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Cohort analysis of food consumption: a case of rapidly changing Japanese consumption

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1. Introduction

According to the "1989–91 USDA Survey of Food Intakes," older American adults consume much more coffee than younger ones, while the opposite is the case with pop (soda) (Table 1). In forecasting consumption of coffee and pop in the future, as the US population ages as a whole, there can be two extremely different projections. One is that those in their twenties and thirties in the 1980s might consume much more coffee and much less pop as they reach their forties and fifties, resulting in a substantial increase and decrease, respectively, in consumption of coffee and pop (as a nation). The other possibility is that those younger adults in the 1980s might retain their consumption habits for soft drinks as they get older, resulting in drastic decreases and increases, respectively, in consumption of coffee and pop (Rentz & Reynolds, 1991).

According to Tanaka and Mori (1998), in 1989, Japanese adults in their twenties and thirties consumed, at home, approximately 5 kg of mandarin oranges as compared to approximately 15 kg consumed by those in their late forties, fifties and early sixties, per capita, per year. In the early 2000s, consumption of mandarin oranges would have increased substantially if the younger adults in the 1980s eat as much mandarins after 20 years as the middle-aged groups in the 1980s, period effects ignored. However, on the contrary, consumption would have decreased substantially, if these younger adults in the 1980s retain their consumption habits of mandarins even after they reach their forties or fifties.

The first prediction, either for soft drinks or mandarins, is based on the assumption of pure age effects alone and the second on the assumption of predominance of consumers' cohort membership effects in consumption changes.

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Table 1
Mean intakes per person per day, by age, 1989–91

Age (Years) Males	Coffee	Carbonated soft drinks (regular)
	----grams----	
20–29	166	311
30–39	353	256
40–49	524	207
50–59	483	124
60–69	501	67
70 and over	410	57

Source: Interagency Board for Nutrition Monitoring and Related Research, Third Report on Nutrition Monitoring in the United States, Appendix, VA-68.
Original Source: USDA Continuing Survey of Food Intakes by Individuals, 1989–91.

Consumption of any food product is influenced by the structure of age and cohort membership of population and period and their interactions (Nakamura, 1995). The period effects involve economic factors, such as income and prices, and noneconomic factors, such as health consciousness and "westernization," for example, in Japan.

In the past four decades, Japanese food consumption has been studied extensively by traditional demand theory analyses, single commodity approach at the earlier stages (Yuize, 1971; Dyck, 1988; to name a few), and the demand system approach in the more recent years (Sasaki, 1987; Hayes et al., 1990; Mori & Lin, 1990, to name a few). There have appeared lately some suspicions among noted Japanese economists that the traditional approach by means of economic factors may have become less effective in clarifying Japanese food consumption patterns which seem to have reached "maturity" (Tokoyama & Egaitsu, 1994; Tokoyama, 1995).

In 1979, the Japanese government Management and Coordination Agency (MCA) began publishing consumption data by the age groups of head of household (HH) in the *Family Income and Expenditure Survey (FIES)*. Mori and Inaba (1997) developed a unique methodology to estimate individual consumption of family members by age by incorporating the age structure of families by HH age groups into the model. Their approach, indirect in nature and far from perfection, is unquestionably superior to the traditional method of simply dividing household consumption by HH age groups by respective number of family members (Mori, 1998).

With the individual consumption estimates available by 15 age classes, 0–4, 5–9, . . . , 65–69, and 70 and over, for the past 20 years, a cohort analysis of Japanese food consumption is attempted in this study. Lewis et al. (1997) and Mori (1998) have already shown statistically that older Japanese consume more traditional products such as rice, fish and sake than younger Japanese, whereas the latter consume more nontraditional products, such as bread, beef and beer than the former. They perceived age in a broad sense and did not explicitly separate it into age in a narrow sense, or "pure age" and generation, or cohort membership (Schrimper, 1979, pp. 1059–60). They tried to trace changes in consumption of various products over time by major age groups, but failed to identify pure period effects with age and cohort effects compensated.

The main purpose of this paper is to measure effects of age, generation or cohort membership, and period on changes in Japanese consumption of selected food items over the past 20 years. In doing so quantitative guidelines will be generated for the more realistic and dependable forecasts of future food demand in Japan. It is hoped that marketers, either domestic or overseas, can use the information presented in this paper or to be further refined to develop effective strategies geared to specific cohorts or current age classes.

2. What is a cohort?

A cohort is a group of people within a given population who experience a life event at about the same time. The life event is one that shapes the group's attitudes, preferences, or lifestyles. Different cohort types include boom/depression, ethnic, education, or geographic cohorts. The simplest and easiest cohort to track is the birth cohort. Those born within the same time period tend to enter various stages of life at about the same time (Glenn, 1977).

It is important to distinguish between the terms "birth cohort" and "age groups." An age group includes people who are of a certain age at the time of the survey. This could be an age group of people 65 to 69, say, retirement age. It is possible to compare the group's activities, savings or consumption of a particular product 20 years ago, with the same group's current activities. In doing so, note that the members of this group change, in age, from survey period to survey period.

