Age-Free Income Elasticities of Demand for Foods : New Evidence from Japan

Hiroshi Mori, Kimiko Ishibashi, Dennis Clason, and John Dyck

1. Introduction

Many factors influence food purchasing behavior by households, but economists have most often focused on the role of income and prices in helping determine purchases and diet. However, income and price effects are not isolated from other variables, and empirical measurements and observation have long shown that the levels of income and price elasticity for a given food vary both across parts of the world and over time. Rice consumption per person, for example, began to be negatively associated with income changes in the late 1960s in Japan and around 1985 in South Korea (Chino, 2005; Ito, Wesley, Peterson, and Grant, 1989; Han, 2005), after centuries of positive correlation between changes in income, wealth, and rice consumption. This is not an aberration: in projecting food demand in one country for a very long period time such as a half a century, or food demand across countries of different stages of economic development, it is essential to consider the stage of economic development reached by different parts of the world, and the movement of countries from one stage to another (Seale, Regmi, and Bernstein, 2003).

The 20th century witnessed the transformation of major parts of the world's population from rural, subsistence-farming households to urban, wage-earning households. That transformation (which continues) was associated with substantial changes in household food purchase patterns. In the 21st century, it appears that demographic transformations related to, and building on the shifts of the 20th century will have important impacts on food consumption. The decrease in fertility and the increase in average life span that have occurred over most of the world in the second half of the 20th century are leading to a slowing of population growth and a higher average age of the population in the 21st century. In most countries, it behooves us to ask the question, how does the aging of the population affect food consumption? Among the developing countries, these demographic shifts accompany continuing urbanization, and, in fortunate cases, strong economic growth. However, an important subset of countries has emerged that may merit the static term "developed." In a few of these countries in Asia and a larger number in Europe, both the population and the economy have been showing slow or negative growth over the last 15 years. While changes in total population, urbanization, and GDP have been small and gradual, the change in the age profile of these countries has been rapid and profound. They may provide good laboratories for teasing out the effects on expenditures that accompany an aging population. Luckily, these same countries have relatively detailed and robust surveys of expenditure. Japan offers both a leading example of aging and a wealth of statistical detail, and is the case which this article examines.

Societal aging is a complex phenomenon. Not only do individuals live longer, but the average age of the population rises. Urbanization had both physical implications for calorie demand (in general, urban residents burn up fewer calories in a day than do subsistence farmers) and offered greater access to a larger variety of purchased foods. Similarly, aging changes the amount of food a body demands, and also shifts the way individuals purchase or prepare food. Furthermore, there is good reason to expect that food tastes and purchase patterns differ by generations (see below, and also Morishima, 1984; Ishibashi, 1997; Mori, eds., 2001).

In an economy where people's basic needs are met not only in nutritional intake but also in respect to variety, consumers' food preferences can vary appreciably by age and birth cohorts (or generation). When people's food demand is affected by such age factors to a non-negligible extent, estimates of income elasticities of demand could be severely biased, unless these factors are explicitly recognized in analysis. This may particularly be the case with Ja-

Table 1 Monthly wages[1] of male workers by age, 1985 and 1995 (all firms employing 10 or more workers)

	1985	1995
High-school Graduates	100yen/month	100yen/month
25 years old	1,635	2,122
30	2,099	2,611
40	3,132	3,695
50	4,238	5,077
55	3,837	5,171
College Graduates	100yen/month	100yen/month
25 years old	1,668	2,266
30	2,213	2,866
40	3,602	4,528
50	5,081	5,657
55	5,742	6,192

1: Median figures of regular wages paid in June, excluding overtime payments.
Source: Magota,R. "Wages and Lifetime Livelihood Guarantee", p.87, 1997.

Table 2 Wage disparity by age, 1980, 1988 and 1998 —the case of male college graduates (the ratios of 50-54 years old with 30+ years sevice/25-29 years old with 5-9 years service)

	Regular Wages			Bonus Payment	
	1980	1988	1998	1988	1998
All industries	2.36	2.60	2.29	3.25	2.71
Construction	2.45	2.62	2.42	2.81	2.96
Manufacturing	2.58	2.63	2.36	3.25	2.96
Transportation-Communication	1.95	2.52	2.36	2.78	2.50
Finance-Insurance	2.61	2.48	2.15	2.80	2.37
Wholesaling-Retailing	2.37	2.54	2.16	3.21	2.47

Source: Nakamura, A. "Analysis of Wage Statistics," p.263, 2001.

pan, where age is highly correlated with income in cross-section samples. In Japan, job seniority plays an important role in determining wages in the labor market; for example, male college graduates in their early 50s with 30 plus years service earned 2.6 times more wages on average than those in their late 20s with 5-9 years service in 1988 (see Tables 1 and 2 for details). Since household consumption of most food products in Japan varies to a noticeable extent by the age groups of the household heads, disentangling the connections of income and age to food consumption may be important (see Lewis Hendrickson, et al., 2001).

Recent issues of the Bureau of Statistics' *Family Income and Expenditure Survey* (*FIES*) reports, calculate and print elasticities of expenditure on each item with respect to total living expenditure, using broader categories (e.g., fresh meat and fish) rather than individual products of beef and pork (see Table 3). These elasticities are all positive, even for rice. However, it

Table 3 Estimates of elasticity of expenditure on selected food groups to living expenditure, 2000 and 2003, as reported by *FIES*

	2000		2003	
	Elasticity	T-value	Elasticity	T-value
All food	0.63	30.44	0.66	30.47
Rice	0.31	8.34	0.21	4.89
Bread	0.67	10.92	0.67	12.46
Noodles	0.41	5.87	0.48	8.93
Fresh fish and shell fish	0.54	10.52	0.51	9.53
Fresh meat	0.74	19.03	0.75	19.47
Fluid milk	0.54	12.75	0.57	15.48
Eggs	0.51	11.72	0.52	11.16
Fresh vegetables	0.50	15.20	0.46	12.32
Fresh fruit	0.41	4.60	0.31	4.44
Eating-out	1.19	14.52	1.31	16.64
Alcoholic beverage	0.43	6.48	0.56	8.30

Sources: Bureau of Statistics, *Family Income and Expenditure Survey,* 2000 and 2003, Appendix Table 4.

is commonly accepted that the income elasticity of rice and a number of other goods, including fresh vegetables has been negative for some times. Why don't the *FIES* estimates confirm this, or isn't the common notion objectively conceived? If older Japanese, more specifically the older cohorts, consume more rice and fresh vegetables, respectively than the young (Ishibashi, 1997 and 2004; Mori, et al., 2004), it may be that the simple cross-sectional regression with no regard for age factors would produce positive coefficients. This is because households headed by older persons before retirement in Japan have, on average, much higher income per person than households headed by younger persons.

2. Structure of the Paper

In the following sections, we try to isolate the impact of the age factors on food consumption and then determine the elasticity of demand for certain foods with respect to household expenditure level, controlling for the age factors. We first use cross-section approaches, and then time-series approaches. Taking advantage of a very large sample, we move progressively from examining household consumption across subsets provided by the panel data to using cohort techniques to per capita individual consumption by age, always trying to increase our evidence about the impact of different income levels on food consumption. More specifically, in conducting cross-sectional analysis in Section 3, we classify the panel data of household food consumption by household types provided by the survey data structure, such as households containing a married couple in their 30s and two children aged under 10; a married couple in their 60s with no child; etc. In conducting time series analysis (over the past 20 years) in Section 4, we first follow the traditional approaches of using per capita consumption data obtained by simple division (dividing household consumption by the number of persons within the household) to look at income effects. Next, we derive individual consumption by age, incorporating household composition matrices by household head. By applying a Bayesian cohort model to the time-series consumption data organized by age, we determine "pure time effects" in consumption changes since the early 1980s that are independent of both age and cohort effects. In Section 5 we compare the estimates obtained from both cross-sectional and time-series approaches, with and without controlling for age, and discuss the plausibility of the signs and magnitudes of income elasticities that we derive for selected products.

Mori, Tanaka, Inaba, and Ishibashi (2005) and Mori, Clason, and Lillywhite (2006) estimated price elasticities of demand for apples and mandarin oranges while controlling for age-cohort effects in Japan, following the initial lead of Matsuda and Nakamura (1993). In the case of apples, they succeeded in obtaining an economically plausible, negative sign for own price elasticity, instead of the positive coefficients obtained when age variables were not used.

In this article, we focus on income effects for a broader set of commodities. Several technical refinements, though minor in nature, were undertaken in deriving per capita individual consumption from the household data and also in decomposing individual consumption into age, period, and cohort effects.

To summarize, these are the steps taken to analyze income effects on consumption:

1. Regress consumption per person against household income per person in each year of the sample (cross-section)
2. Regress consumption per household against household income for households of similar age and structure in each year of the sample (cross-section)
3. Regress average consumption per person against household expenditure (as proxy for income) per person over the years of the sample (annual time-series)
4. Derive individual consumption by age, using family composition matrices from the panel data
5. Decompose changes in consumption per person into age, cohort, and time effects
6. Regress grand mean plus time effects against average household expenditure per person over the years of the sample (annual time-series)

3. Analysis of Panel Data

a. Data sources

The Bureau of Statistics of the Government of Japan has conducted year-round surveys of household purchases of various goods and services, including housing and education, since the late 1940s. Approximately 8,000 chosen urban households across the country, excluding single person households[1], are requested to keep daily accounts of all transactions, both in money and kind (the books are collected monthly) over a six month period. One sixth of the households are replaced each month. The Bureau publishes the compiled results in monthly and annual reports on the (*Family Income and Expenditure Survey*) *FIES*.

The products chosen for this study are rice, fresh pork and fresh beef (pork and beef hereafter), and aggregate fresh fruit. The *FIES* provides information about at-home consumption of these foods. Increasingly, food consumption in Japan has shifted to eating more away from home, purchasing more cooked or semi-finished products to take home, or having food delivered at home. The *FIES* does not tell us how much rice, meat, and fruit the survey households consume from such sources, and counts only expenditures on food purchased in stores for cooking or preparation at home. It is estimated that (direct) household consumption accounts for 46.6 % of rice consumption, and 42 %, and 34 % of pork and beef, respectively in 2002 (MAFF, 2004). It is likely that most fresh fruit, except for some minor varieties for confectionaries, is consumed at home.

