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A Cohort Approach for Predicting Future Eating Habits: The Case of At-Home Consumption of Fresh Fish and Meat in an Aging Japanese Society

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Abstract

Due to a rapidly aging society, stagnating per capita income and rather stable prices, traditional economic analyses methods lost their power in the 1990s to predict future food product consumption in Japan. This study, in part, remedies this problem by projecting future consumption of selected products, using a cohort approach with economic factors tentatively set aside. Per capita consumption of individual household members by age was derived by incorporating family age composition into household data classified by age groups of household head (HH). Individual consumption estimates were decomposed into age, cohort and time effects, using the Nakamura's Bayesian cohort model. These effects were synthesized to predict per capita consumption in each population age cell in 2010 and 2020. Although some method refinement is warranted, the cohort approach proves a useful tool in improving prediction of future food product consumption and, combined with economic factors, may prove useful in future economic forecasting.

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Introduction

Until the early 1990s, the Japanese government Ministry of Agriculture, Forestry and Fisheries (MAFF, 1995, 1998) did not consider the age factor when projecting the demand for various food products in the mid-term future. Until that time, the traditional economic demand analyses, based on income and prices, were adequate because per capita income was rising steadily each year and prices were unstable due to uncontrollable weather conditions, and, in part, marketers' speculative behaviors in a closed economy (Yuize, 1971; MAFF, Outlook; Dyck, 1988; Hayes et al., 1990; Mori and Lin, 1990). However in 1991, the "bubble" burst. Japanese per capita real national income, which had quadrupled between 1960 and 1990, became stagnant (EPAa). At the same time, Japanese food prices, high by international standards, began to decline to international levels, due to gradual trade liberalization under the GATT Uruguay Round (EPAb). To add a new perspective in consumption changes, Japanese society was rapidly aging. 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, 2002). Faced with these converging trends, traditional economic analyses lost their power to predict future food product consumption.

In this paper, we attempt to remedy this problem, in part, by projecting future consumption of selected products, using a cohort approach with economic factors tentatively set aside. We will focus on Japanese consumption of fresh fish and fresh meat. The former is conceived generally to represent the traditional protein item and the latter its modern counterpart.[1]

Age-consumption relationships have long been incorporated explicitly into models to project long-term demand for selected food products in the United States (Salathe, 1979; Blaylock and Haidacher, 1985; Blaylock and Smallwood, 1986; Price, 1988; Lin et al., 2003; Blisard et al., 2003). As early as in 1979, Schrimper raised an important issue at an American Agricultural Economics Association (AAEA) meeting: "Is it reasonable to expect all generations to follow the same transformation of eating habits over the life cycle?" (Schrimper, 1979, p. 1059). In the latest ERS/USDA reports, it is implicitly assumed 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, younger age groups will assume the eating habits of older age groups as they age." (Lin, 2003, pp.13-14). In this study, we try to explicitly separate the age factor in food consumption into chronological age and generational cohort effects, realizing that the estimation procedures employed might be subject to further substantial refinements.

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[1] In 1955 when the Japanese economy was said to have recovered to the pre-war level, per capita consumption of meat was 3.2 kg, compared to 31.3 kg in 1995, whereas that of fish and shell fish was 26.2 kg, compared to 38.2 kg in the corresponding years.

Consumption of various food products varies significantly by age and generation in Japan (Ishibashi, 1997, 2001; Mori et al., 2001). Sawada and Sawada (1994) and Eales and Wessells (1999) suspect that there has been a structural change in Japanese households' preferences for meat and fish. Given the drastic change in the age composition of Japanese households (Table 1) and appreciable variations in consumption by age (Table 2[2]), a "structural change" in demand should be deemed inevitable. For the purpose of pure economic analysis, which is not our current concern, if one succeeds in eliminating the likely changes in consumption attributable to demographic factors, it might be feasible to estimate economic parameters such as income and price elasticities with fewer biases[3].

In the following section, we will derive per capita individual consumption by age from household data classified by age groups of household head (HH), using the Mori and Inaba model (Mori and Inaba, 1997). Cohort tables consisting of 14 age categories by five-year intervals from 10-14 up to 75- for the period, 1979-2001 are presented. In succeeding sections, we attempt to decompose age, generational cohort and period effects, using the Bayesian cohort model developed by Nakamura (1982,1986) and project individual consumption by age for the years 2010 and 2020, synthesizing age and cohort effects estimated in the later section. Since the period effects for the future years are unpredictable, we assume implicitly that they will remain unchanged from the last few years of the survey period.

Table 1: Percentage Distribution of Japanese Households, by Age of Household Head, 1980 and 2000

Age group	1980	2000
Total	7803 (100.0)	7992 (100.0)
(yrs.)	(%)	(%)
~29	580 (7.3)	329 (4.2)
30~39	2429 (30.4)	1326 (17.0)
40~49	2240 (28.0)	1657 (21.2)
50~59	1590 (19.9)	1812 (23.2)
60~	1154 (14.4)	2678 (34.3)

Sources: Bureau of Statistics, *Family Income and Expenditure* Survey, various issues.