As the birth cohort moves through the life cycle, events shape the group's preferences and attitudes. The most profound is "coming of age." This generally occurs between the ages of 17 and 21, or maybe slightly younger, or even older. The economic and social environment at this time shape lifelong attitudes within the group. These are "formative years," that will have lasting, profound effects on the cohort group (Meredith & Schewe, 1994).

The population of the United States can be divided into birth cohort groups. For instance, the depression cohort includes those born between 1912 and 1921. They were not born during the Great Depression, but they entered adulthood between 1930 and 1939. It can be hypothesized that devastating economic conditions during this time created a strong desire to save and prepare for the future. The depression cohort is estimated to have maintained this financially conservative behavior to the present day (Attanasio, 1997; Gokhale et al., 1996). These habits are in stark contrast to those of the first boomer's cohort. They were born between around 1946 and 1954. When they came of age from 1963 to 1972, the nation was experiencing good economic times. This group is marked by a desire to maintain the good lifestyle they experienced while growing up. The assumption of large amounts of debt was one way to do this.

In Japan, food was in short supply before, during and soon after World War II. Even in 1955, the year when the Japanese economy was said to have been restored to the prewar level (*Economic Planning Agency*), most people depended on cereals for the important part of caloric intakes and took very little animal protein, such as meat and dairy products. As the

Table 2
Per capita food supply, 1955, 1965, 1975 and 1995

Fiscal Year	(kg/year)			
	1955	1965	1975	1995
Cereals	155.5	145.0	122.2	102.0
(Rice)	(110.4)	(111.7)	(88.1)	(67.8)
Meat	3.2	9.2	17.9	31.3
Hen Eggs	3.4	11.6	14.0	17.6
Milk and Dairy Products	12.0	37.4	53.3	91.2
Fish and Shell Fish	26.2	29.2	34.9	38.2
Vegetables	82.2	109.6	111.3	105.5
Fruits	12.3	28.5	43.0	40.7
Caloric Intake (kc/day)	2,000	2,460	2,520	2,638

Sources: *Food Balance Sheet*, Ministry of Agriculture, Forestry and Fisheries, various issues.

economy leaped forward since then, people's diets drastically changed toward a "western" type, namely, greatly decreased cereal consumption, particularly rice, and increased consumption of meat and dairy products (Table 2).

Those born before and during WWII came of age during the food shortage periods and/or "periods of much cereal and little meat." They may have formed their eating habits, if not willingly, under circumstances quite opposed to those who came of age, say after the late 1960s when the economy reached the level of that of a developed economy, or those born after 1970 or so who experienced affluence of everything in life during their formative years. These generations may have different preferences for and patterns of food intake, the age factor set aside.

Cohort analysis has been used in demography, sociology, and medical studies (Meredith & Schewe, 1994; Ryder, 1965; Mason & Fienberg, 1985). Its use in other disciplines has been much more limited. In economics, cohort analysis has been employed in rather primitive form to examine the declining savings in the United States (Attanasio, 1997; Gokhale et al., 1996). Cohort analysis of food consumption is relatively unexplored (Rentz & Reynolds, 1991).

3. Research methods

Analysis of food consumption trends from the viewpoint of age is limited by the availability and nature of the data. The Japanese government publishes yearly *Family Income and Expenditure Surveys* (*FIES*). These surveys include consumption data for approximately 8,000 households. Beginning in 1979, the surveys report consumption and expenditures according to age groups of head of household (HH). This makes it possible to address the age issue.

It is necessary to derive individual consumption of household members by age from the household consumption data. A common method of addressing this issue is simply to divide household consumption by the average household size. This method has severe shortcom-

Table 3
Standard cohort table—a hypothetical case of certain food intakes by age groups, 1970, 1980 and 1990

Year	Age (years old)		
	20–29	30–39	40–49
	kg/person		
1970	10	15	18
		(1)	(2)
1980	10	17 (3)	20
1990	8	14	21

ings, however. The inherent assumption is that each member of the household is the same age which may be true only in the case of households consisting of a same-age couple only.

A model to more accurately derive individual consumption was developed by Mori and Inaba (1997). The model makes use of household composition estimates. The use of this method has solved, if not without weakness, the problem of individual consumption derivation. The resulting data contains *per capita* consumption estimates of household members by age group for individual commodities.

With data available in this form over time, it is possible to estimate age, period, and cohort effects. Period effects are those influences attributed to the time period of the survey, such as changes in income, prices or trade policy, or food-borne disease outbreaks. Age effects are those effects associated with physical and mental aging. Over the life cycle, nutritional requirements change, as do tastes and preferences. Cohort effects are those influences attributed to a particular birth cohort. These include major events or shifts in social attitudes that shape tastes and preferences for particular foods.

A cohort table has survey period on one axis, and age groups on the other. If the survey period is every 10 years, then defining age groups with 10-year intervals will create a "standard cohort table" (Table 3). A "general cohort table" is one in which the range of the age groups does not necessarily correspond with survey periods.

Exact evaluation of a cohort table is not as easy as it may look. For example, consider the diagonal line labeled as (1) in Table 3. The 20–29 year-old group in 1970 and the 30–39 year-old group in 1980 belong to the same (birth) cohort, born during the 1940s. Their consumption increased from 10 to 17 kg from 1970 to 1980. The difference of 7 kg can be attributed to two factors, aging effects from twenties to thirties and period effects from 1970 to 1980 which are combined and not readily identifiable.