The panel data survey approximately 8,000 households for 12 months, or 96,000 households each year. In practice, it is impossible to follow an individual household's reports across the 6 months in which it is in the survey. As noted above, one sixth of the households are rotated in/out each month. We treat each month's data as essentially independent from those of the other months. Since none of the products selected for our analysis exhibits distinct seasonality, we analyze 12 months of data, approximately 96,000 households each year, in the following investigations.

In filling out the questionnaire, each household is requested to report annual income by all members of the household earned during the past 12 months, which does not include imputed income to owned housing and use of personal savings.[2] Monthly household purchases are regressed against income for the preceding year (not for the particular month).

Apparent "outliers" in monthly purchases are problematic. For example, one household purchased 360 kg of rice in one month, compared to the average 15.3 kg purchase for all households of the same type in that month. The monthly purchase amount of 360 kg could possibly be an error in reporting or data entry, or very likely reflect gift uses for distant friends and relatives. Fresh fruit data often reflect likely purchases of local fruits in season for shipment to friends in other cities. Beef and pork data raised few concerns. In order not to bias estimates, such outliers should be eliminated beforehand. It is not easy, however, how to delineate normal and abnormal observations in the panel data we have at our disposal. Since criteria for outliers such as Smirnov and Grubb's tests proved not very efficient for our data[3], we excluded those data with purchases more than 3 times the median of observations within each household category. In the case of rice, we calculated the median purchase while excluding zero purchases (because a number of Japanese households purchase rice in large amounts only every two, or possibly three months, zero purchase of rice rarely implies zero consumption for rice)[4].

1. In July 1999, the households engaged in agriculture, forestry and fisheries were included in the coverage of Survey but were independently tabulated until the end of the year. In this investigation, we selected only urban households for analysis. In January 2002, the households of one-person were incorporated into the coverage of *FIES*. These households had been independently surveyed by the *Income and Expenditure Survey for One-person Households* from 1995 through 2001.
2. Most cross-sectional analyses apply dummy variables representing demographic factors such as family size and composition, using panel data (Dong, Shonkwiler, and Capps, Jr., 1998; Perali and Chavas,

2000). We classify the data by the types of household first, since we have quite large number of samples and partly because income as reported by *FIES* is not the same in content as stated in the text (the imputed rent to the residence owned and the drawings from the saving are not counted which should account for large portion of actual expenditures by those retired households in their 60s, for example.

3. Grubbs' test detects one outlier at a time. This outlier is expunged from the data-set and the test is iterated until no outliers are detected.

4. Dong, Shonkwiler, and Capps(1998) suggest that "the appropriate treatment of non-consuming households constitutes an area of research that requires careful and thoughtful analysis." (472). Perali and Chavas (2000) state, "the behavioral information contained in the observations with zero expenditures has significant econometric as well as economic implications." (1024). In the case of rice in Japan, however, the vast majority of households consume rice almost every day and zero expenditures on rice in particular months may simply manifest that they held sufficient stocks from purchases in the preceding months.

b. Basic model

For simplicity and the ease of interpretation, the following basic form is chosen:

$$\log v_i = a + b \log v_0 \quad \cdots\cdots(1)$$

or

$$\log q_i = a + b \log v_0 \quad \cdots\cdots(2)$$

where:

v_i is expenditure on the particular product, q_i is the quantity of the particular product purchased (= consumed), and v_0 is income.

Following the traditional approach taken by Prais and Houthakker (1971), we first regress monthly household purchases of the individual products—rice, pork, beef, and aggregate fresh fruit—against household incomes. Prais and Houthakker use household expenditure and quantity consumed per person[5] on/of a particular product against total expenditure (as proxy for income[6]) per person. Our first exercise simply regresses household demand per person for the selected four foods against household income per person in each year of our sample (i.e., a cross-section regression). Obtained results are in Tables 4-A and 4-B, and are discussed later.

Some careful studies adjust household data for household composition, incorporating "consumer units," or "(adult) equivalence scales" into their models (Wold, 1982, pp. 215-224; Prais and Houthakker, pp.139-145; Gardes, et al.,1996; Deaton and Paxson 1998; Kooreman and Wunderink, 1997). The next step in this study is to divide the households into subsets that are classified by the number and compostion of household members. For example, one household type is a married couple in their 30s with 2 children under 10. Regressions are then done on each subset for each year. In this exercise, data are not converted to a per-person basis, since the subsets already divide households into groups of the same number of members. Indicative results are discussed in the subsequent section 3d below.

5. Food is “almost entirely private (goods)”, the scope for economies of scale is likely to be very small (Deaton and Zaidi, 2002, 46-49).
6. In comparing household incomes of different size and composition, the problem of scale economies should be considered (Prais and Houthakker, op. cit., 146-152; Deaton and Zaidi, 2002, 46-51). In our subsequent analysis, however, the same size households are compared, by classifying the data by the type of households as mentioned in the text.

c. Cross-sectional analysis of the pooled households

Tables 4-A and 4-B show the income elasticity estimates for rice, pork, beef and fresh fruit, respectively, using the above forms (1) and (2)[7], for the calendar years, 1987, 1991, and 1999. The results in Table 4-A represent income elasticities of expenditure on the food product. Expenditure on a product reflects the price paid as well as the quantity purchased, and thus retains information about the quality, as well as quantity, of the food choice by the household. The results in Table 4-B correspond to the ordinary income elasticities of demand which relate to the physical amount of consumption (Stigler, 1966, p. 33; Friedman, 1976, p.45), without considering the quality/variety elements of the product. For our products, this can be im-

Table 4-A Estimates of income elasticities of at-home expenditures for rice, fresh pork, fresh beef, and fresh fruit, using pooled household data, 1987, 1991, and 1999

		Rice	Fresh Pork	Fresh Beef	Fresh Fruit
1987	Elasticities	−0.03(−1.44)	0.18(10.72)	0.35(19.38)	0.20(7.52)
	Adj. R^2	0.04	0.82	0.94	0.69
1991	Elasticities	−0.06(−1.94)	0.17(10.96)	0.29(21.08)	0.08(2.05)
	Adj. R^2	0.10	0.83	0.95	0.11
1999	Elasticities	−0.18(−4.42)	0.14(12.04)	0.18(8.10)	−0.06(−1.19)
	Adj. R^2	0.43	0.85	0.72	0.02

Table 4-B Estimates of income elasticities of at-home consumption (physical quantity) of rice, fresh pork, fresh beef, and fresh fruit, using pooled household data, 1987, 1991, and 1999

		Rice	Fresh Pork	Fresh Beef	Fresh Fruit
1987	Elasticities	−0.07(−2.92)	0.10(5.29)	0.25(19.57)	0.11(4.64)
	Adj. R^2	0.23	0.52	0.94	0.45
1991	Elasticities	−0.09(−3.12)	0.11(6.03)	0.24(15.57)	0.02(0.59)
	Adj. R^2	0.26	0.59	0.91	−0.03
1999	Elasticities	−0.22(−6.02)	0.10(9.54)	0.14(7.78)	−0.11(−2.31)
	Adj. R^2	0.59	0.78	0.70	0.15

Notes: (1) figures in parentheses denote t-values.

portant. For example, in Japan wagyu beef and imported beef or sirloin and ground beef have very different prices and uses. In terms of quantity, however, this analysis is forced to treat them as the same product.

All the elasticity estimates in Tables 4-A and 4-B, except for rice and fresh fruit, carry positive signs, with the parameter estimate significantly different from zero in most cases.

7. Data is converted into per capita basis, by dividing expenditure/quantity and incomes by number of household members in this sub-section, since we are dealing with all households of different sizes.

d. Panel data classified by household types

In a first assessment of the age factors in at-home food consumption, we selected the following four categories of household[8]: a married couple in their 30s and two children under 10 years of age; a married couple in their 40s and two teen-age children; a married couple in their 50s and a child in the 20s; and a married couple in their 60s with no dependents.

Tables 5-A and 5-B show the regression results by household type: elasticities of expenditure and of quantity of individual consumption with respect to annual income, for the same period as for Tables 4-A and 4-B. Notable differences between Tables 4-A&B and 5-A&B include:

- (1) the elasticities for fresh fruit in Tables 5-A and 5-B are positive in sign, with good statistical performance; and
- (2) with a few exceptions, elasticities for pork in Tables 5-A and 5-B are statistically not different from zero, when the data are broken out by these household types, whereas the coefficients (for pork) carry significantly positive signs with high R^2s in Tables 4-A and 4-B when no age factors considered.

Table 5-A Estimates of income elasticities of at-home expenditures for rice, fresh pork, fresh beef, and fresh fruit, 1987, 1991,and 1999
I : HH 30s with 2 children under 10

		Rice	Fresh Pork	Fresh Beef	Fresh Fruit
1987	Elasticities	−0.09(−0.95)	0.17(3.42)	0.33(5.20)	0.41(8.37)
	Adj. R^2	−0.01	0.47	0.54	0.79
1991	Elasticities	0.14(1.46)	0.13(1.83)	0.29(5.62)	0.39(10.43)
	Adj. R^2	0.09	0.14	0.59	0.84
1999	Elasticities	0.11(0.88)	0.19(3.50)	0.42(5.87)	0.52(9.82)
	Adj. R^2	−0.02	0.48	0.61	0.81

Table 5-B Estimates of income elasticities of at-home consumption (physical quantity) of rice, fresh pork, fresh beef, and fresh fruit, 1987, 1991, and 1999
I : HH 30s with 2 children under 10

		Rice	Fresh Pork	Fresh Beef	Fresh Fruit
1987	Elasticities	−0.15(−1.88)	0.02(0.43)	0.21(3.87)	0.36(6.74)
	Adj. R^2	0.19	−0.04	0.39	0.71
1991	Elasticities	−0.05(−0.78)	−0.02(−0.37)	0.15(2.66)	0.36(7.32)
	Adj. R^2	−0.02	−0.04	0.22	0.78
1999	Elasticities	0.08(0.68)	0.12(2.05)	0.30(4.37)	0.41(7.60)
	Adj. R^2	−0.05	0.21	0.44	0.72

Notes: (1) figures in parentheses denote t-values.