[2] It is obvious that the older households consume on a per capita basis much more fresh fish and somewhat less meat than the younger ones. It also is apparent that these age-consumption profiles should have changed over time, implying a possible generational cohort effect.
[3] Following the lead of Matsuda and Nakamura (1993), Mori and Gorman estimated, in single linear function, income and price elasticities of demand for fresh fruit, fresh fish and fresh beef, respectively, using age and cohort effects compensated consumption (grand mean effects + period effects) as dependent variables. They obtained intuitively more reasonable estimates for income elasticities for fresh fruit and fresh beef, respectively, i.e., positive (+0.38) instead of negative (–0.59) for fruit and much lower elasticity(+0.29<+0.83) for beef, compared to the results from the demographic factors non-compensated approach (Mori and Gorman, 1999).

Table 2: Per Capita At-Home Consumption of Fresh Fish and Fresh Meat, by Age of Household Head, 1980 and 2000

Age group	Fresh Fish		Fresh Meat	
	1980 (kg)	2000 (kg)	1980 (kg)	2000 (kg)
Total	13.21	11.86	12.23	12.77
(yrs.)				
~29	9.90	4.74	10.67	10.75
30~39	11.29	5.76	11.27	10.69
40~49	13.13	9.08	13.46	13.39
50~59	15.84	14.50	12.87	14.34
60~	16.58	15.68	11.35	12.12

Sources: ibid.

Estimating Individual Consumption by Age from Household Data

In 1979 the Japanese government Bureau of Statistics began reporting household purchases (regarded as consumption in this paper) by age groups of household head (HH). These data have been published annually in the *Family Income and Expenditure Survey* (*FIES*). A rough estimation of per capita consumption by age may be obtained by simply dividing household consumption by the number of persons in the respective household[4]. This method, however, does not reflect the differences in consumption between adults and children and/or between adults of HH age group and their parents or dependents in the same household. Mori and Inaba (1997) improved on this simple division method by introducing household age composition matrices to derive individual household members' consumption by age from household data classified by HH age groups. *FIES* classifies age groups of HH by 5-year intervals in 10 groups : -24, 25-29,---, 60-64, and 65-. In this study, we classify individual household members into15 age groups: 0-9,10-14,15-19,20-24,----,70-74,and 75-. If X_i denotes average consumption by individuals in the ith age group (i=1,-- ,15), Q_j household consumption where HH is in the jth age group (j=1, -- ,10), and H_{ij} (average)family age composition of HH jth age group, then:

$$(1) \qquad \sum_{i}^{15} H_{ij} X_i = Q_j$$

We try to estimate X_i in such a way as to minimize the sum of squared residuals,

$$(2) \qquad \sum_{j}^{10}\sum_{i}^{15} \left(Q_j - H_{ij} X_i\right)^2$$

[4] Yamaguchi (1987), Matsuda and Nakamura (1993) and the Japanese government Ministry of Agriculture, Forestry and Fisheries (1995) depended on this simple division method to discuss the age factors in food consumption.

We have classified individual age groups into 15 classes (i.e., we have 15 unknowns), but the equation set (1) comprises only 10 sub-equations. To minimize the equation (2), we must add at least 5 more "assumption sub-equations" (Lewis et al., 1997). In this paper, we add 14 sub-equations such as:

(3) $X_i - X_{i+1} = e_i$

on the intuitive assumption of zenshinteki hennka (Nakamura,1982) that the differences in per capita consumption between successive age groups should not be abruptly large. Individual consumption by age, X_i, per capita average consumption by individual, *i'* years old in the ith age group is estimated, using the LS method on the basis of the Mori and Inaba model (Mori and Inaba,1997) in which the squared sum of equations (2) and (3) are to be minimized.

In this paper we illustrate this approach using *FIES* consumption data for fresh fish and fresh meat, representing traditional and modern protein sources in the Japanese diet (footnote 1). Estimated average per capita at-home consumption by age for fresh fish and fresh meat for 23 years from 1979 to 2001 is shown in Tables 3 and 4, with the corresponding t-values for the estimated parameters provided in Appendix Tables 1 and 2, respectively.

In the next section, we will decompose changes in individual consumption by age groups into (chronological) age, period (annual) and birth cohort on top of grand mean effects, using the Nakamura's Bayesian cohort model (Nakamura, 1982, 1986).