The 30–39 year-old group and 40–49 year-old group consumed 17 and 20 kg, respectively, in 1980 (the horizontal line (2)). The difference of 3 kg cannot be explained by the age factor alone, since the latter age groups belong to the different cohort, born during the 1930s. Here again, the composite effects of age and cohort are not easy to separate.

Lastly, the 30–39 year-old group consumed 17 and 14 kg in 1980 and 1990, respectively [vertical line (3)]. The difference of 3 kg in this case cannot be ascribed to the passing of time from 1980 to 1990 alone, a part of which may result from the difference in birth cohort, since those who were 30–39 years old in 1990 were born in the 1950s.

There is an exact linear relationship among cohort, age, and period: a subject i years of age at the jth year of the study belongs to birth cohort $j - i$. This linear relationship presents a problem in model identification, and results in infinitely many least squares solutions for parameter estimates (Mason & Fienberg, 1985). Overparameterized models have been widely studied by statisticians (Graybill, 1978). Nakamura (1986) presents a "Bayesian approach" to selecting among the class of least squares estimates. Nakamura begins with the usual cohort model:

$$\mu_{ij} = \beta + \beta_i^A + \beta_j^P + \beta_k^C + \epsilon_{ij,} \tag{1}$$

where μ_{ij} represents the consumption of age group i, in survey period j, and ϵ_{ij} represents sampling error in the survey. Nakamura then adds an assumption of "gradual changes" (*zenshin-teki henka*) in the parameter estimates:

$$\begin{aligned}&\beta_i^A - \beta_{i+1}^A \approx 0,\\ &\beta_j^P - \beta_{j+1}^P \approx 0,\\ &\beta_k^C - \beta_{k+1}^C \approx 0\end{aligned} \tag{2}$$

along with the usual sum to zero constraints:

$$\Sigma\beta_i^A = \Sigma\beta_j^P = \Sigma\beta_k^C = 0 \tag{3}$$

With these added constraints the parameters can be uniquely estimated using least squares techniques. Specifically, we find the parameter estimates that minimize

$$\Sigma[\mu_{ij} - (\beta + \beta_i^A + \beta_j^P + \beta_k^C)]^2 \tag{4}$$

subject to the side constraints that

$$1/\sigma_A^2\Sigma(\beta_i^A - \beta_{i+1}^A)^2 + 1/\sigma_P^2\Sigma(\beta_j^P - \beta_{j+1}^P)^2 + 1/\sigma_C^2\Sigma(\beta_k^C - \beta_{k+1}^C)^2 \tag{5}$$

The side constraints require an iterative solution, and are evaluated using the ABIC (Akaike's Bayesian Information Criterion) function. Nakamura uses a grid search over the range of the hyperparameters σ^2 from 2^{-7} to 2^7. In this study, the range is restricted to 2^{-2} to 2^2, for reasons explained in Mori and Gorman (1999, pp. 85–88).

4. Results for selected commodities

Using the individual consumption derivation method provided by Mori and Inaba (1997) and Lewis et al. (1997), several commodities were analyzed. The method was refined and more recent data were included (Tanaka & Mori, 1998; Mori, 1998; etc.). Cohort analysis was performed on resulting individual consumption estimates by age classes for the various

Table 4
At-home versus away-from-home consumption of beef and pork, Japan, 1979–96

	Beef		Pork	
	At home	Eat out	At home	Eat out
1979	63.3%	23.3%	52.3%	25.1%
1989	50.2%	37.9%	40.7%	28.4%
1996	41.0%	50.0%	40.0%	29.0%

Source: Ministry of Agriculture, Forestry and Fisheries, Division of Meat and Eggs, Japan.

commodities. A SAS 6.12 program that incorporates Nakamura's (1986) algorithm was used. The results for rice, fresh fish, beef, sake, beer, and fresh fruits are presented here.

The data analyzed was for at-home food consumption only. The Japanese, like Americans, are consuming more and more food away from home (Table 4). This trend is more pronounced in the younger Japanese age groups. The older age groups eat out less frequently than do their younger counterparts.[1] Adequate data were not available to fully incorporate away-from-home food consumption. Our tentative analysis of eating-out by Mori and Inaba and Lewis's approach demonstrates a relatively greater tendency for the younger age groups to eat out (unpublished material).

4.1. Rice (Fig. 1)

Rice is one of the traditional Japanese foods with a high annual per capita consumption level. The grand mean from the analysis was 40.96 kilograms per year. Younger ("pure") age groups tended to consume less than the older groups. In particular, those between age 20 and 40, with the period and cohort effects controlled, consume 6 to 10 kilograms less than the grand mean. Those 45 and older consume 6 to 7 kilograms more than the grand mean. These differences by age may largely reflect changes in eating out. More important are the rather pronounced cohort effects for rice. Those people born before World War II have a steady, positive cohort effect of 8 kilograms. Each succeeding cohort group has a lower cohort effect for rice consumption. The newest cohort, those born between 1987–1991, has a negative 16 kilogram cohort adjustment. The period effects are generally decreasing. This is consistent with the evidence that rice is an inferior good (Ito et al., 1989; Matsuda & Nakamura, 1993). As average Japanese income has risen, consumption of animal proteins and fat has increased steadily and rice consumption has declined accordingly.

