7	19.3	20.4	20.3	18.5	16.1	13.8
1981	7.9	10.4	10.7	10.8	11.2	12.1	13.8	14.3	15.7	19.3	19.8	20.6	18.1	16.0	13.8
1982	7.5	9.9	9.6	9.2	9.4	11.3	13.0	14.3	15.2	19.5	20.8	19.0	18.9	17.2	15.1
1983	7.5	10.2	10.2	10.0	10.1	11.2	13.3	14.9	15.4	20.2	21.0	20.2	19.0	16.8	14.5
1984	6.5	8.8	9.1	8.7	9.2	12.3	13.9	15.8	18.3	18.9	21.2	21.9	19.9	17.3	14.8
1985	6.5	8.3	8.3	8.6	9.3	10.9	12.5	16.6	17.7	19.2	20.6	20.3	20.0	18.0	15.7
1986	5.7	7.7	8.0	8.6	9.3	11.2	13.3	16.5	18.2	20.5	21.7	18.6	18.6	17.0	14.9
1987	5.7	7.7	7.7	7.3	7.5	10.3	12.2	15.9	18.9	18.9	19.9	20.3	18.5	16.1	13.8
1988	4.9	6.5	6.6	6.6	6.6	10.9	12.6	16.9	19.2	19.4	20.5	20.3	19.0	16.7	14.4
1989	6.0	7.9	7.7	7.5	7.5	8.6	10.6	14.0	18.7	19.4	19.4	20.4	19.1	16.9	14.5
1990	5.2	6.8	6.8	6.6	6.7	8.5	11.0	14.6	18.3	19.1	19.0	20.2	18.5	16.2	13.9
1991	4.4	5.9	6.0	6.4	6.6	9.3	11.9	14.6	18.7	20.0	19.9	19.2	19.3	17.7	15.4
1992	4.8	6.3	6.6	7.2	7.6	7.9	11.6	14.8	19.1	20.5	21.1	21.2	20.6	18.4	16.0
1993	4.8	6.2	6.1	6.4	6.7	8.0	10.9	14.7	19.8	21.2	21.5	20.8	21.3	19.6	17.2
1994	5.3	6.9	6.9	6.8	6.8	8.2	8.8	13.3	18.3	21.6	20.7	20.2	19.8	17.8	15.5
1995	5.2	7.0	6.9	6.8	6.4	7.0	8.4	11.5	18.8	21.6	22.0	20.1	19.7	17.8	15.5
1996	4.1	5.5	5.5	5.7	6.0	6.7	8.2	12.7	17.0	20.8	22.5	20.8	19.9	17.7	15.3
1997	4.2	5.7	5.8	5.8	5.9	6.4	8.1	12.6	16.1	21.3	22.1	22.2	20.1	17.4	14.9
1998	4.1	5.5	5.5	5.6	6.0	6.8	8.0	12.0	16.3	20.5	22.0	20.9	19.8	17.6	15.2
1999	4.1	5.3	5.2	5.2	5.7	6.7	7.7	11.0	15.6	18.9	21.4	21.0	20.4	18.4	15.9
2000	3.6	4.9	5.0	5.1	5.4	5.8	7.3	12.3	13.5	22.0	23.0	20.8	20.5	18.6	16.2
2001	4.0	5.5	5.6	5.6	5.7	5.5	6.6	10.7	13.0	18.7	21.3	20.4	19.9	18.0	15.6

estimated parameters were obtained.

Estimates of per capita individual (at-home) consumption of fresh fruit and fresh fish are presented in Tables 5 and 6, respectively. When compared to the estimates by Mori and Inaba [20]; Mori [22]; and Mori and Gorman ([23]: Appendix Tables 1, 2, and 3), the crucial differences lie in the estimates for children under 15 years of age. The current estimates are substantially larger for children under 10 and in the low-teens than the previous estimates by means of the "quadratic programming method" without proper weights. Accordingly*, estimates for young adults in their 20s, 30s and the early 40s are somewhat larger in the previous analyses (*recall that the basic structure of the model is that children's consumption + their parents' consumption ≈ household consumption).

As mentioned earlier, Mori [22] and Mori and Gorman [23] suspected that per capita individual consumption by children was underestimated in their analyses. The only remedy they had at their discretion was the condition of non-negativity in individual consumption. When judged "unreasonable" by common sense, they refrained from making their estimates public.