Decomposing Age, Period and Cohort Effects

In the simple A/P/C cohort model, the average per capita consumption by an individual in the ith age group at the period t, X_{it} is expressed as follows (Glenn, 1977; Rentz and Reynolds, 1991):

(4) $X_{it} = B + A_i + P_t + C_k + E_{it}$

Where:

B = the grand mean effect
A_i = the effect to be attributed to the age represented by the ith age group
P_t = the effect to be attributed to the period represented by the year t
C_k = the effect to be attributed to the cohort represented by the birth group k
E_{it} = random error

Table 3: 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

Table 4: Estimates of Per Capita Individual At-home Consumption of Fresh Meat 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	10.0	13.5	13.7	13.7	13.6	12.5	13.5	13.6	13.8	13.7	12.2	11.4	10.2	8.8	7.2
1980	10.1	13.9	14.0	13.1	12.7	12.4	13.4	14.5	14.9	13.9	11.5	12.1	10.5	8.9	7.3
1981	9.8	13.5	13.6	12.8	12.2	12.1	13.2	14.3	14.9	13.9	11.7	11.0	10.3	9.2	7.6
1982	9.7	13.3	13.5	12.4	11.6	12.3	13.7	14.7	16.1	14.8	12.6	10.9	10.7	9.8	8.2
1983	9.4	12.7	13.8	12.2	11.8	11.9	13.5	15.3	15.8	15.0	12.1	9.7	9.7	8.9	7.4
1984	10.5	13.9	13.6	12.6	11.7	11.9	12.1	16.6	16.2	13.6	12.5	11.2	9.7	8.3	6.8
1985	9.3	12.5	13.2	12.9	12.1	12.9	13.1	17.3	19.1	14.0	12.6	11.5	9.9	8.5	6.9
1986	9.3	13.4	14.2	13.9	13.2	12.8	14.4	16.1	17.8	13.0	12.8	11.0	10.3	9.2	7.7
1987	10.5	14.2	14.0	13.1	12.4	11.5	12.8	17.3	17.0	14.4	13.7	11.3	10.3	9.0	7.3
1988	10.6	14.3	13.9	12.7	11.8	11.3	12.7	17.3	16.9	14.4	13.5	11.7	9.9	8.3	6.7
1989	9.0	12.4	13.0	12.6	11.9	12.1	13.6	17.6	19.2	14.1	12.9	12.1	9.8	8.5	6.9
1990	9.6	13.6	14.3	13.2	12.0	11.1	12.4	15.7	17.1	15.0	12.5	12.1	10.3	8.7	7.1
1991	8.6	12.7	13.6	13.1	12.8	12.1	14.0	15.9	17.6	13.9	13.5	11.6	10.6	9.4	7.7
1992	9.6	13.9	14.6	14.1	13.9	10.7	11.6	15.5	16.5	13.9	13.0	12.4	10.7	9.2	7.4
1993	9.6	13.4	14.3	14.0	13.3	11.6	11.9	16.0	17.2	15.6	13.8	12.3	11.1	9.7	8.0
1994	9.5	12.8	13.2	13.2	13.1	12.4	11.9	17.2	17.4	16.9	12.8	13.3	10.4	9.2	7.6
1995	9.5	13.4	14.4	14.2	13.6	12.3	12.6	15.6	17.3	16.0	13.4	13.2	10.8	9.4	7.7
1996	10.2	13.9	14.3	14.0	14.0	11.5	10.8	15.3	16.1	14.2	14.6	12.3	11.3	9.9	8.2
1997	9.3	13.3	14.3	14.1	13.5	11.7	12.5	14.6	16.3	15.1	14.2	13.3	11.6	10.0	8.2
1998	9.5	12.8	13.4	13.8	13.6	12.4	11.7	15.5	15.4	15.7	14.1	12.8	11.4	9.8	8.1
1999	9.5	12.7	13.3	13.4	13.3	12.9	11.8	15.2	15.7	15.2	14.8	13.9	12.1	10.7	8.9
2000	8.9	12.0	12.7	12.9	12.8	12.3	12.4	15.9	17.0	17.0	14.7	13.8	11.8	10.4	8.7
2001	9.1	12.5	13.3	13.4	13.2	12.2	11.7	14.4	15.4	15.0	13.7	13.3	10.9	9.8	8.1

Those individuals in their 30s in 1980, those in their 40s in 1990 and those in their 50s in 2000, respectively, were born from 1941 to 1950, and thus belong to the same birth cohort. In the standard cohort table in which age classification matches the survey period-intervals (10 years in the case of Table 5), all the cells along the diagonal line belong to the same (birth) cohort. Suppose that those in their 40s in 1990 belong to cohort k(C_k) and those in their 30s in the same year are expressed as cohort k+1(C_{k+1}), in the sense that those in the latter group were born one time period after those in the former group.