Table 5-A Estimates of income elasticities of at-home expenditures for rice, fresh pork, fresh beef, and fresh fruit, 1987, 1991,and 1999
II : HH 40s with 2 teenaged children

		Rice	Fresh Pork	Fresh Beef	Fresh Fruit
1987	Elasticities	−0.12(−3.02)	0.15(2.56)	0.46(7.26)	0.40(7.73)
	Adj. R^2	0.28	0.19	0.69	0.72
1991	Elasticities	−0.09(−1.35)	0.18(4.08)	0.31(5.42)	0.37(8.06)
	Adj. R^2	0.04	0.42	0.56	0.74
1999	Elasticities	0.15(0.81)	0.17(2.18)	0.21(2.24)	0.56(4.22)
	Adj. R^2	−0.03	0.26	0.17	0.60

Table 5-B Estimates of income elasticities of at-home consumption (physical quantity) of rice, fresh pork, fresh beef, and fresh fruit, 1987, 1991, and 1999
II : HH 40s with 2 teenaged children

		Rice	Fresh Pork	Fresh Beef	Fresh Fruit
1987	Elasticities	−0.19(−4.81)	0.12(1.74)	0.37(5.07)	0.30(5.40)
	Adj. R^2	0.51	0.12	0.51	0.55
1991	Elasticities	−0.17(−2.55)	0.09(2.30)	0.24(4.29)	0.32(5.77)
	Adj. R^2	0.23	0.16	0.44	0.59
1999	Elasticities	0.04(0.27)	0.07(1.07)	0.06(0.65)	0.38(3.86)
	Adj. R^2	−0.04	0.01	−0.03	0.56

Notes: (1) figures in parentheses denote t-values.

Table 5-A Estimates of income elasticities of at-home expenditures for rice, fresh pork, fresh beef, and fresh fruit, 1987, 1991, and 1999
III : HH 50s with 1 child in 20s

		Rice	Fresh Pork	Fresh Beef	Fresh Fruit
1987	Elasticities	−0.19(−1.68)	0.14(2.46)	0.23(3.42)	0.28(3.74)
	Adj. R^2	0.13	0.18	0.32	0.38
1991	Elasticities	−0.21(−2.96)	−0.04(−0.60)	0.24(2.30)	0.18(3.13)
	Adj. R^2	0.26	−0.03	0.16	0.21
1999	Elasticities	−0.10(−0.84)	0.05(0.88)	0.07(0.72)	0.30(4.13)
	Adj. R^2	−0.02	−0.01	−0.02	0.42

Table 5-B Estimates of income elasticities of at-home consumption (physical quantity) of rice, fresh pork, fresh beef, and fresh fruit, 1987, 1991, and 1999
III : HH 50s with 1 child in 20s

		Rice	Fresh Pork	Fresh Beef	Fresh Fruit
1987	Elasticities	−0.15(−2.48)	0.03(0.54)	0.14(1.88)	0.20(3.19)
	Adj. R^2	0.18	−0.04	0.10	0.30
1991	Elasticities	−0.26(−3.49)	−0.06(−0.73)	0.20(2.31)	0.14(2.18)
	Adj. R^2	0.34	−0.02	0.16	0.15
1999	Elasticities	−0.09(−1.33)	0.05(0.64)	−0.03(−0.19)	0.14(1.95)
	Adj. R^2	0.03	−0.04	−0.07	0.11

Notes: (1) figures in parentheses denote t-values.

Table 5-A Estimates of income elasticities of at-home expenditures for rice, fresh pork, fresh beef, and fresh fruit, 1987, 1991, and 1999
IV : HH 60s with no children

		Rice	Fresh Pork	Fresh Beef	Fresh Fruit
1987	Elasticities	−0.16(−3.23)	−0.04(−0.43)	0.42(6.05)	0.29(7.13)
	Adj. R^2	0.36	−0.09	0.64	0.89
1991	Elasticities	−0.02(−0.40)	0.05(0.89)	0.28(4.81)	0.37(10.14)
	Adj. R^2	−0.05	−0.02	0.47	0.89
1999	Elasticities	−0.02(−0.47)	−0.01(−0.33)	0.25(5.47)	0.29(4.71)
	Adj. R^2	−0.03	−0.04	0.54	0.59

Table 5-B Estimates of income elasticities of at-home consumption (physical quantity) of rice, fresh pork, fresh beef, and fresh fruit, 1987, 1991, and 1999
IV : HH 60s with no children

		Rice	Fresh Pork	Fresh Beef	Fresh Fruit
1987	Elasticities	−0.20(−4.08)	−0.08(−1.14)	0.32(5.22)	0.16(3.74)
	Adj. R^2	0.48	0.02	0.58	0.35
1991	Elasticities	−0.06(−1.10)	−0.05(−1.11)	0.20(2.60)	0.32(8.38)
	Adj. R^2	0.01	0.01	0.32	0.85
1999	Elasticities	−0.10(−1.76)	−0.07(1.71)	0.15(2.99)	0.23(4.06)
	Adj. R^2	0.08	0.07	0.35	0.51

Notes: (1) figures in parentheses denote t-values.

8. The nuclear family of two generations (parents and children) is the dominant form of Japanese households today, accounting for 79.2 % of all households, excluding single person-households, in 1995 (*Statistics of Japan,* 2000).

4. Analysis of Time-series Data

a. Changes in average per capita household consumption

Annual reports of *FIES* provide data pertaining to average number of persons; (total) living expenditure; expenditure, quantity, and price of individual commodities and their sub-groups purchased; and expenditure on certain individual goods and services. The Bureau of Statistics publishes consumer price indexes (CPI) for overall consumption, and by commodity group for each month and year. In the following time-series analysis, we use the expenditures and prices deflated by the overall CPI.

FIES began publishing household purchases of individual commodities and services by the age group of the household head (HH) in 1979. We will draw upon this information in this study to estimate individual consumption (= per capita consumption by individual members of a household) by age. This is partly the reason why we cover the period from 1979 on. The decade since the early 1980s is known as the years of the economic “bubble” and the years after the bubble burst in 1991 are often called the “lost decade” (Tanaka, 2002). The stock price (TOPIX) sharply rose from 474.0 in 1980 to 997.2 in 1985, and 2177.96 in 1990 and then fell to 1178.14 in 1998 and 974.49 in 2002. Urban land prices steadily rose from 24.5 in 1980 to 33.6 in 1985 and 103.0 in 1991 and fell to 39.0 in 2000 (six largest cities: 1990 =100; *Economic Annals 2002*). Consumer prices, including foods, however, have stayed relatively stable during these turbulent years, with the overall CPI rising from 75.2 in 1980 to 92.1 in 1990 and 100 in 2000 (Appendix Table 1).

Using the data across years, we repeat with time series regressions the process used with annual cross-sections of the data. Table 6 presents the non age-compensated estimates of income and own price elasticities of demand for rice, pork, beef, and fresh fruit, obtained from ordinary double log LS method—see equation (3), regressing per capita consumption of an individual commodity (*CapQ*) against real per capita living expenditure (*RLE*) and the real price of the commodity (*RP*) calculated as the average unit price paid (adjusted by the overall CPI).

$$\ln(CapQ) = a + b\ \ln(RLE) + c\ \ln(RP) + D \quad \cdots\cdots(3)$$

The regressions use the data from the past two decades since 1980. The time period covered excludes 1979, the year of the second oil crisis in Japan when all the economic activities were disturbed by the sudden hikes in the crude oil prices from $13.89 per barrel in 1978 to $23.08 in 1979 and $36.94 in 1980. The year 2001 is omitted for beef and pork, because of the incidence of BSE in the domestic beef production in that year which caused demand for beef to be quite unstable and demand for pork to surge upward.

Japanese rice production suffered from a devastatingly cool summer in 1994, and the resulting influx of imported rice (gaimai) was said to have diverted Japanese consumers' taste to other staples, such as spaghetti, Chinese noodles, and the like. For that reason, a "chill" dummy variable is applied to the years 1994 through 2001(with a zero value for 1980-93, and a value of 1 for 1994-2001)[9]. In the case of beef and pork, the incidence of E-coli O-157 in 1996 seems to have had lasting impacts on household consumption of the red meats. The dummy variable, *O-157* was applied to the time series regression for both beef and pork throughout in this study[10], including for the age factor-controlled analysis.

Table 6 demonstrates that rice, pork, and fresh fruit are negatively correlated to income with high statistical significance. Quantity elasticities with respect to living expenditure are estimated at -1.40, -0.72, and -1.10, respectively. Beef is positively correlated to living expenditure, with the elasticity estimated at +1.08. The estimates for own-price elasticity, are found not significantly different from zero for rice and pork, that for beef is -0.4, and for fresh fruit -0.15. While a negative income elasticity for rice corresponds to a common assumption about Japan, income elasticities for pork, and, especially, for fresh fruits are usually assumed to be positive.

Table 6 Elasticities of demand for rice, fresh pork, fresh beef, and fresh fruit: simple per capita consumption as dependent variable, using OLS double log form for the period of 1981 to 2001[1]

	parameter estimate	standard error		parameter estimate	standard error
Rice			**Fresh Beef**		
intercept	12.911	0.662	intercept	2.745	1.017
living expenses[2]	−1.388	0.081	living expenses[2]	1.081	0.102
own price[2]	0.068	0.054	own price[2]	−0.395	0.059
chill dummy[3]	−0.081	0.015	O-157 dummy[4]	−0.107	0.013
adjusted R^2		0.9791	adjusted R^2		0.9795
D-W		1.47	D-W		1.36
Fresh Pork			**Fresh Fruit**		
intercept	13.956	1.397	intercept	11.7955	0.651
living expenses[2]	−0.722	0.137	living expenses[2]	−1.098	0.121
own price[2]	−0.080	0.090	own price[2]	−0.150	0.121
O-157 dummy[4]	0.034	0.009			
adjusted R^2		0.8866	adjusted R^2		0.8941
D-W		1.63	D-W		0.98

Notes: (1)1980-2000 for pork and beef, since 2001 was an abnormal year due to the incidence of BSE in the beef production; (2) deflated by aggregate CPI; (3)chill impact dummy for 1994 trough 2000; (4) O-157 impact dummy for 1996 through 2000.

As early as the mid-1980s, a few market experts noticed that young Japanese were consuming less fresh fruit (Endo, 1986). The 1994 *White Paper on Agriculture* drew public attention to the phenomenon of “wakamono no kudamono-banare” (leaving off fresh fruit by the young), by analyzing the time-series consumption of mandarins and apples using data organized by the age group of the household head (MAFF, 1995). In order to investigate if declining overall fresh fruit consumption over time, and changes in the consumption of the other foods, are a function of rising incomes or changing tastes by population segments in an aging society, or both, we incorporate age factors into the time-series analysis of food consumption in the subsequent sections.