The analysis points to a continued decline in Japanese at-home rice consumption. As the newer cohorts age, and the older ones move out of the population, the negative period effects will be compounded. Per capita rice consumption should decline at an increasing rate.

4.2. Beef (Fig. 2)

Beef is consumed in relatively small amounts by Japanese households. However, it is one of the goods that is being consumed in increasing amounts. The grand mean of the analysis was 3.12 kilograms per year. Younger age groups, with the other effects controlled, consume

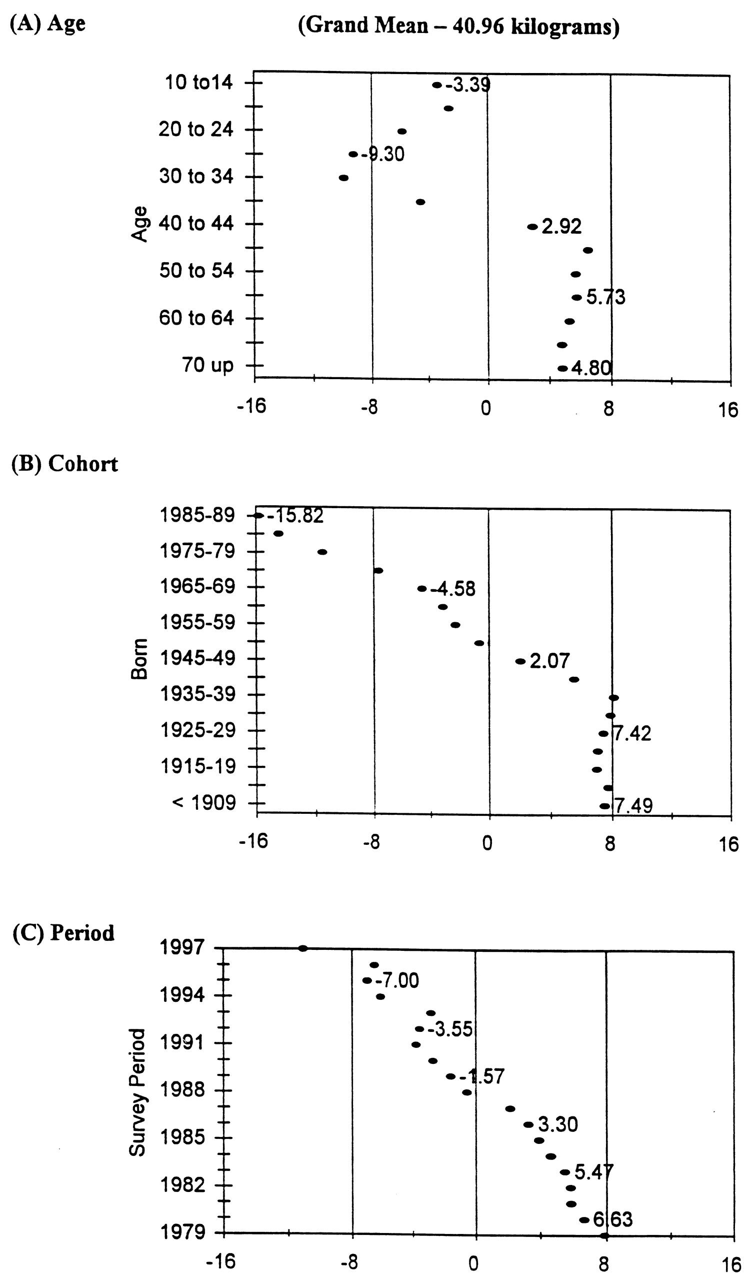

Fig. 1. Estimates of age, cohort and period effects for rice.

less beef than older ones (again, at-home only). In sharp contrast with rice described above, those cohorts born before World War II are found to have inclination to consume less than those born after the war. Additionally, there is a strong trend of increasing consumption due to period effects. Thus, as those cohorts that are in the lower consumption stages of their age