Table 5: Standard Cohort Table Showing Hypothetical Consumption Data by Selected Age Groups for 1980, 1990 and 2000

(kg/person)

Year	Age			
	20-29	30-39	40-49	50-59 yrs.old
1980	10	15	18	18
1990	10	17	20	21
2000	8	14	21	20

In a hypothetical case in Table 5, 20kg consumed on average by those in their 40s in 1990, for example, can be expressed as follows:

(5) $X_{45.90} = B + A_{45} + P_{90} + C_k + E_{45.90} = 20$

Likewise, 17kg by those in their 30s in the same year and 20kg by those in their 50s in 2000, respectively, can be expressed as follows:

(6) $X_{35.90} = B + A_{35} + P_{90} + C_{k+1} + E_{35.90} = 17$
(7) $X_{55.00} = B + A_{55} + P_{00} + C_k + E_{55.00} = 20$

Although there is no theoretical and/or empirical evidence, we assume in this study that food consumption habits last a lifetime. Cohort effects in food consumption, in our terminology, are formed during early adolescence, instead of in early adulthood, as is the case of political behavior such as voting (Nakamura, 1995; A. Tanaka, 2003) and economic behavior such as saving (Deaton and Paxson, 1994; Fukuda and Nakamura,1995; Attanasio,1998). On this ground, the first age column in Tables 3 and 4, 0 to 9 years old, is eliminated for the purpose of estimating age, period and cohort effects. We have 14 (age groups) ×23 (years) = 322 observations and 14 (age effects) + 23 (period effects) + 19 (cohort effects) = 56 parameters to be estimated. It looks as if parameters can be estimated, since there are a sufficient number of observations.

However, there are exact linear dependencies among age, period and (birth) cohort (i.e., individuals age 35 in the year 1990 were born in 1955. If i' represents the average age of those in the age group i, and t, the annual year of the survey period, then the annual year, k', when cohort k, C_k was born, is determined:

(8) $k' = t - i'$

This is called the "identification problem" in the estimation of cohort parameters (Mason and Fienberg, 1985; Rentz and Reynolds, 1991; Asano, 2001). To overcome this difficulty, Nakamura (1982, pp.81-2;1986, p. 356) proposed the Bayesian approach on the assumption of zensinnteki henka (i.e., "the successive parameters of the age groups, survey periods, or birth cohorts are not so different, or change gradually"). In this study, we use the cohort programs written in SAS language under Nakamura's (1999) guidance and the helpful comments of various others (Inaba et al. 2002).

We first tried to estimate cohort parameters, age, period and cohort effects, using iterative runs, with Akaike's Bayesian Information Criterion (*ABIC)* (Nakamura, 1982, p.84) as the only criterion in selecting a set of hyperparameters in the additional constraint of zenshnnteki henka:

(9) $$\frac{1}{\sigma_A^2}\sum_{i=1}^{a-1}(A_i - A_{i+1})^2 + \frac{1}{\sigma_P^2}\sum_{t=1}^{p-1}(P_t - P_{t+1})^2 + \frac{1}{\sigma_C^2}\sum_{k=1}^{c-1}(C_k - C_{k+1})^2 = \min!$$

Theoretically, a set of hyperparameters, σ^2_A , σ^2_P , σ^2_C , selected by *ABIC* as an only criterion should be deemed the best (Nakamura, 1982,1986). However, it is not uncommon that cohort parameters, i.e., grand mean, age, period and cohort effects obtained, should produce extremely low or even negative consumption for certain age groups at certain time periods, when synthesized to predict theoretical values[5]. We manipulated a set of hyperprameters to avoid negative values in predicted consumption. Estimated age, time and cohort effects on top of grand mean effects for fresh fish and fresh meat, are shown in Tables 6 and 7.

Average per capita (at-home) fresh fish consumption declined from 13.02 kg in 1979-1981, to 11.87 in 1989-91 and slightly to 11.75 kg in 1999-2001. Fresh meat consumption increased from 12.08 kg in 1979-81 to 12.50 kg in 1989-91, and has remained stable since then.

The results of our cohort analysis indicate that age effects for fresh fish tend to rise as one ages from youth to middle age and to old age. Consumption then declines for those in their 70s (at-home consumption only). On the other hand, older generations born before the mid 20th century are found to have positive cohort effects whereas younger, post WWII generations exhibit negative cohort effects. Generations born after the mid-1960s, in particular, show increasingly declining cohort effects.

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5 One of the IFAMR referees for the first manuscript of cohort analysis of Japanese food consumption by Mori, et al. raised a question, "is it conceivable that young Japanese will not eat rice at all in some future years ?" (Mori, Lowe ,Clason, and Gorman,2001).

Table 6: Changes in Average Individual Per Capita Consumption of Fresh Fish, 1979 to 2001, Decomposed into Age, Time and Cohort Effects

Grand Mean Effects = 13.02; R^2 = 0.9857 (kg/year)