9. A chill dummy was first applied to the year 1994, resulting in better statistical performance, and then to 1995, 1995 and 1996, and so on in turn to conclude that demand for rice seems to have been adversely affected since 1994, i.e., the demand curve has been shifted leftward that much since then.
10. An O-157 dummy was first applied to the year 1996 only, then to subsequent years in turn to conclude that demand for beef may have been adversely affected since 1996 on. On the other hand, the demand for pork seems to have been positively affected to some extent.

b. Deriving individual consumption by age from household data classified by the age groups of household head

FIES has published household consumption by the age group of the household head (HH) in its annual reports since 1979. It has been common for analysts to use the HH data divided by the number of persons in respective households as proxies to derive estimates of consumption per person by respective age groups (Yamaguchi, 1987; Saito, 1993; Matsuda and Nakamura, 1993; MAFF, 1995). In view of the fact that the prevalent households of size 4 usually comprise two adults--a HH and his spouse and two children, or three adults--the HH, his spouse and his mother or father and one child, the simple division approach involves inherent shortcomings. Consumption by non-adults is not available (all HHs are adults) and even the estimates for the HH age groups could be biased by ignoring other family members of different ages, their children and parents who live with them.

Using the family composition matrices from the panel data, we determine individual consumption by all members of household by age in a much more realistic way, by using the Mori and Inaba model (1997), modified by Tanaka, Mori, and Inaba (2004), which is presented below.

In addition to 10 equations representing household consumption by 10 HH age groups, equation (4), we have 14 sub-equations representing the side-constraints of zenshinteki henka (gradual changes between successive individual age groups), equation (5):

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

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

where:

X_i = average consumption by subject in the ith age group, from the youngest, 1-9, to 10-14, ……, 70-74, and 75+, the oldest;

C_{ij} = family composition: number of persons in the ith age group in the jth HH age group;

H_j = average household purchase by the jth HH age group;

E = error term.

We estimate parameters, X_i, using WLS (weighted least squares) to minimize

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

with w_j and w_k set at 1.0 to start, and then modified according to standardized residuals calculated in each run, following the lead of Minotani,1992 and Tanaka, Mori, and Inaba, 2004.

Table 7 Estimates of individual at-home consumption of rice by age, 1979-2001

(kg/yr)

year	～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	27.31	37.63	38.41	36.71	34.90	37.66	49.76	65.56	67.31	65.63	62.64	63.56	65.78	60.86	53.26
1980	27.50	38.52	38.02	33.95	33.18	37.48	48.38	67.07	68.11	63.77	61.90	62.25	60.15	54.01	46.77
1981	26.45	38.16	38.83	34.15	32.20	38.35	47.28	62.71	67.51	64.43	59.38	59.64	58.65	53.30	46.48
1982	24.41	34.37	35.28	32.92	31.51	35.48	46.45	62.61	65.49	62.92	60.46	58.35	60.50	56.11	49.18
1983	21.76	30.36	30.89	28.92	28.28	35.71	45.24	65.92	67.27	65.56	61.87	61.64	61.03	55.43	48.24
1984	23.33	33.22	34.37	32.87	30.07	33.41	42.86	62.19	63.96	62.45	59.93	57.53	57.16	52.04	45.37
1985	19.79	28.91	30.36	27.83	28.00	32.31	44.69	63.39	66.98	63.75	60.92	58.81	58.22	53.00	46.21
1986	19.55	28.66	31.33	31.30	28.90	32.25	39.58	55.67	60.18	61.47	59.74	59.69	59.03	53.62	46.77
1987	17.24	24.61	26.00	25.96	26.97	29.59	38.55	58.36	60.26	60.48	59.74	57.59	54.92	49.01	42.42
1988	14.44	21.79	23.59	23.21	24.61	26.54	38.58	56.35	58.74	57.69	57.06	55.29	51.35	45.27	38.98
1989	14.05	21.06	23.16	23.83	22.44	24.85	37.63	53.39	55.60	56.44	55.86	53.81	50.86	45.27	39.12
1990	13.19	19.75	22.34	23.50	22.19	24.54	33.15	49.59	52.99	54.07	54.49	53.75	51.75	46.42	40.24
1991	11.63	17.76	19.95	20.70	22.72	25.54	33.55	48.83	52.50	53.85	54.80	52.14	50.36	45.32	39.39
1992	13.03	19.94	22.81	24.29	23.65	23.96	34.18	44.08	47.79	50.03	49.30	48.97	51.54	48.05	42.34
1993	13.65	20.07	22.42	23.91	22.61	22.65	29.68	45.48	50.33	51.65	52.97	51.80	52.26	47.85	41.85
1994	9.10	13.86	16.15	17.85	18.71	21.31	26.83	43.63	46.93	49.59	49.77	48.73	47.15	42.45	36.94
1995	10.74	15.93	18.25	20.26	20.44	20.88	26.09	36.25	44.32	46.98	48.21	46.73	47.25	43.35	37.99
1996	10.42	15.37	17.14	18.30	18.99	20.75	26.73	38.23	43.42	44.89	47.83	48.85	48.86	44.54	38.84
1997	10.28	15.65	17.79	18.61	18.48	20.78	26.19	31.37	43.04	44.57	47.36	51.27	48.97	43.68	37.77
1998	7.69	12.60	15.23	16.38	19.68	22.14	24.33	39.26	44.08	44.04	48.30	49.61	49.19	44.80	39.06
1999	8.90	13.41	15.27	17.30	18.69	20.47	25.48	34.73	38.31	42.89	48.84	51.84	51.34	46.52	40.53
2000	9.74	13.90	15.19	16.77	19.09	20.99	27.90	34.65	37.34	44.40	49.75	51.39	50.50	45.56	39.59
2001	9.55	13.96	15.47	16.55	17.08	20.21	26.24	32.45	39.98	42.69	46.21	46.48	48.59	45.26	39.90

Table 8 Estimates of individual at-home consumption of fresh pork by age, 1979-2001

(100 g/yr)

year	～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	42.68	63.59	62.84	61.93	63.51	61.48	60.96	59.35	57.90	56.41	46.73	44.06	38.36	33.59	27.66
1980	43.27	65.96	64.07	57.62	59.60	59.96	61.36	63.93	64.32	56.61	50.32	49.72	42.66	36.13	29.37
1981	41.85	63.79	63.72	60.41	57.93	56.68	58.50	58.76	59.00	54.68	47.93	44.83	41.88	37.03	30.60
1982	39.55	59.65	57.59	53.42	54.30	56.47	60.22	62.15	62.15	59.37	48.31	41.81	40.93	37.03	30.87
1983	38.22	58.58	56.69	53.68	54.06	55.90	59.63	64.11	63.03	62.24	41.08	36.05	35.80	32.60	27.24
1984	41.68	65.71	66.04	62.26	55.72	54.30	54.47	59.41	59.13	50.41	45.84	38.32	34.52	30.11	24.81
1985	38.52	61.33	61.73	57.84	51.23	50.01	51.16	57.79	56.72	52.19	47.42	43.52	37.35	31.70	25.75
1986	39.80	62.73	63.32	60.90	55.64	51.21	53.54	57.07	56.26	50.23	46.21	41.05	38.97	34.81	28.86
1987	37.68	59.92	59.48	54.75	54.47	50.29	53.02	61.44	59.98	53.38	47.85	42.43	39.93	35.62	29.51
1988	36.98	58.89	58.16	52.77	50.95	49.62	54.19	60.65	60.79	51.91	47.75	41.66	35.27	29.81	24.19
1989	36.76	59.18	59.71	53.97	48.13	48.29	52.07	59.72	61.49	54.74	47.44	42.02	35.60	30.34	24.64
1990	33.09	53.95	55.38	50.89	48.97	46.68	52.49	61.55	65.08	59.70	48.82	42.91	39.15	34.63	28.59
1991	32.57	51.65	51.62	47.96	49.75	49.02	53.86	59.81	61.31	53.20	48.15	41.53	37.20	32.55	26.79
1992	32.20	52.37	54.04	49.87	50.89	46.90	48.53	60.00	61.88	54.69	47.63	42.39	38.34	33.76	27.77
1993	31.93	52.14	54.65	53.24	52.39	46.06	48.38	58.54	61.27	57.62	48.88	41.98	38.98	34.79	28.93
1994	30.67	49.08	50.44	49.10	49.83	46.74	47.57	59.74	60.19	57.81	48.02	43.91	39.39	34.39	28.28
1995	33.28	53.45	56.39	55.13	49.91	46.41	46.53	53.78	57.85	53.93	48.70	44.19	40.46	35.74	29.58
1996	34.10	54.46	56.19	54.58	52.18	45.17	46.26	55.13	57.77	53.49	51.20	46.65	43.65	38.87	32.24
1997	31.73	50.44	52.32	51.77	52.05	46.84	48.64	53.67	56.65	55.53	52.12	48.54	44.86	39.64	32.87
1998	33.05	52.42	55.12	55.68	52.78	48.89	48.60	53.80	57.21	56.36	54.25	47.60	43.95	38.80	32.15
1999	34.52	53.84	55.74	56.66	53.65	50.44	48.75	54.85	55.42	56.34	55.13	53.22	48.76	42.96	35.49
2000	31.00	49.02	50.95	50.44	50.98	49.61	51.32	58.55	63.24	63.17	58.36	53.75	48.25	41.96	34.62
2001	34.88	54.62	56.10	55.58	55.02	52.03	53.15	57.32	60.22	59.65	56.37	54.08	49.40	43.21	35.62