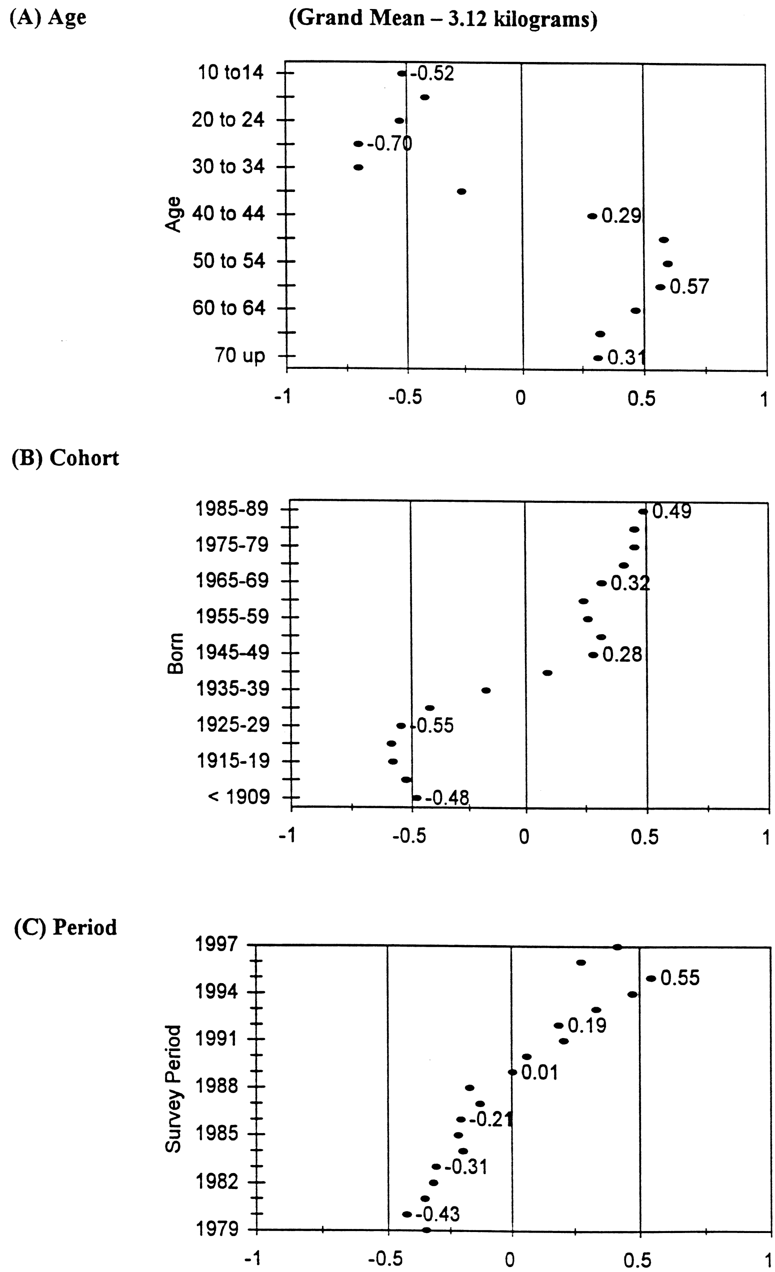

Fig. 2. Estimates of age, cohort and period effects for beef.

cycle grow older, they will consume beef in increasing amounts at home. The strong positive cohort effects from the newer cohorts should combine with the increasing period effects and the age effects of higher consumption by older age groups. This indicates a strong possibility of increased beef consumption rates in the future.