Age Effects: A_i		Time Effects: P_t		Cohort Effects: C_k	
Age groups(yrs.)		Calendar year		Years born	
10-14	-3.12	1979	1.19	~ 1904	-2.32
15-19	-3.71	1980	1.16	1905-09	-1.72
20-24	-4.50	1981	0.68	1910-14	-0.97
25-29	-5.26	1982	0.37	1915-19	0.02
30-34	-5.05	1983	0.69	1920-24	0.67
35-39	-4.47	1984	1.01	1925-29	1.68
40-44	-2.25	1985	0.62	1930-34	1.81
45-49	0.67	1986	0.48	1935-39	2.84
50-54	3.70	1987	-0.13	1940-44	4.81
55-59	5.40	1988	-0.03	1945-49	4.51
60-64	5.85	1989	-0.30	1950-54	2.91
65-69	5.67	1990	-0.72	1955-59	1.40
70-74	4.29	1991	-0.35	1960-64	-0.09
75 ~	2.77	1992	0.25	1965-69	-0.91
		1993	0.40	1970-74	-1.74
		1994	-0.20	1975-79	-2.59
		1995	-0.30	1980-84	-3.21
		1996	-0.62	1985-89	-3.57
		1997	-0.56	1990 ~	-3.55
		1998	-0.71		
		1999	-0.88		
		2000	-0.84		
		2001	-1.21		

Table 7: Changes in Average Individual Per Capita Consumption of Fresh Meat,1979 to 2001, Decomposed into Age, Time and Cohort Effects

Grand Mean Effects = 12.49; R^2 = 0.9434 (kg/year)

Age Effects: A_i		Time Effects: P_t		Cohort Effects: C_k	
Age groups(yrs.)		Calendar year		Years born	
10-14	-0.44	1979	0.11	~ 1904	-2.34
15-19	0.05	1980	0.19	1905-09	-2.29
20-24	-0.26	1981	-0.06	1910-14	-2.24
25-29	-0.59	1982	0.19	1915-19	-1.95
30-34	-1.31	1983	-0.20	1920-24	-1.71
35-39	-0.78	1984	-0.21	1925-29	-0.77
40-44	2.21	1985	0.15	1930-34	-0.29
45-49	3.17	1986	0.34	1935-39	0.14
50-54	1.67	1987	0.18	1940-44	1.70
55-59	0.75	1988	-0.08	1945-49	1.48
60-64	0.37	1989	-0.04	1950-54	1.00
65-69	-0.57	1990	-0.19	1955-59	0.30
70-74	-1.48	1991	-0.01	1960-64	0.47
75 ~	-2.80	1992	-0.12	1965-69	1.29
		1993	0.15	1970-74	1.42
		1994	0.05	1975-79	1.47
		1995	0.19	1980-84	1.10
		1996	-0.09	1985-89	0.78
		1997	0.04	1990 ~	0.42
		1998	-0.16		
		1999	0.05		
		2000	0.05		
		2001	-0.53		

In view of the fact that the Japanese population has drastically aged in the past few decades, one would expect the total consumption of fresh fish to have increased in that respect. However, total consumption may have been negatively affected by another force, i.e., older generations with slightly negative (cohorts born before the 1920s) or conspicuously positive cohort effects being replaced by newer ones with increasingly negative effects.

In the case of fresh fish, "pure" time effects, *compensated for age and cohort effects*, broadly match changes in actual average per capita consumption stated above, implying that positive aging effects may have been offset by the negative effects accruing from the replacement of the older generations by the newer ones. In the case of fresh meat, however, *the age factor-free time effects* are estimated to be constant around zero over the entire period, implying that the small increase in actual per capita consumption for the first decade of the survey period could have been caused by cohort replacement effects which more than offset the conceivable negative effects from population aging .

At any rate, with age, time, and cohort effects estimated above, we should be able to predict individual consumption by age (and cohort) in future years, by synthesizing these three effects on top of grand mean effects which are set at constant.

Predicting Individual Consumption by Age (and Cohort) in Future Years

Time effects that reflect economic variables, such as income and prices, and changes in consumers' preferences and attitudes, such as health consciousness and convenience orientation, cannot be predicted with certainty (Tokoyama and Egaitsu, 1994; Eales and Wessels,1999). However, future time effects may be approximated in several ways, such as extrapolation from past trends or assuming them unchanged from those observed in the near past.

We have not tried to explain the estimated changes in "pure" time effects (Column 2, Tables 6 and 7) in this paper and, for the sake of simplicity, will assume that the time effects in years 2010 and 2020 will remain unchanged from the immediate past, 7 years since the mid-1990s. This assumption may lead to an optimistic prediction of future fresh fish consumption, which has shown a somewhat decreasing trend in time effects over the entire survey period (Column 2, Table 6).

There is another minor problem in deriving individual consumption for younger age groups in future years. Those who will be in their teens in 2020 were not born yet in the end-years of our survey period and those who will be in their teens in 2010 have not reached the youngest age groups in our cohort analysis. Therefore, we must fill these gaps in some way. Fresh fish is found to show significantly decreasing trends in cohort effects, increasing in negative value, for the generations born after the mid-1960s. In the case of fresh meat, the younger generations also are found to carry slightly decreasing trends in cohort effects (Column 3, Tables 6 and7). We might guess the likely cohort effects for newly arriving generations by extrapolating cohort effects from the post-war generations. In this study, we substitute the average figures of the three newest cohorts, as of the late 1990s (born 1980-84, 1985-89 and 1990-) for the newly entering younger generations in 2010 and 2020. It should be emphasized that this treatment may give rise to upward biases in the predicted consumption of fresh fish, in particular, by the young in the future years.