Table 9 Estimates of individual at-home consumption of beef by age, 1979-2001

(100g/yr)

year	～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	17.56	26.70	26.25	26.27	26.49	25.87	27.97	28.45	27.94	28.64	29.73	27.13	25.97	23.18	19.25
1980	17.32	26.27	25.98	25.27	24.43	25.48	26.88	27.78	27.97	28.21	26.92	26.00	25.54	23.10	19.26
1981	17.05	25.72	25.24	23.52	22.33	26.81	29.25	30.43	32.06	31.48	29.69	23.94	24.02	22.00	18.46
1982	18.85	28.53	27.90	26.73	25.84	27.47	29.48	30.53	30.66	30.81	29.00	26.47	25.46	22.84	19.02
1983	17.80	27.27	27.30	25.91	24.89	26.28	29.51	30.25	32.45	31.52	30.16	26.86	24.88	21.96	18.21
1984	18.39	28.31	27.23	24.60	23.69	26.85	29.69	32.69	33.28	32.38	30.67	30.04	28.87	25.90	21.54
1985	17.31	27.10	26.51	23.91	23.49	25.75	29.07	33.02	34.00	32.94	29.67	28.29	27.17	24.42	20.34
1986	18.11	28.15	27.55	24.88	23.35	25.74	30.99	33.41	34.41	32.00	30.75	29.88	28.07	24.90	20.56
1987	18.31	29.32	28.85	25.44	24.40	27.23	31.80	37.44	39.40	37.17	34.73	28.39	25.49	22.29	18.42
1988	19.94	31.58	30.13	26.51	24.42	27.20	32.19	39.94	38.80	36.75	33.66	30.69	29.69	26.80	22.32
1989	18.90	30.06	29.67	26.42	25.41	26.69	33.43	39.23	39.92	36.76	33.29	31.98	30.51	27.38	22.69
1990	19.16	30.26	30.37	27.22	27.40	30.25	33.92	37.90	40.73	38.67	34.46	32.28	29.28	25.75	21.22
1991	20.81	32.84	33.35	31.68	29.40	30.45	33.60	38.68	40.45	39.53	36.51	33.75	32.12	28.78	23.92
1992	21.75	34.22	34.70	33.87	33.55	32.60	34.01	38.72	39.23	38.09	37.98	33.39	31.19	27.65	22.85
1993	21.73	34.92	36.18	34.06	29.77	30.63	34.69	40.67	44.93	42.93	37.40	35.53	33.76	30.32	25.25
1994	22.22	34.97	34.29	30.92	30.34	33.15	37.74	48.30	49.39	46.67	39.35	36.77	33.50	29.44	24.24
1995	22.23	35.38	35.93	33.81	32.64	33.97	38.37	45.77	48.77	47.32	42.81	39.30	33.90	29.28	24.04
1996	20.45	32.45	32.80	31.18	32.37	30.80	32.48	42.13	43.29	40.69	39.86	34.56	31.66	27.87	23.02
1997	21.23	33.81	33.99	32.16	29.90	28.90	33.00	42.09	43.42	41.66	40.01	36.43	32.69	28.40	23.34
1998	19.15	30.42	30.85	29.72	30.42	29.46	31.30	41.85	42.40	41.71	38.07	34.82	31.42	27.40	22.59
1999	19.57	30.48	30.36	29.01	26.22	27.91	30.33	41.20	41.54	41.24	39.38	36.59	33.95	29.89	24.68
2000	18.93	30.04	30.11	28.11	26.76	26.76	31.21	41.26	43.15	41.41	37.69	33.88	32.09	28.71	23.89
2001	16.02	25.80	26.57	25.73	24.19	22.31	24.26	32.65	34.20	32.87	30.67	27.89	25.38	22.24	18.36

Table 10 Estimates of individual at-home consumption of fresh fruit by age, 1979-2001

(kg/yr)

year	～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	34.73	35.34	36.67	37.61	41.43	45.08	46.10	52.09	58.24	61.61	62.20	65.03	64.33	61.06	56.08
1980	30.16	30.76	32.12	33.33	34.37	41.41	47.01	49.36	54.06	58.72	59.13	59.00	57.59	54.40	50.01
1981	27.77	29.53	31.31	32.29	34.10	36.42	40.02	44.71	49.61	52.45	54.09	57.49	56.94	54.09	49.69
1982	26.90	28.87	29.40	29.03	33.03	36.75	42.43	47.96	52.02	54.18	58.88	58.80	55.57	51.65	47.17
1983	25.75	27.17	27.47	28.40	32.21	36.99	44.04	50.22	53.21	58.31	63.43	63.58	61.04	57.13	52.31
1984	23.64	24.57	24.76	24.98	31.49	36.01	38.65	48.41	59.83	53.32	59.68	62.35	61.34	57.99	53.12
1985	19.43	21.02	22.43	23.49	26.94	32.24	38.00	45.11	50.03	53.71	58.62	61.21	60.90	57.99	53.35
1986	19.59	20.98	21.59	22.99	26.65	32.21	36.69	46.14	48.61	53.44	59.30	61.87	61.13	57.96	53.22
1987	17.53	19.31	19.73	20.49	25.87	31.30	42.16	48.41	51.58	55.28	63.85	63.55	63.56	60.72	55.93
1988	17.53	19.64	20.64	21.40	22.33	27.54	36.97	48.91	50.67	52.68	61.20	64.56	64.95	62.04	57.00
1989	13.85	15.86	17.60	18.18	22.15	28.72	35.39	44.08	49.37	51.67	55.74	58.16	60.10	58.24	53.91
1990	10.61	13.16	14.96	15.39	18.28	25.72	35.08	42.78	48.73	51.12	57.17	61.59	62.81	60.50	55.85
1991	8.18	11.06	13.78	15.46	18.53	23.47	33.84	40.90	48.00	51.51	55.73	59.61	60.56	58.24	53.76
1992	8.43	10.71	12.65	14.33	17.49	23.48	31.74	41.98	46.68	52.21	55.34	59.40	61.04	58.96	54.55
1993	8.49	10.57	12.44	13.95	17.43	22.78	32.00	39.15	44.84	48.82	54.81	59.98	63.05	61.43	56.93
1994	5.68	8.18	11.20	14.17	17.59	23.89	29.30	37.58	44.69	52.81	57.85	62.67	67.05	65.89	61.39
1995	6.32	8.56	11.24	13.97	16.48	20.83	26.01	34.10	43.01	48.26	53.89	58.41	62.21	60.95	56.65
1996	5.80	8.00	10.62	13.51	16.09	19.94	25.46	32.52	39.12	47.12	54.49	56.99	60.85	59.84	55.73
1997	4.24	6.38	8.71	11.31	14.48	19.13	27.62	33.88	39.95	49.87	55.33	58.63	62.87	61.92	57.69
1998	2.70	4.72	6.79	9.24	13.85	18.29	25.85	32.42	38.38	48.88	54.36	59.25	61.66	59.89	55.52
1999	3.22	5.03	6.82	9.15	13.65	18.96	24.68	32.24	37.43	44.49	51.44	60.16	63.81	62.48	58.00
2000	3.75	5.10	6.46	8.81	13.12	17.76	24.35	30.84	35.54	46.46	53.10	59.33	64.83	64.27	59.90
2001	2.67	4.61	6.90	9.58	12.83	17.34	23.15	29.47	35.74	44.64	56.12	59.54	63.17	61.96	57.64

Tables 7, 8, 9, and 10 show our estimates of per capita individual consumption by age of rice, pork, beef, and fresh fruit, respectively from 1979 to 2001. More detail about changes and trends in food consumption by age groups is available in earlier publications (Mori and Inaba, 1997; Lewis, Mori and Gorman, 2001; Mori, Clason, Dyck, and Gorman, 2001). It is clear that changes in individual consumption in the past two decades vary both in patterns and magnitude by age. For example,

- rice consumption decreased appreciably across all ages, but non-adults and young adults in their 20s and 30s show much sharper declines than the older adults in their 60s and 70s;
- non-adults and young adults in their 20s and 30s decreased their pork consumption around 20%, whereas older adults in their 60s and 70s increased it nearly 10%;
- beef increased across all age groups but the increase is the greatest among those in their 40s and 50s;
- and, most strikingly, fresh fruit declined more than 50% among non-adults and young adults in their 20s and 30s, whereas the older age groups 65 years old and above increased their consumption slightly over the same period.

Those individuals who were in their 50s in 1980 have aged to their 70s in 2000, and, likewise, those in their 20s and 30s in 1980 were in their 40s and 50s in 2000, likely retaining the eating habits acquired when they came of age 20 to 30 years ago.[11] To incorporate this information, we need to introduce a new analytical perspective: generation, or birth cohort.

11. One's eating habits may be formed firmly, independently from parental influence, during one's adolescence (refer to section 3, Chapter 8, Mori, eds., 2001).

c. Decomposing changes in per capita individual consumption into age, cohort, and (pure) time effects

By the simple A/P/C (age/period/cohort) model of cohort analysis, per capita individual consumption by subject, i years old in the year, t, X_{it} is expressed as follows:

$$X_{it} = B + A_i + P_t + C_k + e_{it} \quad \cdots\cdots(7)$$

where:

B = grand mean effect;

A_i = age effect to be attributed to age i years old;

P_t = period effect to be attributed to the year t;

C_k = cohort effect to be attributed to cohort k;

e_{it} = random error.

Our basic cohort tables consist of 23 rows, from 1979 to 2001, and 14 columns, from age group of 10-14 to 75+, and reflect the assumption that one's eating habits are formed during one's young adolescent years, or 12 columns, from 20-24 to 75+, if we assume that one's eating habits are formed only during one's young adulthood, independently from parental influence. The oldest cohorts are those above 74 years of age in 1979, and the youngest, or the newest ones are those who are 10-14 in 2001 (if we assume the family-influenced eating habits), or who are 20-24 in 2001 (if we assume the young adult period is most formative for food tastes). Thus, we have 19 or 17 cohorts in total, depending on the assumption. The number of parameters to be estimated is 23 (years, 1979-2001) + 12 or 14 (age groups) + 17 or 19 (cohorts) = 52 or 56, and Tables 7 through 10 provide 23 × 12, or 23 × 14 = 276 or 322 observations, respectively for each commodity.

Given the large sample size, it may seem as if there should be sufficient degrees of freedom for estimating cohort parameters, age effects, period effects, and cohort effects on top of grand mean effect. We face, however, the structural problem inherent in the ordinary A/P/C cohort model, i.e., the "identification problem" (Mason and Fienberg, 1985). If we take any two variables, say, the year of investigation, t, and the age group, i, then the cohort, the year when the subject was born, is automatically determined. In circumventing this technical difficulty, we are using the Bayesian cohort model developed by T. Nakamura (Nakamura, 1982 and 1986. For the less mathematically rigorous explanations, refer to Mori and Gorman, pp. 84-88, 1999; Mori, Clason, Dyck, and Gorman, pp. 321-324, 2001; Tanaka, Mori, Inaba, and Ishibashi, pp. 52-55, 2004; Mori and Clason, 2004, pp. 29-30).