In this study, we introduced weights in regression and, more important, we used objective criteria by which to manipulate the weights assigned to the system of equations, which is essentially the same as the (revised)* Mori and Inaba model in structure (*with the assumption of zenshinteki henka between successive age groups).

5. Conclusion and Suggestions for Future Research

Using our revised estimating method, the estimates of per capita individual consumption by non-adults are substantially larger and those for the younger adults somewhat smaller in our present study than in previous studies. It seems, nevertheless, quite apparent that Japanese children and young adults have decreased their at-home consumption of fresh fruit and fresh fish substantially in recent years. Those older than 50 years of age, on the other hand, seem to have maintained their consumption at relatively high levels.

The Japanese population has been aging very rapidly and this tendency is expected to continue at an even faster pace. In 2020, people older than 60 years of age will account for 33.7 percent of the total population, compared to 17.4 percent in 1990 (Social Security and Population [15]). Can one rightly anticipate that total consumption, either of fresh fruit or fresh fish, will grow or, at least, stop declining in the future, since older people are found to eat much more than the young (Tables 5 and 6)? To answer this question squarely, we need to decompose the past changes in individual consumption by age into chronological age and generational effects plus time element.[6] Cohort analysis could provide a useful device for this end. However, using questionable data in cohort models, no matter how sophisticated the models may be, will not produce meaningful insight (Matsuda and Nakamura [17]; Blisard [2][7]). The methods of deriving individual consumption by age should be further developed to furnish more dependable data for future cohort analyses.

1) Due to the short period covered by his analyses, generational cohort aspects were not successfully revealed.
2) Chesher "revealed" the age relationships in intakes of various nutrients in UK, analyzing household food acquisition data, 1974-94 [3]).
3) Ishibashi uses 8000 (per month) times 12 (months) = 96,000 samples per year for her analyses. And yet, her estimates of individual consumption for the younger age groups of certain food products — some fresh fruits and vegetables in particular — are questionable, showing extremely low, almost near zero consumption, or even carrying negative signs ([8] [12]).
4) It is legally prohibited to transfer even part of the micro-data to overseas researchers (Ishibashi [10]).
5) With our current data set, it has proved al most impossible to keep all the residuals, $|e_i^*|$ below 1.95.
6) A group of researchers at ERS, U.S. Department of Agriculture, combined projected demographic changes, including age distribution of the population, with an assumed increase of per capita income to predict food expenditures and consumption of food commodities to 2020 (ERS [5] [6]). They assumed, "as demographic circumstances change, consumers will acquire the expenditure patterns of individuals already

Appendix Table 1. *T*-statistics for estimates of per capita individual consumption of fresh fruit by age, 1979 to 2001