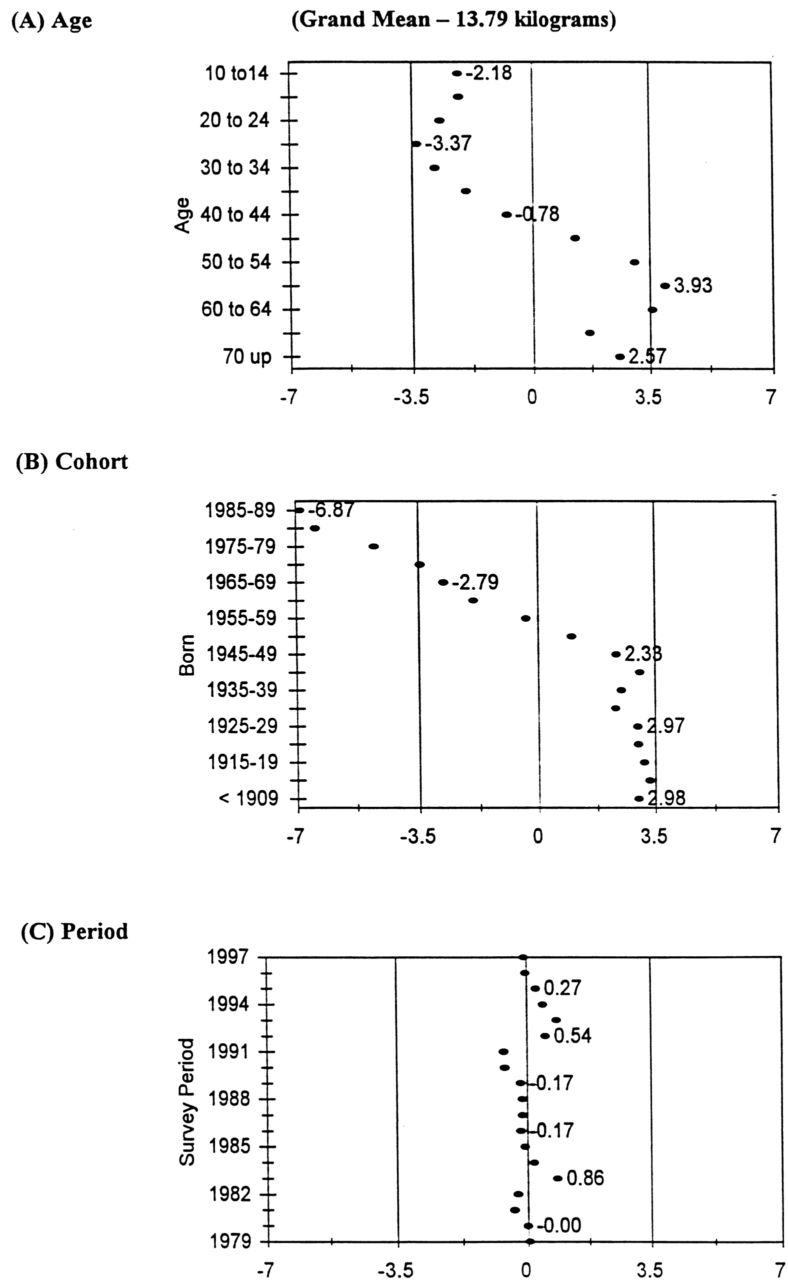

Fig. 3. Estimates of age, cohort and period effects for fresh fish.

4.3. *Fresh fish (Fig. 3)*

Another traditional Japanese food, fish is one of the primary protein sources for the Japanese. The consumption grand mean is 13.79 kilograms per year. Fresh fish has age

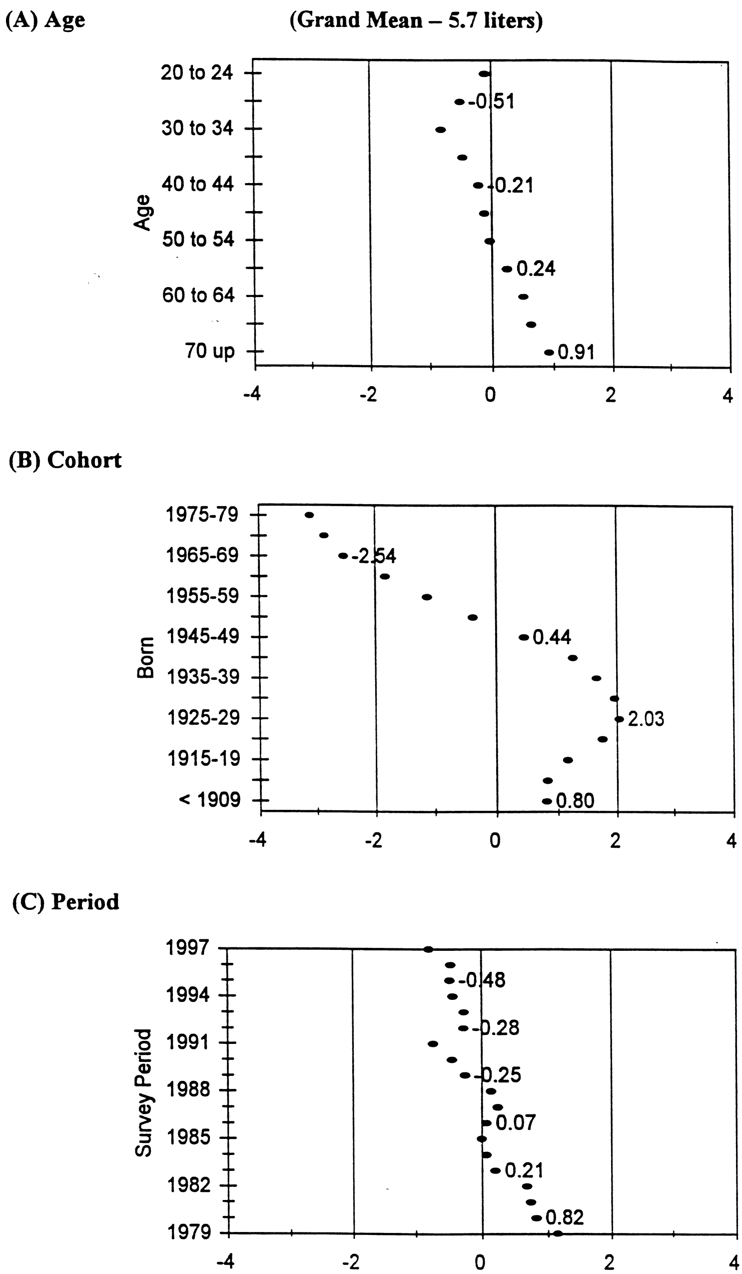

Fig. 4. Estimates of age, cohort and period effects for sake.

effects similar to those for beef and rice, with younger ("pure") age groups consuming less than older age groups, *ceteris paribus.* As with rice, cohort effects for fresh fish are positive for older cohort groups. For cohort groups born after WW II, they begin a sharp decline. The