Tables 8 and 9 represent per capita average consumption of fresh fish and fresh meat by age groups. All age cells from 10-14 to 75 years old and older in the years (2000) [6], 2010 and 2020, respectively, are filled by synthesizing the above estimates of grand mean, age, time, and cohort effects.

Once per capita consumption by age groups is determined, aggregate consumption may be projected by multiplying consumption per person by the number of people in specific age groups in the corresponding year. Our forecast of total at-home consumption of fresh fish and fresh meat for 2000,2010 and 2020 are provided in Tables 10 and 11.

According to our findings, against the base year 2000 (predicted), total at-home consumption of fresh fish is projected to decline slightly, 3.6 percent, toward the year 2020. Fresh meat consumption is projected to rise only slightly by 1 percent to 2010 but decline to the base year level toward the year 2020. All these projected changes are very modest in magnitude.

We had speculated, at first, that consumption of fresh fish would decline drastically in the rapidly aging Japanese society because today's "fish eating" older generations will fade away and today's younger people (who will get old) are not eating very much of this product. In the year 2020, the young, from 10 to 44 years old, will account for 41 percent of Japan's total population. Their share of the market is projected to occupy only 16 percent of total consumption of fresh fish. At the same time, a substantial share of at-home fresh fish consumption is attributed to the elderly who will disappear from the market before long. The situation for fresh meat consumption may be similar, although to a lesser extent (nearly one third of at-home fresh meat consumption will be consumed by those older than 60 years of age in 2020).

Many, if not the majority of, industry representatives seem to be optimistic about the prospect of fresh fish consumption in the future as they hope that today's young people will increase their consumption as they age, saying "Japanese are the fish-eating nation." Our finding does not seem to support this view, because Japanese younger age groups carry large negative (below zero) cohort effects for fresh fish. This does not necessarily imply that they will eat much more of meat in place of fresh fish at home.

What and where do (and will) the young eat? They eat more processed or semi-processed products and they eat substantially more away from home. These important aspects of food consumption, not addressed by this study, may need to be investigated.

[6] In Tables 8 and 9, two sets of figures are presented for the year 2000, one: "actual" directly drawn from Tables 3 and 4, and other: "synthesized", using cohort parameters in Tables 6 and 7.

Table 8: Predicted Per Capita Individual At-home Consumption of Fresh Fish by Age, 2000, 2010, and 2020

(kg/year)

Age group years old	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~[6]
G.M.E.[1]	13.02	13.02	13.02	13.02	13.02	13.02	13.02	13.02	13.02	13.02	13.02	13.02	13.02	13.02
A.E.[2]	-3.12	-3.71	-4.50	-5.26	-5.05	-4.47	-2.25	0.67	3.70	5.40	5.85	5.67	4.29	2.77
T.E.[3]	-0.73	-0.73	-0.73	-0.73	-0.73	-0.73	-0.73	-0.73	-0.73	-0.73	-0.73	-0.73	-0.73	-0.73
Sub-total	9.17	8.58	7.79	7.03	7.24	7.82	10.04	12.96	15.99	17.69	18.14	17.96	16.58	15.06
2000 (predicted)														
Cohort Effects[4]	-3.57	-3.28	-2.71	-1.91	-1.08	-0.25	1.10	2.61	4.19	4.75	3.23	2.02	1.70	0.28
Total	5.60	5.30	5.08	5.12	6.16	7.57	11.14	15.57	20.18	22.44	21.37	19.98	18.28	15.34
2000 (actual)[5]	5.24	5.28	5.31	5.57	6.01	7.23	11.36	14.01	19.21	21.88	20.73	20.28	18.29	15.89
2010 (predicted)														
Cohort Effects[4]	-3.44	-3.44	-3.57	-3.28	-2.71	-1.91	-1.08	-0.25	1.10	2.61	4.19	4.75	3.23	1.57
Total	5.73	5.14	4.22	3.75	4.53	5.91	8.96	12.71	17.09	20.30	22.33	22.71	19.81	16.63
2020 (predicted)														
Cohort Effects[4]	-3.44	-3.44	-3.44	-3.44	-3.57	-3.28	-2.71	-1.91	-1.08	-0.25	1.10	2.61	4.19	3.58
Total	5.73	5.14	4.35	3.59	3.67	4.54	7.33	11.05	14.91	17.44	19.24	20.57	20.77	18.64

[1] grand mean effects;
[2] age effects;
[3] time effects set at the average of 7 years, 1995-2001;
[4] weighted averages of successive cohorts in such a way as 4/5 of cohort born,1960-64 and 1/5 of cohort born 1965-69 for those age group,35-39 in 2000, for example;
[5] simple averages of 1999-2001;
[6] implicitly assumed that this age group comprises age groups of 75-79 and 80~ in half and half.