Tables 11 through 14 show our estimates of cohort parameters, grand mean effect, age effects, period (annual year) effects, and cohort effects for rice, pork, beef, and fresh fruit, respectively. The household consumption of rice, pork, beef, and fresh fruit from 1980 to 2001 was decomposed into per capita individual consumption by age over the same period and then separated by age, period, and cohort effects. The period effects, shown in the second column of each table, are deemed to represent "pure" time effects, compensated for the structural changes caused by aging of and replacement of generations within the population.

Table 11 Changes in individual per capita consumption of rice from 1981 to 2001, decomposed into age, time and cohort effects(1)
Grand mean effects = 40.971 (kg/year)

Age Effects: A_i		Time Effects: P_t		Cohort Effects: C_k	
Age groups(yrs.old)		Calendar Year		Years born	
		1979	……(2)	～1906	7.315
20－24	－7.424	1980	……(2)	1907－11	7.220
25－29	－8.412	1981	6.448	1912－16	8.038
30－34	－7.129	1982	6.543	1917－21	8.768
35－39	－1.680	1983	7.044	1922－26	9.272
40－44	8.734	1984	5.253	1927－31	9.868
45－49	8.725	1985	5.836	1932－36	10.186
50－54	6.054	1986	4.787	1937－41	8.197
55－59	4.345	1987	3.032	1942－46	4.063
60－64	3.148	1988	0.808	1947－51	－1.454
65－69	2.594	1989	－0.145	1952－56	－7.153
70－74	－1.686	1990	－0.904	1957－61	－9.248
75～	－7.270	1991	－1.221	1962－66	－8.726
		1992	－1.858	1967－71	－9.142
		1993	－1.198	1972－76	－10.359
		1994	－4.423	1977－81	－13.422
		1995	－5.060		
		1996	－4.648		
		1997	－4.935		
		1998	－3.858		
		1999	－3.802		
		2000	－3.367		
		2001	－4.331		

Notes: (1) priors assigned to age, time and cohort effects in the estimation are: 1,1 and 1, respectively; (2) the years 1979 and 1980 are excluded from cohort calculation (refer to the text).

Table 12 Changes in individual per capita consumption of fresh pork from 1980 to 2000, decomposed into age, time and cohort effects(1)
Grand mean effects = 47.125 (100g/year)

Age Effects: A_i		Time Effects: P_t		Cohort Effects: C_k	
Age groups(yrs.old)		Calendar Year		Years born	
		1979	……(2)	～1905	－14.199
20－24	4.137	1980	6.691	1906－10	－11.880
25－29	1.886	1981	4.216	1911－15	－9.869
30－34	－1.362	1982	3.978	1916－20	－6.782
35－39	－0.490	1983	2.284	1921－25	－4.604
40－44	5.094	1984	0.417	1926－30	－0.395
45－49	6.366	1985	－0.669	1931－35	2.825
50－54	3.344	1986	－0.049	1936－40	5.500
55－59	－0.448	1987	0.460	1941－45	8.568
60－64	－2.206	1988	－1.334	1946－50	8.123
65－69	－3.041	1989	－1.723	1951－55	5.822
70－74	－4.849	1990	－0.319	1956－60	2.749
75～	－8.431	1991	－1.984	1961－65	3.843
		1992	－2.162	1966－70	2.866
		1993	－1.720	1971－75	3.760
		1994	－2.403	1976－80	1.836
		1995	－3.026		
		1996	－1.981		
		1997	－1.597		
		1998	－1.114		
		1999	0.438		
		2000	1.597		
		2001	……(2)		

Notes: (1) priors assigned to age, time and cohort effects in the estimation are: 1, 1 and 1, respectively; (2) the years 1979 and 2001 are excluded from cohort calculation (refer to the text).

Table 13 Changes in individual per capita consumption of fresh beef from 1980 to 2000, decomposed into age, time and cohort effects(1)
Grand mean effects = 31.215

(100g/year)

Age Effects: A_i		Time Effects: P_t		Cohort Effects: C_k	
Age groups(yrs.old)		Calendar Year		Years born	
		1979	……(2)	～1905	1.071
20－24	－3.161	1980	－5.785	1906－10	－0.115
25－29	－5.035	1981	－4.957	1911－15	－1.277
30－34	－4.388	1982	－4.180	1916－20	－2.704
35－39	－1.469	1983	－4.240	1921－25	－2.368
40－44	4.267	1984	－3.016	1926－30	－2.348
45－49	6.395	1985	－3.592	1931－35	－1.614
50－54	6.250	1986	－3.054	1936－40	－0.356
55－59	4.745	1987	－1.621	1941－45	2.014
60－64	2.659	1988	－0.490	1946－50	3.532
65－69	0.750	1989	－0.117	1951－55	3.298
70－74	－2.888	1990	0.437	1956－60	1.849
75～	－8.124	1991	1.896	1961－65	0.011
		1992	2.265	1966－70	0.408
		1993	3.654	1971－75	0.240
		1994	5.497	1976－80	－0.821
		1995	6.260		
		1996	2.799		
		1997	2.905		
		1998	2.005		
		1999	1.948		
		2000	1.388		
		2001	……(2)		

Notes: (1) priors assigned to age, time and cohort effects in the estimation are: 4, 2 and 2, respectively; (2) the years 1979 and 2001 are excluded from cohort calculation (refer to the text).

Table 14 Changes in individual per capita consumption of fresh fruit from 1981 to 2001, decomposed into age, time and cohort effects(1)
Grand mean effects = 39.784

(kg/year)

Age Effects: A_i		Time Effects: P_t		Cohort Effects: C_k	
Age groups(yrs.old)		Calendar Year		Years born	
		1979	……(2)	～1906	8.499
20－24	－2.579	1980	……(2)	1907－11	11.352
25－29	－4.537	1981	－2.274	1912－16	13.799
30－34	－5.251	1982	－1.414	1917－21	15.992
35－39	－4.456	1983	1.690	1922－26	16.958
40－44	－2.578	1984	0.959	1927－31	17.362
45－49	－1.792	1985	－0.761	1932－36	15.228
50－54	－0.601	1986	－0.493	1937－41	13.096
55－59	2.772	1987	1.846	1942－46	10.294
60－64	5.053	1988	1.333	1947－51	4.343
65－69	6.407	1989	－0.986	1952－56	－1.842
70－74	5.078	1990	－0.568	1957－61	－7.782
75～	2.485	1991	－1.316	1962－66	－14.414
		1992	－0.897	1967－71	－19.505
		1993	－0.420	1972－76	－23.954
		1994	1.786	1977－81	－29.713
		1995	－0.857		
		1996	－1.321		
		1997	0.317		
		1998	－0.147		
		1999	0.514		
		2000	1.418		
		2001	1.591		

Notes: (1) priors assigned to age, time and cohort effects in the estimation are: 1, 1 and 1, respectively; (2) the years 1979 and 1980 are excluded from cohort calculation (refer to the text).

d. Regressing (*grand men effect + period effects*) as proxies for "pure" time effects against changes in price and income over time

By replacing (*capQ*) in equation (3) in 4.a. by (*gm* + *pe* : grand mean effect + period effects) provided by Tables 11 through 14, as shown in equation (8) below, we estimate income and price elasticities of demand for rice, pork, beef, and fresh fruit, respectively, with **age**-related differences removed from the dependent variable. The time periods covered for respective products are basically the same as for the analysis in 4.a, equation (3).

$$\ln(gm + pe) = a + b\ln(RLE) + c\ln(RP) + D \quad \cdots\cdots(8)$$

Table 15 shows the results of the regressions. Generally, we have obtained reasonably good statistical fits. More importantly, the estimated elasticities seem to better conform to the statis-

Table 15 Elasticities of demand for rice, fresh pork, fresh beef, and fresh fruit: (A) simple per capita consumption as dependent variable (replica of Table 6) and (B) grand mean plus period effects derived from cohort analysis as dependent variable, estimated using OLS double log form for the period of 1981 to 2001(1)

	(A) dependent variable=simple per capita consumption		(B) dependent variable=grand mean+period effects	
Rice	parameter estimate	standard error	parameter estimate	standard error
intercept	12.911	0.662	11.843	0.595
living expenses(2)	−1.388	0.081	−1.134	0.073
own price(2)	0.068	0.054	−0.025	0.049
chill dummy(3)	−0.081	0.015	−0.069	0.013
adjusted R^2	0.9791		0.9726	
D-W	1.47		1.61	
Fresh pork				
intercept	13.956	1.397	11.419	2.156
living expenses(2)	−0.722	0.137	−0.981	0.212
own price(2)	−0.080	0.090	−0.139	0.139
O-157 dummy(4)	0.034	0.009	0.050	0.014
adjusted R^2	0.8866		0.8416	
D-W	1.63		0.96	
Fresh beef				
intercept	2.745	1.017	−1.132	0.920
living expenses(2)	1.081	0.102	0.993	0.092
own price(2)	−0.395	0.059	−0.408	0.054
O-157 dummy(4)	−0.107	0.013	−0.102	0.012
adjusted R^2	0.9795		0.9820	
D-W	1.36		1.41	
Fresh fruit				
intercept	11.796	0.651	3.046	0.521
living expenses(2)	−1.098	0.121	0.277	0.103
own price(2)	−0.150	0.121	−0.349	0.103
adjusted R^2	0.8941		0.3245	
D-W	0.98		2.01	

Notes: (1) 1980-2000 for pork and beef; (2) deflated by aggregate CPI; (3) chill impact dummy for 1994 through 2000; (4) O-157 impact dummy for 1996 through 2000.

tical inference from the findings of cross-sectional analysis in section 3, particularly in the case of fresh fruit, compared to the results from the non age-compensated time-series analysis in 4.a. The non age-compensated analysis gave rise to negative income elasticity as large as -1.10 for fresh fruit, whereas the (*gm* + *pe*) approach produced a positive elasticity, +0.28, with reasonable t-value close to 3, along with acceptable own price elasticity of -0.35 with t-value larger than 3 (but with lower explanatory power for the equation—R^2 drops from .89 to .32).