Age	0-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-yrs.
1979	7.23	8.27	9.57	12.37	19.32	12.44	10.13	13.26	18.47	34.72	46.21	39.88	29.18	23.42	13.50
1980	6.89	7.57	8.92	11.50	18.02	11.81	11.59	12.76	18.70	39.90	53.13	43.55	30.66	24.50	14.24
1981	6.82	8.10	9.44	11.29	18.27	10.97	10.23	12.34	18.52	33.75	41.41	41.33	30.34	24.18	13.91
1982	6.04	7.20	8.19	9.58	15.18	9.79	9.67	11.70	16.13	26.38	49.79	40.18	25.92	20.33	11.45
1983	5.37	6.05	6.39	8.18	12.96	9.01	9.09	12.12	15.66	29.28	52.67	37.82	26.38	20.86	11.82
1984	8.62	9.60	10.00	12.07	19.09	12.92	10.57	17.03	21.95	37.12	74.73	61.71	41.99	33.72	19.07
1985	5.19	5.98	6.49	7.50	11.77	8.84	8.15	11.90	17.25	29.09	53.58	48.93	31.18	25.92	15.28
1986	5.99	6.47	6.44	7.74	12.29	9.17	7.64	13.06	15.35	30.81	59.37	58.78	33.81	28.02	16.46
1987	4.56	5.30	5.95	7.47	11.32	8.20	8.93	12.45	15.94	27.35	57.67	51.36	30.75	26.11	15.53
1988	5.99	6.64	6.96	8.23	11.26	8.90	9.39	16.74	21.05	34.78	67.33	77.98	40.75	34.25	20.15
1989	4.13	4.89	5.37	6.03	8.50	6.76	6.70	9.80	17.09	26.97	47.23	53.69	30.36	24.71	15.14
1990	3.17	3.51	3.84	4.05	5.67	5.30	6.00	8.77	15.81	24.02	44.65	55.50	29.12	23.26	14.12
1991	3.53	4.00	4.59	5.55	8.47	6.36	8.05	11.41	20.86	34.09	57.65	73.71	39.01	31.05	18.84
1992	3.60	3.91	4.38	5.41	7.93	6.65	7.15	11.92	16.29	35.52	53.90	69.91	37.63	30.14	18.38
1993	2.89	3.34	3.89	4.88	7.32	6.25	6.48	9.28	17.56	28.12	49.24	64.30	34.97	28.50	17.18
1994	2.45	2.73	3.08	4.00	6.60	6.21	4.89	8.41	14.96	32.65	52.18	65.19	35.49	30.26	18.13
1995	2.27	2.57	2.82	3.62	5.82	5.03	4.42	7.23	14.46	24.16	43.11	55.52	30.93	25.53	15.47
1996	1.76	2.23	2.74	3.81	5.79	4.71	4.40	6.23	10.83	22.61	41.88	44.86	25.64	23.82	14.14
1997	1.61	2.06	2.61	3.65	5.58	4.64	5.19	6.81	11.57	27.65	46.59	50.97	28.67	27.04	15.91
1998	1.89	2.30	2.81	3.74	6.21	4.71	5.23	7.33	12.26	31.42	51.71	63.60	35.35	31.35	18.47
1999	2.23	2.47	2.80	3.65	6.22	5.61	4.79	7.99	11.51	26.08	46.21	63.26	35.42	33.02	19.44
2000	1.72	2.01	2.20	2.84	4.64	4.10	4.01	6.01	8.66	22.85	39.06	47.62	26.77	26.34	15.39
2001	2.60	2.97	3.27	4.00	5.24	4.98	4.51	6.89	13.03	28.73	58.29	67.64	36.89	36.45	21.24

observed in those circumstances" (ERS [5] p. 30) and that "as any individual moves from one demographic group to another, his/her preferences immediately take on the characteristics of the new group. For example, the younger age group will assume the eating habits of older age groups as they age" (ERS [6] : p. 14). In short, cohort effects, if any, are not taken into account in their projections.

7) Blisard, "following the lead of Deaton and Paxson", assumes no time trend in his cohort analysis of (U.S.) food expenditures from 1982 to 1995 ([2] : p. 2). Skinner mildly, and rightly, criticized Deaton and Paxson for their cohort analysis of saving in Taiwan from 1975 to 1990, by referring to the saying, "the rising tide raises all boats, or at least boats of all ages." ([28] : p. 360).

References

[1] Ando, A. and A. B. Kennickell. "How Much (or Little) Life Cycle Is There in Micro Data? The Case of the United States and Japan," in R. Dornbush, S. Fisher and J. Bossons, eds., *Macroeconomics and Finance*. MIT Press, 1985.

[2] Blisard, N. *Income and Food Expenditures Decomposed by Cohort, Age, and Time Effects*. ERS, Tech. Bull. #1896, USDA, 2001.

[3] Chesher, A. "Diet Revealed? : Semiparametric Estimation of Nutrient Intake—Age Relationships," *Journal of The Royal Statistical Society, Series* A, Vol. 160, Part 3, 1997, pp. 389-428.

[4] Deaton, A. and C. Paxson. "Saving, Growth, and Aging in Taiwan," in D. A. Wise, ed., *Studies in the Economics of Aging*. Chicago University Press, 1994.

[5] ERS, U. S. Department of Agriculture. *Food and Agricultural Commodity Consumption in the United States: Looking Ahead to 2020*, Agricultural Economic Report, #820, February, 2003.

[6] ____. *Food Expenditures by U.S. Households: Looking Ahead to 2020*. Agricultural Economic Report, #821, February, 2003.

[7] Huber, P. J. *Robust Statistics*. New York : John Wiley & Sons, 1981.

[8] Ishibashi, K. "Demand Forecast and Trends in Vegetable Consumption," *Japanese Journal of Farm Management*, Vol. 35, No. 1, 1997, pp. 32-41.