Table 9: Predicted Per Capita Individual At-home Consumption of Fresh Meat by Age, 2000, 2010, and 2020

(kg/year)

Age group years old	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~[6]
G.M.E.[1]	12.49	12.49	12.49	12.49	12.49	12.49	12.49	12.49	12.49	12.49	12.49	12.49	12.49	12.49
A.E.[2]	-0.44	0.05	-0.26	-0.59	-1.31	-0.78	2.21	3.17	1.67	0.75	0.37	-0.57	-1.48	-2.80
T.E.[3]	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06
Sub-total	11.99	12.48	12.17	11.84	11.12	11.65	14.64	15.60	14.10	13.18	12.80	11.86	10.95	9.63
2000 (predicted)														
Cohort Effects[4]	0.70	1.04	1.40	1.43	1.31	0.64	0.33	0.86	1.38	1.66	0.45	-0.20	-0.68	-1.78
Total	12.69	13.52	13.57	13.27	12.43	12.29	14.97	16.46	15.48	14.84	13.25	11.66	10.27	7.85
2000 (actual)[5]	12.42	13.06	13.23	13.12	12.46	11.97	15.15	16.05	15.73	14.37	13.64	11.60	10.31	8.55
2010 (predicted)														
Cohort Effects[4]	0.77	0.77	0.70	1.04	1.40	1.43	1.31	0.64	0.33	0.86	1.38	1.66	0.45	-0.72
Total	12.76	13.25	12.87	12.88	12.52	13.08	15.95	16.24	14.43	14.04	14.18	13.52	11.40	8.91
2020 (predicted)														
Cohort Effects[4]	0.77	0.77	0.77	0.77	0.70	1.04	1.40	1.43	1.31	0.64	0.33	0.86	1.38	0.76
Total	12.76	13.25	12.94	12.61	11.82	12.69	16.04	17.03	15.41	13.82	13.13	12.72	12.33	10.39

[1] grand mean effects;
[2] age effects;
[3] time effects set at the average of 7 years, 1995-2001;
[4] weighted averages of successive cohorts in such a way as 4/5 of cohort born,1960-64 and 1/5 of cohort born 1965-69 for those age group,35-39 in 2000, for example;
[5] simple averages of 1999-2001;
[6] implicitly assumed that this age group comprises age groups of 75-79 and 80~ in half and half.

Table 10: Total At-Home Consumption of Fresh Fish by Age Group, Projections to 2000, 2010, and 2020

(kilo tons)

	Total	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.)
2000	1472.99	36.72	39.76	42.87	50.22	54.17	61.54	87.05	139.07	211.10	196.35	65.62	142.22	108.03	138.26
2010	1474.16	33.84	31.14	28.03	28.72	38.83	58.07	78.30	101.99	130.38	174.54	221.51	183.61	135.84	229.38
2020	1420.16	30.89	29.85	26.17	22.55	25.09	35.03	62.55	107.28	127.48	135.07	139.62	164.48	184.77	329.31

Table 11: Total At-Home Consumption of Fresh Meat by Age Group, Projections to 2000, 2010, and 2020

(kilo tons)

	Total	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.)
2000	1511.46	83.22	101.43	114.50	130.17	109.31	99.92	116.98	147.02	161.94	129.85	102.69	83.00	60.70	70.75
2010	1527.11	75.35	80.28	85.47	98.64	107.31	128.52	139.39	130.31	110.09	120.72	140.67	109.31	78.17	122.90
2020	1512.43	68.79	76.96	77.85	79.22	80.81	97.92	136.87	165.34	131.76	107.04	95.28	101.71	109.33	183.56

Last, but not least, we have to mention a few limitations in our projections. First, our projections do not cover future consumption by the youngest age group of 0-9 years old, since we failed in this study to estimate the age effects for this group, as we assumed at the outset that food consumption cohort effects will be life-long and may be formed in early adolescence. This assumption may need to be scrutinized in a future study. Second, the average of the three newest cohorts as of the year 2000 were used as cohort effects for the two youngest age groups, 10-14 and 15-19 years old in 2010 and the four youngest groups from 10-14 through 25-29 in 2020. This was done because the two youngest groups had not reached the youngest age of 10 in our cohort analysis. We suspect that this might lead to a slight overestimation for the younger age groups for fresh fish which shows somewhat declining tendencies in estimated cohort effects for the newer generations in our study (Table 6); on the contrary, consumption of fresh meat (by the young) might well be somewhat under-projected as the newer generations seem to carry slightly increasing tendencies in cohort effects. Third, and perhaps most important, estimated "pure" age effects for the oldest age group, 75 years old and older could be too big for projections, particularly for the year 2020 when much larger percentage of the elderly will be represented by those over 80 years in age who generally do not consume as much food as those in their late 70s. Most existing official statistics relating to individual food consumption set the oldest age class at 70 years old and older (*Nutrition Survey*; *FIES*, 2000- 2002). For the more realistic analysis, age classification may need further breakdown of consumption by the elderly.