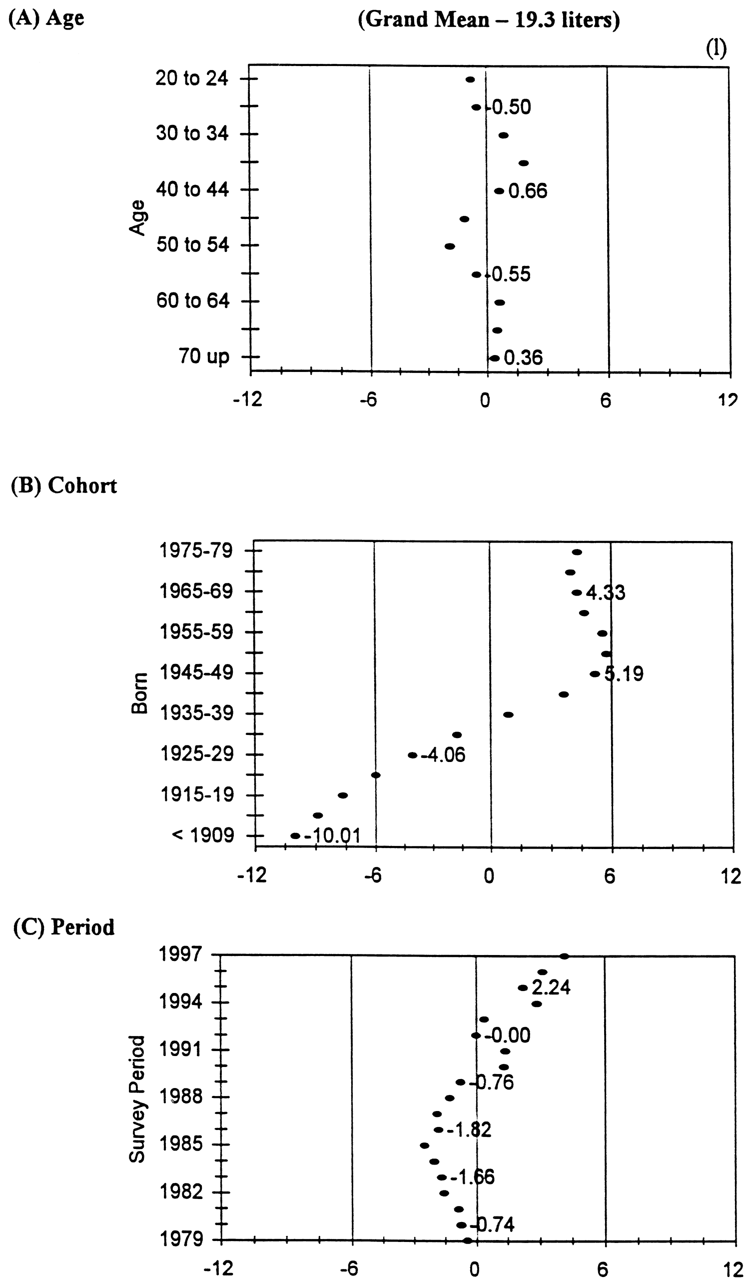

Fig. 5. Estimates of age, cohort and period effects for beer.

newest cohorts have a negative 7-kilogram consumption adjustment, about half of the grand mean. There are little period effects associated with fresh fish. Consumption of fresh fish can be expected to continue to decline as newer cohorts replace older cohorts.