[9] ____. "Changes in Japanese Dietary Patterns by Age : Is 'the Japanese Style' Disappearing?" *National Agricultural Research Center Rural Economic Research*, Vol. 36, 1997, pp. 17-

Appendix Table 2. *T*-statistics for estimates of per capita individual consumption of fresh fish by age, 1979 to 2001

Age	0-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-yrs.
1979	6.95	7.79	8.87	11.81	21.70	12.84	10.68	10.08	13.54	36.18	46.28	42.97	29.37	22.14	12.56
1980	5.24	6.05	7.09	9.08	17.27	11.08	10.23	10.21	15.21	29.24	43.02	34.72	23.30	17.35	9.74
1981	6.13	7.16	8.14	10.50	18.58	11.91	10.62	10.77	14.54	34.35	51.58	40.81	26.18	21.09	11.64
1982	5.12	5.98	6.45	8.03	13.17	9.79	8.81	9.51	12.33	31.04	49.71	36.52	26.03	20.43	11.41
1983	6.21	7.33	8.22	10.44	17.03	9.01	9.09	12.12	15.66	29.28	52.67	37.82	26.38	20.86	11.82
1984	3.43	4.24	4.86	5.70	8.74	8.14	7.38	8.39	12.32	23.07	33.90	30.49	19.75	14.79	8.16
1985	5.43	6.49	7.15	8.88	15.41	12.09	10.58	14.67	18.99	34.66	59.47	49.95	32.40	25.86	14.89
1986	3.37	4.21	4.92	6.44	10.77	8.75	7.99	10.34	13.94	26.76	43.16	34.32	21.10	17.08	9.90
1987	3.61	4.61	5.37	6.12	9.91	8.49	7.83	10.76	16.23	27.76	46.33	44.06	24.17	18.67	10.56
1988	4.09	5.16	6.19	7.38	11.88	11.61	10.66	15.07	22.10	38.06	65.50	66.43	34.58	27.15	15.42
1989	5.25	6.20	7.14	8.19	12.64	9.98	9.30	12.42	22.66	38.41	60.21	69.80	35.60	26.33	15.36
1990	3.42	4.07	4.74	5.45	8.51	7.45	7.32	9.82	16.55	28.41	44.38	51.48	25.65	18.79	10.93
1991	3.73	4.53	5.60	6.97	10.12	10.03	10.10	12.60	22.39	39.05	61.83	70.34	37.33	28.59	16.98
1992	4.82	5.71	7.18	9.80	14.78	10.66	11.68	15.28	27.48	49.29	76.91	87.45	44.55	33.48	19.69
1993	4.19	4.87	5.78	7.67	11.95	10.42	9.65	13.35	26.41	45.78	69.04	77.67	40.89	31.47	18.44
1994	4.16	4.80	5.52	7.03	11.00	9.52	7.12	10.59	20.19	40.78	59.95	68.20	34.37	25.99	15.13
1995	4.40	5.27	6.06	7.75	10.45	8.56	7.29	9.87	22.91	44.57	65.67	70.86	36.42	27.56	16.04
1996	2.59	3.11	3.62	4.98	7.87	6.44	5.60	8.17	15.01	33.03	53.22	53.43	26.58	21.73	12.29
1997	2.68	3.28	3.86	5.15	7.95	6.28	5.65	8.25	14.33	34.85	53.65	58.52	27.64	21.96	12.27
1998	2.86	3.39	3.90	5.10	8.80	7.06	6.00	8.45	15.45	35.17	57.59	59.65	29.60	24.12	13.63
1999	3.29	3.79	4.31	5.67	9.48	8.61	6.75	9.12	17.26	36.28	63.28	68.51	34.55	29.82	16.83
2000	2.78	3.24	3.69	4.98	8.19	6.92	6.04	9.58	13.14	34.17	60.49	60.54	31.30	27.09	15.37
2001	3.71	4.41	5.16	7.00	10.81	7.96	6.62	10.04	16.02	40.49	71.90	76.29	38.58	33.33	18.84

31.

[10] ____. Chief, Marketing Research Section, National Research Institute of Agricultural Economics, Personal communication, 1998.

[11] ____. "Structural Changes in Household Beef Consumption Following the Trade Liberalization, with Emphasis on Household Types and Age Factors," *Quarterly Journal of Agricultural Economics*, Vol. 52, No. 4, 1998, pp. 1-35 (in Japanese).