Conclusion

In this study, we have attempted to augment food product consumption forecasts by applying a cohort approach. We first derived per capita individual consumption by age from household data classified by age groups of household head, using a model developed by Mori and Inaba (1997). Next, we attempted to decompose age, generational cohort and period effects using the Bayesian cohort model developed by Nakamura (1982,1986). We then projected individual consumption by age for the years 2010 and 2020, synthesizing age and cohort effects estimated in the previous two steps.

We applied this method to consumption data of fresh fish and fresh meat compiled by the Japanese government *Family Income and Expenditure Survey (FIES).* We had speculated initially that consumption of fresh fish would decline drastically in the rapidly aging Japanese society because younger people today are not eating as much of this product. Our results, however, indicate that the decline will be much less severe – only about 3.5 percent toward the year 2020. Fresh meat consumption is predicted to stay unchanged over the same period. Although substantial refinement of our methods is warranted, we believe the cohort approach is a useful tool in supplementing prediction of future food product consumption, and combined with economic factors may prove realistically useful in future economic demand analyses, especially when a "structural change" in consumers' preferences are suspected.

Appendix

Appendix Table 1: 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

Appendix Table 2: T-statistics for Estimates of Per Capita Individual Consumption of Fresh Meat 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	11.68	14.30	16.03	19.57	35.23	18.44	15.91	15.92	20.31	34.77	40.30	33.82	22.07	16.13	9.07
1980	8.32	10.46	11.67	13.62	22.62	12.88	11.10	12.05	15.72	25.22	29.09	25.33	16.21	11.70	6.47
1981	10.60	13.22	14.61	16.46	27.48	16.53	14.44	15.40	20.13	31.58	38.72	30.36	21.52	16.27	9.02
1982	7.76	9.67	10.88	12.39	18.58	12.39	11.04	11.81	16.38	25.74	32.91	23.25	16.48	12.84	7.14
1983	10.13	12.34	13.66	15.93	25.14	16.22	14.51	16.30	21.21	34.32	44.71	26.19	20.49	15.96	8.89
1984	8.95	10.74	11.50	13.77	18.42	12.92	10.37	14.03	16.95	26.49	33.77	26.42	16.46	11.98	6.54
1985	6.87	8.29	9.78	12.65	18.05	12.64	9.63	13.05	17.10	23.87	33.69	25.90	14.88	11.10	6.24
1986	6.78	8.55	10.31	13.29	19.01	12.28	10.29	11.75	15.50	21.70	33.14	26.14	14.81	11.61	6.65
1987	8.63	10.69	11.70	14.07	20.26	12.53	10.56	14.79	17.39	26.89	39.24	29.81	16.79	12.86	7.23
1988	7.34	9.14	9.86	11.27	15.52	10.34	8.86	12.56	14.77	22.27	32.60	28.86	13.51	9.97	5.51
1989	6.55	7.99	9.20	11.76	16.41	11.60	9.95	12.77	17.36	23.16	32.54	32.69	14.07	10.34	5.94
1990	5.74	7.41	8.57	9.52	13.40	8.74	7.58	9.69	13.43	19.30	25.14	26.38	12.13	8.52	4.85
1991	5.54	7.15	8.52	10.61	15.01	10.14	9.00	10.22	14.19	19.95	29.54	27.46	13.59	9.92	5.79
1992	6.70	8.53	9.97	12.45	18.20	9.20	7.94	10.71	14.58	21.52	31.21	33.05	15.04	10.65	6.10
1993	6.93	8.74	10.14	12.51	18.56	12.06	8.84	12.03	17.37	25.16	33.16	34.21	15.90	11.52	6.59
1994	10.16	12.33	13.72	17.27	27.09	19.21	13.08	19.01	25.62	38.39	45.46	54.49	20.62	16.03	9.09
1995	6.73	8.56	10.05	12.34	17.60	12.58	9.21	11.51	17.05	24.44	31.19	35.89	14.62	10.82	6.13
1996	7.99	9.88	11.30	14.00	22.09	13.10	9.25	12.58	17.49	25.86	39.39	36.22	17.57	14.01	7.81
1997	6.61	8.54	10.15	12.60	19.04	12.55	9.66	10.88	16.02	24.57	34.70	35.27	15.92	12.42	6.90
1998	9.29	11.27	12.84	16.82	26.50	18.34	12.47	15.82	20.55	34.33	47.19	46.94	21.67	16.93	9.42
1999	11.60	13.97	16.08	20.49	31.88	25.11	15.85	19.81	26.38	41.68	61.53	62.87	26.62	23.48	13.02
2000	9.85	11.84	13.61	17.60	28.01	21.23	15.09	18.41	25.35	40.28	54.86	56.83	23.66	20.82	11.58
2001	9.33	11.49	13.46	16.95	25.11	19.34	13.12	15.56	21.48	33.92	46.71	49.84	19.56	17.75	9.88

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