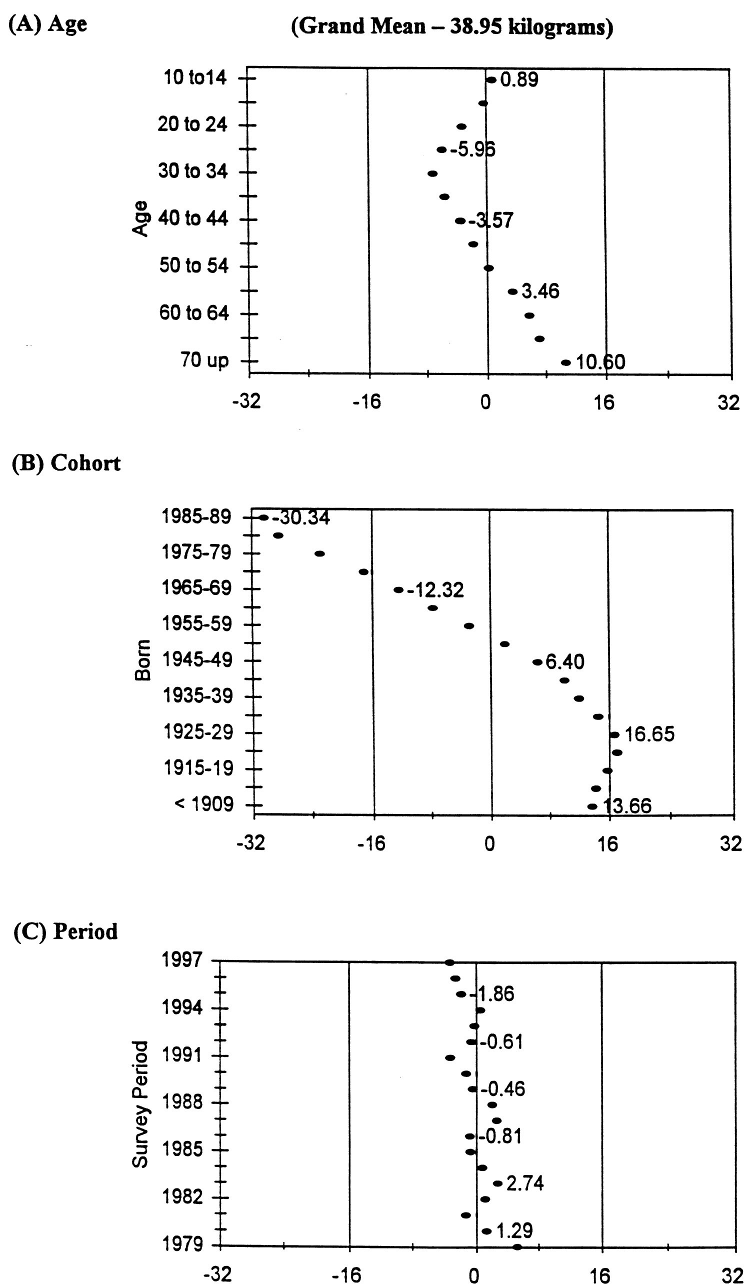

Fig. 6. Estimates of age, cohort and period effects for fresh fruit.

4.4. Sake (Fig. 4)

A rice wine, sake is a traditional alcoholic beverage in Japan. Sake has a grand mean of 5.7 l consumed per year. There are slight age effects for sake, with younger ("pure") age groups tending to consume less than the older age groups. There are very strong negative cohort effects for newer cohort groups. On the whole, older cohorts have apparently positive cohort effects. There is a negative trend in period effects, although not a substantial one. The negative cohort effects for newer cohorts will lead to continued decline in overall at-home sake consumption.

4.5. Beer (Fig. 5)

The analysis resulted in a grand mean of 19.3 l of beer consumed (at home) annually. The age effects showed no clear trend, but were close to 0 for each age group. The currently younger age groups had strong positive cohort effects of from 4 to 6 l. Those born before 1932 had increasingly negative cohort effects. There was a slight tendency for increasing positive period effects. With the larger number of newer cohorts preferring beer than older cohorts, consumption should continue to increase if the pure period effects do not operate quite favorably.

4.6. Fresh fruit (Fig. 6)

Per capita fresh fruit consumption has been declining steadily from 45.2 to 31.7 kg in the past 20 years. The grand mean from the analysis was 38.95 kilograms per year. The age effects are negative for those between 20 and 50, other effects controlled. Older "pure" age groups have positive age effects. More significantly than the case of rice and fish, those born before 1952 have strong positive cohort effects, while those born after 1952 have sharply increasingly negative cohort effects. The newest cohort group has a −32 kilogram cohort adjustment to fruit consumption. There is no apparent trend in period effects. Most of the decline in overall consumption levels can be explained through the cohort effects, the older cohort groups being replaced by newer ones. It is expected that fruit consumption will continue to decline at an increasing rate, unless the industry launches effective marketing actions to reverse the negative cohort effects of the newer generations immediately, which could include subsidized provisions of fresh fruits to school lunch programs for primary- and middle-school children, nationwide (Rentz & Reynolds, 1991).

4.7. Appendant (Table 5)

The resulting period effects from the analysis were used to perform a least-squares regression of fresh fruit consumption over time from 1979 to 1997. The grand mean was adjusted by the amount of the period effect for each survey year. The resulting quantities were regressed against real prices and *per capita* living expenditures. The same regression was performed with actual *per capita* figures from the *FIES* instead of the estimated quantities from our analysis.

Both regressions resulted in significant models. The major difference between the two was the income elasticity estimates. Using the actual figures from the *FIES* resulted in a −0.59 income elasticity. The quantities from our cohort analysis resulted in a +0.38 income elasticity (Table 5). Fresh fruit, however, is not considered an inferior good. Cross section-

Table 5
Elasticity estimates of demand for fresh fruit: (A) period effects derived from cohort analysis and (B) simple *per capita* consumption derived from dividing household consumption by household members, 1979 to 1997

(1) Fresh fruits	(A) Dependent variables = period effects + grand mean		(B) Dependent variables = simple *per capita* quantities	
	Parameter estimate	Standard error	Parameter estimate	Standard error
Intercept	0.55	2.86	13.40	2.18
Living Expenses	0.38	0.25	−0.59	0.19
Price	−0.47	0.13	−0.38	0.10
Adj R^2	0.63		0.94	
D-W	1.69		1.38	

ally, fresh fruit has been consumed in greater amounts by those with higher incomes in any year of the period under consideration (Mori & Inaba, 1997). This prior evidence supports the results of our cohort analysis.

5. Implications and conclusions

Cohort analysis can be useful in marketing and forecasting and should provide more reliable long-run data to demand analysis where conspicuous effects of age in a broader sense and/or age and cohort are observed. It becomes possible to more accurately target specific age groups and/or cohort groups. This could serve to outline future opportunities as well as warn against adverse future trends in consumption. Once future demand is predicted, short-term and long-term marketing plans can be implemented to take advantage of cohort trends or to possibly shift future cohort trends. This can be done accurately only if age and cohort effects are carefully determined independently from each other.

Notes

1. The rate of eating out for supper was 12.2 and 10.5% for the 40–49 and 50–59 year-old groups, respectively, in 1993, whereas that for the 20–24, 25–29 and 30–39 year-old groups, respectively, was 20.7, 18.4 and 13.6% in the same year (*Nutrition Survey*).

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