On the other hand, the income elasticity for pork is estimated at -0.72 by the non age-compensated approach, compared to -0.98 by the (*gm* + *pe*) approach. For rice, the non age-age compensated estimate is -1.40 vs.-1.13 from the age compensated method. For beef, the elasticity estimate is 1.08 without compensation for the age-related effects, vs. 0.99, when age-related effects are separated. Except for the case of fresh fruit, we are not in the position to instantly affirm that our attempt to compensate for the age factors has produced better results than the ordinary age-neglected approach in 4.a.

5. The Impact of Age Factors in Determining Income Elasticities of Demand: Discussion

Cross-section evidence for the quantity consumed per person indicates that rice is an inferior good in the sense that consumption tends to decline as income increases. Pork quantity consumed appears to be income-neutral. Beef and fresh fruit appear to be normal goods, since the quantity consumed tends to respond positively to income in present day Japan. When the age-factors are controlled, income elasticities obtained from cross-sectional panel data for selected years in the 1980s and 1990s seem to confirm this (see Table 5 A). When expenditure as opposed to just quantity consumed are measured, rice is found still slightly negative, and pork slightly positive with respect to income changes. In view of the fact that beef and fresh fruits vary very widely in price on the market in Japan (Mori and Lin, 1994, Chapter 1), consumers are revealed in the cross-sectional analysis to purchase the higher priced products as their income increases (Figures 1 and 2 for the cases of rice and beef, for example). As expected, the income elasticities of expenditure (on individual commodity) are generally larger than those of quantity (see Prais and Houthakker, Chapter 8 for the cases in British and Dutch households). These findings conform to our intuitions based on every day observations.

Per capita household rice consumption has been steadily declining since the mid 1960s, and per capita fresh fruit consumption since the mid 1970s. Fresh pork consumption per person increased steadily until the late 1980s and has essentially remained constant since then. Beef

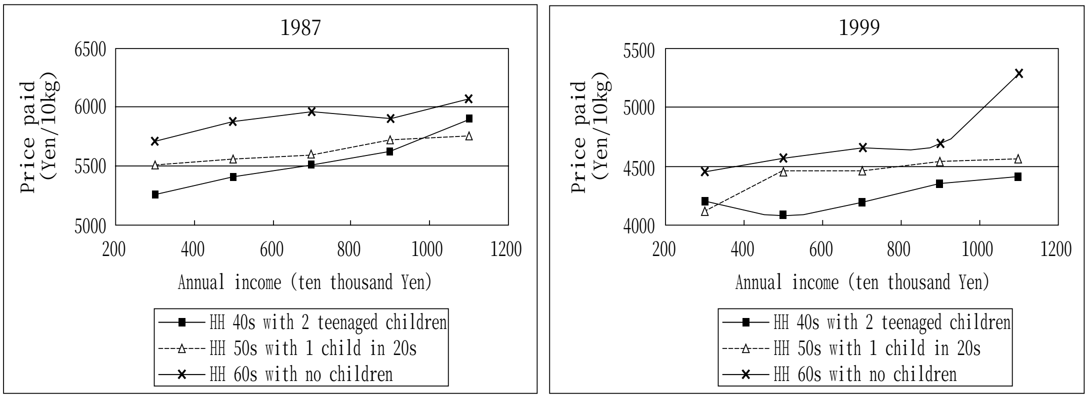

Fig1. Price paid for rice by annual income level of selected household types.

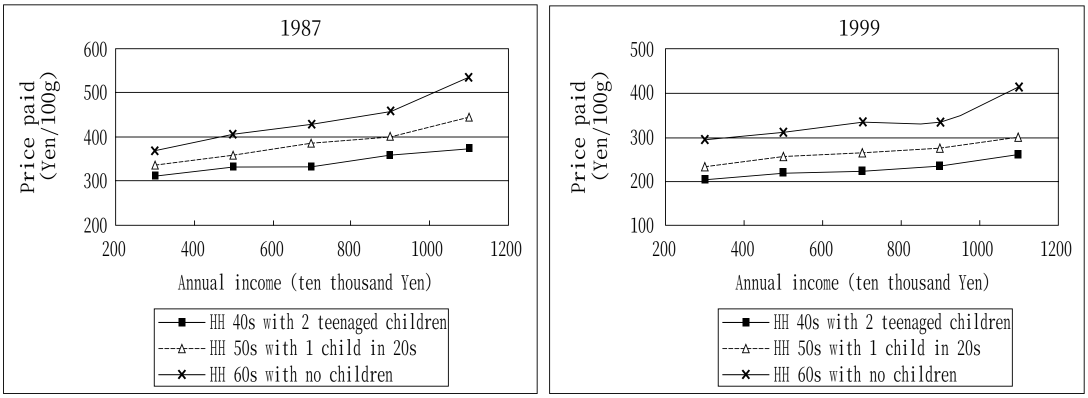

Fig1. Price paid for fresh beef by annual income level of selected household types.

consumption per person has increased steadily for the past decades until recently (the incidence of e-coli O-157 in 1996 and that of BSE in 2001 curbed beef demand).

When the age factors, the impacts of aging and cohort-replacement as well, are eliminated from the time-series data, fresh fruit is found positively related to income changes over time, with the expenditure elasticity estimated at 0.28, compared to -1.10 without the age factor compensation. In the case of rice, an upward impact of aging seems to have been more than offset by the opposing effect of the cohort replacement, resulting in an expenditure elasticity -1.13, much lower than -1.39 estimated without age factor modifications. This may imply that an increase in income might lead to somewhat slower decreases in rice consumption in future years than anticipated from the non-age compensated econometric approaches.

On the other hand, fresh pork is found slightly more “inferior” when the age factors are incorporated into the time-series model than otherwise, with the expenditure elasticity estimated at -0.98, compared to -0.72 from the non-age compensated model. In the cross-section analysis, pork is found to be income-neutral, when the age factors are controlled. This gap between cross-sectional and time-series results with respect to income responses should be investigated by further research.

Similar reasoning seems to apply in the case of fresh beef. The income elasticity of beef is estimated at 0.99 when age factors are considered, compared to 1.08 in the non-age compensated model. Examining the over-time changes in per capita individual consumption by age shown in Table 9 and the estimated cohort parameters in Table 13, the impact of both aging and cohort-replacement may have slightly accelerated overall beef consumption in the past two decades or so.

6. Conclusion

Earlier work has used the age structure and cohort composition of the Japanese population to project overall consumption of selected food products in future years, with no regard to economic impacts, i.e., changes in income and prices (Tanaka and Mori, 2004; Tanaka, Mori, Inaba, and Ishibashi, 2004; Mori and Clason, 2004). Now that we have obtained the estimates of the age-free economic parameters, the income and price elasticities determined here allow future food demand to be projected using both economic and demographic perspectives. Integrating the age-related factors into the demand systems approach which is the norm today (Theil, 1980; Deaton and Muellbauer,1980; Matsuda, 2000; Seal, Regmi, and Bernstein, 2003; Thompson, 2004; Gardes, Duncan, Gaubert, Gurgand, and Starzec, 2005; Reed, Levedahl, and Hallahan, 2005; Meyerhoefer, Ranney, and Sahn, 2005) remains to be done in both cross-sectional and time-series approaches.

We have demonstrated that the demographic factors such as age and generational cohorts exercise substantial influences on individual food intakes in present day Japan. As clearly shown by the differences in income elasticities, estimates of income effects can be confounded with age-related effects. Age-related influence may be unique to Japan, but, more likely, are prevalent to one degree or another in other populations, both in developed and developing countries like China and Thailand[12]. More research efforts should be focused explicitly on demographic aspects of food consumption, first in data collection and then the development of workable analytical techniques, using even limited information available (various LSMS working papers; Trivedi, 1987; Deaton, 1987).

12. It was revealed that a great disparity in per capita consumption of rice should exist between urban, semi-urban and rural areas in Thailand (Somporn Isvilanonda, 2005).

Appendix Table 1 Consumer price indices, aggregate, and food: rice, fresh meat, and fresh fruit, 1975 to 2004

Year	Aggregate	Food	Rice	Fresh Meat	Fresh Fruit
1975	54.5	59.1	64.1	80.1	56.9
1976	59.7	64.4	73.7	89.6	61.1
1977	64.5	68.7	81.0	88.9	69.1
1978	67.3	71.1	85.7	88.2	68.7
1979	69.8	72.6	87.6	87.3	71.0
1980	75.2	77.0	90.1	88.7	71.9
1981	78.8	81.1	93.2	92.4	80.4
1982	81.1	82.6	96.7	93.5	77.6
1983	82.5	84.3	99.0	95.0	77.3
1984	84.4	86.6	102.7	95.2	82.5
1985	86.1	88.1	106.0	94.6	92.1
1986	86.7	88.3	106.8	93.3	85.1
1987	86.7	87.5	106.8	91.3	80.5
1988	87.3	88.1	105.0	90.3	81.5
1989	89.3	90.1	106.6	91.5	89.1
1990	92.1	93.7	107.8	93.7	99.7
1991	95.1	98.2	107.7	96.3	110.9
1992	96.7	98.7	111.6	97.7	112.2
1993	98.0	99.8	114.7	97.1	99.0
1994	98.6	100.6	125.6	95.9	104.0
1995	98.5	99.4	110.7	95.9	107.6
1996	98.6	99.3	108.0	97.1	107.5
1997	100.4	101.1	107.1	101.3	104.8
1998	101.0	102.5	102.8	102.4	105.3
1999	100.7	102.0	104.4	101.6	108.5
2000	100.0	100.0	100.0	100.0	100.0
2001	99.3	99.4	96.9	99.7	99.2
2002	98.4	98.6	96.5	100.4	95.8
2003	98.1	98.4	100.1	101.7	96.6
2004	98.1	99.3	109.1	105.6	100.3

Sources: Bureau of Statistics, *Annual Report of Consumer Price Indexes,* various issues.

References

Blundell, R., P. Pashardes, and G. Weber. 1993. "What Do We Know about Consumer Demand Patterns from Micro Data?" *American Economic Review*, 83(3), June, 570-597.

Chino, Jinjiro. 2005. "Keizai Hatten nitomonau Kome Shouhikouzou no Henka (Changes in Rice Consumption Structure Accompanying Economic Development), *Rice Economy in the International Setting*, eds. by Shimizu, Kobayashi and Kaneda, Tokyo, Tokyo University of Agriculture Press.

Deaton, A. and J. Muellbauer. 1980. *Economics and Consumer Behavior*, Cambridge, UK, Cambridge University Press.