[12] ____. "Nenreikaikyubetsu Shouhiryou no Suitei — Kakeichousa Kohyoudeta wo Shiyoushite (Estimating Individual Consumption by Age, Using Panel Data)," Chap. 7 in H. Mori ed., *Cohort Analysis of Japanese Food Consumption : New and Old Generations*. Tokyo : Senshu University Press, 2001.

[13] Japanese Government, Bureau of Statistics. *Family Income and Expenditure Survey*. various issues.

[14] Japanese Government, Ministry of Health and Welfare. *Present Status of National Nutrition*. various issues.

[15] Japanese Government, National Research Institute of Social Security and Population. *Estimates of Future Population in Japan*. January, 2002.

[16] Lewis, M. A. "Estimating Japanese Per Capita Consumption of Selected (Food) Products by Age Groups, 1979-1995," Master Thesis in Agricultural Economics, New Mexico State University, Las Cruces, NM, July, 1997.

[17] Matsuda, T. and T. Nakamura. "Analysis of Rice Consumption in Household : Using the Data Classified by Age of a Head of Household," *Journal of Rural Economics*, Vol. 64, No. 4, 1993, pp. 213-220.

[18] Minotani, C. Keiryoukeizaigaku Niokeru Gannken Suitei (*Robust Estimation in Econometrics*). Tokyo : Taga-Shuppan, 1992.

[19] Modigliani, F. "Life Cycle, Individual Thrift, and the Wealth of Nations," in *Macroeconomics and Finance*, op. cit., 1985.

[20] Mori, H. and T. Inaba. "Estimating Individual Fresh Fruits Consumption by Age," *Journal of Rural Economics*, Vol. 69, No. 3, 1997, pp. 175-185.

[21] Mori, H., D. L. Clason, J. Dyck and Wm. D. Gorman. "Age in Food Demand Analysis : A Case Study of Japanese Household Data by Cohort Approach," Chap. 10, in H. Mori, ed., *Cohort Analysis of Japanese Food Consumption*, op. cit., 2001.

[22] Mori, H. "Analysis of Consumption of Se-

lected Foods and Alcoholic Beverages, by Age, 1979-1996," *Senshu (U) Economic Bulletin*, Vol. 30, No. 3, 1998, pp. 131-162.

[23] Mori, H. and Wm. D. Gorman. "A Cohort Analysis of Japanese Food Consumption : Old and New Generations," *Senshu (U) Economic Bulletin*, Vol. 34, No. 2, 1999, pp. 71-111.

[24] Mori, H., E. G. Lowe Ⅲ, D. L. Clason and Wm. D. Gorman. "Cohort Analysis of Food Consumption : A Case of Rapidly Changing Japanese Consumption," *International Food and Agribusiness Management Review*, Vol. 3, 2000, pp. 189-205.

[25] Morishima, S. "Sedaibetsu no Kome Jyuyou Bunseki" (Analysis of Demand for Rice by Generations)," Chap. 6, in S. Sakiura, ed., Kome no Keizai Bunseki (*Economic Analysis of Rice*). Tokyo : Nourin Toukei Kyoukai, 1984.

[26] Nakamura, T. "Bayesian Cohort Models for General Cohort Table Analyses," *Annals of the Institute of Statistical Mathematics*, Vol. 38, Part B, 1986, pp. 353-370.

[27] Sawa, T. Kaiki Bunseki (*Regression Analysis*). 12 th Print, Tokyo : Asakura Shoten, 1995.

[28] Skinner, J. "Comment" on the Presentation by Deaton and Paxson, " Saving in Taiwan," op. cit., 1994, pp. 358-361.

[29] Tanaka, M. "Kakeichousa-data o Mochiita Cohort Bunseki" (A Cohort Analysis, Using *Family Income and Expenditure Survey* Data), *Sougou Kenkyu*, No. 21, 2002, pp. 161-173.

[30] Tokoyama, H. and F. Egaitsu. " Major Categories of Changes in Food Consumption Patterns in Japan," *Oxford Agrarian Studies*, Vol. 22, No. 2, 1994.

[31] Tokoyama, H. "The Relationship between Trends and Income Elastcities in Food Consumption Structure : An Attempt to Quantitatively Define 'Maturity' in Food Consumption," *Journal of Rural Economics*, Vol. 67, No. 1, 1995, pp. 10-19.

(Received September 17, 2003 ; accepted February 12, 2004)