Deaton, Angus. 1987. "Estimation of Own- and Cross-Price Elasiticies from Household Survey Data," *Journal of Econometrics*, 36, Sept-Oct, 7-30.

Deaton, Angus. 1998. "Quality, Quantity, and Spatial Variation of Price," *American Economic Review*, 78(3), June, 418-430.

Deaton, A. and C. Paxson. 1998. "Economies of Scale, Household Size, and the Demand for Food," *Journal of Political Economy*, 106(5), 897-930.

Deaton, A. and S. Zaidi. 2002. *Guidelines for Constructing Consumption Aggregates for Welfare Analysis*, Living Standards Measurement Study (LSMS) Working Paper No. 135, Washington, D. C., The World Bank.

Dong, D., J.S. Shonkwiler, and O. Capps, Jr. 1998. "Estimation of Demand Functions Using Cross -Sectional Household Data: The Problem Revisited," *American Journal of Agricultural Economics*, 80 (August), 466-73.

Endo, Hajime. 1986. Executive Director, Japan Federation of Horticultural Cooperative Associations, Personal Communications on various occasions.

Friedman, Milton. 1976. *Price Theory,* Chicago, Aldine Publishing Company.

Gardes, F., S.Langlois, and D.Richaudeau. 1996. "Cross-section versus time-series income elasticities of Candadian consumption," *Economic Letters*, 51, 169-175.

Gardes, F., G.D.Duncan, P.Gaubert, M.Gurgand, and C. Starzec. 2005. "Panel and Pseudo-Panel Estimation of Cross-Section and Time Series Elasticities of Food Consumption: The Case of U.S. and Polish Data," *Journal of Business and Economic Statistics*, 23(2), April, 242-253.

Han, Doo Bong. 2005. "Dilemmas and Challenges of Korean Rice Economy after the Rice Negotiation," in Proceedings for Workshop on *Rice in the World at Stake*, March 13-14, Tokyo,39-53.

Ishibashi, Kimiko. 1997. "Demand Forecast and Trends in Vegetable Consumption," *Japanese Journal of Farm Management*, Vol. 35, 32-41 (in Japanese).

Ishibashi, Kimiko. 2004. "Changes in Household Rice Consumption by the Household Type and Income Level," *Journal of Food System Research*, Vol. 11, 1-15 (in Japanese).

Isvilanonda, Somporn. 2005. "Trend in Rice Consumption in Thailand," in *Rice in the World at Stake*, op. cit., 55-65.

Ito, S., E. Wesley., F. Peterson, and W.R.Grant.1989. "Rice in Asia: Is It Becoming Inferior Good?" *American Journal of Agricultural Economics*, 71(1), February, 32-42.

Japanese Government, Bureau of Statistics, *Family Income and Expenditure Survey*, Annual Report, various issues, Tokyo.

Japanese Government, Bureau of Statistics, *FIES,* Panel Data, various months, Courtesy: Bureau of Statistics through Ministry of Agriculture, Forestry and Fisheries.

Japanese Government, Agency for General Affaires. 2000. *Statistics of Japan*, Tokyo.

Japanese Government, Ministry of Agriculture, Forestry and Fisheries. 1995. *White Paper on Agriculture-1994*, Tokyo.

Japanese Government, MAFF. 2004, Personal Communications

Japanese Government, Prime Minister's Office, Economic and Social Research Institute, *Economic Annals 2002*, Tokyo.

Kooreman, P. and S. Wunderink. 1997. *The Economics of Household Behavior*, New York, St. Martin's Press.

Lewis Hendrickson, M., H. Mori, and Wm. D. Gorman. 2001. "Estimating Japanese At-home Food Consumption by Age Groups while Controlling for Income Effects," *Cohort Analysis of Japanese Food Consumption*, eds. by H. Mori, 93-121.

Magota, Ryouhei. 1997. "Wages and Lifetime Livelihood Guarantee," in *Today's Wage Problems*, eds. by Social Policy Editorial Committee, Kyoto, Keibunsha (in Japanese).

Mason, T. and S.E. Fienberg. 1985. *Cohort Analysis in Social Research: Beyond the Identification Problem*. New York. Springer-Verlag.

Matsuda, Toshinobu. 2004. "Incorporating Generalized Marginal Budget Shares in a Mixed Demand System," *American Journal of Agricultural Economics*, 86(4) November, 1117-1126.

Matsuda, T. and T. Nakamura. 1993. "Analysis of Rice Consumption in Household: Using Data

Classified by Age of a Household," *Journal of Rural Economics*, Vol. 64, 213-220 (in Japanese).
Meyerhoefer,C., C. Ranney, and D. Sahn. 2005. "Consistent Estimation of Censored Demand Systems Using Panel Data," *American Journal of Agricultural Economics*, 87(3), August, 660-672.
Minotani, Chiohiko. 1992. *Robust Estimation in Econometrics*, Tokyo, Chiga-shuppan (in Japanese).
Mori, Hiroshi (eds.). 2001. *Cohort Analysis of Japanese Food Consumption—New and Old generations*, Tokyo, Senshu University Press.
Mori, H. and B.H. Lin. 1994. *Japanese Beef Market—Distinctly Unique*, Tokyo, Senshu University Press.
Mori, H. and T. Inaba. 1997. "Estimating Individual Fresh Fruit Consumption by Age from Household Data, 1979 to 1994," *Journal of Rural Economics*, Vol. 69(3), 175-85.
Mori, H. and Wm. D. Gorman. 1999. "A Cohort Analysis of Japanese Food Consumption: Old and New Generations," *Senshu University Economic Bulletin*, Vol. 34(2), 71-111.
Mori, H., D.L. Clason, J. Dyck, and Wm. D. Gorman. 2001. "Age in Food Demand Analysis—A Case Study of Japanese Household Data by Cohort Approach," *Cohort Analysis of Japanese Food Consumption*, eds. by H. Mori, 311—345.
Mori, H., M. Tanaka, and T. Inaba. 2004. "Predicting At-home Consumption of Rice and Fresh Fish under a Rapidly Aging: A Cohort Approach," *The Annual Bulletin of Social Science,* Vol. 38, Senshu University, 41-62 (in Japanese)..
Mori, H. and D.L. Clason. 2004. "Cohort Approach as an Effective Means for Forecasting Consumption in an Aging Society: The Case of Fresh Fruit in Japan," *Senshu University Economic Bulletin*, Vol. 38(2), 45-70.
Mori, H. and D.L. Clason. 2004. "A Cohort Approach for Predicting Future Eating Habits: the Case of At-home Consumption of Fresh Fish and Meat in an Aging Japanese Society," *International Review of Food and Agribusiness Management Review*, Vol. 7(1), 22-41.
Mori, H., K. Ishibashi, M. Tanaka, and T. Inaba. 2005. "Determining Income and Price Elasticities of Demand in the Presence of Age-Cohort Effects," *The Annual Bulletin of Social Science,* Vol. 39, Senshu University, 39-59 (in Japanese).
Mori, H., D. Clason, and J. Lillywhite. 2006. "Estimating Price and Income Elasticities in the Presence of Age-Cohart Effects," *Agribusiness: An International Journal,* 22(2), J. Wiley & Sons.
Morishima, Masaru. 1984. "Shokuryou Jyuyou no Douko"(Trend in Food Demand), *Journal of Rural Economics*, Vol. 56(2), 63-69 (in Japanese).
Nakamura, Atsushi. 2001. "Analysis of Wage Statistics," in *Wages in Japan during the Post War Eras*, Tokyo, Social and Economic Productivity Center (in Japanese).
Nakamura, Takashi. 1986. "Bayesian Cohort Models for General Cohort Tables," *Annals of the Institute of Statistical Mathematics*, Vol. 38, 353-370, Tokyo.
Perali, F. and J-P Chavas. 2000. "Estimation of Censored Demand Equations from Large Cross-Section Data," *America Journal of Agricultural Economics*, 82(4), November, 1022-1037.
Prais, S.J. and H.S. Houthakker. 1971. *The Analysis of Family Budgets*, Cambridge at The University Press.
Reed, A., J. Levedahl, and C. Hallhan. 2005. "The Generalized Composite Commodity Theorem and Food Demand Estimation," *American Journal of Agricultural Economics*, 87(1), February, 28-37.
Saito, Akio. 1993. "Kudamono no Keizai Bunseki (1): Nenrei to Kudamono Jyuyou"(Economic Analysis of Fruit: Age and Fruit Demand), *Chuo Kajitsu Kikin Report*, No. 44, Tokyo, Cuou Kajitsu Fund, 21-29.
Seal, J., A. Regmi, and J. Berstein. 2003. *International Evidence on Food Consumption Patterns*,

United States Department of Agriculture, Economic Research Service, Technical Bulletin No. 1904.

Stigler, George J. 1966. *The Theory of Price*, third edition, New York, Macmillan Publishing Company.

Tanaka, M., H. Mori, T. Inaba, and K. Ishibashi. 2004. "Projecting Future Household Consumption of Sake and Beer—A Cohort Analysis," *Japanese Journal of Research on Household Economics*, No. 61, Winter, 50-61 (in Japanese)..

Tanaka, M., H. Mori, and T. Inaba. 2004. "Re-estimating per Capita Individual Consumption by Age from Household Data," *The Japanese Journal of Rural Economics*, Vol. 6, 20-30.

Tanaka, Takayuki. 2002. *Japanese Economy in the Bubble and Post-Bubble Eras*, Tokyo, Nihon-Hyouronsha (in Japanese).

Thompson, Wyatt. 2004. "Using Elasticities from an Almost Ideal Demand System? Watch out for Group Expenditure!" *America Journal of Agricultural Economics*, 86(4), November, 1108-1116.

Theil, Henri. 1980. *The System-Wide Approach to Microeconomics*, Chicago, The University of Chicago Press.

Trivedi, Pravin K. 1987. "Editor's Introduction," *Journal of Econometrics*, 36 (1987), 1-6.

Wold, Herman, in Association with L. Jureen. 1982. *Demand Analysis : A Study in Econometrics*, reprinted, Westport, Connecticut, Greenwood Press.

Yamaguchi, Kikuo. 1987. *Changing Trends in Food Consumption*, Tokyo, Nihon Keizai Shinbunsha (in Japanese).

Disclaimer : The views in this paper are those of the authors and do not necessarily reflect the views of the organizations to which they belong.